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# The Madras Agricultural Journal

SPECIAL CONFERENCE NUMBER

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WE are publishing the Madras Agricultural Journal this month as a special Conference Number, embodying the papers that were presented for the Symposium on Manuring of Crops on the occasion of the Thirty-Fourth College Day and Conference in July 1951. An apology is needed this year also, for the time-lag between the presentation of these papers and their publication this month. This delay was due to various unavoidable circumstances, but it is a matter for satisfaction that it was possible to publish the symposium papers in a single issue, with the aid of a special grant which the Government was kind enough to sanction, in March 1952.

The symposium is a fairly comprehensive one and contains helpful information to everyone who is interested in agriculture. In addition to giving a useful summary of the work that has been done so far in Madras on the vital subject of manuring crops, the symposium also indicates the lines along which the future work should be carried out on the manurial aspects of various crops in our State.

The general conclusion that emerges from the symposium papers is that Nitrogen is the prime requisite for nearly all the crops that are grown in Madras. The particular form in which it is supplied, whether in the form of green leaf, or as bulky organic manures or as oil-cakes or in the form of concentrated inorganic fertilizers like ammonium sulphate, appears to be relatively unimportant. From the practical farmers' view-point, this is very helpful, as it gives him a very wide choice in drawing up his manurial programme.

Phosphates are useful only in certain places and for certain crops and a good deal of further study is needed before we can reach the stage of definiteness that is possible now in the case of nitrogenous manures.

Potash in general is not quite essential for South Indian crops, except for coccnut on the West Coast.

The discerning reader will no doubt find a certain amount of variation in the conclusions drawn regarding the effect of manures on various crops and the recommendations made thereon. The perennial question regarding the relative merits of organic manures, and inorganic fertilizers also finds place in the symposium and opinions both for and against are presented on this subject. Such differences in viewpoint are however only to be expected in a subject so vast and varied as Manuring and in fact they serve to emphasise the many-sided aspects of manuring and show how much more still needs to be done on this vast subject.

# Manuring of Rice with Reference to Different Environmental Factors

*By*

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**Introduction:** There are no two opinions that one of the surest methods of increasing the yields of crop plants is to increase the capacity of the soil to supply nutrients to the plant by manuring. It has also been the experience that identical results are not obtained by identical methods practised.

At the outset it may be stated that in the paragraphs that follow, no distinction is made between the words 'manures' and 'fertilizers'. Manures in this special sense mean substances belonging to plant residues while fertilizers imply those of mineral origin. It is not proposed to give any detailed recommendations about manuring, but certain basic principles based upon past experience at various Research Stations and the crop in general will be presented.

While considering the efficient use of manures, we have to take into account (1) the soil type and (2) the available water supplies. Different soil groups and even soil types within the same group differ in their content of available plant nutrients, and hence respond differently to the same quantity and quality of manures.

It is also essential to consider in the effective use of fertilizers, the long-term effects both direct and indirect, taking the whole rotation into consideration rather than immediate results.

Fertilizing practices may also need revision from time to time to meet changing conditions, crop growth etc. The efficient use of fertilizers and manures on a crop is bound up with proper seed, tillage, protection against pests and diseases, orderly system of water use and disposal, and conservation of organic matter. No one particular practice is always effective, but an intelligent combination of practices brings us the desired result.

**Manure and Water:** Water and manure form an inseparable couple in agronomy. The best results in manuring are obtainable only when there is sufficient moisture in the soil. Conversely, manured plots do not suffer from drought as much as plots which have not been manured, especially with organic manures. It has been reported that when a dry land crop is converted into an irrigated or garden land crop, the yields have been trebled. This gives a clue that in the interests of the nation as a whole the available short supplies of manures could more advantageously be used in places where there are assured water supplies.

It has also been borne out that the best effects of manuring are secured in well-drained soils. The differences are sometimes very wide. That is why we get the highest yields in very light, shallow soils with intense manuring, as in the soils of Chittoor, portions of Salem, South Arcot etc. This fact is again very important in that the drainage in large areas of the deltaic region had to be improved considerably, for the best results from improved crop practices.

It is found that manuring has a very great influence in the economy of water, especially in the rainfed areas. The following results from a pot-culture experiment conducted in Bengal should be of interest.

| Manuring | Water transpired / Dry matter produced | Average yield per plant |
|---|---|---|
| Farmyard manure + Amm. Sulphate ... | 408 | 10·0 |
| Farmyard manure + Amm. Phosphate ... | 458 | 10·9 |
| Farmyard manure alone ... | 400 | 9·4 |
| No manure ... | 481 | 6·8 |

Hence, to ensure the best results of manuring, all water resources, even in the delta areas have to be improved.

**Soil and Manuring:** Soil types have a profound influence on the action of manures in crop production. The rice soils of the Madras State may be divided into (1) the black cotton soils of the Godavary system, (2) the lighter clay or alluvial types of the Cauvery delta, (3) the light loamy zone of the Central Districts and the Carnatic and (4) the light sandy loams of laterite origin on the West Coast. This being so, it is possible that each of these types requires different treatments as far as manuring is concerned. Rice is a crop which is grown under puddled conditions. The time of planting and the duration under which the soil is in this condition may vary. But there is quite a general agreement in the common requirements of the rice grown in these soils.

**Results of Experiments in Madras:** From the experiments so far conducted at various stations, the following general conclusions emerge :

(1) There is a universal response to nitrogenous manures in all the stations.

(2) Of the several kinds of nitrogenous manures, green manure is the most economical and up to 8,000 lb may be applied.

(3) It is found that while 30 lb. of N per acre as ammonium sulphate is an optimum dose with a basal dressing of leaf up to 4,000 lb., even 15 lb. N as ammonium sulphate top dressing plus 4,000 lb. of leaf secures a positive response, by way of increase yields.

(4) The response with $P_2O_5$ fertilizers is somewhat variable. In some stations, specially on the lighter soils, the yields increased with super-phosphate doses. In combination with leaf the response was still more pronounced.

It is of course possible that there may be minor differences in the several district zones. In the Coimbatore soils green manure was found more efficacious than ammonium sulphate on a 30 lb. N. dosage. On the West Coast ammonium sulphate was more efficacious than leaf at the same dosage in the second crop season.

It is necessary that this difference should be investigated more fully, so as to arrive at the most efficient method of using these natural manures.

**Laterite Soils and Liming:** The laterite soils of the West Coast require special mention. They are poor in organic matter and the nitrogen content is variable; the $P_2O_5$ supplies too, are generally low, though $K_2O$ is sufficient. They are poor in bases and acidic in reaction, the intensity varying with different types. These are met with in the high rainfall tracts of the West Coast and on the Hills even if there is no high rainfall. There is a lot of iron and alumina in them. In these types of soils, for good crop production, soil amendments such as lime have to be incorporated and a liberal use of phosphates is also necessary. It is an established fact that a neutral soil or a near-neutral soil is helpful in the fixation of nitrogen from air, conversion of nitrogen into soluble forms and making $K_2O$ and $P_2O_5$ more available.

Even among 'acid' soils there is some difference; acid soils rich in clay have higher reserves of acidity than sandy soils and a mere pH value may not give us a sure guide of the quantity of lime to be added. For clay soils more lime may be necessary than for a sandy soil, though both may have the same pH value.

In a recent experiment conducted in South Kanara for three seasons the following yields were obtained.

| | |
|---|---|
| Lime (2,000 lb.) plus green manure (4,000 lb.) | 131 |
| Green manure alone (4,000 lb.) | 123 |
| Lime alone (2,000 lb.) | 117 |
| No lime, No green manure | 100 |

There was residual effect of lime on the subsequent paddy yields, amounting to 11 per cent. There was an improvement in the lime status of the soil after three years.

**Nitrogenous Fertilizers:** It has been found that ammonium sulphate is effective in increasing the yields of rice, the increases depending upon the soil conditions and cropping practices. In the recent intensive manuring campaign, tests with 30 lb. and 45 lb. doses of ammonium sulphate per acre conducted on ryots fields have given some revealing figures. It has been found the higher the fertility status of the soil, the higher was the percentage increase upto the limit when too much vegetation involves premature lodging. Hence, whenever cultivators are able to purchase ammonium sulphate, they may use it with advantage upto 150 lb. of sulphate per acre with some basal dressing of organic matter, leaf or cattle manure.

**Phosphates:** In general the response to phosphates is not as great as in the case of nitrogen in most of the research stations. This lack of response is rather surprising since the soils in most of these areas are known to be deficient in available phosphates. This aspect requires further study. In this connection attention may be drawn to one feature of phosphate application to paddy soils. In many of the experiments the phosphate is 'broadcast, top-dressed' either before or even sometime after the transplanting of rice. We are told that in most of the soils about two-thirds of the phosphorus stays in the soil within an inch or two of the place of application and also that it is no longer soluble in water having 'reverted' to an unavailable form. Thus two points emerge: (1) that the phosphate must be placed much below the surface (deeper than 2″ if possible) and (2) that every year phosphates may be applied in fairly large quantities, or to get over the loss through reversion, some other method of applying phosphates has to be thought of. There appear to be one or two methods which may serve these ends. It is reported that if the phosphates are applied to the green manure crops (where such are grown) preceding the paddy crop, they are built up into the green manure crop in a more easily available form (being in the organic state) and as such are absorbed by the plant more readily. Thus, phosphate manuring through the crop of green manure, satisfies the crop requirements in an easy manner.

It is also suggested that the phosphates may be composted with green manure and this compost applied to the soil. The $P_2 0_5$ is said to be in organic combination and so is not reverted. Besides it prevents nitrogen losses in the composts to a great extent. These aspects are now under investigation on a comprehensive scale at several Research Stations.

Thus fertilizers can be of use to indirectly build up the humus of the soil, which is the pivot of crop production in this country, since humus is easily lost by high temperature and erosion etc. It may also be possible that in course of time continuous application of phosphates as outlined above may build up the phosphate status of the soil to a degree where further applications could be smaller.

It is not fully realized that a high nitrogen status can be maintained in a soil only when the phosphate status is maintained at the proper levels. Then again, the quality of humus may depend upon the mineral status and not merely on the quantity of organic matter. Further research on these lines is also necessary.

It is often suggested if we take care of the phosphorus, the nitrogen will take care of itself. In essence, more attention has to be given hereafter to phosphate manuring in rice soils in addition to the other soil amendments that may be considered necessary.

**Green Manuring:** As already mentioned, green manuring is found to be the most useful for all the rice soils of the State. There is a variety of green manure crops available, to suit different soil types and cropping practices. Sunnhemp is the queen of fodders-cum-green manure crops, being the shortest in duration, but it is suited only to limited areas. Daincha is more or less universally useful. Pillipesara comes up well in rich clay soils with two or three irrigations. Wild Indigo comes in most of the soils but is very slow-growing. *Sesbania speciosa* is drought-resistant and will take kindly to even moderately saline soils but it is rather very slow in growth. It may be possible to grow only a fifth of the area under green manuring in this State due to limitations of soil moisture, at the time of sowing and in later stages of their growth. But an earnest effort is to be made in spite of these handicaps, as sometimes unexpected rains do help us.

One point which must be borne in mind in green manuring is this: where green manure crops are raised in the field itself and puddled in, the the green manure crops remove $P_20_5$ as well as $K_20$ from the soil and so they must be replenished now and them. Though in Indian soils depletion of $K_20$ may not occur in the near future, the case is different with $P_20_5$ in which our soils are woefully deficient in many places. It may also be pertinent to point out that where a portion of green manure is removed for fibre or for cattle food, to that extent the soil loses $P_20_5$ and $K_20$, unless these are made good through other sources. This problem of supplying green matter may be approached from another angle which is now engaging the attention of the Agricultural Department of this State. Addition of green leaf got from outside the plot does not involve the handicaps mentioned above, of lessening the $P_2O_5$ supplies in the soil. Hence it is proposed to utilize the bunds and the edges of the fields for raising quick-growing shrubs as *Gliricidia* and *Sesbania* species for green manure plants. It is possible that a good part of the demand for green matter for rice may be met by a widespread practice of these methods. All waste places, channel, bunds etc., should be made available for producing green leaf, so vital to the rice crop which has to solve the food needs of our country.

**Combination of manures:** There is a general apprehension, that in the combined application of fertilizers, particularly ammonium sulphate on paddy soils, however rich it may be in the humus content at the beginning, gradual losses of other minerals specially lime, may occur and also probably phosphate which may ultimately impair the crop production. Through there are no facts to prove or disprove this opinion, it stands to reason that a 'single element' nutrition is always risky and it may not be practised continuously or long. A favourable balance between important mineral nutrients, organic matter, suitable physical conditions of the soil, and microflora is one which results in the best crop production. In fact fertilizers by themselves are wasteful on farms that are not maintained by proper farming practices. It is essential that there must always be humus in the soil; and hence a basal dressing of organic matter before 'artificials' should always added to the soil.

As a general practice, it is recommended that whenever possible a basal dressing of 4,000 lb. of leaf should be added to the soil before fertilizers are applied.

It must be admitted that no experiments have been conducted so far, to fix what should be the dosage of compost of farmyard manure that would serve as a basal dressing. Probably we may require as much as 5,000 lb. per acre.

It may also be noted that land to which organic matter is added, requires less of the costly nitrogen and phosphate fertilizers in the long run.

There is some controversy, with no prospect of an immediate solution, regarding the efficiency of 'fresh' or 'rotted' manure to paddy soilds which are under 'anærobic' conditions. We are told that fresh straw stimulates growth of bacteria at the expense of nitrogen, but after the material is decomposed, they release the nitrogen contained in them. Therefore to minimize the losses in bulk in the preparation of rotted manure it may be advantageous to add fresh manure to rice soils. Thus the practice of burying fresh straw or even leaves of palmyrah in some parts of the country, derives some justification in this connection.

**Time and method of application of manures:** When once it is decided what manure or fertilizers are to be used for a particular crop, the important problem of determining when and how they are to be applied in order to get the maximum benefit, has still to be solved. For an efficient use of the fertilizer, it is necessary that they should be suppiied at the right time and in the right way.

In regions of low summer rainfall, nitrogenous fertilizers, it is reported, give the best results when applied 10 – 12 – cms. below the surface. It is always found more advantageous if applications of cattle manure are made shortly before planting than when they are applied earlier.

In China paddy seed is mixed with dry manure and sown in open furrows when the crop is raised by direct sowing.

In a recent communication, some light is thrown on new a practice of applying ammonium sulphate. Prof. Pearsall in studying marsh conditions in Cumberland, found measurable differences in the water-logged soils; oxidation took place at the soil-water surface but reduction lower down. The Japanese have recognised the bearing of this finding on the rice problem. Sulphate of ammonia put on the surface of the mud in the usual fashion was quickly oxidized to nitrate, which was washed down below and reduced to gaseous nitrogen. But if sulphate of ammonia was pushed down through the oxidation zone into the region of reduction it lay there safely till the plant took it up. If nitrates are used they may be used as top dressings later during the growth". — (Russell – World Crops – Vol. 1. No. 2. 1949)

This requires some serious thought, as it is at variance with the usual practice of broadcasting ammonium sulphate sometime after the crop is established.

**Varieties and Manuring:** It is argued that the total amount of nutrient elements contained in a crop cannot be used to calculate its fertilizer requirement as the feeding mechanisms of plants vary from crop to crop, as also their ability to assimilate nutrients from relatively insoluble compounds.

Whether the different strains within a crop variety will show different ability to make use of soil nutrients has not been fully studied in this country. However, an interesting study made some years ago with the 'cultures' from one variety and the ryots' mixed bulk disclosed that the strains were able to a utilize soil nutrients to a greater degree than the control. This supports the results of Paul (1935) who found differential responses of strains of maize and tomato to manurial ingredients.

This raises an important issue. One school of thought contends that the strains 'exhaust' the soil much more quickly than the mixed 'variety' of the ryot, because the former give higher yields. The other view is that the strains are able to to utilize the soil nutrients more efficiently. It may be that a strain which has a particular type of root system reaching a certain definite depth, possibly depletes soil fertility at this particular zone in course of time. But if some sort of rotation is practised, i. e. using different strains of rice in different years, this contingency may not arise. It may also be possible that the strains might be able to utilize soil nutrients differently. Obviously this important issue requires investigation and work has recently been started in this direction in this State.

However, there are some experiments where different varieties were included under one level of manuring. The results show that within a particular duration group there are not much differential responses under normal conditions. But in years of insufficient rainfall certain varieties show a greater response than certain others.

Another point which is of some importance in a manuring policy, is that of response of short and long duration crops to manuring. It was found that the short duration groups show a better response.

This result can be explained from the fact that short duration varieties are generally grown at a time when there are no weather disturbances and when more secure conditions of water supply exit. Thus, if a decision has to be taken between application of manure to short duration or long duration crops alone, the choice should be in favour of short duration crops.

**Manuring and Quality of Rice:** 'Quality' in rice is a very ambiguous term as the conception varies with the several interests concerned in the rice industry. But what we are primarily concerned as consumers is the nutritional aspect, which is governed by the vitamin content, protein, phosphates, calcium, etc. Much of the data in other countries show that where the soil contains a well-balanced supply of plant nutrients or where conditions are optimum for plant nutrients and for plant growth, the vitamin content of the produce is also high. Excessive use of single element fertilizers or of unbalanced fertilizers result in crops of low biological value. It may be treading on ground which is not the legitimate province of a plant breeder, but it may be pertinent to mention some valuable conclusions reached in this regard in rice. Some experiments were conducted under schemes initiated by the Indian Council of Agricultural Research on this aspect of rice in the past and the following figures speak for themselves.

| | | N. | $P_2O_5$ | Ash | |
|---|---|---|---|---|---|
| I. | No manure | 8·20 | 0·674 | 1·32 | Variety Co. 10 |
| | Manured (Super — 224 lb. Amm. Sulphate 112 lb. and leaf 4,000 lb. per acre) | 8·76 | 0·699 | 1·64 | |
| II. | Leaf at 2,000 lb. per acre | 10·28 | 0·564 | 1·32 | Variety GEB. 24. |
| | Leaf — Super 112 lb. per acre | 10 03 | 0·584 | 1·40 | |
| | Leaf + Amm. sulphate | 10 88 | 0·660 | 1·68 | |

Thus proper manuring not only gives higher yields but gives also a product of better nutritive value. Preliminary experiments carried out on a number of Agricultural Research Stations with the same manuring and the same varieties, show differences in the chemical composition of grain. Under ill-drained conditions the grain contains lesser $P_2O_5$ and even less proteins. Again in lighter soils, the manured grain is richer than in unmanured soils; whereas in heavy soils this is not quite so marked. Here again it is obvious that these problems call for detailed investigation.

**Conclusion:** At the present moment an integrated plan of work is necessary for increasing rice production in this country. To bring home this point, the example may be cited of the Japanese way of rice cultivation, who doubled their per-acre production in four decades. Their soils are no more rich than most of our soils. But the Japanese farmer cultivates his rice field as if it were a garden. There is no slovenly corner in any field. Each crop gets its adequate manuring. The manure he gives to rice would stagger us; viz. 45–100 lb. Nitrogen, 60–80 lb. $P_2O_5$—in addition to a lot of organic matter in the form of composts of all organic wastes, from man, animal and plant. Rice is inter-cultivated two or three times during its growth. Water is given and taken out as and when necessary. Eighty per cent of the rice area is grown to improved seed, developed by the plant breeders. 50 per cent of the wetlands is cropped twice in a year, with either rice, wheat, sweet potato, peas, or some crop or other. We have, no doubt, record yields of upto 10,000 lb. in some places in the State, but the average has to be pushed up by a co-ordinated plan of efficient cultivation, if the over-all production of rice in our State is to be improved in any definite manner.

# Manuring of Millets in Madras

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Millets are small-grained cereals which are very ancient in origin. They have served as food for man and his domesticated animals from prehistoric times. Growing wild in virgin soils, they yielded grain and fodder to the nomadic ancestors of the present civilised nations. Later on, settled life and pressure of population induced cultivation and selection, and innumerable varieties and forms came into existence. The important millets that are under cultivation are Sorghum *(Cholam* or *Jonna), Pennisetum typhoides (Cumbu* or *Sajja), Eleusine coracana (Ragi), Setaria italica (Tenai), Paspalum scrobiculatum (Varagu* or *Arika), Panicum miliare (Samai* or *Samalu), Panicum miliaceum (Panivaragu* or *Variga),* and *Echinochloa frumentacea (Kudirai vali).* Millet grains take no part in international commerce as they are the food of the poorer classes of people, and are very little cultivated in the more advanced agricultural regions. However, millets form the staple food of a quarter of the world's population of 2,000 millions, and they are the dominant cereals in the whole of Africa except the north, and that they are the mainstay of the population of Africa, China, Manchuria and about 30% of the population of India. Their importance is also enhanced by the fact that they have certain advantages over the other cereals. Some of them, particularly the Panicums, grow very rapidly and ripen more quickly than any other cereal and are hence suited to areas where the rainy season is short. Most of them thrive in arid regions and resist drought in a remarkable way. They flourish on land which is too thin or too poor to grow any other cereal, require less attention and have fewer pests than rice, wheat, maize etc. All of them are richer than rice and wheat in fat and minerals, while some are richer than wheat in protein also. All these facts point to their high status as important sources of human food and cattle fodder in the hotter and drier regions of the world. In India, they occupy about 64 million acres with an annual production of 12 million tons of grain, while their area in the Madras State is 12·8 million acres, the annual grain production being 3·2 million tons. In Madras, 30% of the population and 60% of the cattle are entirely dependent on millets. Hence the importance of millets can never be over-emphasised. In this State too, however, they have not received adequate attention, particularly with regard to manuring. A brief review of the outstanding results achieved in the State through manuring, and some recommendations are presented in this paper.

**Place of Millets among manured crops:** Manure is the index of the commercial or economic importance of any crop, and the care with which the required quantity and quality of manures is applied directly reflects the esteem in which the crop is held by the farmer. Thus sugarcane, bananas, tobacco etc., among commercial crops, and paddy, wheat, maize etc., among grain crops are invariably manured and the farmer pays much attention to them. But, millets, being the poor man's crop and commercially of much less importance, are not generally manured. There are other reasons also. The bulk of the millets, nearly 90% of the total area, are rainfed and are subject to the vagaries of the monsoons, thus imposing limitations to the application of manures. The best effect of manure can be obtained only when sufficient water is available. The quantity of manure available for all crops is another limiting factor and the more important crops invariably get the available manures. The vast majority of the millets, particularly the rainfed crops, are sown in rotation or mixed with pulses and other leguminous crops, and the atmospheric nitrogen fixed by the latter is a source of nitrogen to the cereal. Where millets follow a commercial crop, particularly under irrigation, the heavy dose of manure applied to the previous crop is expected to leave sufficient residual effects to sustain the millet crop. Thus, due to various reasons millets do not receive adequate manuring, and the maximum yields of grain and straw that can be obtained from this group of crops are never realised in this State.

**Response of millets to manuring:** Millets are a group of crops which respond very well to manuring. Both rainfed and irrigated crops can be manured with advantage, if adequate moisture is available for the crops. Unlike sugarcane, paddy etc., millets require much less water and can thrive on a variety of lands where paddy and other grain crops cannot be successfully grown. Hence with the same amount of manure and water, a much heavier harvest of grain and fodder can be obtained from millets than from other cereals. Unfortunately this fact is neither well known nor its significance fully realised to derive benefits through its practical application. Experiments conducted at the Research Stations in this State have clearly established that millets respond very well to the application of both organic manures and also artificial fertilizers, paying a handsome return for the expense and trouble involved especially with irrigated millets. Rainfed cholam manured at 2 cwts. of ammonium sulphate and 1 cwt. of super phosphate with or without a basal dressing of 5 cartloads of cattle manure ($2\frac{1}{2}$ tons) per acre gave 67 to 72% increased yields over the control. These experiments were conducted at the Agricultural Research Stations, Guntur, Hagari, Nandyal and Koilpatti. Apart from the artificial manures, the application of green manures viz. *Pillipesara*, *Teegapesara* or cowpea was tried for a period of three years with and without superphosphate on *Pyru Jonna* at Guntur. All the three green manures gave 40 to 60% increased yields over the control, cowpea proving to be the best green manure. The application of molasses at 8 tons per acre at Hagari resulted in an increased yield of 100% over the control. The effect of ammonium sulphate and groundnut cake individually and in combination at different levels of nitrogen over a basal application of 1 cwt. of superphosphate and 1 cartload of cattle manure per acre were studied at Koilpatti. It was found that the application of nitrogen either as ammonium sulphate or a mixture of both resulted in increased yields going upto 144% over the control at the highest level of nitrogen as groundnut cake. The residual effects of ammonium sulphate at 2 cwts, and superphosphate at 1 cwt applied to cotton, over a basal dressing of 5 cartloads of cattle manure per acre, were tested both on *Pyru jonna* grain and fodder crops over a period of two years at the Agricultural Research Station, Guntur. The artificials, in combination with cattle manure proved better than cattle manure alone with increases in yield of 20 and 15% respectively. Similar results were obtained at Hagari, Nandyal and Koilpatti also. These residual effects were traced even to the second year with increases in yield ranging between 10 and 18%. Similar experiments were conducted on *cumbu* at Koilpatti with varying doses of groundnut cake, ammonium sulphate and superphosphate over a basal dressing of 6 cart loads of cattle manure per acre. All the treatments gave significant increases yield over the control, 2 cwts. of ammonium sulphate giving the highest yield. Very encourag'ng results have been obtained from the application of fertilisers to *ragi*. Experiments conducted on *korra (tenai)* at Hagari showed that the application of Indore compost and farmyard manure to supply 50 lb. of nitrogen per acre was highly beneficial and resulted in increases in yield ranging from 26 to 35% over the control. In another experiment, the optimum dose of farmyard manure was found to be 6,000 lb. per acre and gave 28% increase of grain yield over the control plot. A dose of 50 lb. of nitrogen in the form of farmyard manure, compost or artificials, has a'so been found to give very high yields in all the minor millets - *varagu, samai, panivarugu,* and *kudiraivali* These experiments have been reviewed and the results summarised in the Madras Agricultural Journal Vol. XXXII, Nos. 1 to 4. An abstract of the results obtained at the different research centres in this State is given in Table. 1.

**Abstract of Results of Manurial experiments conducted on Millets in the Madras State**

| Name of crop | Centre of trial | Manure applied (per acre) | Increased yield (as a percentage over control) | Remarks |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| **Rainfed cholam (Jonna):** | | | | |
| Grain crop | Nandyal | Artificials with or without cattle manure (at 5 C. L.) | 55 | |
| ,, | ,, | Am. Sulph. 80 lb. | 43 | Control not manured |
| ,, | Hagari | Am. Sulph. 2 cwt. & Super phos. 1 cwt. | 72 | Control not manured |
| ,, | Lam (Guntur) | do | 67 | Control manured at 5 C.L. of cattle manure |
| ,, | ,, | Pillipesara, Teegapesara or Cowpea. | 40–60 | |
| Fodder crop | ,, | Am. Sulph. 2 cwt. & Super phos. 2 cwt. | 93 | Control 5 C. L. of cattle manure |
| **Irrigated cholam:** | | | | |
| Grain crop | Hagari | Molasses at 8 tons. | 100 | Control yield 318 lb. |
| ,, | Central Farm, Cbe. | Am. Sulph. 2 cwt. & Super phos. 1 cwt. | 63 | |
| ,, | ,, | Artificia's (Am. Sulph., Super phos.) with a basal dressing of cattle manure | 25–62 | |
| ,, | ,, | Do. without basal dressing of Cattle manure | 4–205 | |

| Name of crop | Centre of trial | Manure applied (per acre) | Increased yield (as a percentage over control) | Remarks |
|---|---|---|---|---|
| ,, | Koilpatti | G. N. Cake with Am. Sulph. | 123–144 | |
| ,, | ,, | Do. with cattle manure & cotton compost (6 C. L.) | 226 | |
| ,, | ,, | Cattle manure, & Am. Sulph. 2 cwt. & Super phos 1 cwt. | 352 | |
| Fodder Crop | ,, | Nitrolime 2 cwt., fish guano 5 cwt., singly & in combination | 41–61 | No manure control |
| ,, | ,, | F. Y. M. and G. M. cake & Articials (Am. sulph & super phos) | 19–157 | |
| Cumbu Grain crop | ,, | Nitrolime 2 cwt. & Super phos ½ cwt | 44–73 | |
| ,, | ,, | 6 C. L. of F. Y. M. (Basal) & G. N. cake (125 to 250) plus Am. sulph. & super phos. (artificials ½ to 2 cwt) | 60–160 | Control manured at 6 Cart loads Farm Yard Manure |
| Fodder crop | ,, | Am. sulph. 2 cwt; & super phos. ½ cwt. | 14–120 | |
| ,, | ,, | Am. sulph. 2 cwt. | 70 | |
| **Irrigated Ragi:** | | | | |
| Grain | Palur | Indore compost & F. Y. M. to supply 80 lb. of nitrogen each | 37–53 | Control no manure |
| ,, | ,, | Am. phos. 1 cwt. & 5 C.L. cattle manure | 31 | Over 5 C. L. cattle manure control |
| ,, | Central Farm Cbe. | Artificials to supply N. K. etc. either singly or in group with or without cattle manure | 7–72 | |
| **Rainfed Tenai:** | | | | |
| Grain crop | Hagari | Indore compost or F. Y. M. | 26–35 | Control no manure 320 lb. grain. |
| ,, | ,, | F. Y. M. at 3,000, 60,000, & 9,000 lb. | 20–30 | Control no manure 380 lb. grain. |
| **Irrigated Panivaragu:** | | | | |
| Grain crop, | Central Farm Cbe. | Cattle manure at 5 C. L. per acre | 23 | Control no manure |

Abbreviations used indicate the following:

| | | | |
|---|---|---|---|
| Am. Sulph. | Ammonium sulphate | Super. phos. | Superphosphate |
| C. M. | Cattle manure | C. L. | Cart loads |
| F. Y. M. | Farmyard manure | G. N. cake | Groundnut cake |

It will be seen from the above table, that millets respond very well to manuring and that profitable returns can be obtained by the application of organic manures as well as artificial fertilizers.

**Manures suitable to Millets:** There is a large variety of manures which are found suitable to millets. They fall into two groups, organic manures and artificial fertilizers. Under the organic manures may be listed the manures obtained from the livestock kept on the farm, compost made on the farm, municipal rubbish and other refuse decomposed and converted into manure, compost made with night soil, dung, urine, etc., applied to the field direct by sheep-penning and cattle penning, oilcakes, bonemeal etc. Amongst the artificials, the commonest fertilizers now in use are ammonium sulphate, super phosphate, etc. In addition to these, green leaves. dry leaves, earth from old village sites, red soil from fertile spots, tank silt etc., are also applied to the fields to enrich and improve them. Depending upon the availability of these manures and fertilizers and the agricultural practices prevailing in the different tracts, different manures may be applied to the various millets cultivated in the State. The primary consideration in the application of manures is to put back into the soil what is removed in the form of grain and straw. Large quantities of nitrogen and phosphoric acid and potash are required for obtaining high yields of most crops. Millets are largely grown as dry crops which are completely dependent upon rains. As already stated, nearly 90% of the total area under these crops are completely rainfed, and subject to the vagaries of the monsoons, while the remaining area is cropped with the help of irrigation. The irrigated millets are invariably manured directly or indirectly in all parts of this State, and depending upon the availability, cost and other factors, varying quantities are applied. While only organic manures such as cattle manure, compost, etc., were applied in olden days, the need for and the advantages of incorporating heavy doses of both organic manures and artificial fertilizers have been realised of late by the gardenland cultivators, and manuring has become a regular practice in the garden lands in the central and southern districts of this State. Apart from these manures, heavy doses of tank silt, poudrette, compost etc., are also applied. Among the irrigated millets, *Ragi, Cholam,* and *Cumbu,* are the most important and they receive the bulk of the manures. *Tenai,* and the minor millets are also grown under irrigation here and there, and they are also occasionally manured with artificials along with the organic manures. The manuring of the rainfed millets, on the other hand presents many difficult problems connected with season, availability of manures, economic position of the farmers, etc. In the first place, while the organic manures like cattle manure may safely be applied to the drylands, it is not available in adequate quantities to meet the needs of the dryland farmers. Hence its application is considerably restricted, and in some tracts, manure is added only once in two or four years, while in other tracts, the practice is completely given up. The next problem is the precarious nature of the monsoon, with the result that if the season fails, the benefits of manuring are not realised, and the crop is a failure.

Though artificial manures are available to supplement the shortage in organic manures, they cannot be safely applied to the rainfed crops in those tracts where the rainfall is low or precarious. If the season fails, not only do the artificials become infructuous, they do positive harm and the crops dry up in patches in unfavourable seasons. Hence artificial fertilizers like ammonium sulphate, superphosphate, potassium sulphate etc., should be applied to rainfed millets, only in those tracts where the rainfall is dependable, well distributed and adequate for the successful growth of such crops. A very valuable and safe manure for such lands is the compost made from night soil and town waste which are at present almost thrown away in our country. A beginning in this direction has been made in the large municipalities of our State, and the great value of poudrette as a source of manure, has been realised. But further work is required in this direction.

As with manures, great variations are met with in their dosages and also methods of application. Depending upon the availability, heavy doses are applied in some districts. The organic manures are invariably incorporated before the field is prepared for sowing or planting. Sometimes it is sprinkled in plough furrows along with the seeds. The artificials, on the other hand, are applied in one or two doses after the crop is sown or planted. The results of trials conducted in the Permanent Manurial plots at the Agricultural Research Institute, Coimbatore on irrigated *cholam* and *ragi* indicate that joint application of nitrogen and phospheric acid increase the yield in all cases. Large responses are noticed in the case of plots continuously manured with cattle manure. It is also indicated that phosporic acid is an essential supplement to nitrogen. From the experiments conducted in this State, the following conclusions may with advantage be adopted in the cultivation of millets.

(i) Continuous manuring of fields with cattle manure gives good response and increases the yield of millets. It builds up soil fertility.

(ii) A joint application of ammonium sulphate at 2 cwt. and superphosphate at 1 cwt, over a basal dressing of farmyard manure at 5 cartloads per acre, is more effective than applying each of them alone.

(iii) Phosphates are an essential supplement to nitrogen and maximum benefit can be obtained from nitrogenous fertilizers only with the addition of phosphatic manures.

(iv) Among the several sources of nitrogen, ammonium sulphate is the best for millets.

(v) In the case of dry crops, if the rainfall is not normal and adequate, there is a depression in yield after the application of inorganic nitrogen, and adequate response is not found in the case of phosphates also.

(vi) The economic doses of nitrogen, phosphoric acid and potash that are to be applied to different types of crops vary considerably and have to be fixed with reference to soil and climatic conditions. Application of fertilizers to supply 30 lb. of nitrogen and about the same amount of phosphoric acid are considered adequate for rainfed crops and 50% more for the irrigated crops in this State. *Ragi* alone requires heavy doses of potash. The others require only light doses. Higher doses of all these fertilizers lead to wastage and become uneconomic in the end.

**Economic possibilities of manuring millets:** That millets respond very well to manuring and give profitable returns has already been pointed out. As millets occupy nearly 13 million acres in this State, the economic possibilities of obtaining increased production from these crops through judicious use of fertilizers and organic manures are enormous. Among the major millets, *ragi*, *cholam* and *cumbu*, are heavy yielders under favourable conditions. More than 57% of the total area under ragi, 12% of cholam and about 12·5% of cumbu are irrigated, and offer the greatest scope for the application high yielding fertilizers. About a lakh of acres of the other millets i. e. about 3% of the total area, are also grown under irrigation, and if properly manured they also will give high yields Thus 19 lakhs of irrigated millets are available for proper manuring. The major portion of the millet acreages are, however, rainfed and the application of artificial fertilizers is neither feasible nor possible in all cases. But the maximum yields from such lands also, could be obtained through the application of organic manures, which give better results than the artificials under adverse conditions. A rough estimate of the economic results of manuring both rainfed and irrigated millets is given in a tabular form below. To obtain the best results from manures, the fundamental principles generally to be observed in the use of fertilizers have to be borne in mind. Briefly stated, the crop returns from the use of fertilizers depend on many factors other than the kind of fertilizers selected. All fertilizers give the best results, if their use is combined with good soil, good tilth, adequate doses of all fertilizers, optimum moisture, proper time of sowing, improved seeds and efficient crop management. Since equivalent amounts of fertilizers give more or less the same yield, their relative cost is also an important consideration in working out the economics of manuring.

As the cost of fertilizers as well as that of the produce varies from season to season, neither the expenditure nor the money value of the increase in yield is indicated in the following table. The figures will however show the increased yields that can be obtained and the enormous possibilities of manuring these small-grained cereals and realising higher yields.

**Table showing the possible increases in yield from millets as a result of manuring**

| Name of Millet | Area in lakhs of acres | | Total increased production (in tons) | | |
|---|---|---|---|---|---|
| | Rainfed | Irrigated | Rainfed | Irrigated | Total |
| Cholam | 43 | 5 | 2,05,000 | 1,67,000 | 3,72,000 |
| Cumbu | 23 | 3 | 1,18,000 | 80,000 | 1,98,000 |
| Ragi | 7 | 10 | 90,000 | 3,34,000 | 4,24,000 |
| Tenai and Minor Millets | Rainfed and Irrigated 36 | | Rainfed and Irrigated | | 64,000 |
| | | | | Total | 10,58,000 |

**Notes:** 1. The normal yields given in the Season and Crop Reports (1948—1949) are taken for calculation. They are 575 lb. 555 lb. and 720 lb. per acre for dry crops and 1,500 lb. 1,200 lb., 1,500 lb. for irrigated crops of cholam, cumbu and ragi respectively.

2. Manures recommended for application are 2 cwt. of ammonium sulphate and 1 cwt. of superphosphate over a basal application of 5 cartloads of cattle manure per acre.

3. The expected increase in yield has been taken at 40% in the case of rainfed and 50% in the case of irrigated crops. In the experiments conducted in the various Agricultural Research Stations in the Madras State, the application of different manures gave increased yields from 14 to 160% for rainfed crops and 90 to 206% in the case of irrigated crops.

4. The total normal area under *cholam* is 48 lakhs of acres of which about 43 lakhs are rainfed and the rest irrigated. Out of this 43 lakhs, about 20 lakhs of acres will be classified as suitable for the application of manures including artificials. Hence this area alone is taken for estimating the increased yield that can be obtained from this crop.

5. In the case of *cumbu*, out of 26 lakhs of acres cultivated, 3 lakhs are irrigated and the entire area can be manured with advantage. Of the remaining 23 lakhs of unirrigated area, 12 lakhs are taken as capable of being manured.

6. In the case of *ragi*, it is taken that the entire area can be manured. Out of the total area of 17 lakhs of acres, 10 lakhs are irrigated and 7 lakhs rainfed.

7. *Tenai and minor millets* together occupy about 36 lakhs of acres and about 25% of this area or about 9 lakhs are capable of being manured under unirrigated or irrigated conditions.

It has been estimated that an additional production of one million tons of millets can be obtained by a scheme of intensive manuring of millets in the State and the provision of sufficient quantity of manures.

**Conclusion:** The value of millets as the premier dryland crops of this State is known to every farmer. But due to various reasons, the maximum yields that could be obtained from these crops are not realised. Apart from the use of improved strains, one of the easiest ways of increasing the yields is by the application of manures. This is particularly possible in the case of the irrigated millets which are grown over 19 lakhs of acres in the State. With proper manuring and irrigation, very heavy yields can be obtained from most of the millets, particularly *ragi*, *cholam* and *cumbu*. The yields of the rainfed crops of millets, can be increased by the application of organic manures, and also artifical fertilizers in those districts, where the rainfall during the growing period of the crop is adequate and well distributed. From the results of the experiments conducted in this State, the types of manures that give the best results and possible increases in yield that can be obtained through their application have been indicated. It has been estimated that in millets increased production of a million tons could be obtained in the State by a scheme of intensive manuring of millets and the provision of necessary quantities of manure for the purpose. Further investigations are necessary to fix the precise economic doses of these fertilizers for the different regions.

# Manuring of the Coconut Crop

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**Introduction:** The coconut is an important crop, particularly in Madras where there is an area of about 6·2 lakhs of acres producing about 1,500 million nuts and accounting for 41% of the acreage and 46% of the production in India. On the West-Coast where 69% of the area under coconut in this State is concentrated, the crop is of considerable economic importance. The present production in India which is estimated at 3,300 million nuts falls short of the requirements of the country by about 50%. This naturally results in abnormal rise in prices and necessitates importing coconut products from foreign countries. There is, therefore urgent need to step up production. This can be done by two ways: (1) by extending the existing area under the crop, and (2) by increasing production of the existing area. The first is a long-range method; and the production from the existing area can be stepped up by adopting proper manuring and cultivation. This paper deals with this aspect of the subject.

**Object of Manuring:** Manure is food for the crop and manuring serves two purposes: (1) to replenish the manurial ingredients of the soil which have been removed by the crop and (2) to maintain the crop in a normal condition so as to ensure proper yields. The manure to be applied naturally consists of such ingredients as are required for the purpose mentioned. These, broadly speaking, are (1) nitrogen, (2) potash and (3) phosphoric acid. In addition to these three main ingredients a number of other elements are required to keep the plant in healthy and proper condition. It is presumed that secondary elements are found in the required quantity in the soil and are, therefore not ordinarily added to the manure that is given to the crop. However, to give the plant or the crop a complete food it is necessary to analyse the soil and find out exactly the constituents of the soil and see whether they are present in the required quantity and in an available form sufficient for the growth of the crop. If not such want has got to be made good.

**Manurial Requirements of the Coconut:** The work done on the manurial requirements of the coconut in this State has been mostly confined to the Coconut Research Station, Kasaragod, South Kanara district. The soil is a deep sandy loam with the following analysis:—

| | |
|---|---|
| Loss on ignition | 2·25 |
| Available $P_2O_5$ | 0·001 |
| Available $K_2O$ | 0·002 |
| Lime | Trace |
| Magnesia | 0·07 |

A regular bearing coconut garden yielding about 2,000 nuts per acre, per year has been found to require about 24 lb. of nitrogen, 12 lb. phosphoric acid and 60 lb. of potash. These figures include the quantities required to build up the trunk, to form the leaves and flowering bunches and also the nuts. These figures are much less than those given for Malaya and Philippines. Therefore, it goes without saying that these ingredients have to be given back to the soil so as to maintain its normal fertility.

Coconut is a perennial crop, producing nuts practically throughout its life time from the time of commencement of the first flowering. Every month a bunch of nuts is produced. Therefore, the manurial ingredients from the soils are being regularly and constantly removed and it is necessary that manuring has to be done regularly every year if not every month. The effect of manuring in the coconut as expressed in terms of yield of mature nuts is perceptible only in a period of about 3 years from the commencement of manuring because, the time taken from the formation of the primordia of the flowering bunch till the time of harvest is about three years. And this process of formation goes on practically throughout its life under normal conditions. Therefore, it is obvious that the necessary supply of plant food should be available to the plant all through its life-time. The main ingredients of the coconut manure consist of three major elements namely, nitrogen, phosphoric acid and potash. To find out the quantity that should be applied, a well-laid out experiment consisting of N, $K_2O$ and $P_2O_5$ singly and in combination and if possible at different levels is necessary to arrive at a clear indication of the requirements of the crop. The response of the crop to the treatments given as expressed in terms of yield has to be considered. Some experiments in this direction have been carried out at the Coconut Research Station, Kasaragod. The first set of manurial experiments was started in 1922—1923 and continued till 1931—1932. Nitrogen in the form of ammonium sulphate and fish guano, potash in the form of potassium sulphate and ash, and phosphoric acid in the form of super-phosphate were given. Also cattle manure, salt and lime were tried singly and in combination. In this experiment, the maximum response was obtained with ammonium sulphate 3 lb. and 20 lb. of wood-ash per tree per year. The next best was cattle manure at the rate of 100 lb. per tree, per year. Significant increase in the yield viz., 14·5% was obtained in the case of low-yielding palms (below 30 nuts per year) and also medium bearers (27% increase) but not in the high-yielding ones, giving 80 or more nuts per tree, per year. It must be noted in this connection that though the high-yielding palms have not given increased yield consequent on manuring, it goes without saying that they also should be manured to maintain soil fertility and the normal production of nuts. Otherwise, the soils will soon be deprived of the manurial ingredients and the yield would naturally go down in due course. In this connection it may be stated that ammonium sulphate alone did not give as much marked response as ammonium sulphate and ash. Salt and lime did not give any significant increase of yield. Based on the indications obtained in the previous experiment, a new series of experiments were laid out in 1932 with ammonium sulphate and ash and cattle manure applied broadcast and in basins (6′ radius 1′ deep.) It was conclusively proved that ammonium sulphate 3 lb. and ash 20 lb. gave the highest yields and that broadcasting of the manure was better than applying it in basins. The experiment was further elaborated in 1937—1938 to find out whether a higher dose of 4½ lb. of ammonium sulphate would give better results than 3 lb. and also whether it could be substituted with groundnut cake, and ash with potassium sulphate. It was found that increased dose of ammonium sulphate, namely 4½ lb. per tree, per year gave higher yields than 3 lb. of it per tree, per year. It was also found that ammonium sulphate can be replaced by groundnut cake on equivalent nitrogen basis and ash can be replaced by pottassium sulphate on equivalent potash basis. It may be stated that no significant response was obtained consequent on the application of $P_2O_5$. The soil contained only 0·35 of total and ·001 of available $P_2O_5$. Perhaps this quantity though small meets the normal requirements of the crop. Still, as large quantities (12—40 lb.) are being annually removed by the crop, it is necessary to add $P_2O_5$ in some form or other as superphosphate or as bonemeal. As the soils are acidic in reaction and as coconut is said to thrive better under a slightly alkaline medium, it is desirable to add some lime also to the soil. The ash applied which contains about 22% of CaO, is considered to be helpful in this respect.

**Organic matter and green manuring:** The Kasaragod soils were poor in organic matter, the loss on ignition being only 2·25%. Therefore, to augment the supply of organic matter it is necessary to add it in the form of farmyard manure, compost or green-leaf, or as oil-cakes. Farm yard manure is available only in very limited quantities and is required for other crops. Oil-cakes are in short supply. The best and cheapest form of organic matter appears to be a green manure crop grown in the field and ploughed in. All the known green manure crops that are likely to be of use for coconut plantations have been tried and the best is the wild sunhemp or *Crotalaria striata*. This leguminous plant has at times given as much as 20,000 to 30,000 lb. of green stuff per acre and it comes up very well under the shade of coconut trees. In this connection it should be mentioned that it is desirable to return to the soil as much as possible of coconut by-products other than those required by man. For example all the dried leaves, husks and all the refuse usually found in a coconut garden which contain valuable manurial ingredients should be buried in the field in trenches, or the ash obtained by burning them should be given back to the soil. Where the green husks are utilised in the manufacture of coir, they cannot be used as manure. But dried husks prove very valuable to the soil. In an experiment conducted at the Kasaragod station for a period of 7 or 8 years it was found that burying of coconut husks at the rate of 1,000 husks per tree with all the dried leaves and refuse obtained in the garden was found to benefit it and increase the yield to a marked extent (70%). The effect of burying the husks and leaves once, lasted for about 5 years without the addition of any other manure. The field received, however, regular cultivation and a crop of green manure was grown in the field and ploughed in and incorporated in the soil. This practice of burying husk is of considerable value particularly in rain-fed gardens.

**Importance of ash:** In the manuring of the coconut gardens, special attention should be paid to the application of potash. It is perhaps more important then even nitrogen itself, because potash is the main ingredient in the various parts of the palm, particularly the leaves (4% $K_2O$), husks (1%) and kernel (·4%). From the manurial experiments conducted, it was found that even the application of ash alone at the rate of 20 lb. per tree, per year) gave highly significent increase in yield of about 34 nuts more than the control plot without ash. In one of the manurial experiments mentioned in the previous para, it is stated that ash, which is not available in the required quantity can be replaced by potassium sulphate. Though the yield is not affected by this substitution, it must be stated that ash is a better manure for the coconut in the long run than potassium sulphate, because potassium sulphate contains only $K_2O$ while ash contains other ingredients also, besides $K_2O$ and CaO. Therefore, it is worthwhile finding out an artificial product approaching the ordinary ash in analysis and containing all the ingredients.

**Precautions in applying ammonium sulphate, ash and cattle manure:** Ammonium sulphate applied alone without ash did not give significant increase in yields. It is very important, therefore that ammonium sulphate should always be applied with ash. However, it should be borne in mind that ammonium sulphate is acidic and ash is alkaline in reaction and the two manures should not be mixed up and applied. They should be applied separately at an interval of fortnight or a month. Cattle manure at the rate of 100 lb. per tree, per year gave a significant increase in yield coming next in rank to ammonium sulphate and ash. But cattle manure cannot be had on a large scale and in sufficient quantities and its use can only be very limited. Also in places where cattle manure is applied, there is the danger of the soil breeding the rhinoceros beetle which is a bad pest of the coconut.

**Time and method of application:** Manures should be applied only when there is sufficient moisture in the soil, though not too much of it. The best time to apply the manures under the West Coast conditions is some time in September. Incompatibles like acid and alkali manures should not be mixed.

The method of applying manure is an important consideration. As feeding roots of the coconut are found all over the field, it is considered necessary to apply the manures broadcast all over the field. The feeding roots go to a depth of some 3 or 4 feet below the ground level and it is desirable to put in the manure as deep into the soil as possible. For this purpose the soil should be ploughed deep so as to incorporate the manures in the deeper layers of the soil. In an experiment conducted on the method of application of manures it was found that application by broadcasting gave better yields than applying them in basins dug near the bases of the trees. However, in the case of young seedlings or palms where the root system has not spread throughout the field, the manures may be applied near the palms, extending to a radius of about 5′ or 8′ all round. The dose of the manure to be applied to the young palms till they come to the bearing stage is about half the dose of the adult trees.

**Effect of manuring on the produce:** It has already been stated that the yield of nuts particularly of low bearers, increases considerably as a result of manuring. It has effect on the quality of crops also, which contain more of N and $P_2O_5$. Palms receiving complete manure (viz. N, P, and K), cattle manure and green manure, had higher copra content per nut, and in the case of palms receiving ammonium sulphate the percentage of oil also increased.

**Manuring and disease:** A coconut garden which is regularly cultivated and manured is able to withstand the vagaries of the season better than a neglected garden. In times of severe drought and other adverse conditions, properly maintained gardens do not suffer to the same extent as the neglected ones. Where the trees are weak due to neglect they suffer more, consequent on the incidence of pests and disease than robust healthy trees. In the trials conducted at the Coconut Research Station, Pilicode, where 'shoot rot' disease is prevalent it was found that a regular application of potassium sulphate warded off the disease to a marked extent.

**Manuring and Cultivation:** In the coconut, manuring goes hand-in-hand with cultivation of the soil. In an experiment designed to find out the effect of cultivation alone and manuring alone it was found that there was significant increase in the yield of plots receiving regular cultivation alone without manuring (166% over the unmanured and uncultivated plot), while the plots receiving manuring alone (5 lb. of fish guane, 40 lb. of ash and 40 lb. of greenleaves per tree) without cultivation did not give significant increase in yield. It is therefore, evident that cultivation by itself is more important than manuring alone without cultivation. In normal practice it is necessary that manuring should be practised along with regular cultivation of the soil. Cultivation by ploughing not only keeps down the growth of weeds but also gives a root pruning at the surface of the soil and helps to keep the roots below the ground level which is considered beneficial for the coconut. Also regular cultivation aerates the soil and also enables the rain water to soak into the soil.

**Schedule of manuring:** The following schedule of manuring will be found to be the best and most suitable for coconut gardens in the West Coast under rain-fed conditions. Plough the land in February-March with a mouldboard plough so as to create soil mulch and receive the summer rains. In May, when there is sufficient rainfall, sow a green manure crop, like *Crotalaria striata,* at the rate of about 20 lb. per acre and cover with a light plough or a cultivator like the Junior Hoe. In September-October, after the cessation of the South-West monsoon rains broadcast ammonium sulphate and bonemeal at the rate of 4½ lb. of the former and 2 lb. of the latter. Plough in the manures applied and also the green manure crop by means of a heavy iron plough. If the green manure crop cannot be ploughed into the soil it is to be cut and buried in shallow trenches between rows of trees, the position of trenches being shifted every year. Then in November-December broadcast wood-ash at the rate of 30 lb. per tree and work a light plough or cultivator so as to incorporate the manure into the soil and also to put down the growth of weeds.

Ammonium sulphate can be replaced by groundnut cake or other oil cakes on equivalent nitrogen basis. While ammonium sulphate contains about 20% of N, groundnut cake contains about 8% of N. Ash can be replaced with potassium sulphate on equivalent potash basis. Ash contains 3% of potash and potassium sulphate contain 43%. Among the phosphatic manures bonemal contains about 16% of $P_2O_5$ and superphosphate - ordinary 22%. If it is not possible to grow a crop of green manure in the field green leaves (1% of N) at the rate of about 50 lb. per tree may be applied. The schedule given in the foregoing is a complete scheme of manuring and cultivation which not only maintains the soil at a high level of fertility but also ensures regular and increased yield of the trees. As has already been explained it is important that these operations are carried out regularly every year. If it is not possible to give nitrogenous and other manures, attempts should be made to supply every year at least ash or potassic manures. If even this is not possible a green manure crop may be regularly grown and ploughed into the soil. If, however, even the green manure crop cannot be grown or green leaves applied, the soils should be regularly ploughed and cultivated once or twice in a year.

In addition to manuring and cultivation it is very necessary that the garden is protected from pests and diseases by taking prompt action and adopting remedial mensures in time. Regular and systematic search for the rhinoceros beetle in the crowns of palms should be made and the beetles killed. It may be pointed out that neglect in this respect is usually responsible for a loss of about 10% or more of the yield.

**Economics of manuring:** After all, agriculture as a business proposition should pay. Intercultivation and manuring of the coconut as indicated in the foregoing can easily increase the yield considerably. The increase in yield should cover the cost of manuring and cultivation and leave a reasonable margin. The major manures to be used and the quantity to be applied depends on the availability of manures and their prevailing market prices. Taking the price of ammonium sulphate at about as 2½ per pound and ash at about Rs. 2 per 100 lb. and bone meal at as 2 per pound, the schedule of manuring and cultural operations mentioned cost about Rs. 2—8—0 per tree at per year. And the yield is put at an average of about 50 nuts per tree, per year, valued at Rs. 10/-, which leaves a net profit of about Rs. 7—8—0 per bearing tree, or about Rs. 470/- per acre. In a neglected garden taking the yield at about 20 nuts per tree, per year, the net profit due to manuring, per tree, is about Rs. 3—8—0 per year. At the present high prices for coconut, manuring and cultivation certainly do pay. But it should be remembered that the garden should be always looked after and cared for, irrespective of the market price of the coconuts. The system of manuring and cultivation advocated in this paper pertains mostly to the West Coast rain-fed conditions and cannot be said to be applicable in full to the other coconut tracts of the State. To get at the correct data of manuring, a regular experiment should be conducted in the tract concerned for a series of years and then alone can the findings be advocated with confidence.

## Summary

The coconut is an important oil seed crop of the Madras State with an area of 6·2 lakhs of acres, mostly in the West Coast. Still the production is only 50% of the demand and has to be stepped up. This can be done by manuring. The crop yields nuts throughout the year and practically throughout its life-time from the time of commencement of first fruiting. Considerable quantities of plant food are being continually removed by the palm to build up its body and produce nuts. Therefore complete manuring has to be done regularly every year so as to replenish the soil with the ingredients removed, and maintain the palms in good condition and high productivity. As a result of a series of experiments conducted at the Coconut Research Station, Kasaragod, it has been found that the best manure for the coconut is 4½ lb. of ammonium sulphate or 15 lb. of groundnut cake, 30 lb. of superphosphate, in addition to a crop of green manure *(Crotalaria striata)* grown in the coconut garden and

incorporated into the soil. The most important ingredient is potash contained in ash. Manuring goes hand in hand with regular cultivation. Even if the soil cannot be manured it should be regularly cultivated. A schedule of manuring for the West Coast rain-fed gardens is given. It is very desirable that all unwanted dry leaves, spathes, dry husks and other refuse which contain valuable manurial ingredients are buried in the garden.

The effect of manuring on the yield is perceived in a period of two to three years after the commencement of the operations. Low yielders (below 30 nuts per tree per year) respond best to manuring with an increased yield of even 65%, and the medium yielders can give 27% increase. But the heavy yielders giving about 80 nuts per tree cannot further increase their yields. Still they should be manured regularly to maintain the yields. Manuring improves the quality of produce also. At a modest estimate a regularly cultivated and manured garden can give a net ptofit of Rs. 470/- per acre at the prevailing market rates.

The schedule of manuring given here is not quite applicable to all the different coconut tracts of the State, and experiments have to be conducted in each tract before recommending the best manure suitable for the tract.

**REFERENCES**

1. Patel, J. S. (1938) — *The Coconut—A monograph.* Government Press, Madras.
2. Copeland, E. B. (1931) — *The Coconut.* Macmillan & Co., London.
3. Sampson, H. C. (1923) — *The Coconut Palm.* John, Batesons Daniels & Sons, Ltd., London.

# Manures — in relation to cotton production in Madras State

*By*

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The place of manures and fertilisers in a system of integrated crop production needs hardly to be emphasised. In Madras, cotton is grown over 1·6 million acres annually, and as a cash crop plays a vital role in the economy of the farmer. The need for augmenting cotton yields is obvious, especially due to short production of raw cotton needed for the country and the high cash return assured to growers due to attractive price levels.

The major cotton growing regions in the Madras State may be grouped under (1) the rainfed black soils of Southern Districts, (2) irrigated red soils of Central and Southern Districts, (3) arid black soils of Ceded districts, (4) rainfed black soils of the Circars and (5) irrigated black soils under the Tungabadhra Project in the Ceded districts. The Agricultural Research Stations representing these tracts in which cotton manurial trials have been conducted in the past are as follows :

| Name of cotton zone | Station | Soil type | Mean annual rainfall | Preceeding cereal | Cotton irrigated or rainfed |
|---|---|---|---|---|---|
| 1. Tinnies | Koilpatti | Black loam | 31″ | Cumbu | Rainfed |
| 2. Cambodia | Coimbatore | Loamy | 27″ | Sorghum | Irrigated |
| | Palur | Alluvial | 51″ | Ragi | Irrigated |
| 3. Westerns | Hagari | Black soil | 20″ | Sorghum | Rainfed |
| 4. Northerns | Nandyal | Clay loam | 28″ | Sorghum | Rainfed |
| 5. Cocanadas | Guntur | Heavy black soil | 32″ | Sorghum | Rainfed |
| 6. New area (Tungabadhra Project). | Siruguppa | Deep black soil | 25″ | Sorghum | Irrigated |

The results of past trials at these stations may be summarised as follows :

**1. Koilpatti :** Experiments conducted at this station have conclusively established that rainfed Tinnies cotton responds to the direct application of nitrogenous manures, whether organic or inorganic. The application of 2 cwt. of Ammonium Sulphate and 1 cwt. of Superphosphate or 500 lb. of groundnut cake and 1 cwt. of Superphosphate per acre were found to increase the yield of kapas by 41% and 35% respectively, over the 'no manure' control yield of 410 lbs. kapas per acre.

It was also observed that an application of 1,000 lb. of Neem cake per acre resulted in an yield increase of 47% over no manure, that gave 440 lb. kapas per acre.

**2. Coimbatore:** In recent experiments conducted since 1944–'45 good response for manuring was obtained in 2 out of 3 seasons, An application of 75 lb. Nitrogen in the form of ammonium sulphate or groundnut cake, along with 30 lb. of phosphoric acid was found to increase the yields by 30% over the 'no manure' control which gave 840 lb. kapas per acre. In another year 90 lb. Nitrogen in the form of ammonium sulphate or groundnut cake gave an yield increase of 22% over the 'no manure' control which recorded 440 lb. kapas per acre.

In rainfed Karunganni, experiments to compare the effects of Nitrogen in the form of ammonium sulphate or groundnut cake at different doses with and without phosphoric acid did not give significant results.

**3. Palur:** In the trials conducted at the Agricultural Research Station, Palur on irrigated cotton, no definite indications were obtained, possibly due to flower shedding resulting frem contabescent anthers.

**4. Hagari:** The results of manurial experiments with ammonium sulphate, superphosphate and groundnut cake, conducted at different periods have not given consistent results. In years of deficit rainfall, even depressing effects on yield have been apprehended.

**5. Nandyal:** At this station, the experiments conducted in the early thirties indicated that the direct application of 2 cwt, of ammonium sulphate and 1 cwt. of superphosphate had no response from cotton. On the other hand, the indirect application of similar quantities to previous *jonna* was attended with 25% increase over control in the kapas yield of succeeding cotton. The control treatment of cotton which was raised in 'no manure' plot cropped with *jonna*, gave 225 lb. of kapas per acre.

**6. Guntur:** The application of grouudnut cake and ammonium sulphate at doses upto 60 lb. Nitrogen did not give any significant results in two season' trials at this station. The addition of phosphoric acid also as one of the variants in the third year did not give significant results.

**7. Siruguppa:** At this station, which represents the irrigated black soils of the Tungabadhra Project area, consistently good response was obtained for applications upto 80 lb. Nitrogen per acre in the form of organic manures like groundnut cake and farmyard manure and green manure, or inorganic fertilisers like ammonium sulphate.

The above results show that irrigated cotton under the future Tungabadhra Project area and rainfed cotton in Tinnies area offer the greatest scope for intensifying production through manuring. The results of the past trials at Coimbatore and Palur representing the irrigated Cambodia area of the South have not been conclusive. Further trials with a wider range of doses and at more centres representative of the tract need to be undertaken for making useful recommendations. In these experiments, the question of cumulative effects of the manures have also to be examined.

It appears as if no benefit is likely to be obtained by manuring cotton grown as rainfed crop, in areas receiving about 20″ of rain. Thus, the Westerns area will not lend itself for intensifying production through manuring. The Cocanadas and Northerns area would appear to offer less scope for manuring than the Tinnies tract.

The review (Panse *etal* 1949) of the results of the co-ordinated manurial trials on rainfed cotton in India including those at Koilpatti, Guntur, Nandyal and Coimbatore in Madras shows that there is no difference in response between ammonium sulphate and groundnut cake as sources of Nitrogen. except uuder conditions of high fertility, and presumably for large quantities of Nitrogen, when ammonium sulphate was found to give a somewhat higher increase in yield. The method of application made no difference in the case of ammonium sulphate which may be broadcast. Under conditions of high fertility and for large applications, groundnut cake was better when drilled. The rate of increase in yield per unit quantity of nitrogen was found to increase with increasing fertility of the soil.

A set of co-ordinated manurial trials with superphosphate at different levels, in combination and without Nitrogen have been proposed to be conducted at Coimbatore on irrigated Cambodia and at Koilpatti on rainfed Tinnies. These experiments and the contemplated manurial trials on irrigated Cambodia at Coimbatore, Avanashi, Salem, Lower Bhavani, Palur and Siruguppa outlined by the Government Agricultural Chemist, which may take into account the cumulative effects also, should ultimately provide the solution for augmenting cotton yields through adequate mannring.

**Summary:**

Manuring of crops has been recognised to be an important method for increasing crop production. Next only to food in importance, the need for augmenting cotton yields through manuring is obvious due to acute shortage of raw cotton in the country.

In Madras the results of past trials on cotton at the different Agricultural Research Stations have shown that rainfed Tinnies in the Southern districts, Irrigated Cambodia in the Central and Southern districts and Irrigated American Cottons under the Tungabadhra Project would offer the greatest scope for intensifying production through adequate manuring.

The need for future experiments at different centres representative of the tracts, with wider range of doses and taking into account cumulative effects also, is indicated.

**REFERENCES:**

1. Panse, V. G. Sahasrabudhe, V. B. and Mokashi, V. K. 1949 The new series of manurial trials on rainfed cotton in India. Fourth Conf. Cott. Grow. Pubn. India, I. C. C. C.

# Manuring in relation to insect pests

*By*

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It is a matter of common knowledge that only a fertile soil can ensure a vigorous growth of crops and produce bumper yields. A number of factors like soil texture, mineral elements etc., go to make up this fertility but by far the most important of these is the presence of the requisite quantity of organic matter, which in other words is known as humus. In nature, this precious materal is added to the soil by the gradual accumulation of plant and animal residues which are in turn converted into humus by certain natural agencies.

Under intensive agriculture, this plant food is rapidly consumed by the crops grown and its depletion has been compensated from time immemorial by the application of organic manures like green leaves, cattle dung etc., etc. But the demand has always been disproportionately higher than the supply, the latter being inadequate owing to the small quantities available and the imperfect methods of gathering and preservation of what little could be produced. This situation has indirectly served as a potent incentive for the large-scale advent of several forms of synthetic fertilisers. The general experience has been that the application of manures, either organic or synthetic, has a profound effect in increasing crop production.

The main theme of the paper being the influence of manuring on insect pests, it has first to be admitted that very little work has been done in India and much less in this State on this aspect, except for the solitary instance where Andrews (1) tackled the problem of the tea mosquito in North India from various angles, of which manuring was one. This paper is only a compilation of the outstanding lines of research conducted elsewhere.

Before proceeding further, a resume of the available information on the influence of the nature of the soil itself on the incidence of insect pests may cover a certain amount of the preliminary ground for the discussion. Williams (33) has recorded that the pea thrips — *Kakothrips robustus* Uzel, was less prevalent in untilled clayey soils than on light tilled soils, the probable reason being that the adults are unable to emerge from their underground pupae in hard soils. Nougaret and Lapham (26) have concluded that grape-vine suffers less from the root aphis — *Phylloxera vastatrix* Planch, in loose-textured soils, while the vines grown on heavy soils are infested to a more severe extent. This is due to the fact that the bugs are able to lurk under the cracks and crevices common in hard soils, while they get exposed and perish in friable lands. While investigating the incidence of pests on sugarcane, like spittle insects, frog hoppers, etc., Turner (32) mentions that the blighted fields show an appreciable deficiency in calcium carbonate and are markedly acidic, and that the blight-free fields are either alkaline or slightly acidic. Dwight Iseley (7) concludes that wire worms — *Hornistonotus uhleri* Hon., and the Melolonthid grub — *Macrodactylus subspinosus* F., thrive better in sandy light soils and that the apple woolly aphis — *Eriosoma lanigera* H., gets the upper hand in heavier soils. Coming nearer home, Andrews (1) mentions that a water-logged condition in heavy soils increases the susceptibility of the bushes to the tea mosquito — *Helopeltis antonii* Sign. He also mentions that such a condition promotes acidity of the soil and that the presence of sufficient quantities of potash in the soil is closely connected with resistance to insect damage. Apart from these factors, soil moisture also, as shown by Cook (5) has some bearing on the incidence of the cut worm — *Lycopholia margaritosa* Haw.

Another aspect worth mentioning here is the relationship between the physiological condition of the plant and insect incidence. Evans (8) and Less (19) mention that the reproduction of aphids is positively correlated with the nitrogen and protein contents of the plant. Andrews (1) concludes that the relative proportions of potash and phosphoric acid fluctuate in the tea leaf during the season and that the infestation by *Helopeltis* is parallel to these fluctuations. The work of Greenslade, Massee and Roach (12) indicate that resistance to woolly aphis is associated with an alcohol-insoluble, but ether-soluble material present in the host tissue. In the case of the Colorado beetle — *Leptinotarsa decemlineata* Say, the preference of the beetle was due to certain attractive principles which appear to be nitrogenous compounds contained in the potato leaves (Raucourt and Trouvelot (29)). The presence of higher tanning matter increases the resistance of the African cacao to the larva of *Ephestia elutella* Hb. (Molz (23)). Prell (28) attributes the immunity of certain pines from the damage by the Nun moth (*Lymantria monacha* L.) to the small quantities of turpentine contained in the needles. Oshima (27) has recorded that the immunity of teak and cypress to termites is due to the presence of a sesquiterpene alcohol.

Coming to the subject matter of the paper, the thought-provoking theory of Howard (15) in his book "The Agricultural Testament" is worth mentioning here. The author, who has spent over 40 years in India, is strongly of opinion that the application of humus which is highly favourable for the mycorrhizal development, is probably the only panacea for all complaints. He expounds that insects and fungi are not the real causes of plant diseases and that they attack only unsuitable varieties of crops grown imperfectly. His theory is that Nature has provided a marvellous piece of machinery for conferring disease-resistance in crops. This machinery is active in soils rich in humus and inactive or absent in infertile land. The fuel needed to keep the machinery in motion is a regular supply of freshly prepared humus. The debatable point in his argument, however, is his confirmed prejudice against artificial manures which he says are the very bane of good soil husbandry. Lady Eve Balfour (18), another ardent votary of the humus school, lends enthusiastic support to Howard's theory in her book "The Living Soil". Apart from attributing innumerable virtues to humus, she mentions, in one context, that the presence of this material encourages the development of over 50 varieties of parasitic fungi which control eel worms. Hopkins (14), making a critical review of the opinion of these two workers, mentions as follows: Humus is an important part of the plant diet and a sufficiency of the same is necessary for them to be virile. There is however, very little evidence to prove that pest incidence increases with the application of fertilisers, as the experience has even been contrary in certain cases. Malnutrition may lower the resistance but the primary reasons for epidemics are to be linked with several other factors unconnected with the nutrition.

Quoting a few examples where insect pests are reported to have been controlled by manuring, Frew (9) has concluded that the application of certain fertilisers especially superphosphates has a marked beneficial effect in reducing the infestation by the Barley Gout Fly — *Chlorops taeniopus* Meig. The resistance appears to be effected by stimulating the growth of the earlier internode and the maturity of the earhead. McCollach and Salmon (22) have concluded that silica applied in the form of sodium silicate wards off the Hessian fly — *Mayetiola destructor* Say, on wheat. Hawkins (13) states that fertilisers, when used judiciously, stimulate the growth of sweet corn resulting in heavier yield, though the population of the wire worm — *Agriotus mancus* Say — ran into thousands. One of the general conclusions at the Rothamsted Research Station (Hubert Martin (16) ) is that increased nitrogenous manuring leads to an increased liability for diseases and that plots not manured with potash are the first to succumb to insect pests. According to Andrews (1) potash manure affords indications of its value in allaying *Helopeltis* damage and the effect of adding superphosphate has been harmful. He concludes that nitrogenous manures should be used with caution. Gepson and Gadd (10) have shown that the machanical damage caused by the teak shot-hole borer — *Xyleborus fornicatus* Eich., heals up quickly with nitrogenous manuring.

Another line of control which is probably of academic interest is the addition of Selenium in the form of Sodium selenate in culture solution. The absorption of this poisonous chemical up to a concentration of 45 parts in a million was highly toxic to aphids and mites (Neiswander and Morse (25).) But the presence of the salts in the plants is supposed to be highly toxic to animals consuming these. Gnadinger (11) has also recorded that selenates are poisonous to red spiders. The chemical is reported to be specific in action without any marked insecticidal properties. Mason and Phillis (21) report that the inclusion of selenium in the nutrient solution for cotton grown in sand culture, rendered it free from insect attack.

In this connection the novel method of applying the chemicals direct to the root is worth mentioning. Andrews (1) claims that a direct feeding of a 1% solution of potassium chloride to the roots of tea bushes conferred complete freedom from attack by *Helopeltis.*

A certain amount of work has also been done in the control of insects by the injection of certain chemicals into the plant tissue which in its turn renders the plant sap distasteful to the insects. Dementiev (6) has found that the injection of barium chloride into an infested apple tree caused the disappearance of the woolly aphis — *Eriosoma lanigera,* in about ten days. Muller (24) records similar results by injecting pyridine and aluminium sulphate. Other examples of relief obtained by injection consist of the treatment with potassium cyanide against the fluted scale — *Icerya purchasi,* Mask. (Sanford (30) ) and against boring insects on elms (Shattuck (31).

The possibility of the influence of trace elements in the relationship between the host and the pest is another factor. Brenchley and Thornton (4) found that the presence of boron is necessary for the symbiotic development of bacteria in Leguminosae. The small quantities of essential oils in the rind of citrus fruits have been found to deter the Mediterranean fruit fly — *Ceratitus capitata* Wied. (Back and Pemberton (2) ).

Several instances of relief obtained against soil insects by the applications of chemicals, like carbon disulphide, paradichlorobenzene, carbolic acid, calcium sulphide etc., are on record but a discussion on these does not come under the purview of this paper.

Coming to a few examples of the cursory work done in this line in this State, the application of ammonium sulphate to paddy crops infested by the stem borer — *Schoenobius incertellus* W., and the root grub — *Echinocnemus oryzae* Marshall, and farmyard manure against the sorghum fly — *Atherigona indica* M., has afforded some relief against the respective pests. Krishna Iyer (17) has also recorded that the application of ammonium sulphate reduces the susceptibility of plants to the root-knot eelworm. It should also be mentioned here that most of these treatments have exerted little or no control over the pests themselves but have served only as stimulants to invigorate the growth of the crops which have had a set-back due to the insect damage. It has also been recorded by Balasubramaniam and Kesava Iyengar (3) that application of groundnut cake and cattle manure has increased incidence of the cotton jassid — *Empoasca devastens* D., though the variations were not significant.

**Conclusion:** Though the matter reviewed above can, by no means, claim to be complete, yet from an overall survey of the information on hand, there is little doubt that a judicious and balanced manuring will ensure the production of good crops. But experimental evidence regarding the efficacy of manuring as a measure of pest control is lacking except in a few cases, and even here, it appears to be effected more by the reaction on the plant tissue than on the insect itself. When there is a severe outbreak of an insect pest, the farmer wants immediate relief and that relief can be afforded only by insecticidal means. With the recent advent of synthetic chemicals like B H C. and D D T., the solution of many an insect problem is in sight and the outlook, on the whole, is quite bright.

## REFERENCES.


1. Andrews, E. A. (1923) Factors affecting the control of the tea mosquito bug, *Helopeltis theivora*. *Indian Tea Assn.*
2. Back, E. A. and Pemberton, C. E. (1915) *J. Agric. Res.*, Vol. 3 P. 311.
3. Balasubramaniam, R. and Kesava Iyengar, N. (1950) The problem of jassids on American cotton in Madras with special reference to black soil of Ceded districts. *4th Conf. on cotton growing problems in India.* Indian Central Cotton Committee.
4. Brenchley, W. E. and Thornton, H. G. (1925) *Proc. Roy. Soc.*, Vol. 98, P. 373.
5. Cook, W. C. (1923) *Tech. Bull. Minnesota Agri. Ext. Stn.* Vol. 12.
6. Denentiov, A. (1915) *Rev App, Ent., Series A*, Vol. 3. p. 394.
7. Dwight Isley. (1948) Insect control by soil management. *Methods of insect control, Part I*, p. 17–78.
8. Evans, A. C. (1938) Physiological relationship between insects and their host plants; *Ann. Appl. Biol*, Vol. 25. p. 558–561.

| | | | |
|---|---|---|---|
| 9. | Frew, J. G. H. | (1924) | On Chlorops taenipus Meig. the Gout fly of Barley. *Ann. App. Biol.*, Vol. II. p. 175–218. |
| 10. | Gepson, F. P. and Gadd, C. H. | (1926) | *Bull. Dept. Agric., Ceylon,* p. 78. |
| 11. | Gnadinger, C. V. | (1933) | *Ind. Eng. Chem,* Vol. 25, p. 633. |
| 12. | Greenslade, R. N,. Massee, A. M and Roach, W. A. | (1933) | *Ann. Rep. East Malling Res. Sta.* p. 220. |
| 13. | Hawkins, J. H. | (1930) | Wireworm control in Maine *J. Econ. Ent.*, Vol. 23 p. 349–352. |
| 14. | Hopkins, D. P. | (1944) | Chemicals, Humus and the Soil. |
| 15. | Howard, A. | (1949) | An Agricultural Testament. |
| 16. | Hubert Martin. | (1940) | The Scientific principles and plant protection. |
| 17. | Krishna Ayyar, P. N. | (1938) | Some factors affecting the resistance of plants to insect pests *Proc. Assoc. Econ. Biol. Coimbatore,* p. 1–5. |
| 18. | Lady Eve Balfour | (1938) | The living soil. |
| 19. | Less, A. H. | (1926) | Insect attack and internal condition of the plant, *Ann. Appl. Biol.,* Vol. 22, p. 506–515. |
| 20. | Macgill, E. I. | (1930) | The biology of the Thysanoptera with reference to the cotton plant *Ann. Appl. Biol*, Vol. 17, p. 150–151. |
| 21. | Mason, T. G. and Phillis, E. | (1937) | *Emp. Cott. Grow. Rev.* Vol. 14, p. 308. |
| 22. | McColloch, J.W. and Salmon, S.C. | (1923) | The resistance of wheat to the Hessian fly-*Mayelilo destructor*-A progress report. J. Econ. Ent., Vol. 16, p. 293–298. |
| 23. | Molz, E. | (1918) | *Int. Rev. Sci. Pract. Agric.,* Vol. 19, p. 554. |
| 24. | Muller, A. | (1926) | Die. innere. Therapie. *Der Pflanzen Mongraph Angew. Ent., Berlin.* |
| 25. | Neiswander, C.R. and Morse, V.H. | (1949) | Introduction of Selenium into plant tissues as a toxicant for insects and mites. *J. Econ. Ent.* Vol. 33, p. 507–525. |
| 26. | Nougaret, R.L. and Lapham M.H. | (1928) | A study on Phylloxera infestation in California as related to types of soils-Grape vine diseases. *U. S. A. Dept. of Agric. Tech Bull. No. 20.* p. 1–38. |
| 27. | Oshima, M. | (1919) | *Philip. J. Sci.* Vol. 15, p. 319. |
| 28. | Prell, H. | (1925) | *Z. Pflkrankh,* Vol. 25, p. 82. |
| 29. | Raucourt, M. and Trouvelot, B. | (1936) | *Ann. Epiph. Phytagen.*, Vol. 2, p. 51. |
| 30. | Sanford, F. | (1914) | *Scinnce,* Vol. 40, p. 519. |
| | ,, | (1915) | ,, Vol. 41, p. 213. |
| 31. | Shattock, C. H. | (1915) | ,, Vol. 41, p. 324. |
| 32. | Turner, P. E. | (1929) | The lime status of soil in relation to an insect pest of Sugarcane, *J. Agric. Sci.,* Vol. 19, p. 26–35. |
| 33. | Williams, C. B. | (1915) | *Ann. Appl. Biol. I,* p. 222. |

# Manures and their effects on incidence of diseases in crops

*By*

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Manures are applied to provide nutrients to crop plants. Proper nutrition is necessary for the normal growth and reproduction of plants. It is recognised that malnutrition or deficiencies in the nutrients lead to several diseases in men and cattle. Plants are also similarly affected by unbalanced manuring or by the lack of one or more components of plant food. The effects may be directly visible as different types of 'hunger' signs (chiefly chloroses and reduced growth) exhibited by the crop, depending on the particular component in deficit. But these become evident only when the deficiency is pronounced. The influence may also be felt by the upsetting of the equilibrium of host—parasite relationship between the crop plants and disease-causing organisms. Consequently the intensity of incidence of diseases caused by parasites may be altered.

Balanced manuring results in well-nourished, robust plants. These are able to withstand the onset of diseases better than ill-nourished weak ones. Well-fed plants are able to outgrow the early set-back produced by initial infection while the underfed ones are not able to readily replace the affected parts or outgrow infection by quick and vigorous growth and as a result often succumb to diseases. This is mainly applicable to those varieties of crops which are not immune or highly susceptible to particular diseases, but which exhibit normally a certain amount of resistance. Even here there are exceptions. Obligate parasites like rusts and mildews infect robust plants more readily than the weaklings. The more healthy the hosts, the more do the mildews prosper. *Septoria apii* causing blight of celery occurs generally on well-fed crops. But the majority of other parasites however, are able to infect undernourished plants much more readily. Some diseases like smuts are not appreciably influenced by the manure applied.

In scientific literature a distinction is made between manures and fertilizers. The former consist of those materials which predominantly supply humus with lesser components of nitrogen, phosphorus and potassium, while the latter are those which mainly supply the three components mentioned above with little or no humus content. But in the present context the term has been used in a comprehensive manner, including both the organic and inorganic (mineral) types. The influence of manures on the incidence of crop diseases caused by parasites varies according to the disease, the crop and the proportion of the various ingredients, so that no sweeping generalisation is possible. However, reliable results have been otained in field and water-culture experiments with several crops in different parts of the world indicating the nature of reaction between particular components of the manures and the intensity of certain diseases, especially those affecting the foliage. An overall picture of these results is presented here.

Nitrogen occupies a significant place among the nutrients which markedly influence the disease disposition of the crop. It has been observed in several instances that more nitrogen leads to more disease. The experiments on the influence of graded doses of nitrogen either as ammonium sulphate or as groundnut cake to supply 40, 80 or 120 pounds of nitrogen per acre, on the incidence of blast disease of rice (*Piricularia oryzæ*) at Coimbatore, have clearly demonstrated over several seasons that the incidence of the disease increased in direct proportion to the dosage of nitrogen. This reaction was significant in moderately resistant and susceptible varieties. But in the highly resistant variety Co. 4 there was no increase in blast even with 120 lb. nitrogen per acre. Root rot of sugarcane caused by a species of *Pythium* was on the increase in a neighbouring ryot's land after a heavy application of ammonium sulphate. The increase in the intensity of root-rot of sugarcane caused by *Pythium arrhenomanes* following high doses of nitrogenous manures has been reported from Hawaii and the Philippines (Carpenter, 1934). Rust susceptibility of wheat is heightened by liberal applications of nitrogenous manures. Nitrogen favours the metabolism of the plant and protein content of the leaves increase. A parallel rise in rust susceptibility is also evident. But a generalisation like this is likely to be erroneous. In some varieties of wheat, susceptibility to certain races of rust is increased by increased nitrogen but decreased to other races. A similar behaviour was reported in the reaction of certain varieties of beans to bean rust. No simple explanation can be given for this differential reaction to varied nitrogen supply regarding susceptibility to rusts. At all levels of nitrogen tried, the immune varieties remained immune and highly susceptible ones highly susceptible. The alteration in the reaction was evident only in varieties of intermediate susceptibility. Susceptibility to late blight of potato is increased by large applications of nitrogenous manures. *Phytophthora infestans* utilises amino-acids as a source of energy. The increased nitrogen content of the plants consequent on high doses of nitrogenous manures provides a favourable substraate for the rapid development of the fungus and hence to increased infection. Resistance to bacterial storage rots in potato is also broken down when the plants had been manured with excess of ammonium sulphate or calcium cyanamide. Cralley (1939) carried out extensive field and pot-culture experiments to find out the effects of nutrition on the incidence of stem-rot of rice (*Sclerotium oryzae*). In culture solutions a high nitrogen content increased the susceptibility of the plants to the disease while with low nitrogen the susceptibibility was reduced to a minimum. Similar reactions were observed in the field also. Reyes (1929) and Nakata, (Padwick 1930) also observed that the nitrogenous fertilizers increased the intensity of the disease.

*Verticillium* wilt of tomatoes is encouraged by nitrogenous manuring. The cell sap rich in nitrogenous compounds favours quicker growth of the parasite while the fungus is unable to maintain itself when there is a shortage of nitrogen Apple scab caused by *Venturia inæqualis* has been known to be aggravated by nitrogenous manuring. The incidence of the disease is considerably reduced by not applying nitrogen to the orchard. Though the disease is minimised by this method the size of the crop gets reduced. Evidence has been obtained to show that the juice of leaves of N – deficient trees is more toxic to the spores of the pathogen than the juice from the manured trees. The club root disease of cabbage (*Plasmodiophora brassicæ*) was increased either by excess or by lack of nitrogen.

Thus there is considerable evidence to show that more nitrogen encourages more disease. How this is brought about can be explained in certain diseases. Nitrogen favours rank vegetative growth. This produces a thick stand with increased humidity within the crop which is favourable for the reproduction and spread of the causal fungi. The maturation of the crop is delayed and the pathogens have more chances of infecting plants and causing higher incidence of disease. Rusts of cereals (e.g. black rust of wheat) in many cases affect the crop in maturing stages and if this phase is prolonged more infection will result. Further, the host tissues became soft and the protective cuticle remains thin. Under these conditions the fungus is able to infect the hosts more readily and cause more disease. In addition several fungi are able to infect and grow in tissues with a higher nitrogen content much more readily than in those with a lower content. Vasudeva (1930) has shown that *Botrytis allii* which is normally non-pathogenic to apples produced definite infection if supplied with nitrogenous substances. Heavy applications of nitrogen make the plants more vulnerable and also stimulate the growth of the pathogen. The nitrogen effect depends on the relative balance of potassium and phosphorus (Gaumann 1948).

There are a few instances however, of diseases which could be minimised by the application of nitrogenous manures. Beneficial results have been reported from the U. S. A. in the control of Texas root-rot of cotton caused by *Phymatotrichum omnivorum* by nitrogenous manuring. Leach and Davey (1942) have stated that the damage caused by *Sclerotium rolfsii* rot of sugarbeet in California was considerably reduced by the addition of nitrogenous fertilizers. Pea root rot due to *Aphanomyces enteliches* has been retarded by the use of nitrate of soda or ammonium sulphate. Smith (1944) mentions the decrease of bacterial wilt of tobacco caused by *Pseudomonas solanacearum* in some of the states of the U.S.A. by the addition of nitrogenous fertilizers. Loest (1939) has reported that the dry root of oranges caused by *Diplodia natalensis* in South Africa was common under conditions of nitrogen starvation. Application of large amounts of nitrogen is recommended as one of the measures for controlling the disease. These instances serve to indicate how obscure the interactions to nutritional experiments may be even with components which have given the most consistent reaction.

The influence of phosphatic manures on the incidence of diseases has been varied. One of the effects of phosphate manuring is to accelerate maturation processes of the plants with the result that the crop may escape infection. The influence of phosphates depends to a large extent on the available nitrogen and potassium levels. When phosphorus is present in excess relative to potassium and nitrogen, resistance to diseases is heightened. Browning root-rot of wheat caused by *Pythium arrhenomanes* has been found to flourish in soils with a high nitrogen and low phosphorus content. Vanterpool (1940) has shown that the addition of phosphatic manures removes this unbalanced nutritional condition and controls the disease. A similar response is shown by sugarcane to infection by the root rot caused by species of *Pythium*. In the unbalanced nutritional condition the host tissues are not able to resist infection but with the addition of phosphates the parasites are not able to make any progress. Clump rot of cardamoms prevalent in some of the plantations in South India is caused by *Pythium vexans* and

*P. aphanidermatum.* The retults of experiments carried out at Singampatti have shown that applications of two to four ounces of superphosphate or ammonium phosphate per clump kept down the disease. Here again it appears to be a case of unbalanced nitrogen - phosphorus content of the soil which favoured the disease. There is evidence to show that phosphorus increased the resistance of wheat to brown rust *(Puccinia triticina).*

Deficiency of phosphorus weakens the plants and renders them more susceptible to fungal parasites. But sometimes this weakening of the tissues has the opposite effect. The tissues become hyper sensitive to certain strains of rusts and die quickly. Thus the obligate parasite is not able to make further progress and the plants remain free from infection.

Increased incidence of disease has been associated with phosphate manuring in several instances. Wilt of redgram caused by *Fusarium udum* behaves in this manner. The rusults of manurial experiments conducted over several years at Pusa have shown that the incidence of wilt is significantly increased by the addition of phosphatic manures. Similar reaction was found in the case of cotton wilt *(Fusarium vasinfectum)* in America where the disease was increased iu plots manured with acid phosphate. From the United States it was reported that the infection by flax rust, *Melampsora lini* was increased in plots receiving phosphates. The growth of the plants in phosphate manured plots was much more luxuriant and the incidence of rust was proportional to the luxuriance of the crop. The results of water-culture experiments have shown that phosphoric acid alone increased the susceptibility to rusts. Plentiful supply of phophorus increased the susceptibility to rusts. This effect may be large enough to nullify the rust-inhibiting effect of potassium. Hence in regard to rust infection, potassium and phosphorus are often antagonstic to each other. While investigating the effects of nutrition on the stem rot of rice Cralley (1934) found that phosphatic manures in general tended to increase the incidence of the disease. Nitrogen and phosphorus applied together resulted in heavier infection than when applied separately, though the yield of rice also was more from the combined applications. But when potash was also applied along with nitrogen and phosphorus (6 parts ammonium sulphate, 8 parts superphosphate and 24 parts of potassium sulphate) the severity of infection was low. It thus becomes evident that when ammoninm sulphate and phosphorus are applied to rice crops in localities where the stem rot is common (Tanjore and Krishna) the fertilizers have to be balanced by potash also.

Potash increases resistance to diseases in several crops. The results of extensive investigations carried out at various centres in the U. S. A. have clearly shown than that the wilt of cotton *(Fusarium vasinfectum)* is most severe in potash-deficient plots. Application of potash resulted in a marked decrease of this disease. It has been reported that in the permanent manurial plots at Rothamsted high incidence of rust of wheat was always in the potash-starved plots and least in those receiving potash manure.

Incidence of certain fungus diseases of tomato grown in glass-houses in England has been checked by potash manuring. Resistance to dry rot of potatoes *(Fusarium coerulum)* was fund to be highest in tubers from plants receiving excess of potasn and lowest in those from plants deprived of potash. The leaf disease of coconuts at Pilicode (Malabar) with which *Gliocladium roseum* is associated is found to be greatly reduced by potash manuring. Potash manuring is sometimes recommended as one of the methods of reducing damage caused by various parasitic fungi. Potash hardens the tissues by intensifying the cell-wall development and this is correlated with increased resistance to infection by fungi. Further the plants mature early and escape infection. The action of potassium is generally opposite to the nitrogen effect. In some instances it is able to counteract the effects of excess of nitrogen. But in others it has been found that the increased susceptibility of plants brought about by excess of nitrogen cannot be fully counteracted by any amount of potash.

There are a few intances however of the adverse effects of potash manuring on the incidence of diseases. Club root of turnips *(Pasmodiophora brassicæ)* was in some varieties found to be more in plots where potassium was in excess and lack of potash greatly reduced it. In comparing the effects of N., P and K separately and in diffent combinations it was observed that potato leaf roll was markedly higher in plots where K was applied. Among the various combinations the incidence was highest in N K plots and lowest in the K P plots.

Of the other mineral nutrients the influence of lime on disease disposition has been investigated in some instances. Calcium exerts its influence directly on the plant and indirectly by amending the reaction of the soil. Increase in calcium enhances resistance to spread of infection by bringing about the hardening of the tissues especially the cell wall. The root rot of groundnut prevalent in irrigated crops and caused by *Macrophomina phaseoli* is often minimised by application of lime. Club root of cabbage *(Plasmodiophora brassicæ)* is common on acid soils. Amendment of the soil reaction by heavy applications of fresh burnt lime (2 to 3 tons per acre) eight to twelve months in advance of planting time is the accepted method of combating the disease.

Some diseases are however favoured by addition of lime to the soil. Root disease of flax caused by *Phythium megalacanthum* increased with excess of calcium, in Holland. In Australia infection by flag smut of wheat *(Urocystis tritici)* was enhanced by the addition of calcium (Millikan 1939). There was correlation between the calcium content of the plant and reaction to the smut.

Silica has been reported to increase the resistance of rice to blast *(Piricularia oryzæ)* and blight *(Helminthosporium oryzæ)*. Addition of silicic acid resulted in the increased silicification of the cell walls in the leaf and stem. In water culture experiments Yoshi (1941) was able to note that with increasing amounts of silicic acids to the solution, the resistance of rice leaves to blast was increased. Susceptibility to blast was inversely proportional to the silica content of the leaves. A similar response was noticed in wheat plants to infection by *Erysiphe graminis* when silica was added. The resistance to powdery mildew was heightened by the silica.

Among the other minor elements the addition of zinc to soils has been found to have different effects on different diseases. Millikan (1938) found in Australia that the disease of wheat caused by root rotting fungi like *Helminthosporium sativum*, *Curvularia ramosa* and *Fusarium culmorum* could be minimised to a great extent by the application of 15 to 30 pounds of zinc sulphate per acre to the soil. The action of this substance was not so much on the host plant but in affecting the sporulation of these soil fungi. Spore formation was also found to be inhibited when the substance was added to the cultures of the fungi. Lack of sporulation must have resulted in minimising infection. Zinc nitrate caused heightened susceptibility of wheat to rust (yellow) and mildew (Spinks, 1913).

Addition of lithium has been found to have a marked influence in increasing resistance to rust. Watering the plants with dilute solutions of lithium chloride enhanced the resistance of wheat seedlings to brown rust. Resistance to powdery mildew of wheat also followed a similar trend. Seedlings of *Phaseolus vulgaris* were able to resist infection by *Botrytis cinerea* when lithium chloride was added to the soil. In localities where there is boron deficiency the susceptibility of sunflower to *Erysiphe cichoracearum* is found to be increased. Increased susceptibility of wheat to *Septoria nodorum* is reported to be a concomitant of magnesium deficiency.

The role of the trace elements may be in improving the conditions of the host plants or in the inhibition of soil pathogens. There is some evidence to show that lithium and molybdenum inhibit sporulation of *Fusarium vasinfectum* (Sadasivan 1951). In some instances the multiplication of saprophytes is stimulated. How far this knowledge can be utilised for soil amendment with these substances for the control of soil-borne diseases caused by *Fusarium* and similar fungi is a problem for future investigations.

The other types of manures to be examined are the organic manures. These have been considered as the 'life of the soil'. Besides improving the texture and adding to the fertility of the soil these manures have been reported to profoundly influence the incidence of diseases. Apostles of the 'humus' school go the extent of firmly believing that application of organic matter to the soil in the form of farmyard manure or composts will keep off all diseases. They denounce the use of mineral fertilizers and attribute the incidence of diseases of crops to the continued use of these fertilizers. In support of their view they point to the virgin forests which grow in soils rich in humus and in which diseases are alleged to be absent. The latter supposition is not correct for diseases are found in forest trees also. But owing to the mixed type of the population the occurrence of disease is not as clearly apparent as in the case of 'one plant' cultivated crops.

It is contended that when organic matter is present in sufficient quantities in the soil the development of mycorrhiza is encouraged. These fungal growths form sheaths to the finer root ends and thus help to increase the surface area of the roots. Further they help in the greater absorption of nutrients from the soil and small quantities of growth-promoting substances are also reported to be absorbed by the plants from the mycorrhiza. Howard is of the firm opinion that if proper mycorrhizal connections are established the growth of the plants would be very vigorous and plant diseases would disappear. Leaving aside this extreme view, evidence is forthcoming to show that organic manures do help in keeping down some soil-borne diseases. It is attributed not so much to the mycorrhizal development in all cases as to the encouragement of the multiplication of numerous saprophytic organisms by the presence of the organic matter. These organisms by competition and by biological antagonism lead to reduction and gradual disappearance of the pathogens from the soil.

It has been demonstrated that perfect control of the cotton root-rot (*Phymatotrichum omnivorum*) can be achieved by heavy applications (15 to 30 tons per acre) of farmyard manure or alfalfa hay. Certain root diseases caused by *Fomes* are common in light soils, especially when the organic content is low. By the addition of heavy doses of organic manures the incidence of such diseases have been brought down. But the addition of organic manures has not been always of unmixed benefit. Experiments conducted over a number of years at Pusa have shown clearly that applications of farmyard manure always resulted in increasing the wilt disease of red gram (*Fusarium udum*). Diseases caused by *Rosellinia* are more in evidence when the organic matter content of the soil is high. These instances are against the opinion of the humus school.

But addition of organic matter in the form of green manures have given consistently favourable results in controlling a number of diseases caused by soil-borne pathogens. Red gram wilt (*Fusarium udum*) is significantly reduced when sunnhemp (*Crotalaria juncea*) is ploughed in as green manure. Fulton (1907) has stated that ploughing under of cowpeas and other leguminous crops decreased the amount of wilt of cotton (*F. vasinfectum*). Potato scab caused by (*Actinomyces scabies*) has been reported to be controlled successfully by liberal dressings of green manures in small holdings. (But in some field-scale trials green manuring has not been so successful owing to the fact that the mixture of soil and green manure had not been so homogenous). This procedure encouraged the development of saprophytic forms of *Actinomyces* which swamped out the pathogenic species Even powdery scab caused by *Sponogspora subterranea* common in lighter soils has been known to be checked by incorporating green manures. Thus green manures have been uniformly useful in reducing incidence of soil-borne diseases.

Thus enough evidence has accumulated to show that different diseases respond differently to the changes in the nutrition of the host, so that sweeping generalisations are out of the question. Many of the reactions are not easily explained. It can be seen that in many instances heavy doses of nitrogen increase disease. This is seen in diseases caused by airborne infection on foliage as well as in soil-borne diseases affecting roots Potash invariably increases resistance. Phosphates are useful for reducing the alkalinity of the soil and for the control of diseases flourishing under alkaline reactions (*Pythium* root-rot). But in many other instances the results obtained from phosphatic manures have been conflicting. When the same manure decreases the incidence of a disease and directly increases yield it can be safely recommended as a useful measure of control e. g. green manuring. But when the manures that are used increase the incidence of disease and also lead to high yield other methods of combating diseases have to be sought. Nitrogenous manures increase scab of apples and also the yield. On this account application of nitrogen cannot be stopped. Other methods of control like spraying with fungicides will have to be resorted to. It is better to have a heavier crop with some disease rather than a poor crop with no disease. Balanced manuring has to be followed to improve the vigour and growth of plants so that they may be able to stand the strain of the incidence of disease if it occurs and at the same time produce a remunerative crop.

## REFERENCES.


| | | |
|---|---|---|
| Butler, E. J. & Jones, S. G. | (1949) | Plant Pathology. MacMillan & Co., London, 172–180. |
| Carpenter, C. W. | (1934) | Hawaiian Planter's Record, *38*, 279–338. |
| Cralley, E. M., | (1939) | Rev. App. Myc. *18*, 815. |
| Garret, S. D. | (1944) | Root disease fungi., Chronica Botanica, Waltham. |
| Gaumann, | (1950) | Principles of Plant Infection. Eng. Ed. by W. B. Brierly, London. |
| Howard, A. | (1950) | An Agricultural Testament. Oxford University Press, London. |
| Leach, L. D. & Davey, A. E. | (1942) | *Journ. Agric. Res. 64*, 1–18. |
| Kelley, A. P. | (1950) | Mycotrophy in Plants. Chronica Botanica. Waltham. |
| Millikan, C. R. | (1938) | *Journ. Dept. Agric.* Vict. *37*, 302–8. |
| ,, ,, | (1939) | *Journ. Dept. Agric.* Vict. *37*, 302–8. |
| Padwick, G. W., | (1950) | Manual of Rice Diseases, C. M. I. 53. |
| Reyes, G. M. | (1929) | Philipp. Agri. Res. *22*, 313–31. |
| Sadasivan, T. S. | (1951) | *Proc. Indian Acad. Sci. 33.* |
| Smith, T. E. | (1944) | U. S. *Dept. Agric. Circular,* 692. |
| Spinks, G. T. | (1913) | *Journ. Agric. Sci. 5,* 231. |
| Suzuki, H. | (1935) | J. Coll. Agri. Tokyo, *13*, 235–321. |
| Vanterpool, T. C. | (1940) | *Sci. Agri. 20,* 735–749. |
| Vasudeva, R. S. | (1930) | *Ann. Bot. 44,* 469–493. |
| Yoshii, H. | (1941) | *Rev. Appl. Myc. 21,* 159–160 (1942). |

# On Planning Manurial Experiments in Sugarcane in Madras State

*By*

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**Introduction:** In increasing yield per acre, varieties and manures constitute the two major factors. The problem is a complex one and as such there is still some gap in our knowledge and also between the experimental results and ryots' field practice.

From 1914 to 1950, there have been 38 experiments in representative sugarcane tracts of this State on manuring sugarcane. Of these, 16 were at Anakapalle, 8 at Samalkot, 8 at Palur and 6 at Gudiyattam. In spite of the large number of experiments laid out, the quantitative knowledge in respect of manuring the crop is not advanced very much. The results of experiments recorded year after year are so varying that conclusions based on three-year data have been of only qualitative value. Further, the results of these experiments were not tested in ryots' fields and therefore are not very helpful in extension service. It is therefore desirable to critically review the manurial experiments, to detect the causes for the fluctuating results recorded and to explore the possibilities of better technique for future experiments.

**Review**: A complete list of experiments so far conducted in this State is shown in appendix 1. A scrutiny of the treatments in the various experiments as shown in column 3 indicates that prior to 1930, the manurial doses were determined on the bulk of manure and not based on chemical analysis of the manurial constituents. The experiments were also not laid out on the modern techniques which lend themselves to statistical analysis. This period is also characterised by the exotic types: J. 247, Purple Mauritius. and Fiji B being the main varieties under test. Nitrogenous and bulky organic manures were chiefly tested during this period.

Farmyard manure, green manure, cakes and fish-guano were the manures under test till 1925, after which ammonium sulphate also entered the field. The average yield recorded in most of these experiments was low as compared to the yields recorded in later years. This low yield was due to varieties, which were later ousted from cultivation by the Coimbatore canes and also due to the form of manures in use then. Farmyard manure recorded better results than no manure, but fish guano proved better than farmyard manure. Even the application of 30 tons of farmyard manure did not equal 10 bags of castor cake. These experiments therefore established the superiority of cakes over green manure or farmyard manure. Dr. Rege (1941) also pointed out that the value of cattle manure as a nitrogen supplier was not much.

From about 1925, ammonium sulphate came into use as a fertiliser for sugar cane. Experiments comparing this with cakes and cattle manure, revealed the superiority of the fertiliser in increasing yields. Even when it was applied on Nitrogen basis, this fertiliser recorded greater increases in yield than cakes. But, beyond certain levels it depressed juice quality, whereas this depression was not so marked, when cakes were applied. It was therefore brought out that if high yields and good quality jaggery are to be aimed at, there is need to mix the cakes and fertilisers in proper proportions.

The experiments that were laid out after 1930, are therefore on considerations of (i) form of nitrogen and optimum proportion between different forms (ii) Manures being applied based on chemical analysis of ingredients involved (iii) statistical analysis of yield data (iv) Co. canes being the main varieties under test (v) the value of other nutrients such as P and K being evaluated. It may therefore be considered that the manurial experiments in the last two decades were on sound lines.

These experiments indicated that the optimum doses of nitrogen for the different tracts were as follow :

| | | |
|---|---|---|
| Anakapalle | ... | 100 lb. N per acre. |
| Samalkot | ... | 150 lb. N per acre. |
| Gudiyattam | ... | 200 lb. N per acre. |
| Palur | ... | 250 lb. N per acre. |

In regard to the form of nitrogen, a proportion ranging from 1 : 1 to 3 : 2 between cake and ammonium sulphate was considered good The experiments now in progress at five centres, have indicated no difference in yield or quality due to form of manure. But this should be tested by permanent manurial experiments to bring out the cumulative effect of each form of manure. The experiments on time of application indicated that application of the entire dose at planting time was not good ; application in 2 to 3 doses was more efficient. Late application of the manure, i. e. beyond the fourth month of the crop, depressed juice quality. Basal dressing with farmyard manure did not influence yield or juice quality, though small beneficial effects were discernible during periods of drought.

Potassium did not influence either yield or quality ; in certain cases it even depressed yields.

Phosphates did not influence yield or quality. It did not improve setting of jaggery nor the keeping quality. However, there is still an impression in certain quarters that phosphates improve setting of jaggery.

The experiments so far conducted have clearly indicated that nitrogen in organic and inorganic forms mixed in certain proportions, is the only ingredient that records increase in yield, while potassium and phosphates have little effect on yield or quality.

III. **Fluctuations in recorded data** : The chief mode of interpreting the results was by averaging the recorded yield data. Results recorded in column 10 of the appendix 2 show that the actual responses to manuring from year to year had been very widely varying.

The variations are far beyond what may be attributed to experimental error. In the past, these wide variations have been ignored in interpreting the data, though this does not seem to be justifiable. It is necessary to analyse the basic causes for such fluctuations in the recorded yield-responses to manures.

(a) *Soil fertility:* The basic fertility of the plot in which the manurial experiments have been laid down was not considered in arriving at the quantum of added nitrogen or in interpreting the data. That such basic fertility of soil have a large influence on yield fluctuations is brought out at Palur in a series of manurial experiments, which alternated in two sets of fields from year to year.

**TABLE I.**

**Variations of yields in Manurial Experiments at Palur.**
**(Weight of canes in tons per acre.)**

| Dose of N lb./acre | Field Nos. 31 to 34 | | | Average for 3 years | % over 50 N | Fds. No. 24—27 | | Average for 2 years | % increase over 50 N |
|---|---|---|---|---|---|---|---|---|---|
| | 1928-'29 | 1930-'31 | 1932-'33 | | | 1929-'39 | 1931'-32 | | |
| 50 N | 21·8 | 17·9 | 20·5 | 20·1 | 100·0 | 13·3 | 9·9 | 11·6 | 100·0 |
| 100 N | 24·5 | 21·5 | 25·00 | 23·6 | 117·4 | 21·6 | 17·6 | 19·6 | 168·6 |
| 150 N | 32·8 | 26·7 | 33·4 | 31·0 | 154·2 | 32·3 | 28·7 | 30·5 | 263·0 |

If the manurial experiments are to give precise indications on the quantities of nitrogen to be added, three important factors should be considered viz., variety, soil and water. For such a step, a workable method of estimating the nitrogen available from soil must be determined. If chemical analysis of soil does not directly indicate the quantum of nitrogen to be added—and generally it may not—other methods of determining this must be evolved. In all the agro-biological experiments (Willcox, 1930) the N present in the soil must be taken into account, if the quantum of nitrogen to be added is to be predetermined. If not, the plant itself is to be used as an index during its growth to determine whether the growth is taking place under sufficiency or deficiency levels of nitrogen in plant tissues (Craig 1939). Addition of a fixed quantity of nitrogen by time schedule irrespective of the initial quantities present in the soil and the rate of its utilisation by the crop cannot offer precise data on the quantitative relationship between nitrogen and yield. The large fluctuations in experimental results from year to year in manuial experiments is due to such defects in the experiments.

(b) *Water:* That water is an important factor in the proper utilisation of the added manure needs no emphasis. In none of the manurial experiments, was this factor strictly controlled or evaluated. The quantity of water to be added by irrigation cannot be determined by mere acre-inches or by frequency of irrigation. Similarly the value of rainfall cannot be evaluated by total fall or by rainy days. The relationship of water to growth should be considered in terms of soil moisture and availability of water to the plant from the soil. Water in the soil has three important roles in relation to manuring viz., (i) it determines soil aeration, biological and chemical activities in the soil (ii) as a solvent for plant nutrients, it determines uptake of nutrients by the plant, (iii) under excess-conditions, it leaches out the nitrogen beyond the reach of roots of the plant. In other words it determines the release of nitrogen by the soil or added manure, the loss due to leaching and the uptake by the plant. In all these three ways, water is an important factor to be taken into consideration in evaluating nitrogen of the manures or soil. At Gudiyattam, which receives insufficient rainfall in South-West Monsoon, the relationship between water and nitrogen-utilisation was brought out in an experiment. When the plots receiving 200 lb. Nitrogen per acre were irrigated frequently, the crop arrowed profusely and ceased growth earlier than in the plots receiving irrigation at longer intervals. The crop growth in plots with frequent irrigation was similar to the plot receiving low Nitrogen dose.

A review of the yield data in the manurial experiments of different Research Stations as related to rainfall, shows some interesting indications.

In the manurial experiments at Anakapalle between 1933—'36 to 1935—'36, response to Nitrogen was nil in two years, and good in one year. The yields of jaggery at 25 N were 828 lb., 10,449 lb. and 9,025 lb., while those for 100 N were 9,444 lb., 13,555 lb. and 7,175 lb., respectively. In the second year, there had been some depression in yield. The years 1934—'26 recorded very hot weather. But the two monsoons were favourable in 1934—'35 while drought continued in 1935—'36. The response to manure was good in 1934—'35 while there was no response but only a depression in 1935—'36.

In the series of experiments from 1944—'45 to 1946—'47, canes were damaged in the first year due to lodging and in the second year by cyclone. In the third year yield differences between Zero N and 250 lb. Nitrogen were not significant.

In the graded dose N experiments laid out at Palur, there was good response to manuring in 1943—'44 and 1946—'47 but very little in 1944—'45, and 1945—'46. In the year of good response, the South-West Monsoon was well distributed. When there was drought, the manure was not utilised.

In the experiments at Gudiyatham, the response was graded for increasing doses in 1946—'47 while in 1945—'46, the dose 100 N came under one bar. In 1945—'46, there was 14·73 inches of rain in 19 rainy days in July–August, while in 1946—'47 there was only 6·55 inches in 16 rainy days. Receipt of good showers pulled up the crop and the manure was efficiently utilised. There was drought in November-December. Late receipt of showers in 1946—'47 may be responsible for graded response to manure in this year.

The yield data from manurial experiments are variable from year to year due to variable soil moisture, depending upon rainfall and its distribution.

What are considered as optimum doses for the different tracts is already mentioned. A scrutiny of this variable optimum indicates the possibility that the increasing dose of Nitrogen from northern to southern regions is closely linked with the soil-moisture-plant relationship in these tracts. The northern districts which receive good showers in South-West Monsoon recorded high-yields with 100–150 N, while the southern districts which receive poor showers in South-West Monsoon required higher doses of Nitrogen. In areas subject to limited supply of water, larger doses of Nitrogen are needed. Studies at Anakapalle revealed that when water supply is copious throughout the life-cycle of the crop, loamy and clayey soils show equal crop-producing potentialities, while when the water supply is at deficiency levels the lighter soil withstands drought better and utilises manure better than the clayey soil. At about 10% soil moisture, the crop in loamy soil grows up well, while it exhibits deficiency of moisture in clayey soils. The type of soil in relation to soil moisture and crop growth is important in studying manurial needs of the crop.

From the above it is clear that the recorded data are variable and due to lack of information on soil moisture status, the response to nitrogen in the different Agricultural Research Stations cannot be expressed in quantitative terms.

IV. **Some practical aspects:** Some broad indications from the different manurial experiments have been stated above. It is necessary to examine the practical bearing of the above experiments in field practice.

A thirty-ton crop of sugarcane removes the following ingredients from an acre of land.

**TABLE II.**

**Plant nutritional elements removed from soil.**

| Elements | 30 ton crop of Co. 419. lb./acre. | 3 tons jaggery lb./acre. |
|---|---|---|
| Nitrogen. | 69·7 | 1·9 |
| Phosphoric acid. | 132·8 | 7·8 |
| Potash. | 261·3 | 16 0 |
| Lime. | 265·6 | 12·0 |

Only a small fraction enters in the final product, while the rest are left in the crop residues as waste products. In the case of sugar, none of the manurial ingredients are found in it and as such it should be theoretically possible to return to the soil all that is removed by the crop. In the case of jaggery some proportion of the manurial ingredient are found in jaggery and a 30-ton crop will remove nutritional elements as shown in table above.

Cane tops are used for feeding cattle and begasse for feeding the furnace. Therefore, in factory or jaggery areas some amount of trash is available as a waste organic material. When the trash is composted and returned to soil it is possible to return 50 lb. Nitrogen through waste products.

In many tracts, it is possible to raise a crop of sunnhemp or other green manure crops either preceding the crop or as an intercrop. By this system, about 40 lb. Nitrogen may be added to the soil per acre. The review by Dr. Rege indicates that there is greater availability of nitrogen by green manuring. Thus, it is possible to add not less than 50—60 lb. Nitrogen to the soil if one of the methods mentioned above is adopted.

Oil-cakes are nowadays rather costly and ammonium sulphate was difficult to secure until recently. The Venkataraman Committee (1950) reported that the manurial bill constitutes upto 30% of the total cost of cultivation. Therefore, the best way to manure sugarcane is to apply as much Nitrogen possible by utilising the waste products and supplementing the same with green manures, and ammonium sulphate. This method is the cheapest for the cane grower and also the best in respect of national economy in which soil fertility is maintained and cakes may be spared as cattle feed. Such agricultural practices will encourage automatic recuperation of soil without importing costly materials from outside the field for the purpose.

In recent years, due to high cost of oil-cakes and ammonium sulphate and also due to non-availability of these in the open market, cane growers have been purchasing manure mixtures from different firms. A list of firms which prepare and sell special mixtures for sugarcane and the chemical analysis of these are furnished in table III.

**TABLE III.**

| | Name of the firm | Name of mixture | Guaranteed analysis Nitrogen Organic | Guaranteed analysis Nitrogen Inorganic | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|---|---|
| 1. | The Scientific Fertiliser Co., Ltd., Coimbatore | Sugarcane fertiliser | 1·5 | 15·5 | 1·5 | ... |
| 2. | Mysore Fertiliser Co., Madras | Sugarcane Special | 1·7 | 13·3 | 4·5 | ... |
| 3. | Nilgiri Fertiliser Ltd., Coonoor | Sugarcane fertiliser | 1·5 | 11·07 | 3·5 | 2·0 |
| 4. | Premier Fertiliser, Ltd., Tanjore | Sugarcane fertiliser No. 1 | 4·0 | 3·0 | 5·6 | ... |
| | | No. 2 | 4·0 | 5·5 | 6·5 | ... |
| 5. | T. Stanes Co., Ltd., Coimbatore | Sugarcane manure | 2·8 | 10·2 | 4·4 | ... |
| 6. | The Cochin Fertiliser, Ltd., Trichur., | Special Sugarcane manure mixture | 2·4 | 11·6 | 4·2 | ... |
| | | Sugarcane fertiliser | 4·8 | 5·5 | 4·5 | ... |
| 7. | Jupiter Manure and Bone Mills, Ltd., Kakinada | Delta Sugarcane fertiliser | 3·55 | 8.10 | 5·0 | 0·5 |

| Name of the firm | Name of mixture | Guaranteed analysis Nitrogen Organic | Inorganic | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|---|
| | Sugarcane Special | 3·55 | 9·60 | 7·0 | 0·4 |
| | Tapeswaram sugarcane fertiliser | 1·30 | 10·30 | 4·2 | 0·5 |
| | Polnadu Sugarcane fertiliser | 2·00 | 12·00 | 6·0 | ... |
| 8. A. S. T. F. Rodrigues & Co., Katpadi | Sugarcane mixture | 1·65 | 8·82 | 5·50 | ... |
| | Sugarcane special | 3·31 | 12·32 | 5·50 | ... |
| 9. Parry Co., Ltd., | Karur Sugarcane fertiliser | 0·8 | 13·2 | 6 0 | ... |
| | Samalkot Sugarcone fertiliser | 0·8 | 13·2 | 6 0 | ... |
| | Sugarcane special mixture | 2·5 | 12·4 | 1·8 | ... |
| | Cuddalore sugarcane A. | 4·1 | 4·9 | 5·6 | ... |
| | Cuddalore sugarcane B. | 5·4 | 4·9 | 2·2 | ... |
| | Cuddalore sugarcane No. 1 | 3·8 | 6·6 | 1·0 | ... |
| | No. 2 | 4·9 | 6.4 | 3·8 | ... |
| | Samalkot sugarcane A | 1·3 | 6·4 | 1 0 | ... |
| 10. Coimbatore Chemicals & Fertilisers, Ltd., Pottanur | Sugarcane mixture | 1·4 | 8·2 | 8·0 | ... |
| 11. Deccan Fertiliser, Co., Coimbatore | Sugarcane fertiliser | 2·6 | 8·4 | 9·0 | ... |
| 12. C. Raju, Kakinada | Sugarcane mixture special | 3·4 | 9·1 | 5·0 | ... |

Even though experiments at various Research Stations in this State have shown that phosphates do not increase either yield or quality, all the firms adopt a formula in which some quantity of phosphates are included. Phosphates are useful to grain crops in increasing yields, particularly to paddy. Therefore, application of phosphates to sugarcane crop, when there is no immediate use for this ingredient is to be considered a waste. If there are phosphate-deficient soils or pockets in the sugarcane tracts of this State, they still remain to be detected. If the popular impression that phosphates improve setting of jaggery, not confirmed by experiments of this Department, is true, even then phosphate need not be directly applied to sugarcane. A better way should be its application to the preceding crop of paddy and and leaving the residual effect to sugarcane, or better still, will be its application to the preceding green manure leguminous crop, as is being recommended by the Government Agricultural Chemist on the T. V. A. system.

Thus, apart from other aspects to be detailed hereafter, the practice by ryots is neither aimed at cheapening the manure bill nor at natural improvement in soil condition that will increase efficiency in utilisation of the available soil nutrients. The experiments on Research Stations have been mostly confined to import of outside materials, ignoring the natural recuperating power of soil. Such aspects of manuring have not been taken up in any of the manurial experiments as the latter have always been planned on a short-range policy.

V. **Suggestions:** In the design of manurial treatments in the past, cakes and ammonium sulphate played important roles. In supplying bulky organic manure, farmyard manure was the main source. Under ryots' conditions, farmyard manure is not available in sufficient quantities for application to crops. Cakes are valuable as cattle feed and can be used for better purposes than being buried in the soil. In recent times, it has become a scarce and also costly commodity. The best agricultural system is one which uses farm wastes and also which permits raising legumes to recuperate the soil. In the case of sugarcane, a great deal of organic wastes is available at harvest time and these must be utilised properly to increase the organic matter of soil. Secondly, in most places sunnhemp or daincha can be raised preceding cane; where it is not possible to do so, the green manure crop can be raised intersown in cane in early stages. These two possibilities for increasing the humus of soil must be tested on a long-range basis.

The experimants so far conducted reveal that ammonium sulphate is superior to cake in increasing yield of cane, but cake is superior in respect of quality. The possibility of increasing yield and quality by increasing humus of soil as described before and using ammonium sulphate only as fertiliser, leaving cake for other better uses, needs to be investigated.

Phosphates have not increased yield or quality. So also other elements. But such experiments were conducted for short periods only. Under ryots' conditions, there is a fall in yields in the course of a decade or so and change of variety is considered necessary. Recent experience in Bombay indicates that even change of seed by importing from a distant place increases yield. In all these cases, soil deterioration is suspected to be the cause. There is need to investigate this aspect also. Complete analysis of soil and plant, including the minor elements in plots laid down on a permanent basis to test efficacy of the different organic and inorganic forms, also seems necessary.

In recent times, manurial requirements of crops are sought to be studied by (1) agro-biology (2) foliar diagnosis (3) initial fertility tests on soil by chemical analysis or by using indicator plants (4) by studying intensity of nutrition by the plant. In the experiments so far conducted no such criteria were adopted. After the manure was applied, only the yield was considered, ignoring the physico-chemical-biological changes in the soil during crop growth and the reactions of the plant to the existing growth factors. The law of diminishing returns was the only consideration, while the law of growth factors and the law of limiting factors were ignored.

Certain precautions seem to be necessary in order to ensure uniformity in yield data from year to year and to assess the value of added Nitrogen in quantitative terms instead of arriving at empirical conclusions by averaging the results, a process which ignores variations and their causes.

In the recent experiments at Anakapalle both the soil and the plant were analysed periodically and this gaves more precise information than similar experiments laid out previously on the station. An attempt is being made to see if foliar diagnosis could be taken as a reliable index for the application of Nitrogen to the soil. Similarly studies on water requirement revealed that irrigation based on soil moisture can give definite data while irrigations based on intervals alone do not yield quantitative information. Another important factor for variation in yield from year to year is the variation in population.

VI. **Conclusion:** Certain modifications in the present technique of conducting manurial experiments are necessary. The modifications suggested are (1) periodical soil and plant analysis (2) studies in soil moisture (3) ensuring uniformity in stand and working up to minimum population. For the adoption of the first two, the Research Stations, are to be equipped with staff and other facilities; but it is worthwhile doing it even at some cost. If not, the data collected even during the course of long periods, do not furnish definite knowledge on the scientific application of manures. Under the present conditions, there are losses due to wastages in applied manure, or insufficiency in applied manure. When the experimental results are analysed, the scientific criteria should be immediately tested in ryots' plots to assess the fertility variations in the tract and the application of farm data to field conditions.

## LITERATURE CITED:

Annual Report of Sugarcane Research Scheme, Anakapalle and Gudiyattam (1947—48—50—51.)

Craig (1939) Tenth Annual Report of the Sugarcane Research Station, Mauritius.

Lakshmikantham M. (1949): Optimum Nitrogen requirements of Sugarcane in Anakapalle. Madras Agricultural Journal. XXXVI. p. 12.

Madras Agricultural Station Reports (1912—'13 to 1947—'48.)

Noel Deer (1921) Cane sugar. Norman Rodger, London.

Paddy Specialist and Government Agricultural Chemist (1944): A Review of manurial experiments on the Agricultural crops of the Madras Presidency for the decennial period (1930—'40.) Madras Agricultural Journal XXXII. p. 3.

Rege R. D. (1941): Fertiliser experiments on sugarcane in India (1932—'39) Indian Council of Agricultural Research Publication.

Stewart A. B. (1947): Soil fertility investigations in India with special reference to manuring: Indian Council of Agricultural Research Publication.

Vaidyanathan M. (1934): Analysis of manurial experiments in India. Indian Council of Agricultural Research Publication.

Venkataraman Committee (1950): Report.

Willcox O. W. (1930): Principles of Agrobiology. Premier Publishing Corporation, New York.

# APPENDIX I.

*Summary of Manurial Experiments in Madras State*

| Station | Year | Manurial Treatments | Results. | Remarks |
|---|---|---|---|---|
| Anaka-palle | 1916—17 to 1918—19 | Variety J. 247 : Cattle manure 30 cartloads - wild indigo 2000 lb., cattle manure 30 cartloads - castor cake 820 lb, green manure–castor cake 1640 lb. compound. | No definite conclusions were drawn. | Red rot and high variations in plot yields vitiated results. |
| | 1919—20 to 1922—23 | Variety J. 247 : Fish guano $\frac{1}{2}$ ton - 4,000 lb, wild indigo, Fish guano 1 ton compared. | Fish guano at 1 ton per acre recorded higher yields. | |
| | 1923—24 to 1931—32 | Variety J. 247 : 15 cwt. groundnut cake, 10 cwt. groundnut cake - 2000 lb. vempali, 8 cwt. groundnut cake - 4000 lb. vempali, 1 ton groundnut cake. | No significant differences were evident between treatments. | The treatment 1 ton groundnut cake was included in 1925-26. |
| | 1929—30 to 1932—33 | Variety J. 247 : (10,000 lb. cattle manure-2000 lb. wild indigo-640 lb. groundnut cake), (10,000 lb. cattle manure–2000 lb. wild 260 lb. ammonium sulphate), (27,665 lb. cattle manure-2000 lbs. wild indigo) compared. | Substituting cattle manure by ammonium sulphate to give 54 lb. Nitrogen, increased yield. 260 lb. ammonium sulphate can replace $7\frac{1}{2}$ tons cattle manure. | |

APPENDIX I—*(Continued)*.

| Station | Year | Manurial Treatment | Results | Remarks. |
|---|---|---|---|---|
| | 1933—34 to 1935—36 | Variety Co. 213 : *Inorganic Series* : (i) No manure, (ii) 100 N as ammonium sulphate, (iii) N-K (100 lb. N as ammonium sulphate-100 lb. $K_2SO_4$,) (iv) N-P (100 lb. N as ammonium sulphate-300 lb. superphosphate) (v) N-K-P (100 lb. N as ammonium sulphate-9300 lb. super-100 lb. $K_2SO_4$) (vi) K-P (100 lb. $K_2SO_4$ - 300 lb. super), (vii) to (xii) same as (i) to (vi) with basal dressing of farm yard manure at 5000 lb/acre. | KNP is not better in yield over N alone ; organic series better in juice quality than inorganic series. No difference between farmyard manure and no farmyard manure plots in inorganic series. K and P did not recard any difference in quality over N alone plots. | Due to heavy rains and cyclone in October of 1933 the crop was lodged and damaged. 1935 - 36 season was abnormal with inadequate rainfall. No differences were evident between treatments. |
| | 1934—35 to 1935—36 | *Organic Series.* (xiii). No manure, (xiv) 100 N as groundnut cake-50 lb. $K_2O$ as ashes, (xv). 100 lb. N as groundnut cake, (xvi). N-P (100 lb. as groundnut cake-300 lb. $P_2O_5$ as bonemeal 750 lb. $K_2O$ as ashes), XVIII K-P (50 lb. $K_2O$ as ashes-300 lb. $P_2O_5$ as bonemeal). | | |
| | 1934—35 to 1935—36 | Variety Co. 213 : Variety x spacing : 25,50,75 and100 lb. Nitrogen x (3-5), (4-4), (5-5-), (6-4) links spacing. | Yields greater in medium spacing (3-5) and 4-4) than in wider spacing; yields under lower dose of manure as good as higher dose of manure. Quality of juice better under lower doses of manure. | |

| | | | | |
|---|---|---|---|---|
| | 1943—44 to 1946—47 | Variety J. 247 : Intensively fertilised seed material. Nitrogen (1000 lb. groundnut cake–2000 lb. Vempali); 2/3 of the above 1/3 of the above. | Yields were erratic; no definite conclusions could be drawn. In earlier stages of crop growth, intensively fertilised Seed appeared better, but later no differences could be noticed. | |
| | 1943—44 to 1946—47 | Variety Co. 419 : Graded dose of nitrogen with groundnut cake, with and without farmyard manure as basal dressing. Dose of Nitrogen, 0,50, 100, 150, 200 and 250 lb. per acre. | In the first year, 250 lb. N recorded highest yield but was statistically on a par with 200 lb. and 150 lb. nitrogen doses. Next two years, no significant differences. Crops in higher nitrogen plots suffered by lodging. The dose of 100 lb. Nitrogen/acre was judged best on economic grounds. | In the first year treated as bulk, due to lodging. *Second year :* 250N, 150N, 200N, 100N, 50 N, O–N. *Third year :* 100 N, 150 N, 50 N, 200 N, 250 N. O–N. *Fourth year :* Not significant. |
| Anakapalle | 1934—35 to 1935—36 | Variety Co. 213 : Molasses as manure : Basal dressing of farmyard manure at 20 cartloads; 26 lb. as nitrogen as Ammonium sulphate, groundnut cake, pillipesara, molasses to supply 26, 52, 78 lb. Nitrogen. | 26 lb. Nitrogen in the form of Ammonium sulphate was superior to others. Other treatments under one bar. Molasses as manure is as good as cake in yield and quality. | Ammonium sulphate is superior to groundnut cake, and the latter superior to molasses. |

APPENDIX I—(*Continued*).

| Station | Year | Manure Treatments | Results | Remarks |
|---|---|---|---|---|
| | 1945—46 | Variety Co. 419: Salvaged ammonium nitrate: Two levels of nitrogen: 100 lb. and 200 lb. Four forms of Nitrogen: Ammonium sulphate, groundnut cake, ammonium nitrate and mixture of groundnut cake and ammonium sulphate, to supply nitrogen in 2: 1 ratio. | Yield differences not significant. Ammonium nitrate ranked last in the order of yield. | 200 lb. Nitrogen in form of ammonium nitrate yielded 38·73 tons against 46·63 tons when 100 lb. Nitrogen was supplied in the form of ammonium sulphate. |
| | 1944—45 to 1947—48 | Variety Co. 419: Time of application of manure. 150 lb. Nitrogen in the standard of $\frac{2}{3}$ as groundnut cake and $\frac{1}{3}$ as ammonium sulphate. Four times of application (1) all at planting, all at 2 months after planting, (3) all at 4 months after planting (4) half at planting and half at trenching. | | |
| | 1947—48 to 1249—50 | Variety Co. 419: Three levels of nitrogenous manure 100, 150, 200 lb. N/acre in combination with 0, 50, 100 lb. $P_2O_5$. | | |

| | | | | |
|---|---|---|---|---|
| | 1949—50 to 1950—51 | Variety Co. 419: Forms of manure 8, viz., 150 lb. N in the form of (1) all as groundnut cake (2) all as ammonium sulphate, (3) groundnut cake and ammonium sulphate in 1 : 2 proportion on Nitrogen basis, (4) groundnut cake and ammonium sulphate in 1 : 2 proportion, (5) groundnut cake and ammonium sulphate in 1 : 3 proportion (6) groundnut cake and ammonium sulphate in 2 : 1 proportion, (7) Groundnut cake and ammonium sulphate in 3 : 1 proportion (8) groundnut cake and ammonium sulphate in 3 : 2 proportion. | | |
| | 1949—50 to 1950—51 | Variety Co. 419: Compost Experiment: 250 lb. N in the form of compost or farmyard manure compared with No manure. Plots receiving same manurial treatment for rotational crops also. | Yield differences not significant in the first year. Significant in the second year when sugarcane followed paddy in the same treatmental plots. | Due to cumulative effect, the treatment differences are significant in second year. |
| Samalkot | 1902—03 to 1905—06 | Farmyard manure and castor cake compared. | Yield was more when Nitrogen was applied as cake than as farmyard manure, even though total nitrogen was more in farmyard manure. | Juice quality was better under farmyard manure than under cake. |
| | 1909—10 to 1911—12 | 10 tons farmyard manure compared with 10 bags castor cake. | | |

APPENDIX I—(*Continued*).

| Station | Year | Manure Treatments | Results | Remarks |
|---|---|---|---|---|
| | 1912—13 to 1913—14 | Variety B. 208: Cattle manure 30 tons, saffower cake 2,822 lb., gingelly cake 2,049 lb., Pungam cake, 31,815 lb., groundnut cake 1,640 lb., castor cake 2,384 lb. per acre. | Even heavy application of cattle manure was not equal to 10 bags of castor cake. Cake is definitely superior to cattle manure. | Quantities of cakes different in the two years. |
| | 1914—15 to 1918—19 | Variety J. 247: Castor cake 1,640 lb., castor cake 1,230 lb., cattle manure 10 tons. | Combination of cattle manure and cake not superior to cake alone. | |
| | 1919—20 to 1922—23 | Variety J. 247: Castor cake 3,280 lb., fish guano 3,280 lb. | Use of fish guano as substitute for castor cake on average for four years amounted to 57 lb. jaggery. | |
| | 1927—28 to 1932—33 | Purple Mauritius: Castor cake 1,640 lb., Castor cake 547 lb., Ammonium sulphate 522 lb. | In two seasons, ammonium sulphate alone or its combination with castor cake was better. In one season, ammonium sulphate alone was better. Cake alone proved inferior to combination of cake-ammonium sulphats. Dose of Nitrogen applied was 102·5 lb. per acre. | |
| Samal-kot | | | | Cake was applied in one dose and ammonium sulphate in two doses. Differences due to time of application were not considered. |

| | | | |
|---|---|---|---|
| 1929—29 to 1932—33 | Variety: Purple Mauritius: Groundnut cake 1,707 lb. groundnut cake 563 lb.—Ammonium sulphate 407 lb. Ammonium sulphate 610 lb. | Ammonium sulphate alone yielded highest; cake alone was poorest. In 1931-32, groundnut cake+ammonium sulphate was superior to others. In juice quality, cake alone was good with low glucose. In ammonium sulphate plots, sucrose and purity low and glucose high. | When the yields of groundnut cake series are compared to those of castor cake, they are greater. |
| 1933—34 to 1936—37 | Varieties: Co. 213, Co. 281, J. 247 and Purple Mauritius.<br><br>Dose of N: 25 lb., 50 lb., 75 lb., and 100 lb./acre. | In 1934-35 there was response to increasing dose of nitrogen; J. 247 responded best. In 1935-36 between 50, 75, 100 lb. N doses there was no significant difference in yield. | Yields in 3 years were very varying. |
| 1937—38 to 1939—40 | Varieties Co. 419, J. 247 and Purple Mauritius. | Differential responses to manures were significant. 200 lb. Nitrogen per acre yielded higher than 100 lb. N dose, but not significantly. Purple Mauritius responded better in some years than in others. | Purple Mauritius recorded low yields 1939-40 as compared to 1938-39. |
| | —4/10 in June—3/10 2 months after June. | In 1938-39 yields were high but no difference between treatments. In 1939-40, yields were low and more than one application best. | Differential responses recorded. In a season of drought more than one application good. |

APPENDIX I—(*Continued*).

| Station | Year | Manurial Treatments | Results | Remarks |
|---|---|---|---|---|
| Palur | 1922—23 to 1925—26 | Variety: Fiji B: 100 lb. Nitrogen in the form of groundnut cake castor cake, castor cake—ammonium sulphate, fish guano. | Differences between differet treatments not marked. Castor cake plus ammonium sulpate was better than castor cake alone. | Yields in alternate years in a particular field was higher than in another field. In the plot of poor fertility. fish guano was poorest and cake plus ammonium sulphate was best. |
| | 1925—26 to 1927—28 | Fiji B. Manurial treatments: 11<br>100 N in the form of cake, groundnut cake, fish guano.<br><br>100 lb. N as mixture of groundnut cake—ammonium sulphate, castor cake—ammonium sulphate fish guano-ammonium sulphate.<br><br>150 lb. N as castor cake—ammonium sulphate, groundnut cake—ammonium sulphate, fish guano—ammonium sulphate.<br><br>100 lb. N in the form of castor cake—ammonium sulphate, 50 lb. $P_2O_5$ as bonemeal or super. | Not much difference between castor cake and groundnut cake. Combination of cake and ammonium sulphate to supply 150 N is best. Phosphate not effective. | In a field of poor fertility combination with ammonium sulphate increases yield much more than in rich soils. |

| | | | |
|---|---|---|---|
| 1928—29 to 1932—33 | Variety Fiji. B. Basal dressing of farmyard manure to supply 25 lb. N, bonemeal 1 cwt. per acre, potassium sulphate, 50 lb. per acre; treatments: 50 N as groundnut cake, 40 N as groundnut cake—10 N as ammonium sulphate, 100 N as groundnut cake, 80 N as groundnut cake—20 N as ammonium sulphate, 150 N as groundnut cake, 120 N as groundnut cake—30 N as ammonium sulphate, 200 N as groundnut cake, 160 N as groundnut cake—40 N as ammonium sulphate, 20 N as groundnut cake—80 N as ammonium sulphate, 100 N as ammonium sulphate, 75 N as groundnut cake—25 N as ammonium sulphate in one dose; groundnut cake 75 N x—25 N as ammonium sulphate in 2 doses. | 200 N as cake and ammonium sulphate recorded the best yield. 200 N is significantly superior to 100 N and 50 N. Yields in respect of form of N are erratic; with 100 N dose, 60 N and 40 N seems best, but critical examination shows ammonium sulphate as best and depends on distribution of rainfall. Time of application in 3:4:3 is concluded as best. | Distribution of rainfall from year has brought out differences due to time of application of manure. |
| 1932—33 to 1936—37 | Variety Fiji. B. Treatments 9: 200 N as $NaNO_3$, 120 N as groundnut cake—80 N as $NaNO_3$, 120 N as groundnut cake—100 lb. $P_2O_5$, 50 lb. $K_2O$ as pot. sulphate, 120 N as groundnut cake—80 N as ammonium sulphate —100 lb. $P_2O_5$—50 lb. $K_2O$, 200 N—100 $P_2O_5$—50 $K_2O$ as pot. sulphate, 200 N as $NaNO_3$—50 lb. $K_2O$, 200 N+50 lb. $K_2O$+100 lb. $P_2O_5$. | Though complete manure plots recorded higher yields, they are not significant. P and K no effect on yield or quality. K even depresses yield. | |

APPENDIX I — *(Continued)*.

| Station | Year | Manurial Treatments | Results | Remarks |
|---|---|---|---|---|
| Palur | 1939—40 | Variety: P. O. J. 2878: Treatments. O N, 75 N as ammonium sulphate, 150 N as ammonium sulphate, 75 N as groundnut cake, 150 N as groundnut cake, 37½ N as ammonium sulphate—37½ N as ammonium sulphate; 75 N as groundnut cake—75 N as ammonium sulphate. | No differences due to form of Nitrogen, though 1:1 was good. Inorganic form has recorded higher yields though not significantly. 75 N as cake = O-N, but others were superior. | Data for one year only available. |
| | ,, | Varietal x Manurial. Varieties. Co. 349, Co. 419, POJ. 2878. Nitrogen: 0,75,150 lb. $P_2O_5$: 0,35,70 lb. $K_2O$: 0,50,100 lb. | Main effects on yield were due to nitrogen, and then to varieties. None of the varieties responded to K or P. Co. 419 responded highest to N; K and P at different levels had no effect on yield or quality. | |
| | 1943—44 to 1946—47 | Varieties Co. 281, and Co. 349: Manurial treatments—Basal dressing of 10 tons farmyard manure and no basal dressing: Nitrogen dose 0,100, 150,200 and 250 lb. Nitrogen as groundnut cake. | No significant difference between basal and no basal dressing. Increased yields recorded with higher Nitrogen doses. More than 200 lb. Nitrogen depressed juice quality. | |
| Gudiyattam | 1939—40 to 1941—51 | Variety Co. 419: Influence of phosphate on juice quality: 5 tons of farmyard manure—100 N $\frac{2}{3}$ as castor cake—$\frac{1}{3}$ as ammonium sulphate, 1 cwt. super to treated plots. | $P_2O_5$ did not bring out any effect on juice quality. | Unreplicated plot test. |

| | | |
|---|---|---|
| 1945—46 to 1247—48 | Variety Co. 419: Graded doses of N as groundnut cake. 0,50,150,200 and 250 lb. N. | 250 N recorded highest yield. Grad3d decrease with lower N doses Jaggery recovery highest in 50 lb. N and keeping quality better than in higher N plots. |
| 1948—49 to 1950—51 | Variety Co. 419: Nitrogen in relation to Phosphorus. Two doses of N: 200 and 250 lb./acre. Three doses of $P_2O_5$: 0,50,100 lb./acre. | $P_2O_5$ did not influence yield or quality. |

## APPENDIX II.

*Response to Manure in Relation to Rainfall.*

| Station | Year | Season | Rainy days | Rainfall in inches | Variety | Dose of Nitrogen lb/acre | Yield/ acre | Response to manure | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Anakapalle | 1933-34 | Hot weather | 12 | 7·72 | P.O.J. 2878 | 25 | | No increased yield over increased nitrogen. | Rains in hot weather heavy. |
| | | South-West Monsoon | 38 | 25·72 | | 50 | | | South-West monsoon fairly distributed. |
| | | North-East Monsoon | 19 | 12·85 | | 75 | | | |
| | | | 69 | 46·29 | | 100 | | | |

APPENDIX II—*(Continued)*.

| Station | Year | Season | Rainy days | Rainfall in inches | Variety | Dose of Nitrogen lb/acre | Yield/ acre | Response to manure | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | 1934–35 | Hot weather | 4 | 0·80 | ,, | 25 | | Response to manurial dose good. | South-West monsoon copious. |
| | | South-West Monsoon | 38 | 26.86 | | 50 | | | |
| | | North-East Monsoon | 16 | 7-12 | | | | | |
| | | | 58 | 34·78 | | 100 | | | |
| | 1935-36 | Hot weather | 2 | 0·55 | ,, | 25 | | Little response to manure. | Showers in South-West Monsoon inadequate. Far end depression in yield indicates insufficiency of water. |
| | | South-West Monsoon | 32 | 14·93 | | 50 | | | |
| | | North-East Monsoon | 11 | 8·18 | | 75 | | | |
| | | | 46 | 23·66 | | 100 | | | |
| | 1944–46 | Hot weather | 20 | 7·38 | Co.419 | 0 | 35·34 | Increased yield with higher dose of Nitrogen. | Good hot weather rains followed by good showers in June in South-West monsoon. |
| | | | | | | 50 | 44·75 | | |
| | | | | | | 100 | 52·48 | | |
| | | South-West Monsoon | 48 | 19·34 | | 150 | 54·19 | | |
| | | | | | | 200 | 55·13 | | |
| | | North-East Monsoon | 20 | 16·16 | | 250 | 54·46 | | |
| | | | 88 | 42·88 | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1946–47 | Hot weather | 11 | 2·29 | Co.419 | 0 | 39·94 | Response to manure not much. Yield differences not significant. | Deficient rainfall in hot weather and belated rainfall by August in South-West Monsoon. |
| | | | | | | 50 | 49·96 | | |
| | | South-West Monsoon | 60 | 15·89 | | 100 | 49·09 | | |
| | | | | | | 150 | 45·75 | | |
| | | North-East Monsoon | 16 | 6·55 | | 200 | 47·21 | | |
| | | | | | | 250 | 45·04 | | |
| | | | 87 | 24·73 | | | | | |
| Samalkot | 1937–38 | Hot weather | 14 | 14·37 | ,, | 50 | 56·74 | Yields of 200 N and 150 N under one bar; 100 N and 150 N under one bar. 60 N inferior to others. | Beneficial rainfall in hot weather; South-West Monsoon set in early and not well distributed. |
| | | South-West Monsoon | 41 | 17·74 | | 100 | 66·85 | | |
| | | | | | | 150 | 70·04 | | |
| | | North-East Monsoon | 15 | 8·59 | | 200 | 71·78 | | |
| | 1938–39 | Hot weather | 10 | 5·99 | ,, | 100 | 64·96 | Yield differences not significant. | Hot weather rains poor and North-East Monsoon good. Distribution of rainfall in South-West Monsoon was good. |
| | | South-West Monsoon | 48 | 22·47 | | 150 | 63·43 | | |
| | | North-East Monsoon | 17 | 17·82 | | 200 | 63·14 | | |
| | 1939–40 | Hot weather | 5 | 2·33 | ,, | 100 | 62·5 | Differences in yield not significant. | Poor hot weather rains. Late receipt of South-West Monsoon showers with uneven distribution. |
| | | South-West Monsoon | 40 | 22·52 | | 150 | 62·0 | | |
| | | North-East Monsoon | 24 | 30·30 | | 200 | 67·2 | | |
| Palur | 1928–29 | Hot weather | 5 | 1·06 | Fiji-B | 50 | | Yield differences marked. | Rainfall poor in hot weather. South-West Monsoon brought down good showers. |
| | | | | | | 100 | | | |
| | | South-West Monsoon | 43 | 17·34 | | | | | |
| | | | | | | 150 | | | |
| | | North-East Monsoon | 45 | 35·07 | | 200 | | | |
| | | | 93 | 53·47 | | | | | |

APPENDIX II—*(Continued).*

| Station | Year | Season | Rainy days | Rainfall in inches | Nariety | Dose of Nitrogen lb/aere | Yield/ acre | Response to manure | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | 1929–30 | Hot weather | 7 | 1·22 | ,, | 50 | | | Rainfall in hot weather period poor. South-West Monsoon broke out early but there was drought in July. |
| | | South-West Monsoon | 37 | 13·81 | | 100 | | | |
| | | North-East Monsoon | 46 | 34·30 | | 150 | | | |
| | | | 90 | 49·33 | | | | | |
| | 1930–31 | Hot weather | 9 | 11·73 | Fiji-B | 50 | | 150 N and 200 N are significantly superior to 50 N. | Hot weather heavy showers in one day. South-West Monsoon ill-distributed. After June there was drought till middle of August. |
| | | South-West Monsoon | 31 | 12·69 | | 100 | | | |
| | | North-East Monsoon | 51 | 34·26 | | 150 | | | |
| | | | 91 | 58 68 | | 200 | | | |
| | 1931–32 | Hot weather | 7 | 6·69 | | 50 | | Increased response to higher dosage of Nitrogen. | Poor distribution of rainfall in June-July as compared to previous season. Inadequate and intermittent showers in South-West Monsoon Heavy rainfall in North-East monsoon. |
| | | South-West Monsoon | 25 | 11·45 | | 100 | | | |
| | | North-East Monsoon | 48 | 49·51 | * | 150 | | | |
| | | | | | | 200 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1932–33 | Hot weather | 7 | 5·42 | | 50 | | Yield differences significant. | Hot weather recorded in May. South-West Monsoon brought down less rainfall than in 1931–32. Comparatively low North-East Monsoon but distribution good from September to November. |
| | South-West Monsoon | 32 | 11·05 | | 100 | | | |
| | North-East Monsoon | 50 | 29·49 | | 150 | | | |
| | | 89 | 45·96 | | 200 | | | |
| 1943–44 | Hot weather | 15 | 32·93 | Co. 281 | 0 | 17·00 | There is response to increased dose of Nitrogen. Exception in O-N; the differences are not significant. | Cyclone in Summer of 1943. South-West Monsoon started early in July, but drought again continued upto August. |
| | South-West Monsoon | 23 | 15·97 | | 100 | 37·45 | | |
| | North-East Monsoon | 40 | 28·85 | ,, | 150 | 34·60 | | |
| | | | | | 200 | | | |
| | | 78 | 77·75 | | 250 | | | |
| 1944–46 | Hot weather | 18 | 9·48 | ,, | 0 | 22·4 | The increase in yield is not marked. | Summer showers in June. Continued drought till end of August. |
| | South-West Monsoon | 17 | 8·69 | | 100 | 21·95 | | |
| | North-East Monsoon | 41 | 38·32 | | 150 | 31·5 | | |
| | | | | | 200 | 31·8 | | |
| | | 76 | 56·49 | | 250 | | | |

APPENDIX II—(*Continued*).

| Station | Year | Season | Rainy days | Rainfall in inches | Variety. | Dose of Nitrogen lb/acre | Yield/ acre | Response to manure | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | 1945–47 | Hot weather | 6 | 3·84 | | 0 | 12·0 | There is increase in yield with higher dose of Nitrogen. Average yields are low, even with higher dose of Nitrogen. | Drought in Summer. South-West Monsoon low but well distributed. Drought again in North-East Monsoon period from November. |
| | | South-West Monsoon | 17 | 8·41 | | 100 | 19·0 | | |
| | | North-East Monsoon | 16 | 23·23 | | 150 | 22·1 | | |
| | | | | | | 200 | 25·7 | | |
| | | | | | | 250 | 26·7 | | |
| | | | 39 | 35·48 | | | | | |
| | 1946–47 | Hot weather | 9 | 4·07 | ,, | 0 | 21·40 | There is response to manuring upto 150 Nitrogen. Beyond this dose, no significant increase in yield. | Rainfall in summer was fair. Rainfall in South-West Monsoon was good and well distributed. Flood in North-East Monsoon. |
| | | South-West Monsoon | 30 | 16·29 | ,, | 100 | 29·50 | | |
| | | North-East Monsoon | 60 | 67·85 | ,, | 150 | 34·90 | | |
| | | | | | | 200 | 37·60 | | |
| | | | | | | 250 | 38·70 | | |
| Gudiyattam | 1945–46 | Hot weather | 8 | 2·77 | Co. 419 | 0 | 24·77 | O.N. and 50 N significantly inferior. 100 N to 250 N under one bar. | Rainfall in South West Monsoon was not well distributed. It fell mostly in August. |
| | | South-West Monsoon | 23 | 15·74 | | 50 | 30·75 | | |
| | | North-East Monsoon | 21 | 7·95 | | 100 | 45·09 | | |
| | | | | | | 150 | 43·86 | | |
| | | | | | | 200 | 50·30 | | |
| | | | | | | 250 | 49·77 | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1946–47 | Hot weather | 8 | 5·54 | | 0 | 20 38 | Yields under 200 N ann 250 N under one bar. O.N. to 200 N significantly different. | Good showers in April May of hot weather. South-West Monsoon well distributed though not heavy. |
| | South-West Monsoon | 35 | 12·87 | | 50 | 32·67 | | |
| | North-East Monsoon | 51 | 30 93 | | 100 | 42·78 | | |
| | | 94 | 49·34 | | 150 | 48·99 | | |
| | | | | | 200 | 54·78 | | |
| | | | | | 250 | 57·11 | | |
| 1947–48 | Hot weather | ·9 | 2·77 | ,, | 0 | 15·23 | Yield under O N, 50N and 100 N significantly different. 150 N and 200 N under one bar. 200 N and 250 N. | Total rainfall was below normal and season adverse. South-West Monsoon fair in distributed but North-East Monsoon was disappointing. |
| | South-West Monsoon | 23 | 11·45 | | 50 | 21·24 | | |
| | North-East Monsoon | 17 | 8 14 | | 100 | 30·61 | | |
| | | 49 | 22·36 | | 150 | 38·28 | | |
| | | | | | 200 | 38·69 | | |
| | | | | | 250 | 41·81 | | |

# The Role of Organic Manures and Inorganic Fertilisers in Soil Fertility

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In old-time agriculture the only method of increasing soil fertility and crop yields was by stirring the soil with manual labour, to produce a pulverised condition of the soil. It was observed by experience that a similar increase in crop yield could be obtained by the application of cattle dung. Cattle manure was the earliest ingredient known to increase the productive capacity of soil. Subsequently other plant and animal materials were known to have a similar property. During the earlier period when the science of plant nutrition had not developed so much as now, the function of manures was considered to be merely supplying humus, which could be taken up by the plants directly for their growth. This humus theory of plant nutrition held the field for a long time and retarded the progress in the fields of both plant physiology and agriculture. It was by the work of Liebig in Germany, his contemporaries Boussingault in France and Lawes in England, that the humus theory of plant nutrition was replaced by the "mineral" theory. These epoch-making discoveries laid the foundation of agricultural science in general and agricultural chemistry in particular. Liebig stated that plants could take up nutrients in mineral and soluble form. Insoluble substances should be converted into a soluble form to be assimilable by plants. An artificial manure known as Liebig's patent manure was prepared by him and put in the market. This manure failed, because it contained only alkalies (potassium) phosphates and sulphates There was no nitrogen in it, because Liebig considered that it was not needed, as he thought that plants cauld assimilate nitrogen in the form of ammonia from the atmosphere through the leaves. Lawes, on testing the recommendations of Liebig found them to be erroneous. The mineral theory was in turn criticised by others. There was nothing wrong with the theory, but there were two pitfalls: i. e., (i) omission of nitrogen and (ii) conversion of soluble potash and phosphorus compounds into an insoluble state by fusion with lime to prevent them from being leached out with drainage water.

Lawes, the founder of the world-famous agricultural research institute at Rothamsted, in England, started the preparation of superphosphate as a cottage industry by the addition of sulphuric acid to rock phosphate. This process was patented and subsequently developed into a large-scale industry all over the world. Other fertilisers, supplying nitrogen and potash were soon manufactured and put in the market. All the inorganic nutrients prepared commonly are known as fertilizers. They are generally inorganic compounds containing large proportions of plant nutrients in a water-soluble state. Manures on other hand are naturally occurring substances containing a low percentage of plant nutrients mostly in organic forms insoluble in water. Thus it can be seen that the inorganic fertilizers and organic manures are more or less opposite in their characteristics. This leads people to think that they are antagonistic and act in an opposing manner in crop production and on the fertility of soil. The present controversy of organic manures versus inorganic fertilisers is due to this wrong notion.

Some think that fertilisers, though they contain plant nutrients in readily available and concentrated form, spoil the land and make it unproductive for a long time to come. They, therefore advocate the use of only organic manures. In the absence of manure they prefer to leave the land unmanured. This is a most suicidal policy to adopt when the fertility of our soils is low and the supply of indigenous manures is inadequate to satisfy our needs. We are not using much of inorganic fertilisers in India, as revealed by the statistics for 1949—'50.

The following table illustrates this fact:

| | Total area (million acres) | Area under crops (million acres) | Total fertilisers imported (tons) | Quantity used per area | |
|---|---|---|---|---|---|
| | | | | Total area basis (lb.) | Cultivable area basis (lb.) |
| India | 581 | 81 | 145,490 | 0·56 | 0·89 |
| Madras State | 81 | 35* | 76,102 | 2.1 | 4·87 |

* including double - cropped area.

The fertilisers are not used for all lands and for all crops. The commercial crop receive the best attention. Madras leads other States in the use of fertilisers in India.

There are several difficulties in importing more fertilisers into India, chief among which are (1) internal consumption in U. S. A. and Canada; (2) scarcity of foreign exchange resources in India. The annual production of ammonium sulphate in India is only 50 to 60 thousand tons. The Sindri factory in Bihar is expected to produce 3·5 lakhs of tons of this fertiliser from 1951, against an annual requirement of 4 to 5 lakhs of tons.

The following table gives the manure problem of our State:

| | Removed by crops tons | Supplied as organic manures (tons*) | Deficit (tons) | % total removed |
|---|---|---|---|---|
| Nitrogen | 887,000 | 280,000 | 607,000 | 68 |
| Phosphoric acid | 372,000 | 170,000 | 201,000 | 54 |
| Potash | 894,000 | 252,000 | 642,000 | 72 |

* As farmyard manure, compost, oil - cakes, bone meal, fish manure, fish guano and wood ash available in the State.

This deficit should be met by the application of green manures composts and chemical fertilisers. Besides these principal plant nutrients, the food for soil organisms is also to be considered seriously for replenishment. Unless we utilise every possible source to build up our rapidly declining soil fertility and equally rapidly increasing population, we will not be able to solve the national food problem.

Without going into the theoretical aspects of the function of organic manures and inorganic fertilisers, the experimental evidence on their manurial value and their effect on pH value and microbiological activity are given below :

**Permanent manurial experiments, Coimbatore. (Old Permanent Manurial Experiment) :—**

This experiment was started in 1909. Eightyone crops were taken so far, upto 1950. The major nutrients nitrogen, phosphoric acid and potash were applied singly and in combinations containing 60 lb. of N, 38 lb. of $P_2O_5$ and 90 lb. of $K_2O$. Cattle manure at the rate of 5 tons per acre was also included as one of the treatments. The field was originally irrigated till September 1937 and it was left fallow till November 1939 and thereafter treated as rainfed. The following amounts of chemical fertilisers were added :

| | Quantity applied per acre. | lb. of ingredient supplied per acre. |
|---|---|---|
| Ammonium sulphate | 1 cwt. | 22·4 lb. (N) |
| Superphosphate | 3 ,, | 64·8 ,, $P_2O_5$ |
| Potassium sulphate | 1 ,, | 54·0 ,, $K_2O$ |

The average yields of grain of each variety of crop grown are given in Table I.

The data presented above show that when the total yields of all the crops is taken into account the following is the descending order of treatments in their response :

N plus P plus K ; N plus P, Cattle manure ; K plus P, P, K, N plus K, N, No manure.

There is not much response for potash, either alone are in combination. It may be noted in this connection that the ingredients were not added on equal basis. For instances, cattle manure contains nearly 2½ times the amount of nitrogen added in the form of ammonium sulphate, only half of the phosphoric acid added in the form of superphosphate and about twice the amount of potash. Thus except for phosphoric acid, cattle manure contained double the dose of the artificials added. Yet it did not show its superiority to the inorganic fertilisers. The effect of these fertilisers on the biological population and activity is presented in Table II and III.

The results indicate that moisture is the chief factor in increasing the microbiological population of a soil by manuring. With sufficient amounts of moisture available, cattle manure nearly trebled the microbiological population of the soil. The N + P + K treatment was intermediate between the no manure and cattle manure treatments. The microbiological population and activity increased most with the application of cattle manure. Next in rank was N + P + K. Even under rainfed conditions with failure of monsoons, the complete inorganic fertiliser did not depress the biological population and activity of the soil, compared with no manure plot.

The same experiment was repeated under gardenland conditions in duplicate from the year 1925 and continued up to date. Forty crops were grown so far. One set of plots was found to be giving lower yields than others. It received therefore, a basal dressing of 2,000 lb. of cattle manure per acre since 1931. The average results of crop yields with and without basal dressing are given in table IV.

The following is the descending order of response of each treatment :

| Rank | Without basal dressing of cattle manure | With basal dressing of cattle manure |
|---|---|---|
| 1. | Cattle manure | ... |
| 2. | N + P + K | N + P + K |
| 3. | N + P | N + P |
| 4. | P | P |
| 5. | K + P | K + P |
| 6. | N + K | K |
| 7. | No manure | N + K |
| 8. | N | N |
| 9. | K | Basal dressing alone |

Under irrigated conditions, cattle manure responded best. The complete inorganic fertiliser closely followed cattle manure. As in the previous experiment under rainfed conditions, phosphate was the best single plant nutrient that increased the crop yield very markedly. There was little response to potash application either alone or in combinations. The application of a basal dressing of 2,000 lb. of cattle manure containing 12 lb. N, 7·5 lb. $P_2O_5$ 18 lb. $K_2O$, to all except C. M. and C. M. residual per acre increased the response of inorganic fertilisers in a field of low fertility. The dosage of nitrogen in both the experiments is very low.

The analysis of soil of the permanent manurial plots (both old and new) is given in Table V.

There was a definite increase in the soil of the ingredient added as a manure, especially the available form. The percentage of nitrogen and potash were doubled in the cattle manure treatment in the old permanent manurial plots. This was due to the large supply of these ingredients as mentioned before.

There was a marked loss in total lime in the cattle manure treatment. The organic matter seems to be responsible for this mobilisation of lime and consequent loss due to leaching. There is a fall in pH from 7·9 to 7·5 in the N + P treatment. This was also noted in cattle manure treatment and the fall cannot be attributed to the evil effect of inorganic fertilisers. A loss in total calcium was also observed in the new permanent manurial plots in the cattle manure treatment. There was no fall in the pH value due to any manurial treatment in these plots. These results definitly disprove the impression many people have that inorganic fertilisers render the soil acidic and unproductive if used alone continuously for a long time. Forty-two years of experimental evidence is certainly a definite proof against such ill-founded impressions. It is true the microbiological population and activity were not as high in the N + P + K treatment as in the case of cattle manure treatment, but nevertheless, the values were far higher than those in the no manure plot. In no case did the N + P + K treatment depress either the microbial population or their activity.

Experiments were conducted from 1929—'26 to 1932—'33 in the Central Farm, Coimbatore to find out the effect of application of Chilean nitrate (sodium nitrate) alone and in combination with organic nitrogen on paddy. The total dosage of nitrogen applied was 50 lb. per acre. Daincha and cattle manure formed the source of organic nitrogen. The results indicate that Chilean nitrate in combination with cattle manure in a ratio of 3 : 2 gave the best results. The wetlands never became unproductive by the use of Chilean nitrate.

A report from the Tocklai Experiment Station of the Indian Tea Association 1949, (2) show that Chilean nitrate when applied to sandy well-drained soils initially produced increased yields but spoiled the tilth on continuous application for a number of years. This can be corrected by applying 3 parts of ammonium sulphate to 2 parts of sodium nitrate. On heavy soils sodium nitrate produced harmful effects in the year of application itself. Ammonium sulphate was found to give twice the yield given by oil-cakes.

Another experiment was conducted at the Central Farm, Coimbatore to determine the manurial value of calcium cyanamide at the rate of 2 cwts. per acre, alone and in combination with 1½ cwts. of superphosphate. The calcium cyanamide in combination with superphosphate gave better results than the others.

An experiment to find out the effect of ammonium phosphate on paddy as compared with that of ammonium sulphate at 50 lb. of N. level was conducted on the Central Farm, Coimbatore, for two years from 1924. Only ammonium sulphate gave conclusive results.

A field trial on the dose of ammonium sulphate required for paddy alone and in combination with superphosphate, started in 1925—'26 and continued up to 1928—'29 proved that 2 cwts. of ammonium sulphate in combination with 1½ cwts. of super gave the best results consistently.

The results obtained so far establish the superiority of ammonium sulphate to the other forms of inorganic nitrogenous fertilisers commonly used in our State. Niciphos II was also found to be good. Among phosphates, superphosphate was found to be the best for ordinary soils, though their response is poor.

Potassium sulphate was found to be better than muriate of potash.

Though some workers claim that produce obtain by the application of organic manures like cattle manure have higher biological value in proteins and are richer in vitamin content, there is no conclusive evidence in support of this claim.

**Total production of cattle manure**

| | | 1940 | 1945 |
|---|---|---|---|
| *Bovine population (millions):* | | | |
| Adult cattle ... | ... | 97 | 99 |
| Adult buffaloes ... | ... | 25 | 26 |
| Young stock ... | ... | 55 | 52 |
| *Estimated daily production of manure (in lb.):* | | | |
| Per adult cattle ... | ... | 40 | 40 |
| Per adult buffaloes ... | ... | 50 | 50 |
| Per young stock ... | ... | 20 | 20 |
| *Total production of raw manure (Million tons per annum):* | | | |
| Adult cattle ... | ... | 632 | 645 |
| Adult buffaloes ... | ... | 204 | 212 |
| Young stock ... | ... | 179 | 169 |
| Total | ... | 1,015 | 1,026 |
| *Estimated proportion used as fuel* | ... | 66·6% | 66·6% |
| *Balance available as raw manure (Million tons per annum)* | ... | 339·0 | 342·7 |

*(Agricultural Situation, India, April, 1950)*

From the results of our manurial experiments we find that we have to supply a normal dose of 30 lb. of nitrogen and 30 lb. of prosphoric acid per acre over a basal dressing of 2 tons of green leaf or cattle manure for our paddy crop alone. At this rate, we require the following quantities of manures and fertilizers to manure 11 million acres of paddy area :

| | | |
|---|---|---|
| Ammonium sulphate ... | 733,000 | tons |
| Superphosphate ... | 923,000 | ,, |
| Green leaf manure or cattle manure ... | 22,000,000 | ,, |

The available stock of fertilizers are only 59,952 tons of ammonium sulphate and 16,210 tons of super phosphate and assuming that the whole quantity is used only for paddy crop we have a deficit of

| | | | |
|---|---|---|---|
| Ammonium sulphate | ... | roughly | 673,000 tons |
| Superphosphate | ... | ,, | 907,000 ,, |

We have no data to show the availability of cattle manure in our State. If we assume that all the dung is fully utilised as manure and the urine carefully preserved, we can expect about $2\frac{1}{2}$ tons of manure per head of cattle per annum. This works out to 56·5 million tons of cattle manure for the State per annum and it supplies 418,100 tons of nitrogen per acre, when the average percentages of a good manure is taken as 0·75% nitrogen This is never realised in actual practice as nearly $\frac{2}{3}$ of the dung is utilised as fuel and most of urine runs to waste. It is the urine which is the most important source of nitrogen in a readily available form. Thus the superiority of sheep or cattle penning is attributed to the urine added to the soil. The following table gives the quantity of dung and urine voided by 22·6 million heads of cattle per annum on the presumption that 1/3 of our cattle population are young calves and left out of account. Our data at Coimbatore show that adult cattle void daily 35 lb. of dung and 25 lb. of urine per head.

| | Quantity mil. tons | % Nitrogen | Total nitrogen tons | $P_2O_5$ | Total tons |
|---|---|---|---|---|---|
| Dung | 78·54 | 0·33 | 259,182 | 0·10 | 78,540 |
| Urine | 33·79 | 0·60 | 202,740 | 0·02 | 6,758 |
| Total | 102·33 | | 461,922 | | 85,298 |

During decomposition and dryage half the quantity of dung and urine will be lost. It can be seen from the data, that the amount of phosphoric present is only about 1/5 of the total nitrogen present. Cattle manure is thus an ill-balanced manure, and is deficient in phosphates. If cattle manure is used as a source of nitrogen, phosphatic fertilizers have to be added to supply all the necessary plant nutrients. The condition of manure pits in villages is very deplorable. They are exposed to sun and rain and water accumulates during the rainy season. The surface gets so dry that the top surface remains unfermented. The litter also remains in a raw state. It is a very common feature to find as low a value as 0·3% nitrogen in most samples of village cattle manure. The urine is also lost. If we can preserve this source of manure, which is a by-product of agricultural industry it can go a long way towards meeting our manurial deficiency. As it stands at present, the quantity available is so small that the ryot applies cattle manure to his commercial crops and nurseries every year and to some important dry lands only once in 3 or 4 years, at 10 cartloads per acre. The data available from the permanent manurial experiments at Coimbatore and green manure experiments at Anakapalle show that a basal dressing of about 1 ton green manure or cattle manure cannot satisfy the organic matter demand of our soils. Let us take necessary steps to improve the preservation of cattle manure.

Another important source of organic matter is compost. The present drive for compost making has enabled us to conserve a portion of nightsoil from urban areas which used to be wasted hitherto. We have not succeeded much as yet. Only 44,441 tons of compost was made last year in this State. The bulk of population on our country live only in rural areas and the utilisation of nightsoil in rural areas for compost making is not possible for want of conservancy service. The prejudice of the local population and social stigma attached to the handling of nightsoil is another major handicap. From the present population of 54·8 millions, we may expect roughly four million tons of nightsoil per annum available for compost making. It is well known to every student of agriculture that the high fertility of the lands in the Far East is due to the systematic use of nightsoil as a manure. The manurial value of compost prepared from nightsoil with municipal rubbish, and farm waste compost with cattle dung were compared with cattle manure alone on equal nitrogen basis, on selected Agricultural Research Stations of the State, during the years 1949 – '50 and 1950 – '51. The results of these experiments are given in tables VII, VII(a) and VII(b).

In some Stations both nightsoil and farm waste composts gave significantly higher yields than no manure.

In other cases, though increased yields were obtained by the applications of compost over no manure plots, the data were not significant.

In a few cases, compost proved superior to farmyard manure.

Oil cakes which are intermediate in action between fertilizers and manures are very valuable as sources of food to higher plant and bacteria, but they are available only to a limited extent. In the year 1949—'50, 135, 185 tons of groundnut cake was produced. The edible cakes serve as an excellent feed for cattle. In 1948—'49, 29,627 tons of groundnut seeds have been exported from this State which is detrimental to the interests of the State as the cake would have been useful as cattle feed or manure. All the cakes are almost equal in their manurial value on equal nitrogen basis.

Even if ideal methods of preserving all the sources of manures mentioned above are adopted, our manurial needs cannot be met unless we tap the unlimited source, namely, green manures and green leaf manures. Of course, there are limiting factors such as moisture, cattle trespass etc., but these obstacles have to be overcome.

Green leaf available from uncropped lands can best be utilised as manures. Their decomposability is in the following descending order:

Calotropis,
Gliricidia
Pungam
Cassia
Croton sparsiflorus
Delonix
Poovarasu
Datura
Sesbanea speciosa

The results of experiments conducted at the Paddy Breeding Station, Coimbatore show that daincha, wild indigo and Sesbanea speciosa when applied on equal nitrogen basis, have the same effect on paddy (Table VIII.)

Under ideal conditions about 20,000 lb. of green manure can be produced per acre and 75 to 130 lb. of nitrogen can be fixed from the atmosphere. This will be equivalent to $3\frac{1}{2}$ to $5\frac{3}{4}$ cwts. of ammonium sulphate. Experiments at Coimbatore have shown that the following is the descending order of merit of the common green manures grown in this State: Daincha, pillipesara, sunnhemp and cowpea. The yield of paddy grain can be increased from 30 to 100% by the application of green manures. The availability of nitrogen contained in green manures like pillipesara is equivalent to $\frac{2}{3}$ of that of the ammonium sulphate. We can utilise inorganic fertilizers for building up soil humus, if superphosphate is applied to the preceding leguminous green manure crop at the time of sowing. This practice increases the amount of green matter production and nitrogen fixation from the atmosphere and ultimately solves both the problems of soil humus and nitrogen.

There are certain manures like tank silt, earth from old village sites which are used as manures successfully. The amounts available are however, dwindling. Experiments were started in the Central Farm, in 1908—'09 to 1914—15 to find out a suitable manure mixture to replace *Pattimannu*. Nitrogen, phosphoric acid and potash were applied singly and in combination and in double doses. Nitrogen as supplied as 3,000 lb. of sunnhemp; Phosphoric acid as superphosphate 1 and 2 cwts. per acre; Potash as potassium sulphate 1 and 2 cwts. per acre.

The following conclusions were obtained:

Bulky organic nitrogenous manures such as green leaf was found to be quite necessary;

Phosphatic manures when used to supplement the bulky organic manures, slightly improved yields;

No increase in yields was obtained by the application of potassic manures.

At the present market rates, the following is the cost of 1 lb. of nitrogen from the following sources:

| | Rs. | A. | P. |
|---|---|---|---|
| Groundnut cake | 1 | 12 | 9 |
| Ammonium sulphate | 0 | 13 | 6 |
| Chilean nitrate | 0 | 13 | 5 |
| Ammophos | 0 | 13 | 6 |
| Green manure | 0 | 8 | 0 |
| Cattle manure | 0 | 12 | 10 |

The following table gives an idea of manurial values of different fertilizers and manures on paddy crop at different levels (Mitra and Gupta.)

| Manures and Fertilisers | Level lb. of N per acre | Extra yield per lb. of N. applied |
|---|---|---|
| Ammonium sulphate (20% N) | 30 | 11·4 |
| | 60 | 11·4 |
| Niciphos II (contains 17·3% N and 17·4% $P_2O_5$) | 25 | 16·6 |
| | 30 | 13·0 |
| Oil-cakes (groundnut, neem or castor) | 20 | 8·9 |
| | 40 | 7·2 |
| | 60 | 6·0 |
| Farmyard manure | 25 | 6·0 |
| | 50 | 6·7 |
| Green manure | 50 | 21·0 |
| Town compost | 50 | 5·3 |
| | 100 | 5·0 |
| | 150 | 4·0 |
| Mixed Manuring ; Niciphos + Farmyard manure | 25 | 3·8 |
| | 50 | 11·0 |

The largest increase in the yield of paddy was obtained when green manures were used as a source of nitrogen. Next in rank was Niciphos followed by ammonium sulphate, oil cakes, farmyard manure and lastly compost.

It can be seen from the above that the green manures are not only the cheapest but also the most effective in increasing crop yields. Next in rank is ammonium sulphate and no indication was obtained on the deleterious effect of the latter on soil fertility. A combination of green manure and ammonium sulphate and superphosphate or an application of Niciphos in conjunction with green manure would give the best results on paddy.

## REFERENCES:

1 The Agricultural Situation, April, 1950.

2. Indian Tea Association—Tocklai Exp. St. Rept., Soils and Fertilisers XIV (1951): 11.

3. Madras Agri. Sta. Report, 1943—'44, 1944—'45, 1945—'46—526 to 529.

4. Mitra, A. K. and Gupta, P S. 1950—Paddy Manuring and its economics in Uttar Pradesh, Indian Farming, July, 1950, Vol. 11, Page 295—297.

5. Norris, R V.—Note on the permanent manurial plots, Coimbatore, Memoirs of the Department of Agriculture in India, Chemical Series, Volume VI.

6. Season and Crop Report of the Madras State 1948—'49, Government Press, 1950.

7. Sundaram, R. M. (1951)—Land Utilisation Problem and their solution in Madras State—Government Press, Madras, 1951.

TABLE I.

**Showing the average yield of crops in Old Permanent Manurial Plots (O. P. M.)**

| | Name of the crops | Number of crops | No. M | N | N+K | N+P | N+K+P | K+P | K | P | C. M. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Average yield in lb. grain per acre) | | | | | | | | |
| (1) | Ragi | 15 crops (1910–51) | 474 | 552 | 601 | 1500 | 1546 | 1314 | 733 | 907 | 1331 |
| | % on control | | 100 | 116 | 127 | 316 | 326 | 277 | 154 | 191 | 281 |
| (2) | Cholam | 15 crops (1910–51) | 716 | 790 | 820 | 1886 | 1877 | 1617 | 855 | 1069 | 1980 |
| | % on control | | 100 | 110 | 115 | 263 | 262 | 226 | 119 | 149 | 277 |
| (3) | Wheat | 6 crops (1910–51) | 372 | 514 | 536 | 908 | 1021 | 769 | 514 | 564 | 806 |
| | % on control | | 100 | 138 | 144 | 244 | 274 | 207 | 138 | 152 | 217 |
| (4) | Panivaragu | 7 crops (1910–51) | 861 | 671 | 596 | 1119 | 1023 | 980 | 682 | 927 | 1070 |
| | % on control | | 100 | 78 | 69 | 130 | 119 | 114 | 79 | 108 | 124 |
| (5) | Cumbu | 3 crops (1910-51) | 140 | 185 | 221 | 319 | 311 | 211 | 168 | 146 | 271 |
| | % on control | | 100 | 132 | 158 | 228 | 222 | 150 | 120 | 104 | 194 |
| | | Total of yield for all crops: | 2563 | 2712 | 2774 | 5732 | 5778 | 4891 | 2952 | 3613 | 5458 |
| | | For single crops: | 513 | 542 | 555 | 1146 | 1156 | 978 | 590 | 723 | 1092 |

TABLE II.

**Showing the microbiological population of permanent manurial plots (under irrigated conditions) (N. P. M.)**

| Year | Bacteria | | | Fungi | | |
|---|---|---|---|---|---|---|
| | No manure | NPK | CM | No manure | NPK | CM |
| May 1927 to January 1928 (Average) | 1,259,000 | 2,093,000 | 3,205,000 | 2,000 | 5,000 | 6,000 |

## TABLE III.

**Showing the microbiological population and activity under rainfed conditions (O. P. M.)**

| Year | Population: No manure | Population: N+P+K | Population: C.M. | Activity: No manure, With dextrose | Activity: No manure, Without dextrose | Activity: N+P+K, With dextrose | Activity: N+P+K, Without dextrose | Activity: C. M., With dextrose | Activity: C. M., Without dextrose |
|---|---|---|---|---|---|---|---|---|---|
| 1947–48 | 11,40,000 | 11,70,000 | 32,05,000 | 12·84 | 4·60 | 14·90 | 10·83 | 29·18 | 14·01 |
| 1948–49 | 4,20,000 | 6,50,000 | 6,40,000 | 16·15 | 7·82 | 27·19 | 15·33 | 15·93 | 15·14 |
| 1949–50 | 3,59,300 | 7,81,600 | 9,64,700 | | | | | | |
| 1950–51 | 15,09,000 | 14,98,000 | 19,27,000 | 10 472 | 6·644 | 24·024 | 16·786 | 15·884 | 16·192 |

## TABLE IV.

**Showing the average yield of crops in permanent manurial plots under irrigated conditions (N. P. M.)**

| Treatments | RAGI: No basal dressing (Av. 13 crops) (a) | (b) | RAGI: Basal Dressing 2,000 lb. FYM (Av. 9 crops) (a) | (b) | RAGI: Difference on controldue to basal dressing (%) | CHOLAM: No basal dressing (Av. 11 crops) (a) | (b) | CHOLAM: Basal Dressing 2,000 lb. FYM (Av. 6 crops) (a) | (b) | CHOLAM: Difference on control due to basal dressing (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| No manure (Control) | 1141 | 100 | 952 | 100 | — 16 | 1596 | 100 | 1227 | 100 | — 23 |
| N | 1073 | 94 | 1022 | 107 | — 4 | 1600 | 100 | 1462 | 119 | — 9 |
| N+K | 1173 | 103 | 1051 | 110 | — 10 | 1665 | 104 | 1517 | 124 | — 9 |
| N+P | 1807 | 158 | 1631 | 171 | — 8 | 2093 | 131 | 2053 | 167 | — 2 |
| N+K+P | 1842 | 161 | 1754 | 184 | — 5 | 2196 | 138 | 2029 | 165 | — 8 |
| K+P | 1661 | 146 | 1532 | 161 | — 8 | 1945 | 122 | 1678 | 137 | — 18 |
| K | 1116 | 98 | 1372 | 144 | — 23 | 1651 | 103 | 1588 | 129 | — 4 |
| P | 1677 | 147 | 1685 | 166 | — 5 | 1983 | 124 | 1805 | 147 | — 9 |

(a) Yield of grain per lb. per acre

(b) % on control

Cattle manure — Ragi Average yield per acre (22 crops) 1827 lb.
Cholam do. (17 crops) 2108 lb.

**TABLE IV.**—*(Contd.)*

| Treatments Control | Wheat: No basal dressing (Av. 5 crops) (a) | (b) | Wheat: Basal dressing 2,000 lbs. FYM per acre (Av. 3 crops) (a) | (b) | Difference on control due to basal dressing (%) | Panivaragu: No basal dressing (Av. 3 crops) (a) | (b) | Panivaragu: Basal dressing 2,000 lbs. FYM per acre (Av. 3 crops) (a) | (b) | Differences on cotrol due to basal dressing (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| No manure (control) | 752 | 100 | 805 | 100 | 7 | 797 | 100 | 354 | 100 | — 55 |
| N | 724 | 96 | 860 | 107 | 19 | 754 | 95 | 496 | 140 | — 31 |
| N plus K | 815 | 108 | 871 | 108 | 7 | 791 | 99 | 505 | 143 | — 36 |
| N plus P | 971 | 129 | 899 | 110 | —7 | 859 | 108 | 480 | 136 | — 44 |
| N+K+P | 920 | 122 | 758 | 94 | —18 | 857 | 108 | 541 | 153 | — 41 |
| K plus P | 737 | 98 | 727 | 90 | —1 | 717 | 90 | 532 | 150 | — 37 |
| K | 588 | 78 | 680 | 85 | —16 | 696 | 87 | 476 | 134 | — 32 |
| P | 820 | 109 | 662 | 83 | —19 | 722 | 92 | 563 | 159 | — 22 |

Cattle manure Wheat: Grain: Average yield per acre 8 crops—849 lb.
Panivaraghu: do. 13 crops—731 lb.

(a) Yield of grain in lb. per acre.
(b) % on control.

N. P. M.: CUMBU

| Treatments | No basal dressing (Av. 4 crops) Yield of grain in lb/acre | % on control | Basal dressing 2,000 lb. F. Y. M. per acre (Av. 3 crops) Yield of grain in lb/acre | % on control | Difference on control due to basal dressing % |
|---|---|---|---|---|---|
| No manure (control) | 872 | 100 | 713 | 100 | — 18 |
| N | 805 | 92 | 908 | 127 | — 11 |
| N plus K | 904 | 104 | 864 | 111 | — 4 |
| N plus P | 1216 | 139 | 916 | 128 | — 25 |
| N plus K plus P | 1321 | 151 | 1209 | 170 | — 9 |
| K plus P | 1149 | 131 | 1022 | 143 | — 11 |
| K | 875 | 100 | 907 | 127 | — 4 |
| P | 1331 | 153 | 998 | 140 | — 25 |

Cattle manure: Cumbu grain yield per acre (7 crops) 1266 lb.

## TABLE V.

**Showing the analysis of soil from permanent manurial plots.**

| Treatments | O. P. M. Lime | O. P. M. Nitrogen | O. P. M. Total $P_5O_2$ | O. P. M. Avail. $P_2O_5$ | O. P. M. Total $K_2O$ | O. P. M. Avail $K_2O$ | O. P. M. pH | N. P. M. Lime | N. P. M. Nitrogen | N. P. M. Total $P_2O_5$ | N. P. M. Avail $P_2O_5$ | N. P. M. Total $K_2O$ | N. P. M. Avail $K_2O$ | N. P. M. pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. No manure | 1·14 | 0·0295 | 0·032 | 0·0088 | 0·275 | 0·0198 | 7·9 | 1·975 | 0·060 | 0·083 | 0·0253 | 0·623 | 0·0269 | 8·1 |
| 2. N | 1·33 | 0·0358 | 0·035 | 0·0099 | 0·303 | 0·0211 | 7·7 | 1·937 | 0·061 | 0·088 | 0·0255 | 0·666 | 0·0295 | 8·2 |
| 3. N plus K | 1·21 | 0·0371 | 0·032 | 0·0096 | 0·331 | 0·0288 | 7·6 | 1·947 | 0·061 | 0·085 | 0·0238 | 0·636 | 0·0360 | 8·2 |
| 4. N plus P | 1·17 | 0·0414 | 0·078 | 0·0544 | 0·286 | 0·0180 | 7·5 | 1·886 | 0·064 | 0·101 | 0·0378 | 0·618 | 0·0271 | 8·1 |
| 5. N+K+P | 1·01 | 0·0367 | 0·109 | 0·0548 | 0·430 | 0·0265 | 7·6 | 1·843 | 0·062 | 0·094 | 0·0357 | 0·611 | 0·0275 | 8·2 |
| 6. K plus P | 0·89 | 0·0349 | 0·098 | 0·0614 | 0·461 | 0·0252 | 7·7 | 1·920 | 0·061 | 0·098 | 0·0367 | 0·613 | 0·0316 | 8·2 |
| 7. K | 0·95 | 0·0343 | 0·037 | 0·0152 | 0·458 | 0·0264 | 7·8 | 1·832 | 0·064 | 0·089 | 0·0277 | 0·596 | 0·0308 | 8·2 |
| 8. P | 0·99 | 0·0316 | 0·088 | 0·0612 | 0·358 | 0·0150 | 7·6 | 1·795 | 0·087 | 0·094 | 0·0340 | 0·578 | 0·0273 | 8·3 |
| 9. C. M. | 0·86 | 0·0437 | 0·035 | 0·0119 | 0·640 | 0·0348 | 7·6 | 1·730 | 0·100 | 0·088 | 0·0290 | 0·568 | 0·0315 | 8·2 |

## TABLE VI.

Showing the comparative manurial value of ammonium sulphate and groundnut cake at various doses of nitrogen on cotton crop and its residual effect on Sorghum at the Agricultural Research Station, Nandyal.

COTTON N. 14.

| Year | No manure | Ammonium sulphate 20 lb. N. | Ammonium sulphate 40 lb. N. | Ammonium sulphate 60 lb. N. | Groundnut cake 20 lb. N. | Groundnut cake 40 lb. N. | Groundnut cake 60 lb. N. | Significance C. D. |
|---|---|---|---|---|---|---|---|---|
| 1943—44 | 292 lb. | 320 | 337 | 339 | 327 | 326 | ... | 67 |
| 1944—45 | 166 ,, | 165 | 175 | 151 | 166 | 171 | 178 | Not significant |
| 1945—46 | 156 ,, | 158 | 160 | 161 | 151 | 184 | 154 | ,, |

JONNA GRAIN.

| Year | Treatments : 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1944—45 | 856 | 841 | 875 | 839 | 916 | 951 | 1013 |
| 1945—46 | 550 | 543 | 651 | 711 | 649 | 664 | 800 |

## TABLE VII

**Showing the results of experiments where compost gave significantly increased yields.**

### A. NIGHTSOIL COMPOST

**Tirurkuppam :**

| | No manure (1) | Compost (2) | F.Y.M. (3) |
|---|---|---|---|
| 1949—50 : Paddy Co, 19 | | | |
| Acre yield of grain in lb. | 1509 | 2285 | 1853 |
| Percentage on control | 100 | 151·5 | 122·9 |
| Conclusion : 2,3,1 | | | |
| 1950-51 : Paddy Co. 19, Single crop area : | | | |
| Acre yield of grain in lb. | 1284 | 1407 | 1588 |
| Percentage on control | 100 | 109·7 | 123·7 |
| Conclusion : 3, 2, 1 | | | |
| Paddy Co. 2, Double crop area : | | | |
| Acre yield of grain in lb. | 984 | 1037 | 1134 |
| Percentage on control | 100 | 105·4 | 115·3 |
| Conclusion : 3, 2, 1 | | | |

**(Lam : Guntur)** Chillies Crop (G-1)

1950-51

Dosage of manure is the amount to supply 120 lb. N. per acre.

| | No manure A | Farmyard Manure B | Compost. C |
|---|---|---|---|
| Acre yield of chillies in lb. | 574 | 787 | 1122 |
| Percentage on control | 100 | 137 | 195 |
| Conclusion : C, B, A | | | |

**Anakapalle : (Sugarcane Co. 419)**

1950-51

| | No manure A | Compost B | Farmyard manure C |
|---|---|---|---|
| Acre yield of sugarcane in tons | 41·0 | 53·1 | 52·8 |
| Percentage on control | 100 | 129·6 | 128·7 |
| Conclusion : B,C, A | | | |

### B. FARM WASTE COMPOST

**Palur : Sugarcane Co. 449 (1949-50)**

| | No manure A | Cattle manure B | Compost C |
|---|---|---|---|
| Acre yield of sugarcane in tons | 20·6 | 29·8 | 25·5 |
| Percentage on control | 100 | 139·8 | 123·3 |
| Conclusion : B,C, A | | | |

**Ragi : R. 382 (1950)**

| | No manure A | Cattle manure B | Compost C |
|---|---|---|---|
| Acre yield of grain in lb. | 1278 | 1541 | 1516 |
| Percentage on control | 100 | 120·6 | 118·6 |
| Conclusion : B, C, A | | | |

| | | | |
|---|---|---|---|
| **Cumbu : Co. 3 (1950-51)** | | | |
| Acre yield of grain in lb. | 1411 | 1713 | 1695 |
| Percentage on control | 100 | 121 4 | 120·1 |
| | Conclusion : | B,C, A | |

**Aduthurai :**

| | No manure A | Cattle manure B | Compost C |
|---|---|---|---|
| **(Thaladi) second crop paddy (1950-51)** | | | |
| Acre yield of grain in lb. | 2097 | 2324 | 2196 |
| Percentage on control | 100 | 111·4 | 104·8 |
| | Conclusion : | B,C, A | |
| Samba Paddy Co. 25 (1950-51) | | | |
| Acre yield of grain in lb. | 2734 | 3270 | 3144 |
| Percentage on control | 100 | 120 | 115 |
| | Conclusion : | B,C, A | |

**Maruter :**

| | No manure A | Compost B | Farmyard manure C |
|---|---|---|---|
| **Paddy, MTU 5 (1950-51) Single crop area :** | | | |
| Acre yield of grain in lb. | 3092 | 3186 | 3287 |
| Percentage on control | 100 | 103·0 | 106·3 |
| | Conclusion : | C,B, A | |

| Double crop area, MTU. 5 (1950-51) | No manure A | Compost B | Farmyard manure C |
|---|---|---|---|
| Acre yield of grain in lb. | 2841 | 2903 | 3173 |
| Percentage on control | 100 | 102·2 | 111·6 |
| | Conclusion : | C,B, A | |

## TABLE VII—(a)

### Showing the results where increased yields were not significant

A. NIGHTSOIL COMPOST :

**Central Farm, Coimbatore :**

1949-50. **Cholam (Co. 9)** Compost plots gave 7 8% more than No Manure while F. Y. M. yielded only 3·6% more.

**Paddy : Co. 14 :** Compost gave 2·4% more than no manure.

**Sugarcane ( Co. 419 ) :** Compost yielded 27·2% more than No Manure while F.Y.M. gave only 4·8% higher yield.

### Showing the results where compost gave higher yields than F.Y.M.

| Station. | Year | Manure used. | Dose. | Crop. | Percentage increase in yield over No Manure Compost. | F.Y.M. |
|---|---|---|---|---|---|---|
| Tirurkuppam | (1949-50) | Nightsoil compost | 60 lb. N/acre | Paddy Co. 19 | 51·5 | 22·9 |
| Lam (Guntur) | 1950-51 | do. | 120 ,, | Chillies (G.1) | 95·0 | 37·0 |
| Anakapalle | ,, | do. | 250 ,, | Sugarcane (Co. 419) | 29 6 | 28·7 |

## TABLE VII (b)

**Showing the results of experiments where compost gave higher yields than No Manure but the increases in yield were not statistically significant**

| Station. | Year. | Manure used. | Dose. | Crop. | Percentage increase in yield over No Manure Compost | F.Y.M |
|---|---|---|---|---|---|---|
| Coimbatore | 1949-50 | Nightsoil compost | 250 lb. N/ acre | Sugarcane Co. 419 | 27·2 | 4·8 |
| ,, | ,, | ,, | 60 ,, | Cholam Co.9 | 7·8 | 3·6 |
| ,, | 1950-51 | ,, | 60 ,, | Paddy Co. 14 | 15·0 | 11·0 |
| Anakapalle | 1949-50 | ,, | 250 ,, | Sugarcane Co. 419 | 8·6 | 5·8 |
| ,, | ,, | ,, | 60 ,, | Paddy BAM.3 | 11·9 | 11·0 |
| ,, | 1950-51 | ,, | 60 ,, | Paddy BAM.3 | 18·3 | 8·0 |
| ,, | ,, | ,, | 60 ,, | do. | 19·9 | 19·7 |
| Lam (Guntur) | ,, | ,, | 60 ,, | Variga | 23·0 | 43·0 |
| Samalkot | ,, | Farmwaste compost | 240 ,, | Bananas | 63·0 | 200·0 |
| Palur | 1949-50 | do. | 60 ,, | Ragi R. 382 | 10·4 | 12·3 |
| Pattambi | ,, | do. | 60 ,, | Modan paddy | 22·7 | 23·7 |
| ,, | 1950-51 | do. | 60 ,, | do. | 7 9 | 6·3 |
| Maruter | ,, | do. | 60 ,, | Paddy MTU.15 | 15·4 | 21·1 |

## TABLE VIII

**Showing the manurial value of different green leaf manures on paddy at different nitrogen levels**

| Year | Sesbanea speciosa A 1 | 2 | 3 | Daincha B 1 | 2 | 3 | Wild Indigo C 1 | 2 | 3 | Fisher's 'Z' test satisfied or not | Critical difference (P=0·05) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1937–38 | 1468 | 1664 | 1687 | 1633 | 1646 | 1720 | 1500 | 1712 | 2018 | | |
| 1938–39 | 2782 | 3183 | 3474 | 2384 | 2740 | 2812 | 2762 | 2801 | 3326 | Yes | 312 |
| 1939–40 | 2376 | 2537 | 2746 | 2387 | 2515 | 2632 | 2533 | 2665 | 2705 | | |

(1) 15 lb . N. per acre; (2) 30 lb. N. per acre; (3) 45 lb. N. per acre.

Conclusions :—

1937–38 : C3, B3, C2, A2, B2, C1, A2, B1, A1

1938–39 : $A_3, C_3, A_2, B_3, C_2, A_1, C_1, B_2, B_1$

1939–40 : A3, C3, C2, B3, A2, C1, B2, B1, A1

**TABLE IX**

**Showing the relative merits of some common green manure crops.**

| | Sunnhemp | Daincha | Pillipesara | Cowpea |
|---|---|---|---|---|
| Green matter per acre | 27,790 lb. | 21,131 lb. | 22,337 lb. | 21,055 lb. |
| Nitrogen added to soil | 134 ,, | 133 ,, | 102 ,, | 74 ,, |
| Moisture | 70% | 60% | 80% | 80% |
| Decomposability | Moderate | Slow | Very rapid | Rapid |
| Soil nitrogen due to continued application | 0·109% | 0·141% | 0·109% | 0·101% |
| Soil nitrogen – No manure | 0·079 | 0·079 | 0·079 | 0·079 |
| Bacterial population | 4,000,000 | 4,500,000 | 5,300,000 | 4,300,000 |
| do. No manure | 3,600,000 | 3,600,000 | 3,600,000 | 3,600,000 |
| **Yield of paddy:** | | | | |
| Grain per acre | 3,467 lb. | 3,626 lb. | 3,626 lb. | 3,327 |
| Percent over No Manure | 198% | 207% | 207% | 190% |
| Straw per acre | 6,554 lb. | 7,311 lb. | 6,415 lb. | 5,299 lb, |
| Per cent over No Manure | 374% | 417% | 366% | 302% |
| **No Manure:** | | | | |
| Grain | 1,753 lb. | 1,753 lb | 1,753 lb. | 1,753 lb. |
| Straw | 1,753 lb. | 1,753 lb. | 1,753 lb. | 1,753 lb. |
| Remarks :– | Good as green manure. Serves as fodder also. Cannot stand water-logging. | Hardy. Even under adverse conditions grows well. Gives good residual effect to soil. | Take time to grow; useful as fodder and can be cut once or twice and fed to cattle before ploughing in. | Grows thick but requires good drainage in soil. |

# Review of Manurial Experiments in India

*By*

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The production of more FOOD in India is perhaps the most discussed question now by Government, the Press and the Public alike. "Extensive" and "Intensive cultivations" are suggested, but, as the scope for the former is limited, the latter is obviously the more important method, and again, out of the various means suggested such as use of good seed, proper cultivation, judicious manuring etc. in intensive cultivation, the greatest emphasis is laid on manuring. Propaganda is being done by the Agricultural Department, on the proper conservation of organic manures as well as the extensive use of fertilisers.

Under these circumstances, it will be interesting to know the effect of the various manures and fertilisers under Indian conditions on the important food crops.

More than 5.000 manurial experiments, conducted during the past 40 years at more than 100 Experimental Stations distributed in all the Provinces in India, were examined and the results were reviewed critically to understand the performance of 11 different manures and fertilisers individually and in combinations on 7 important cereal crops and on sugarcane and potatoes. The review was manure - war, crop - war, climate - war and soil - war.

(a) Information from 30 years of manurial experiments upto 1930 conducted in the 100 Government Experimental Stations throughout India is furnished by the Provincial Agricultural Chemists and collated by the Statistician. (b) The reports of the Provinces and States from 1930 to date were scrutinised, and also, the experiments conducted by I. C. I. (Imperial Chemical Industries) from 1930 onwards, and the experimental data from schemes financed by the Indian Council of Agricultural Research from 1930 onwards. All these data were examined to understand the performance of various manures and fertilisers on Indian food crops and to arrive at conclusions which can guide us in the manuring of agricultural crops.

The salient features of the review are mentioned below, but a word of explanation is necessary before we come to it. The first 30 years of experimental work i. e. (a) are often criticised as lacking in statistical precision and experimental layout; but with all the shortcomings, the broad conclusions arrived at by a review of the data are quite valid, as the later experiments serve merely to substantiate the former conclusions. This was the case not only with food crops but with sugarcane as well.

III **Salient Features:** (1) In India as a whole: Organic manures (like farmyard manure, green manure, oil cakes, bone meal and fish manure) individually or in combinations with one another are in every case 2 to 3 times as effective as artificial fertilisers (such as Ammonium sulphate, Sodium or Potassium Nitrate, Superphosphate, Niciphos and Potassic manures).

2. Organics plus artificials can be said to be intermediate (except in the case of paddy, where they gave maximum percentage increases in yield over No Manure).

3. Amongst artificials phosphatic fertilisers are very beneficial but the rest are not very effective, directly or residually.

4. Potassic fertilisers gave mostly negative results.

5. A more detailed discussion for each crop and with each manure and the direct, residual and combined effects is given elswhere.

6. Artifiicials leave undesirable residual effects on the crop yields, and soil compostion and structure in contrast to the good residual effects of organics and their steady effects on crop yields and beneficial effects on soil structure.

In India, cropping depends on the vagaries of "Monsoons", and in places of years or precarious rainfall, the use of artificials may be sometimes harmful.

8. There is also the question of the quality or the "Nutritive value" of the produce and the "Cropping capacity of the grain", both of which are very important considerations in the long-term planning of National health and well-being.

9. The response to manuring in general, is more in lands of low initial fertility than on lands of medium and high fertility; and the response in lands of medium fertility is more than that in lands of high fertility.

10. The experiments conducted by I. C. I. and I. C. A. R. from 1930 onwards corroborate the conclusions arrived at by previous experiments upto 1930.

11. Where artificials are to be used, it is always safe to use them in conjunction with organic manures. This is clearly indicated in the case of cereals as well as in sugarcane.

12. The superiority of ammonium sulphate as a manure for paddy and sugarcane is not borne out by the experimental data, (a, b, c and d). By itself, it gave 22·8%, 18·3% and 5·9% increases (considering the direct effects) over No Manure with paddy, jowar and wheat respectively; these are below the increases due to organic manures.

So, the manurial and food problems in India will not be solved by the manufacture of ammonium sulphate alone. Importance has to be attached to the proper conservation of the bulky manures and utilisation of oil-cakes and bone in the country. The experimental technic itself has perhaps got to be remodelled and made simpler, so that an ordinary ryot may carry it out himself and decide which is the best manure for his crops, under his soil and environmental conditions.

**Interpretation of Data:** On the whole, organic manures either individually (54·5%) or in combinations (85·5%) are nearly 3½ times as effective as inorganic fertilisers individually (16·4%) or in combinations (24·6%), while organics plus inorganics occupy an intermediate (46·8%) position.

**Performance of Different Manures & Fertilisers (Individually and**

*( All–India ) Average % increase (+) & decrease (—)*

| | Organic manures (alone) | | | (In combinations) | |
|---|---|---|---|---|---|
| | (1) F.Y.M. | (2) G.M. | (3) Oil cakes | (4) B. M. or Fish | (5) Organic combinations |
| | + — net | + — net | + — net | + — net | |
| *Paddy (I crop)* | | | | | |
| Direct effect | 85·6–80=77·6 | 28·4–7·4=21·0 | 34·6–3·2=31·4 | 35·2–3·1=32·1 | 85·7–4·5=81·4 |
| Residual effect | 27·4–1·7=25·7 | 8·9-6·9–=2·0 | 17·0–9·8=7·2 | 29·2–3·1=26·1 | 17·0-12·6=4·4 |
| Total | 113·0-9·7=1033 | 37·3-19·3=19 0 | 51·6-13·0=386 | 64·4-6·2=58·2 | 102·7-16 9=85·8 |
| Average | (218·1÷4=54·5) | | | | (85·5) |
| *Paddy (II crop)* | | | | | |
| Direct effect | 4·0–?=4·0 | 11·5–?=11·5 | 14–7 ?=14·7 | 10·1–3·6=6·5 | 30·8–?=30·8 |
| Residual effect | ?–?=? | ?–?=? | 40·4–28·8=20·6 | 53·0–20·4=32·6 | ?-?=? |
| Total | 4·0–?=4·0 | 11·5–?=11·5 | 64·1–28·8=35·3 | 63·1-24·0=39·1 | 30·8–?=30·8 |
| Average | (89÷4=22·5) | | | | (30·8) |
| *Jowar* | | | | | |
| Direct effect | 49·6–6·0=43·6 | 8·5–3·2=5·2 | 14·9–?=14·9 | 0·0–?=00·0 | 24·6–?=24·6 |
| Residual effect | 35·8–10·8=25·0 | 50·0–?=50·0 | 14·9–?=14·9 | 12 0–?=12 0 | 16 7?=16·7 |
| Total | 85·4–16·8=68·6 | 58·5–3·3=55·2 | 29·8–?=29·8 | 12·0–?=12 0 | 41·3–?=41 3 |
| Average | 165.6÷4=41·4) | | | | (41·3) |
| *Wheat :* | | | | | |
| Direct effect | 49·5–2·8=46 5 | 28-7-12·5=16·2 | 34·4–3·3=31·1 | 26·5–6·7=19·8 | 28·2–?=28·2 |
| Residual effect | 19·6–?=19·6 | 20·8–?=20·8 | 27·2–=27·2 | 52·0–?=52·0 | 35·0–?=35·0 |
| Total | 68·9–2·8=66·1 | 49·5–12·5=37 0 | 61·6–3·3=58·3 | 78·5–6·7=71·8 | 65·2-?=63·2 |
| Average | (233·2÷4=58·5) | | | | (63·2) |

**in Combinations) on the Important Food Crops in India as a Wole**

*in yield over No Manure, due to manuring:—*

| Org. man. + Inorg. fertilizers | Inorganic fertilizers (alone) | | | | In combination |
|---|---|---|---|---|---|
| (6) | (7) | (8) | (9) | (10) | (11) |
| Organics plus inorganics | Am. Sulph. | Na or $KNO_3$ | Super. etc. | K. fertilizers. | Inorganic combinations |
| + — net | + — net | + — net | + — net | + — net | + — net |
| 42·2–5·3=36·9 | 28·0-5·2=22·8 | 14·6-8·2=6·4 | 39·7–5·7=34 0 | 3·2–5·9=2·7 | 25·9 7·4=18·5 |
| 13·9–4·0=9·9 | 0·6–7·1=6·3 | 1·3–3·0=1·7 | 26·8–16·0=10·8 | 2·2–?=2·2 | 6·1-? = 6·1 |
| 56·1-9·3=46·8 | 28·8-12·3=16·5 | 15·9–11·2=4·7 | 66·5–21·7=4·8 | 5·4–5·9=0·5 | 32–7·4=24·6 |
| (46·8) | (65·5÷4=16·4) | | | | (24·6) |
| 48·8–3·5=45·3 | 13·0-4·5=8·5 | ? – ? = ? | 18·4–5·4=15·0 | 0·9–?=0·9 | 12·7–15=2·3 |
| 7·7-18·4=10·7 | ? - ? = ? | ? – ? = ? | 30 0- ? = 30·0 | ? – ? = ? | 5·1 – 2·3=0·5 |
| 56·5–21·9=34·6 | 13·0–4·5=8·5 | ? – ? = ? | 48·4-5·4=43·0 | 0·9- ?=0·9 | 17·8–17·3=0·9 |
| (34.6) | (52·4÷3=17·5) | | | | (0·5) |
| 16·8 – 8·3= 8·5 | 18·8–0·5=18·3 | 16·1–6·0=10·1 | 44·4-6·0=38·4 | 18·6-?=18·6 | 17·2–5·7=11·5 |
| 23·7–3·3=20·4 | 8·3-15·0=6·7 | 12·0–46 0=34·0 | 8·7 – ? =8·7 | ? - ? = ? | 4·4 – ? = ? |
| 45·5-11·6=28·9 | 27·1-15·5=11·6 | 28·–52·0=23·9 | 53·1–6·0=47·1 | 18·6-?=18·6 | 21·6-5·7=15·9 |
| (28 9) | (53 4÷4 = 13·4) | | | | (15 9) |
| 37·0-14·4=22·6 | 13·1–7·2=5 9 | 30·8-6·3=24·5 | 20·0–4·6=15·4 | 21·3–11=10·3 | 50·2–3·1=47·1 |
| 24·9–1·1=23·8 | 6·3-?=6·3 | 20 0–?=20·0 | ? –12 = – 12 | ? – ? = ? | 21·0–19·1=1·9 |
| 61·9-15·5=46·4 | 19·4-7·2=12·2 | 50·8-6·3=44·5 | 20·0-16·6=3·4 | 21·3-11=10·3 | 71·2-22·2=49·0 |
| (46·4) | (70·4÷4=17·6) | | | | (49·0) |

Discussiug the direct, residual and combined effects of different manures and fertilisers in more detail:—

*Paddy—I Crop:* (Number of experiments reviewed, 3945 for direct effect, plus 470 for residual effect; total 4415).

*Direct effect:* The maximum percentage (81·4%) increase in yield over "No Manure" is obtained by the application of 'combinations of organic mauures'. Farmyard manure occupies the second rank (77·6%) and combinations of organic and inorganics the third rank, (36·9%). Superphosphate (34%), bonemeal (32·1%) and oil cakes (31·4%) are nearly equal, in their direct effects, while green manure is a bit lower (21%). Nitrogenous fertilisers like ammonium sulphate (22·8%) and sodium nitrate (6·4%) are comparatively poorer and potassic fertilisers (—2·7%) are of negative value. Combinations (18·5%) of artificials are not better than ammonium sulphate by itself.

*Residual effect:* Bone meal gave the maximum (26·1%), Farmyard manure is second (25·7%) and 'super' is the third (10·8%) in rank. The residual effects of artificials are negative, e. g., ammonium sulphate (—6·3%) and sodium nitrate (—1·7%). Combinations of inorganics i. e., nitrogenous plus phosphatic fertilisers left residual effects equal to that of super phosphate (10·8%).

Considering the direct and residual effects together, farmyard manure occupies the first rank, 'combinations of organic manures, the second rank, (85·8%) and bone-meal the third (58·2%). 'Combinations of organics plus inorganics' occupy the fourth rank, (46·8%). Superphosphate follows this closely with 44·8% increase. Oil-cakes, (38·6%), 'combinations (24·6%) of inorganics' green manure (18%) and ammonium sulphate (16·5%) are effective in the decreasing order. Sodium nitrate is not very helpful (4·7%), while K. fertilisers actually decreased (0·5%) the yield.

**Paddy:** *Second Crop:* (Number of experiments reviewed, 466 for direct effect, plus 133 for residual effect; Total 599.)

*Direct effect:* 'Organics plus Inorganics' gave the maximum (45·3%) direct effect; 'combinations of organics' are second (30·8%) and oil-cakes (14·7%) third,

*Residually:* Bone meal gave the maximum effect, (52·6%), super phosphate second (30·%) and oil cakes, the third (20·6%).

Considering the direct and residual effects together: Superphosphate stands first, (43%) bone meal next (39·1%), and organics plus inorganics third (34·6%), with the combination of organics (30·8) closely following.

On the whole organics (22·5%) individually are nearly $1\frac{1}{4}$ times as effective as inorganics individually (17·5%), while combinations of organics (30·0%) are far superior to those of inorganics, (0·5%). But organics (34·6%) plus inorganics are better than either.

**Jowar:** Number of experiments reviewed: 996 Direct effect, plus 230 for residual effect; Total 1226.

*Direct effect:* Farmyard manure gave the maximum direct effect (43·6%) and 'super phosphate and combinations of organics' are second and third in rank.

*Residual effect:* Residual effect was maximum with green manure (50%), next in order are farmyard manure (25%) and organics plus inorganics, (20·4%). The residual effects of artificials (except superphosphate) are distinctly negative, e.g. ammonium sulphate (6·7%) and sodium nitrate (—34%).

Considering the direct and residual effects together: Farmyard manure (68·6%) stands first; green manure is second and superphosphate third (47·1). Combinations of organics j (11·3%) and oil-cakes (29·8%) and 'organics plus inorganics' (28·9%) come next.

On the whole, organics (41·5%) individually are nearly three times as effective as artificials individually, (13·4%) while the combinations of the former (41·3%) are $1\frac{2}{3}$ times as effective as combinations of the latter (15·9%). Organics plus (28·9%) inorganics' are snperior to artificials alone (13·4%), or their combinations, (15·9%).

**Wheat:** (Number of experiments reviewed: 2468 for direct effect, plus 265 for residual effect; Total — 2733).

*Direct effect:* 'Combinations of inorganics' stand first (47·1%) followed closely by farmyard manure. Oil-cakes stand third (31·9%) in rank. Ammonium sulphate is the last of all (5·9%).

*Residually:* The residual effect is the maximum (52%) with bone-meal, 'combinations of organics' are second (35%) and oil-cakes the third (27·2%). Superphosphate is the last (12%).

Considering the direct and residual effects together: Farmyard manure stands first, (66·1%) and Combination of organics (63·2%) and oil-cakes (58·3%) are second and third in rank.

On the whole, organics are individually are $3\frac{1}{2}$ times as effective (58·3%) as 'inorganics individually (17·6%) and 'combinations (63·2%) of organics' are $1\frac{1}{4}$ times as effective as those (49·0%) of inorganics.

**Summary:** "Organic manures individually or in 'combinations' are invariably 2 to 3 times as effective as inorganics. "Organics plus inorganics" can be said to be intermediate in effectiveness, but with paddy second crop, these gave the maximum increase. Among the artificials, phosphatic ones are very beneficial. The rest are not very effective, either directly or residually. Potassic fertilizers gave mostly negative results.

## Results of Manurial Experiments in India

*Paddy, First Crop:* 1. *For India as a whole, effect of different manures:* When India as a whole is considered: The maximum direct effect on yield has been with organic manures, over no manure. Next, in order come bone-meal combinations of organic manure, Phosphatic manures and farmyard manure but residually green manure gave the maximum effect and farmyard manure the next best. The residual effect of sodium nitrate is practically nil and that of ammonium sulphate isnegative.

Considering the direct and residual effects together: Green manure tops the list followed by combinations of inorganic fertilizers, farmyard manure, bone meal and phosphatic fertilizers.

The performance of potassic fertilizers is very poor.

2. *Climate-war:* In the arid zone there are no experiments. In semi-arid zones the response of paddy crop to manuring is poor. In humid areas inorganic fertilizers in combinations and individually have given the largest yields; next in order are the organic manures individually and organics plus inorganics. Curiously enough, combinations of organics fared badly in this region, though in the per-humid area organic manures alone topped the list; after which come the inorganic combinations organics plus inorganics and last inorganics alone.

Viewed from the plant-food constitutents supplied by the manures, the response of paddy crop to nitrogenous manures (mostly organics) increased from semi-arid to humid and humid to per-humid area. Next in order are N-K-P and N-P. K alone is not of much use.

3. *Soil-war:* The maximum response to manuring is seen in the red, ferruginous, lateritic soils in which organic manures alone and combinations of inorganic fertilizers top the list.

The response in alluvial lands, loams and black soils is comparatively less. Combinations of organic manures though they did well in the alluvials and loams fared badly in black soils.

Complete manure N-K-P gave the highest returns in laterite soils; next in order are N-P and P. In loams there is a fair response to P and N-K-P. Black soils are the least responsive to paddy manuring.

**Jowar:** (1) *For India as a whole:—* The maximum direct effect on yield has been with farmyard manure, and this effect decreased with the other organic manures, (green manure) and oil-cakes. With bone meal the the direct and residual effects are poor, due probably to lack of sufficient moisture for its decomposition. Combinations of organics plus inorganics are the next best to farmyard manure. Green manure, combinations of organic manures or combinations of inorganic fertilizers are on a par with oil-cakes, while ammonium sulphate was slightly superior.

Residually also, farmyard manure topped the list; green manure being the next best. There are some residual effects with organics plus inorganics and inorganic combinations due mainly to the effect of season, that is, the lack of rain or moisture in the year of application. The rest have practically no residual effects.

Taking the direct and residual effects together: Farmyard manure is the best, green manures come next, and combinations of organics plus inorganics, the third. Sodium nitrate is of negative use. Potassic manures are without effect.

2. *Climate-War:* 'Organic manures individually were very good, in semi-arid, humid and per-humid areas, the effect gradually decreasing in the order mentioned. Inorganics alone and combinations of organic manures were ineffective in semi-arid zones but were effective in humid areas, whereas the behaviour of combinations of organic combinations are the opposite to the above in these climatic zones.

N-K-P (as organics or inorganics) are the best in semi-arid zones, N in per-humid zones and P in humid zones. Behaviour of N-P is the same in semi-arid and humid zones.

3. *Soil-War:* In all soils, organic manures individually are the best. The effect is more pronounced in black soils.

N-K-P (as Organics or Inorganics) is the best, especially on black soils. The effect of nitrogenous manures increased from alluvial to loams, loams to black soils, and reached the maximum in laterite soils.

**Wheat:** (1) *Different Manures:* The maximum direct effects are with 'inorganic plus inorganics.' Next is farmyard manure. Sodium or potassium nitrate is next to farmyard manure; and green manure is next to sodium or potassium nitrate.

As regards the residual effects, green manure is the first, farmyard manure second, and bone meal third. Organic combinations and sodium or potassium nitrate also gave some residual effects.

Considering the direct and residual effects together, farmyard manure is the best manure. Sodium or potassium nitrate and green manures are the next. Bonemeal, combinations of organics or inorganics or organics plus inorganics, all behaved alike. Ammonium sulphate, super or K-Manures are not as effective as oil-cakes. Somehow P was of negative use.

2. *Climate-war:* Organic manures individually did well in all the climatic regions except in arid zones, where organics plus inorganics and inorganics alone, were slightly superior. The maximum response to manuring is seen in humid zones.

N-K-P is best in arid and humid zones and N in semi-arid and per-humid zones. P is more effective in semi-arid areas than in other areas.

3. *Soil-war:* The response to manures in general is more in alluvial and black soils and less in loams and laterites. Organics top the list in all the four types of soil. Organics plus inorganics are the next best, inorganics alone or combined are the third, except in laterites, where the performance of inorganics (7%) alone is superior to combinations.

N-K-P is the best in alluvial and black soils and least effective in laterite soils. N. is very effective in all the four types of soils, and particularly in alluvial and laterite soils. In loams, N-P is the best.

## List of Experimental Stations:

| | | |
|---|---|---|
| 1. | *Madras:* | Aduturai, Coimbatore, Hagari, Koilpatti, Mangalore, Sirvel, Samalkot, Palur, Nanjanad, Nandyal, Anakapalle, Maruteru, Guntur, Bellary, Kasargode, Taliparamba, Vellalur. |
| 2. | *Bombay:* | Alibagh, Arbhavi, Dharwar, Dhulia, Dehad, Jalgaon, Kumpta, Manjri, Mokibaggadu, Nadiad, Ratnagiri, Surat, Poona, Amalsad, Baramathi, Koporgaon, Modibag, Karjat. |
| 3. | *Bengal:* | Mymensingh, Decca, Comella, Dogra, Faridpur, Chinsura, Bankura, Rajashahi, Berhampur, Nursory, Malda, Amrit, Nurser. |
| 4. | *Bihar:* | Cuttack, Kanki, Sambalpur, Sabour, Bikramgang, Sepaya, Baliya Purolia, Jamni, Khurda, Gaya, Kharara, Banka Siwan. Nawada, Dharbhanga. |
| 5. | *Punjab:* | Lyallpur, Hansi, Gurdaspur. |
| 6. | *U. P:* | Cawnpore, Muzaffar-nagar, Gorakhpur, Aligarh Meerut, Tarikhot, Pratapgarh, Shajahanpur, Bundelkand. |
| 7. | *C. P:* | Nagpur, Yeotmal, Powerkhera, Chindwara, Waraseel, Labhandi, Adhartal, Tharsa, Akola, Berar Farm, Borgaon, Basin, Buldana, Chandkwari, Sindiwahi. |
| 8. | *Assam:* | Kamrup, Surma Valley, Sibsagar, Goalpara, Nowgong, Khasi and Jaiti Hils, Jorhat, Upper Shillong Karimgang, Titahar. |

## Manures and Fertilizers:

| | | |
|---|---|---|
| 1. | Farmyard Manure | Organics |
| 2. | Green manure | Organics |
| 3. | Oil cakes | Organics |
| 4. | Bone or Fish Meal | Organics |
| 5. | Organic combinations | |
| 6. | Organics plus Inorganics | |
| 7. | Ammonium sulphate | Inorganics |
| 8. | Sodium or potassium nitrate | Inorganics |
| 9. | Super etc. | Inorganics |
| 10. | Potassic fertilisers | Inorganics |
| 11. | Inorganic combinations | |

## Important Crops:

Paddy, first crop, Paddy, second crop, Jowar, Wheat, Ragi, Bajra, Maize, Korra, Sugarcane, Potato.

# Green Manuring Semi-dry Paddy

*By*

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**Introduction:** In the districts of Chingleput, North Arcot and Chittoor, the bulk of the area under paddy is sown under semi-dry conditions. The sowing is done in July–August, usually by means of a *gorru*, after the onset of the South-West monsoon. The crop makes slow progress with the limited soil moisture, but in a normal season the South-West monsoon showers are sufficient to maintain the stand of the crop in the early stages of growth. After the onset of the North-East monsoon when the tanks get filled, this "semi-dry" paddy is irrigated from the tanks and thereafter the crop is treated in the same way as a wet crop of paddy. By this system of cultivation an early sowing of the crop is rendered possible, which otherwise would have to await the onset of the North-East monsoon. The one drawback in this system is the difficulty in applying green manure to the crop. The semi-dry area is usually manured with what little farm-yard manure is available, which does not exceed five cartloads per acre. Considering the large area under semi-dry paddy a practical method of green manuring the area has to be improvised. Several methods like ploughing in green manure brought from outside a month before sowing and at the time of sowing were tried. The results were not satisfactory, as the decay and disintegration of the green matter were not complete for want of the requisite moisture and when the green leaves were applied 30 days before sowing the undecomposed matter impeded ploughing and sowing operations. Sowing the green manure seeds along with paddy, pulling out and trampling in the green manure crop about two months after sowing when the crop was irrigated, however, gave better results. The following experiment was conducted from 1946—'47 to test the efficacy of this method of green manuring semi-dry paddy.

**Materials and methods:** The variety of paddy used for the experiment was ADT. 22 *(Vadansamba)* the predominant semi-dry variety. As the period of growth for the green manure was limited, a quick-growing crop like sunnhemp was sown. The experiment consisted of two treatments–A. Control (Paddy sown alone) and B. Paddy intersown with sunnhemp-and was laid out in ABBA manner with twelve replications, the sub-plots measuring $\frac{3}{4}$ to 1 cent. The control plots were sown to ADT. 22 by means of a *gorru* drawn by man-power. In the 'Treated' plots, after the sowing of paddy, sunnhemp was sown by means of a *gorru* in between the lines of paddy in lines 2 ft. apart. The seedrate of sunnhemp worked out to 20 lb. and of paddy to 60 lb. per acre. Seven to eight weeks after sowing when the plots were irrigated, the sunnhemp crop in flower was pulled out and trampled in between the lines of paddy. The paddy crop was harvested and the weights of grain and straw were recorded in all the sub-plots.

The experiment was conducted from 1946—'47; but owing to the failure of the North-East monsoon in 1947—'48, 1948—'49, and 1949—'50 the semi-dry area suffered badly and the experiment failed. In 1950—'51 though the season failed, reliable results were obtained as the experiment was laid out in plots which could be irrigated from an adjoining well The results of the trials in 1946—'47 and 1950—'51 are presented below:

**1946—'47.**

Field Number - 4D.
Previous crop - Fodder cholam
Layout - ABB-A repeated 12 times.
Size of sub plot 48′ x 10′
Variety - ADT. 22 (Vadansamba).

Sown :— 28—9—1946
Harvested :— 26—2—1947
Sunnhemp pulled out and trampled in :— 17-11—1946

*Treatments:* A. Control - Paddy alone.
B. Paddy inter - sown with sunnhemp.

**(1946—'47 contd.)**

| Particulars | Treatment | | General mean | 'Z' test satisfied or not | Standard error | Critical difference |
|---|---|---|---|---|---|---|
| | A. | B. | | P = 0·05 | | P = 0·05 |
| Acre yield of grain in pounds ... | 604 | 856 | 730 | Yes | 25·3 | 78·8 |
| Percentage on control (A) ... | 100·0 | 141·8 | ... | | 3·47 | 10·8 |
| Acre yield of straw in pounds ... | 2050 | 2882 | 2478 | Yes | 76·88 | 258·5 |
| Percentage on control (A) ... | 100·0 | 140·5 | ... | | 3·75 | 12·61 |

Conclusions :— Grain :— B, A.
Straw :— B, A.

**1951—'51.**

Field Number—5F.
Previous crop—Daincha.
Layout—12 x 2 randomised blocks ABBA manner.
Size of sub-plot—47′ x 7′
Variety—ADT. 22 (Vadansamba).

Sown :— 2—9—1950.
Harvested :— 25—1—1951.
Sunnhemp pulled out and trampled in :— 10-10—1950.

*Treatments:* A. Paddy sown alone.
B. Paddy intersown with sunnhemp.

| Particulars | Treatment | | General mean | 'Z' test satisfied or not | Standard error | Critical difference |
|---|---|---|---|---|---|---|
| | A. | B. | | P = 0·05 | | P = 0·05 |
| Acre yield of grain pounds ... | 736 | 941 | 839 | Yes | 54·38 | 169·00 |
| Percentage on control (A) ... | 100·0 | 127·8 | 113·9 | | 7·38 | 22·95 |
| Acre yield of straw in pounds ... | 3750 | 4066 | 3908 | No | 187·6 | 583·70 |
| Percentage on control (A) ... | 100·0 | 108·4 | 104·2 | | 5·00 | 15·56 |

Conclusions :— Grain :— B, A.
Straw :— Treatment differences not statistically significant.

**Discussion:** From the results of the experiment in the two years it may be seen that growing green manure and applying it in between the lines of paddy have increased the yield of grain in both the years and of straw in one year. The increase of straw yield in 1950—'51 did not attain statistical significance. By adopting this method of green manuring the net profit in 1946—'47 is Rs. 37—6—0 and in 1950—'51 Rs. 22—14—0 per acre as detailed below:

| | *1946'—47* | | | *1950—'51.* | | |
|---|---|---|---|---|---|---|
| | Rs. | A. | P. | Rs. | A. | P. |
| Cost of extra pair for sowing sunnhemp—½ pair ... | 1 | 8 | 0 | 1 | 8 | 0 |
| Cost of 20 lb. of sunnhemp seed ... | 2 | 8 | 0 | 2 | 8 | 0 |
| Pulling out and trampling in the green manure at 8 women per acre ... | 4 | 0 | 0 | 4 | 0 | 0 |
| Total ... | 8 | 0 | 0 | 8 | 0 | 0 |
| Cost of extra yield of paddy @ as. 2/- per pound ... | 31 | 8 | 0 | 25 | 10 | 0 |
| Cost of straw at 60 lb. a rupee ... | 13 | 14 | 0 | 5 | 4 | 0 |
| Total ... | 45 | 6 | 0 | 30 | 14 | 0 |
| Net gain ... | 37 | 6 | 0 | 22 | 14 | 0 |

This method of green manuring is within the reach of every cultivator. When compared to the application of other manures like groundnut, castor, neem and pungam cakes, the oil cakes are not only difficult to obtain but are more costly.

It is worth while trying the T. V. A. plan of indirect fertiliser application. In the next trial two more treatments—Paddy with super and Paddy intersown with sunnhemp with super may be included.

**Summary:** Several methods of applying green manure to semi-dry paddy were tried. Sowing sunnhemp along with paddy in between the lines of paddy, pulling out and trampling in the green manure crop 6 to 8 weeks after sowing gave satisfactory results.

# Manuring of Rice in Malabar

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**Introduction:** In Malabar, rice is cultivated on three classes of lands, those that lie irregularly along the ridges and slopes of low hills where dry paddy is raised; the terraced level type of lands that skirt the lower slopes where a single crop of swamp paddy is grown and the flat valleys that form the typical wetland paddy areas where two or three crops are raised in a year.

The majority of the soils in Malabar are red loams of lateritic origin with varying proportions of clay and coarse sand. They are generally poor and are subject to constant depletion of finer fractions of the soil and soluble plant foods in the torrential rains during the South - West monsoon period, when 60—80 inches of rain are received within two months, june and july.

According to Ramiah (1936) typical rice soils should contain 40—60 percent of clay and silt. The results of mechanical analysis of the three classes of soils at the Agricultural Research Station, Pattambi, which are representative of the predominant types of soil in the tract, are given in table I.

TABLE I.—Mechanical analysis of soil (percentages).

| | Double-Crop lands | Single-Crop lands | Dry Paddy soils |
|---|---|---|---|
| Clay | 26·49 | 32·78 | 26·61 |
| Silt | 14·17 | 11·79 | 8·77 |
| Fine Silt | 18·55 | 12·90 | 16·22 |
| Coarse Sand | 40·79 | 42·53 | 48·40 |

It will be seen that the single and double crop swamp paddy soils contain 40 - 45 percent of clay and silt while it is only 35 percent in the case of dry paddy soils. All the three types contain a high proportion of sand. Soils of the double crop lands show 41 percent and the other two classes 43 - 48 percent, which is higher than the highest limit set by Jacks (1923) for second class rice soils. Chemical analysis indicates that the soils are adequately supplied with the major plant foods except phosphoric acid and lime.

Intensive manuring of rice is not done in Malabar. The ryots do realise the value of manures like green leaf and cattle manure for rice but apply them in doses that seldom exeed 2,000 lb. per acre. No manuring is given for broadcast crops of paddy, except a sprinkling of wood ash at about 500 to 1,000 lb./acre.

This paper is a brief review of the more important results and conclusions drawn from a number of manurial experiments conducted at the Pattambi Agricultural Research Station. In all cases the layout was in Latin Square or in randomised blocks, each subplot measuring not less than half a cent. Results of statistical analyses are given only for typical experiments conducted for two seasons and more.

**Experimental: I. Application of lime:** In view of the deficiency of the soils as regards lime and phosphoric acid the first set of experiments was designed to find out the effects of lime and phosphoric acid on the yield of paddy.

Lime was applied as finely ground calcium carbonate at the time of planting in doses varying from 500 to 1,000 lb. per acre. The results for three years given in table II indicate very little improvement from lime, the 'Z' test not being statisfied in any of the three years.

**TABLE II.—Lime Experiment.**

*Treatments* :— 1. No manure, 2. Lime at 500 lb. per acre, 3. Lime at 1000 lb. per acre. 4. Lime at 2000 lb. per acre.

Mean yield as percentage on general mean.

| | 1 | 2 | 3 | 4 | 'Z' test satisfied or not | S. E. | C. D. |
|---|---|---|---|---|---|---|---|
| I. Crop : | | | | | | | |
| 1933—34 | 96·7 | 98·1 | 99·8 | 105·5 | No | 3.25 | 8·00 |
| 1934—35 | 88·7 | 96·2 | 99 9 | 115·3 | No | 10·46 | 25·60 |
| 1935—36 | 94·7 | 103 5 | 100·6 | 101·1 | No | 5·66 | 13·85 |
| II Crop : | | | | | | | |
| 1933—34 | 93·5 | 102·5 | 100·4 | 103·3 | No | 4·95 | 12·11 |
| 1934—35 | 96 2 | 100·5 | 100 7 | 102·5 | No | 4·52 | 11·07 |
| 1935—36 | 96·1 | 100·9 | 98·9 | 104·1 | No | 2·83 | 6·93 |

II. **Phosphatic manures:** (a) In one of the experiments in this series, bonemeal and superphosphate was compared with Ammophos (13/45 grade containing both nitrogen and phosphoric acid), with and without a basal dressing of green leaf. The leaves were applied two weeks before planting, phosphates at the time of planting and Ammophos a month after planting. The results are set out in table III. Out of the three years of trial, the 'Z' test was satisfied in two years. Green leaf at 4,000 lb. per acre gave 16·2 percent higher yield than control. The effect of bone-meal and superphosphate was not consistent but that of ammonium sulphate was evident throughout.

**TABLE III.—Phosphatic manures experiment.**

*Treatments* :—

1. No manure.
2. Leaf at 4000 lb. per acre.
3. As treatment 2, plus Bonemeal to supply 30 to $P_2O_5$
4. do. Super phosphate 30 to $P_2O_5$
5. do. Ammophos 30 to $P_2O_5$
6. As treatment 4, plus ammonium sulphate to supply nitrogen equivalent in 3.
7. As treatment 4, plus ammonium sulphate to supply nitrogen equivalent in 5.
8. As treatment 3, plus ammonium sulphate to supply nitrogen equivalent in 5.

Mean yields as percentage on general mean.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 'Z' test | S. E. | C. D. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1933—34 | 91·4 | 100·5 | 100·3 | 102 9 | 104·4 | 101·1 | 103 5 | 95·9 | Not satisfied | 7·35 | 15·18 |
| 1934—35 | 79·8 | 95 9 | 104·6 | 104·7 | 103·0 | 96 5 | 108·8 | 106.7 | ,, | 3·68 | 7·59 |
| 1935—36 | 83·3 | 99·5 | 103·1 | 98·6 | 103·9 | 98 6 | 107·0 | 106·7 | ,, | 2·69 | 5·60 |

(b) Kossier phosphate, which is a finely ground phosphate containing 32 percent phosphoric acid was also tried without any appreciable effect. The same was the case with basic silicophosphate, a product considered to be good for tracts deficient in lime. The manures were applied to supply 40 lb. phosphoric acid per acre.

Further trials on the effect of phosphatic manures were therefore continued with superphosphate to supply from 20 to 50 lb. phosphoric acid per acre, in combination with green leaf at 2,000 lb. per acre and ammonium sulphate to supply 10 lb. nitrogen per acre. The leaves were applied two weeks before planting, superphosphate just before planting and ammonium sulphate a month after planting. It will be seen from the results given in table IV, that in no year was the 'Z' test satisfied.

**TABLE IV.—Kossier phosphate trial.**

*Treatments :—*

1. Green leaf 2000 lb. per acre plus 10 lb. nitrogen as ammonium sulphate.
2. As 1 plus superphosphate to supply 20 lb. $P_2O_5$ per acre.
3. As 1 plus do. 30 lb. do.
4. As 1 plus do. 40 lb. do.
5. As 1 plus do. 50 lb. do.

Mean yield as percentage on general mean.

| | 1 | 2 | 3 | 4 | 5 | 'Z' test satisfied or not | S. E. | C. D. |
|---|---|---|---|---|---|---|---|---|
| 1933—34 | 99·4 | 101·0 | 100·3 | 100·5 | 98 7 | No | 1·70 | 3 70 |
| 1934—35 | 97·5 | 99·9 | 101·8 | 99·4 | 101·3 | No | 2·55 | 5·55 |
| 1935—36 | 99·2 | 97·6 | 101·2 | 101·8 | 101·1 | No | 2·26 | 4·92 |

III. **Organic manures:** Since very consistent results were obtained with green leaf and ammonium sulphate, the next line of work was directed to different organic manures.

(a) One of the experiments in this series comprised application of green leaf, groundnut cake and cattle manure alone and in combinations to supply 15 lb. and 20 lb. nitrogen per acre. Cattle manure and leaf were applied a week before planting and groundnut cake at the time of planting. The results for three years are presented in table V. The best yields are given by groundnut cake alone or in combination with green leaf or cattle manure, the cake on the basis of 30 lb. nitrogen per acre recording 25 percent increased yield. However green leaf or a combination of leaf and cattle manure was more economical.

**TABLE V.—The effect of cattle manure, green leaf and groundnut cake.**

*Treatments :—*

1. Groundnut cake to supply 30 lb. Nitrogen per acre.
2. Green leaf do. 30 lb. do.
3. Cattle manure do. 30 lb. do.
4. Green leaf to supply 15 lb. nitrogen plus groundnut cake to supply 15 lb. nitrogen.
5. Cattle manure to supply 15 lb. nitrogen plus groundnut cake to supply 15 lb. nitrogen.
6. Green leaf to supply 15 lb. nitrogen & cattle manure to supply 15 lb. nitrogen.
7. Cattle manure above to supply 15 lb. nitrogen.
8. Groundnut cake alone to supply 15 lb. nitrogen.
9. No manure (control).

Mean yield as percentage on general mean.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | G.M. | S. E. | 'Z' test satisfied or not | C. D. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I Crop : | | | | | | | | | | | | | |
| 1937–38 | 132·3 | 121·4 | 109·9 | 126·6 | 111·6 | 116·8 | 112·1 | 119·2 | 109·0 | | | | |
| 1938–39 | 99·7 | 90·1 | 83·5 | 90·5 | 92·3 | 83·0 | 75·0 | 85·2 | 76·7 | 100 | 6·50 | Yes | 12·74 |
| 1939–40 | 116 3 | 102·1 | 88·8 | 102·5 | 106 3 | 100·4 | 74 0 | 92·6 | 83·1 | | | | |
| II Crop : | | | | | | | | | | | | | |
| 1937–38 | 101·5 | 93·7 | 75 1 | 95·3 | 99·4 | 83·6 | 62·3 | 83·9 | 81 7 | | | | |
| 1938–39 | 104·4 | 95·1 | 80·4 | 91 3 | 96·9 | 84·8 | 66·4 | 87 3 | 73 9 | 100 | 5·12 | Yes | 10·04 |
| 1939–40 | 143·9 | 133 8 | 119·9 | 137·0 | 132 4 | 129·1 | 106·8 | 121·8 | 118·4 | | | | |

Conclusion : 1937–38 1 · 5 · 4 · 2 · 8 · 6 · 9 · 3 · 7

1938–39 1 · 5 · 2 · 4 · 8 · 6 · 3 · 9 · 7

1939–40 1 · 4 · 2 · 5 · 6 · 8 · 3 · 9 · 7

(b) *Organic and artificial manures:* In this experiment organic manures like cattle manure and green leaf were compared with ammonium sulphate & Nicifos containing 22 percent nitrogen and 18 percent phosphoric acid. The results, set out in table VI, show that green leaf at the rate of 5,000 lb. per acre or ammonium sulphate to supply 30 lb. nitrogen per acre recorded the best yields, on an average 32 percent over ' no manure plots, while in the second crop season, green leaf recorded up to 41 percent, followed by ammonium sulphate, with 29 percent increased yield.

**TABLE VI.—Organic and artificial manures.**

*Treatments* :— 1. No manure. 2. Cattlemanure at 5000 lb. per acre. 3. Green leaf at 5000 lb. per acre. 4. Nicifos 22/18 to supply 30 lb. nitrogen per acre. 5. Ammonium sulphate to supply 30 lb. nitrogen per acre.

Mean yield as percentage on general mean.

| | 1 | 2 | 3 | 4 | 5 | G. M. | S. E. | 'Z' test satisfied or not | C. D, |
|---|---|---|---|---|---|---|---|---|---|
| I Crop : | | | | | | | | | |
| 1937—38 | 65·1 | 76 5 | 93·6 | 77·6 | 95·2 | | | | |
| 1938—39 | 90 1 | 99·9 | 116·2 | 105·4 | 123·2 | 100 | 2·86 | Yes | 5·61 |
| 1939—40 | 85·7 | 105·5 | 128·4 | 118·2 | 119·6 | | | | |
| II Crop : | | | | | | | | | |
| 1937-38 | 88·2 | 103·1 | 129·9 | 108·5 | 120·5 | | | | |
| 1938-39 | 93·2 | 106·6 | 137·8 | 113·6 | 127·8 | 100 | 2·12 | Yes | 4·16 |
| 1939-40 | 94·0 | 101·2 | 129·8 | 106·3 | 112·8 | | | | |

Conclusion : 1937–38 — 3 · 5 · 4 · 2 · 1
II Crop 1938–39 — 3 · 5 · 4 · 2 · 1
1933–40 — 3 · 5 · 4 · 2 · 1

(c) *Leaf versus processed leaf:* The effect of green leaf was so marked that the method of processing the green leaf by using it as a manure later, was followed and the product compared with fresh leaves and cattle manure in doses varying from 2,000 lb. to 8,000 lb. per acre. The results presented in table VII indicate that there is very little to choose between green leaves and processed leaves.

**TABLE VII.—Processed leaf experiment.**

*Treatment:*

| | | | | | |
|---|---|---|---|---|---|
| 1. Green leaf at | 2000 lb. per acre. | | 2. Green leaf at | 4000 lb. per ace. | |
| 3. ,, | 6000 | ,, | 4. ,, | 8000 | ,, |
| 5. Processed leaf at | 2000 | ,, | 5. Processed | 4000 | ,, |
| 7. ,, | 6000 | ,, | 8. ,, | 8000 | ,, |
| 9. Cattle manure | 2000 | ,, | 10. Cattle manure | 4000 | ,, |
| 11. ,, | 6000 | ,, | 12. ,, | 8000 | ,, |

Mean yields as percentage on general mean
Kinds of organic manures.

| | Green leaf G. L. | Processed leaf P. L. | Cattle manure C. M. | 'Z' test satisfied or not | C.D. | Conclusion |
|---|---|---|---|---|---|---|
| 1942–43 | 106·0 | 101·3 | 92·7 | Yes | 3·6 | GL. PL. CM. |
| 1943–44 | 106·6 | 97·8 | 95·4 | No | 3·2 | |
| 1944–45 | 99·7 | 101·0 | 99·4 | No | 5·0 | |

Quantities.

| | 2000 lb. | 4000 lb. | 6000 lb. | 8000 lb. | 'Z' test satisfied or not | C. D. | Conclusion |
|---|---|---|---|---|---|---|---|
| 1942–43 | 94·5 | 100·3 | 101·1 | 103·8 | No | 4·4 | |
| 1943–44 | 97·2 | 100 0 | 99·8 | 103·2 | No | 3·8 | |
| 1945–46 | 91·5 | 100·2 | 103·2 | 105·1 | Yes | 5·9 | 8000, 6000, 4000, 2000 |

(d) *Different oil cakes at different levels of nitrogen:* From the results presented in table V it will be seen that groundnut cake is very helpful in improving the yield of swamp paddy. Its application at a rate to supply 30 lb. nitrogen per acre gave up to an increased yield of 30 percent over 'No manure'. It was therefore proposed to compare cakes of groundnut, neem and castor on equal nitrogen basis. The details of the treatments and results are given in table VIII. All cakes were found to be equally effective on equivalent doses of nitrogen; progressive increases in yield were recorded with increasing doses of nitrogen upto 60 lb. per acre.

**TABLE VIII.—Oil cakes at different levels of nitrogen.**

*Treatments:* Groundnut cake, Neem cake and Castor cake at 0, 20, 40 and 60 lb. Nitrogen per acre

**Cakes only**

| | | Groundnut cake G. | Castor C. | Neem N. | 'Z' test satisfied or not | C. D. | Conclusions |
|---|---|---|---|---|---|---|---|
| I Crop: | 1943–44 | 101·7 | 98·7 | 99·6 | No | | |
| | 1944–45 | 100·5 | 92·5 | 107·0 | Yes | 3 5 | N. G. C. |
| | 1945–46 | 102·8 | 101·9 | 95·2 | Yes | 5·5 | G. C. N. |
| II Crop: | 1943–44 | 99·0 | 102·6 | 98·5 | Yes | 4·2 | C. G. N. |
| | 1944–45 | 98·5 | 97·8 | 103·8 | No | | |
| | 1945–46 | 100·9 | 100·6 | 99 5 | No | | |

**Levels of Nitrogen.**

| | O | 20 | 40 | 60 | 'Z' test satisfied or not | C.D. | Conclusions |
|---|---|---|---|---|---|---|---|
| I Crop : 1943—44 | 88·9 | 99·2 | 102·2 | 109·7 | Yes | 4·0 | 60, 40, 20, 0 |
| 1944—45 | 89·0 | 92·6 | 104·6 | 113·7 | Yes | 6·9 | 60, 40, 20, 0 |
| 1945—66 | 92 4 | 97 0 | 101·4 | 109·1 | Yes | 5,6 | 60, 40, 20, 0 |
| II Crop : 1943—44 | 79·6 | 96 0 | 107·7 | 117·0 | Yes | 4·4 | 60, 40, 20, 0 |
| 1944—45 | 79·0 | 96·7 | 109 2 | 115·2 | Yes | 10·8 | 60, 40, 20, 0 |
| 1945—46 | 82 0 | 96·0 | 103·0 | 109·0 | Yes | 4·2 | 60, 40, 20, 0 |

**Interactions.**

| | Ground nut cake | | | | Castor cake | | | | Neem cake | | | | 'Z' test satisfied or not | C.D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 20 | 40 | 60 | 9 | 20 | 40 | 60 | 0 | 20 | 40 | 60 | | |
| **I Crop :** | | | | | | | | | | | | | | |
| 1943–44 | 89·5 | 102·1 | 101·8 | 113·4 | 87·7 | 100·6 | 101·1 | 105·1 | 89·3 | 94·5 | 103·5 | 110·4 | No | 6·9 |
| 1944–45 | 91·8 | 91·8 | 98·6 | 119 3 | 84·6 | 89·0 | 97·3 | 98·7 | 91·8 | 96·2 | 118·3 | 122·4 | Yes | 11·2 |
| 1245–46 | 95·5 | 97 2 | 105·6 | 112·8 | 93·7 | 101·5 | 99 6 | 112·9 | 88·0 | 92·3 | 99 1 | 101·5 | No | 9 4 |
| **II Crop :** | | | | | | | | | | | | | | |
| 1943–44 | 78·1 | 98·2 | 102·5 | 117·7 | 78·6 | 97 2 | 108 7 | 110·0 | 82·6 | 92·7 | 112·6 | 123·5 | Yes | 7·6 |
| 1944–45 | 79·9 | 93·4 | 104 8 | 116 3 | 76·9 | 98·0 | 107 0 | 108·4 | 80·1 | 98·2 | 116 0 | 120 7 | No | 15·5 |
| 1945–46 | 93·8 | 98·6 | 104 8 | 106·5 | 92·9 | 98·0 | 102 6 | 109·8 | 90·9 | 91·9 | 102·8 | 112·6 | Yes | 7·2 |

(e) *Leaf, oil cakes and ammonium sulphate:* From the results of previous trials it was found that nitrogen had the greatest influence on the growth and yield of swamp paddy. Oil cakes, green leaf and ammonium sulphate were individually found to be effective. Since the bulk of nitrogen has to go in the form of organic manure, an experiment was conducted with different organic manures to supply 30 lb. nitrogen per acre, alone and in combination with ammonium sulphate to supply 15 lb. nitrogen per acre. It is seen from the results given in table IX that the green leaf and groundnut cake gave the maximum increased yield. Green leaf combined with ammonium sulphate was the most economical.

**TABLE IX—Leaf, Oil Cakes and Ammonium sulphate.**

*Treatments :—*

1. Castor cake to supply 30 lb. nitrogen, plus ammoniun sulphate to supply 15 lb. nitrogen.
2. Castor cake above to supply 30 lb. nitrogen.
3. Groundnut cake to supply 30 lb. nitrogen, plus ammonium sulphate to supply 15 lb. nitrogen.
4. Groundnut cake to supply 30 lbs. nitrogen.
5. Neem cake to supply 30 lb. nitrogen, plus ammonium sulphate to supply 15 lb. nitrogen.
6. Neem cake alone, to supply 30 lb. nitrogen.
7. Green leaf to supply 30 lb nitrogen plus ammonium sulphate to supply 15 lb. nitrogen.
8. Green leaf alone, to supply 15 lb nitrogen.
9. Ammonium sulphate alone, to supply 15 lb. nitrogen.
10. No manure.

**Summary of results for organic manures**

| | Castor cake (1) | Ground nut (2) | Neem (3) | Green leaf (4) | No Manure (5) | G.M. | S.E. | 'Z' test satisfied or not | C.D. |
|---|---|---|---|---|---|---|---|---|---|
| 1937—38 | 103·4 | 106·2 | 96·3 | 110·1 | 84 1 | 100 | 2·08 | Yes | 5·97 |
| 1938—39 | 104·1 | 109·5 | 104·2 | 101·1 | 81·3 | 100 | 2·39 | Yes | 4·68 |

Conclusion :— 1937—38. 4, 2, 1, 3,5
1938—39. 3, 2, 1, 4,5

**Summary of results for ammonium sulphate and no ammonium sulphate**

| — | Ammonium sulphate (1) | No amm. sulphate (2) | G.M. | S. E. | 'Z' test satisfied or not | G.D. | Conclusion |
|---|---|---|---|---|---|---|---|
| 1937—38 | 110·8 | 89·1 | 100 | 3·43 | Yes | 10·00 | 1·2 |
| 1938—39 | 116·0 | 84·0 | 100 | 2·49 | Yes | 4·40 | 1·2 |
| 1939—40 | 110·5 | 89·5 | 100 | 3·93 | Yes | 10·10 | 1·2 |

IV. **Time of application of manures:** Experiments were laid out in two series. The optimum quantities of ammonium sulphate and the best time of its application with reference to time of planting were the objects in one of the series. In the other the best time of application with reference to flowering time was determined.

(a) *With reference to planting time:* The experiment was laid out in the second crop season (winter) with a medium duration strain of rice. The results indicate that the application of ammonium sulphate fully or in part doses to supply 30 lb. nitrogen per acre a month or two after planting is more efficacious; an increased yield of 23 percent was recorded.

**TABLE X.—Time of applying ammonium sulphate with reference to planting.**

*Treatments :—*

1. Green leaf at 2000 lb. per acre.
2. As 1, plus superphosphate at 1 cwt. par acre.
3. As 2, plus ammonium sulphate to supply 30 lb. nitrogen at planting.
4. As 2, plus do. do. one month later.
5. As 2, plus do. dr. two months iater.
6. As 2, plus ammonium sulphate to supply 15 lb. nitrogen at planting plus 15 lb. nitrogen 1 month after.
7. As 2, plus ammonium sulphate to supply 15 lb, nitrogen at planting plus 15 lb. nitrogen two months after.
8. As 2, plus ammonium sulphate to supply 10 lb. nitrogen at planting plus 10 lb. nitrogen one month late plus 10 lb. nitrogen two months later.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | S.E. | 'Z' test satisfied or not | C.D. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1933—34 | 90·9 | 92·6 | 95·2 | 110·4 | 100·6 | 102·7 | 101·6 | 106·0 | 4·86 | No | 10·18 |
| 1934—35 | 85·3 | 89·8 | 96·7 | 111·3 | 93 7 | 102·8 | 109·1 | 111·4 | 3·68 | Yes | 7·65 |
| 1935—36 | 86·5 | 91·4 | 100·6 | 105·3 | 99 9 | 99·3 | 108·6 | 108·4 | 4·27 | Yes | 8 88 |

(b) *With reference to flowering:* In this series ammonium sulphate to supply 30 lb. nitrogen per acre was applied six weeks, five weeks, four weeks, two weeks, one week before and at the time of flowering. The three years' results are given in Table XI. It will be seen from these results that the application four weeks before flowering secured the best yield, followed by 5 or 6 weeks before flowering.

**TABLE XI.—Time of applying ammonium sulphate with reference to flowering.**

*Treatments*:— 1. Green leaf at 2,000 lb. per acre.
2. As 1 plus ammonium sulphate to supply 30 lb. nitrogen 6 weeks before following.
3. As 1, plus do. 5 weeks before flowering.
4. As 1, plus do. 4 do.
5. As 1, plus do. 3 do.
6. As 1, plus do. 2 do.
7. As 1, plus do. 1 do.
8. As 1, plus do. at flowering time.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | G.M. | S.E. | 'Z' satisfied or not | C.D. | Conclusions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean yields as percentage on general mean. | | | | | | | | | | | | |
| 1937—38 | 99·2 | 109·6 | 110·9 | 111·9 | 107 9 | 107·2 | 107 9 | 104·4 | 100 | 3·90 | Yes | 7·64 | 4,3,2 5,7,6 8,1 |
| 1938—39 | 91·2 | 99·9 | 98 6 | 101·5 | 88·7 | 90·9 | 86·4 | 88·8 | | | | | 4,2,3 1,6,8 5,7 |
| 1939—40 | 97·1 | 100·5 | 103·0 | 101·5 | 96·9 | 105·0 | 93·5 | 98·4 | | | | | 6,3,4 2,8,1 5,7 |

(c) The best time of applying a concentrated organic manure like groundnut cake was also determined. The cake was applied at 20 lb. and 40 lb. nitrogen per acre in full and in part doses at the time of planting and 2 and 4 weeks later. In no year were the treatment differences significant with reference to time of application, showing thereby that it could be applied at planting time or later.

V. **Other manures and combinations of manures:** (a) *Wood ashes:* It is a common practice in Malabar to apply wood ash to nurseries and broadcast crops of paddy at the time of sowing. No effect was however noticed on the yield of transplant crops when wood ash was applied to nurseries at the rate of 4,000 lb. per acre. An experiment was therefore laid out, to see if the wood ash improves the yield when applied to transplant crops. It was applied at the rate of 4,000 lb. per acre over a basal dressing of green leaf at 4,000 lb. or groundnut cake at 400 lb. per acre. The ash was applied first before transplanting. The experiment was laid out in both the seasons, autumn and winter. The results for 3 years set out in tables XII a, b and c, show that ash alone contributed to an increased yield of 5 - 11 percent and that its combination with groundnut cake rather than green leaf secured the maximum yield.

**TABLE XII.—Wood ash Experiment.**

*Treatments:*— 1. No manure.
2. Wood ash at 4,000 lb. per acre.
3. As 2, plus green leaf at 4,000 lb. per acre.
4. Green leaf at 4,000 lb. per acre.
5. As 2, plus groundnut cake at 400 lb. per acre.
6. Groundnut cake at 400 lb. per acre.

Mean yields as percentage on control.

| Ash application | | No ash | Ash | 'Z' test satisfied or not | C. D. | Conclusions |
|---|---|---|---|---|---|---|
| I Crop: | 1942—43 | 100 | 108·0 | Yes | 7·3 | Ash > No ash |
| | 1943—44 | 100 | 105·3 | No | 7·5 | |
| | 1944—45 | 100 | 109·5 | Yes | 5·8 | Ash > No ash |
| II Crop: | 1942—43 | 100 | 102 3 | No | 4·6 | |
| | 1943—44 | 100 | 122·2 | Yes | 6·2 | Ash > No ash |
| | 1944—45 | 100 | 111 8 | Yes | 7·1 | Ash > No ash |

**Basal Dressings**

| | | No basal dressings N. B. | Leaf G. L. | Groundnut cake G. N. C. | 'Z' test satisfied or not | C. D. | Conclusions |
|---|---|---|---|---|---|---|---|
| I Crop: | 1942—43 | 100 | 113·7 | 113·6 | Yes | 9·9 | GL, GNC, NB. |
| | 1943—44 | 100 | 107·2 | 112·0 | Yes | 8·5 | GNC, GL, NB. |
| | 1944—45 | 100 | 110·7 | 109·3 | Yes | 7·1 | GL, GNC, NB. |
| II Crop: | 1942—43 | 100 | 111·1 | 106·7 | Yes | 5·7 | GL, GNC, NB. |
| | 1943—44 | 100 | 113·8 | 119·8 | Yes | 7·4 | GNC, GL, NB. |
| | 1944—45 | 100 | 111·1 | 112·4 | Yes | 10·0 | GNC, GL, NB. |

**Interactions**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 'Z' test satisfied or not | C. D. | Conclusions |
|---|---|---|---|---|---|---|---|---|---|---|
| I Crop: | 1942—43 | 100 | 108·7 | 120·5 | 116·7 | 125·9 | 110 1 | Yes | 13·9 | 5, 3, 4, 6, 2, 1 |
| | 1943—44 | 100 | 113·0 | 117·4 | 110·2 | 122·7 | 115·1 | Yes | 12·0 | 5, 3, 6, 2, 4, 1 |
| | 1944—45 | 100 | 110·6 | 118·1 | 115·0 | 123 5 | 108·4 | Yes | 9·9 | 5, 3, 4, 2, 6, 1 |
| II Crop: | 1942—43 | 100 | 104·2 | 117·2 | 119·7 | 111·3 | 106·6 | Yes | 8·0 | 3, 4, 5, 6, 2, 1 |
| | 1943—44 | 100 | 115·8 | 136·3 | 109·0 | 143·5 | 115·0 | Yes | 10·6 | 5, 3, 2, 6, 4, 1 |
| | 1944—45 | 100 | 116·1 | 120·0 | 120·0 | 128·5 | 114·0 | No | 12·2 | |

(b) *Fish guano:* Fish and fish products are always available in some quantities on the West Coast. It is considered to be a good manure for paddy but its effect in incremental doses remained to be investigated. Fish guano was applied at the rate of 200 lb. to 400 lb. per acre with and without green leaf at 2,000 lb. and 4,000 lb. per acre. From the trend of the results in table XIII it would appear that a higher dosage than 400 lb. per acre is necessary to equal the effect of leaf at 4,000 lb. per acre. Fish guano at 400 lb. per acre is as good as leaf at 2,000 lb. giving on an average 14 per cent increased yield over 'no manure'.

**TABLE XIII.—Fish Guano Experiment**

*Treatments* :— 1. No manure. (control)
2. Green leaf at 2000 lb. per acre.
3. Green leaf at 4000 lb. per acre.
4. Fish guano at 400 lb. per acre.
5. Fish guano at 200 lb. per acre.
6. Fish guano at 200 lb. per acre plus green leaf 2000 lb.p er acre.
7. Do. 200 plus d. do.

**Mean yields as percentage on control**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 'Z' test satisfied or not | C. D. | Conclusions |
|---|---|---|---|---|---|---|---|---|---|---|
| I Crop : | | | | | | | | | | |
| 1944—45 | 100 | 111·6 | 124·4 | 118·6 | 110·0 | 128·0 | 118·6 | Yes | 6·5 | 6,3,4,7,2,5,1. |
| 1945—46 | 91·4 | 98·6 | 111·8 | 97 5 | 91·4 | 108·2 | 101·1 | Yes | 11·7 | 3.6,7,2,4,5,1. |
| II Crop : | | | | | | | | | | |
| 1944—45 | 100 | 113·6 | 120·9 | 127·5 | 109·6 | 125·2 | 113·9 | Yes | 10 2 | 4,6,3,7,2,5,1. |

(c) Phosphatic manures did not give consistent results when applied either alone or in combination with green leaf or ammonium sulphate. It was therefore proposed to try superphosphate alone and in combination with manures like groundnut cake and wood ash. The details of the experiment and the results for two seasons are brought out in table XIV. It will be seen that the results, so far as the effect of superphosphate is concerned are inconclusive.

**TABLE XIV.—Groundnut cake, Wood ash and Superphosphate.**

*Treatments* :— 1. Green leaf at 2000 lb. per acre.
2. As 1, plus cake at 500 lb. per acre.
3. As 1, plus superphosphate 200 lb. per acre.
4. As 1, plus wood ash at 4000 lb. per acre.
5. As 1, plus cake 500 lb. plus superphospate 200 lb.
6 As 1, plus cake 500 lb. plus ash 4000 lb.
7. As 1, plus superphosphate 200 lb. plus ash 4000 lb.
8. As 1, plus superphosphate 200 lb. plus cake 500 to plus ash 4000 lb.

**Mean yields as percentage on General Mean.**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | G.M. | S.E. | 'Z' test satisfied or not | C.D. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 68·6 | 104·3 | 97·1 | 97·6 | 104·8 | 113·3 | 103 3 | 107·5 | 100 | 3·04 | Yes | 6·32 |
| II | 93·2 | 105·1 | 95·6 | 95·6 | 109 7 | 101·5 | 97·9 | 101·5 | 100 | 3·80 | Yes | 7·90 |

Conclusion :— I.—6, 8, 5, 2, 7, 4, 3, 1.
II.—5, 2, 6, 8, 7, 4, 3, 1.

(d) *Compost manure:* In order to put all the farm wastes into use, they were made into compost and their value as a manure was determined in comparison with farmyard manure on equivalent nitrogen basis. The experiment was laid out in dry paddy and the results are encouraging. The figures for the past two seasons indicate that compost is equivalent to farmyard manure and an increase of 13·8 per cent over 'no manure' was recorded. The experiment is being continued.

VI. **Discussion of Results:** The results would show that the laterite soils of Malabar do not uniformly respond to phosphatic fertilisers like bonemeal, basic silicophosphate, Kossier phosphate and superphosphate when applied even at the rate of 50 lb. phosphoric acid per acre. The effects in combination with nitrogenous and potassic manures also have been inconclusive. Other commercial products like Ultraphos, containing 22 per cent phosphoric acid and Reno hyper phosphate having 28—30 per cent $P_2O_5$ were also tried without any appreciable effect. It is known that the soils contain large percentages of iron and alumina in the presence of which the phosphates are converted into a form unavailable to the plants. The whole problem of phosphate deficiency and its effective application have therefore to be studied in a more intensive manner.

Though the soils on the West Coast are deficient in lime, its application as calcium carbonate at the rate of 2,000 lb. per acre showed very little effect. Experiments are under way to assess its influence at higher doses with and without a combination of green leaves and ammonium sulphate, lime being applied at three doses 1,000, 2,000 and 3,000 lb. per acre. The trend of the results so far indicate that an increased yield up to 24 per cent is recorded by applping lime at 3,000 lb. per acre. Such a large dose is hardly economical, but a study of this type with concurrent analyses of soil would throw light on the reaction and requirement of the soil and the best way of its exploitation for increased crop production.

Of the potassic manures, wood ash has some effect in enhancing the yield of rice. Its application has its limitations, as about 4,000 lb. per acre have to be applied for any appreciable increase in yield. It has the best effect in combination with groundnut cake which has secured 15% increased yield. Potash in the form of potassium sulphate also, it may be mentioned, had very little effect when applied at 60 lb. $K_2O$ per acre. Wood ash is generally applied to the nurseries, presumably for reasons other than improving the yield. Experiments have shown however, that its application at the high rate of 4,000 lb. per acre to the nursery did not influence the yield of transplant crop.

The most important point that is observed in all the manurial experiments is the consistent response of rice to nitrogen, organic or inorganic. It will be seen from the results that each of the three manures namely green leaf, groundnut cake and ammonium sulphate to supply 30 lb. nitrogen which works out to 4,000 to 5,000 lb. of leaf, 400 lb. of groundnut cake and 150 lb. of ammonium sulphate per acre, brings about an increased yield of 30 per cent or 400 lb. of paddy (rice in husk) per acre. There is progressive increase in yields up to 60 lb. nitrogen/acre but 40 lb. nitrogen per acre would appear to be the optimum. The best combination would be a dose of 4,000 lb. of green leaf or 400 lb. of groundnut cake as a basal dressing and 75 lb. of ammonium sulphate per acre as a top dressing. Consistent with economy the dosage could be proportionately increased to a limit of 60 lb. nitrogen per acre.

It has also been possible to fix the best time at which the manures are to be applied for maximum production. Groundnut cake can be applied at the time of planting or sometime after. A month before flowering is the best time for ammonium sulphate. For short duration varieties of 100 to 130 days the time would coincide with a month after planting and in the case of long duration varieties about 2 months after planting.

Fish guano could be applied with advantage along with green leaf. An increase of 14% is obtained by its application at the rate of 400 lb. per acre at which rate it is as efficacious as green leaf at 2,000 lb. per acre.

While the cost and availability should decide the choice of manures like groundnut cake, wood ash and fish guano, it is necessary that every farmstead should aim at self-sufficiency as regards green leaf and cattle manure. Trials have shown that green leaf could be applied up to 8,000 lb. per acre with advantage. It can be supplemented by cattle manure on equal nitrogen basis. The green leaf could be brought from outside or sown and ploughed 'in situ.' As a result of large-scale trials, it has been found that wild indigo, *Daincha, Crotalaria striata* and *Sesbania speciosa* are the best-suited green manures for Malabar.

Grown as a mixed crop with horse gram after paddy in single crop lands, wild indigo would give on an average 2,000 lb. of green matter per acre for the following paddy crop. *Daincha* and *Crotalaria striata* grown in double crop lands after harvest of winter paddy have yielded on an average 8,000 lb. each to an acre and *Sesbania speciosa* over 9,000 lb. per acre. Planted along field bunds, 2 lb. of seeds of *Sesbania speciosa* or 150 lb. of green matter could be obtained from every 100 feet of bund.

VII. **Present and future lines of work:** Since the soils are found to be deficient in lime and phosphoric acid, the reason for the lack of response to lime and phosphatic manures needs more intensive investigation. Experiments are under way to find out their influence in heavy dosages in combination with organic manures. Incremental doses upto 60 lb. $P_2O_5$ per acre over incremental doses of green manure are included in one experiment. The study of laterite soils with reference to their iron and alumina content is also envisaged.

Application of phosphatic manures to leguminous green manure crops (after the TVA plan) would appear to be promising. The investigation is to be continued with *daincha* in double-crop lands and wild indigo in single-crop lands.

Manuring of the broadcast crop of autumn rices is a problem that has not been tackled adequately on the West Coast. Trials have indicated that green leaf could be brought and applied to such crops or green manures could be sown as a mixture at the time of sowing paddy and incorporated later. Another line of work is to manure the winter crop intensively and see if this would obviate the necessity of a basal dressing for the following autumn crop without impairing the fertility of the soil.

VIII. **Summary:** 1. Experiments conducted with nitrogenous, phosphatic and potassic manures conducted at the Agricultural Research Station, Pattambi for two decades have been reviewed.

2. The results with phosphatic and potassic fertilisers were in the inconclusive. Wood ash at the rate of 4,000 lb. per acre gave 15 percent increased yield. Its best combination is with groundnut cake. Fish guano at 400 lb. per acre was found to be as efficient as green leaf at 2000 lb.; an increased yield of 14 percent was recorded.

3. There is consistent response to nitrogen, increased yield being obtained with increasing closes up to 60 lb. nitrogen per acre.

Green leaf at 5,000 lb.; groundnut cake at 400 lb. and ammonium sulphate at 150 lb. per acre to supply 30 lb. nitrogen secured on an average 30% increased yield. The best combination would be a basal dressing of leaf at 4,000 lb. per acre and ammonium sulphate at 75 lb. per acre as top dressing. The dose of nitrogen could be proportienately increased up to 60 lb. per acre.

4. It has been found that groundnut cake can be applied either at planting time or two to four weeks after planting. The best time for ammonium sulphate is a month before flowering.

5. The possibility of growing ones' own green manures and production of seeds are outlined.

6. Dry paddy was found to respond as much to compost manure as farmyard manure, recording an increased yield of 13·1%.

7. Future lines of work are indicated with reference to lime and phosphatic manures and green manure crops.

IX. **Acknowledgment:** Thanks are due to members of the staff of Agricultural Research Station Pattambi, past and present, who were directly or indirectly connected with the conduct of manurial experiments and to Sri M. B. V. Narasinga Rao, Paddy Specialist, Coimbatore, for guidance and help at all times.

## X. Bibiliography:

1. Ramiah K. (1936) Rice in Madras. A popular handbook.
2. Copeland E. B. (1934) Rice. Macmillan and Co., London.
3. Narasinga Rao M. B. V. and Kunhikannan Nambiar K. (1948) The problem of Rice production in Malabar and its solution. The Madras Agri. Journal, Vol. XXXV 3, p. 17.
4. Annual Reports of the Agricultural Research Station, Pattambi, 1933—'34 to 1950—'51.

# The Importance of Liming to the Paddy Soils of South Kanara

*By*

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I. **Introduction:** Favoured with an annual rainfall of over 150 inches and made up largely of hills and valleys, the district of South Kanara is a land of rivers and abundant vegetation. While the rainfall provides an assured supply of water for one crop in normal seasons. its distribution over a short period of four months from June to September, with downpours lasting sometimes for days at a stretch, causes an appalling amount of erosion with all its attendent evils. Year after year, the best part of the soil is washed away into the sea and valuable plant foods are lost by leaching. Under natural conditions, it is probable that the greater part of this erosion would have been effectively checked by nature's own mechanism. When one sees the sudden emergence of green pasture after the first showers in May—June, one is tempted to think that the pre-monsoon showers followed by a short break are intended by nature to prepare the ground to face the rigours of the monsoon. But cultivation practices as adopted by the average ryot pay scant regard to soil conservation practices, so that a serious situation is created in the agriculture of the district.

The poor fertility of the soils of South Kanara is evident from the fact that the yields of important crops like paddy, sugarcane and sweet potato grown in this district are practically the lowest in the whole State of Madras. With the exception of small stretches of land near rivers where the effect of erosion is set off by the deposition of silt during floods, the soil is shallow and mostly sandy. It may indeed appear strange that in a land of such plentiful rainfall, the average cultivator often has an anxious time even during the main season, because even a few days' break in the monsoon causes the plots in the single-crop area (which constitutes the major portion under paddy) to dry up and seriously affect the yields. Compare this low retentivity with that of certain other parts like Nellore, where, despite the lower annual rainfall, it is stated that the paddy plots retain moisture for a period of over three weeks.

Chemical analysis reveals a decidedly acidic reaction and a low lime status in the soils of South Kanara; the pH in most cases ranging from 5·5 to 6. Here then may be the key to the entire problem of low fertility and poor retentivity associated with these soils. Crops like paddy and sugarcane prefer a neutral medium for their best growth and it is natural to presume that raising the pH of the soil cannot fail to exert a favourable effect on yields. Lime is a great binding material and the lack of it may be the factor responsible for the poor retentivity of the soils. The presence of lime in the soil promotes the oxidation of the organic matter and lime has an essential role in the conversion of ammoniacal nitrogen into nitrates. In the absence of sufficient lime in the soil, the soluble form of monocalcic phosphate is converted into phosphates of iron and alumina which are virtually unavailable to plants. When it is further realised that most of the bacteria, which are now definitely established to be essential for keeping the soil healthy and active, also prefer a neutral reaction, one can visualise the chain of ill-effects that can result from a lack of this important substance in the soil. Bacteria play a special role in paddy soils by helping in the aeration of roots. The direct manurial effect of lime has also to be considered. An example commonly cited to prove the inadequacy of lime in the soils of South Kanara is the poor build of the local cattle which apparently results from the lack of calcium in the feed. It may not be out of place to mention here that the inclusion of mineral mixture, as practised on the Paddy Breeding Station, Maugalore in the feed of cattle, was found to be very helpful in improving their growth and general condition.

D. N. Wadia in his "Soils of India" gives a critical account of the nature of the soils of West Coast. (6). "Laterite soils," says the author, "are composed of highly ferruginous and aluminous clay, poor in alkalies and alkaline earths, lime and magnesia being notably deficient. Laterite being largely a product of monsoonic regions with their alternate dry and moist conditions, leaching action in these soils is complete, with the result that they are denuded of exchangeable bases and other fertilizing constituents, giving to the soil a more or less marked acid reaction. Because of the intensive leaching and low base exchange capacity, typical laterite soils are lacking in fertility and are of little value for crop production."

**Materials and Methods:** With the conviction that liming may prove the solution to many of the ills of South Kanara soils, an experiment was started at the Paddy Breeding Station, Mangalore, in 1948, to assess the value of lime in increasing paddy yields. A split-plot technique was employed with leaf at 4.000 lb. per acre and no leaf as the main treatments. The second crop season was chosen for the trial as the application of lime during the first crop season is attended with certain practical difficulties on account of the heavy rains and the possibility of the lime getting washed out of the plots. A plot with an assured supply of water in the lower area of the station was selected for the trial. Four replications were used, the treatments being randomized in each replication. The size of the sub-plots was about one cent each and the strain used was PTB. 19, a selection from the standard local variety of *Athikraya*. Lime was applied and incorporated about ten days before planting. The soil from the field was analysed for pH value and lime content before starting the experiment. Lime being more an indirect than a direct manure, it was programmed to observe the residual effect of the application on the succeeding crop of first crop paddy and the experiment was conducted for a period of three seasons. The residual effect of the application in 1950—'51 is under observation in the field. The soil from each treatment was analysed after each year's trial.

The summary of the results of the experiments for the past three seasons is presented in the following tables.

4. **Discussion:** (Tables I–A, I–B and II). It is seen from the tables that application of lime at doses of 1,000 to 3,000 lb. per acre results in increased grain yields of 10 to 20 per cent during the second and third years of application. There was also a residual effect of lime on the subsequent crop, though this was less conspicuous. Table II shows a rapid rise in the pH of the soil with each years' application, the treated plots being nearly neutral or on the alkaline side at the end of the third year as against the untreated plots where the pH had more or less remained constant. The effect of lime in altering the pH is more perceptible in the leaf series than in the 'no leaf' series, but statistical significance of interaction is, however, observed only during the second year of application. The lime status of the soil has increased correspondingly with increased dosage of lime. The progressive fall in N content perceptible with increased dosage of lime is attributable to the greater utilisation of this plant food resulting from higher yields. This is supported by the fact that in treatment 7 (leaf 2,000 lb.) where the average acre yield has been slightly lowered by vitiating factors, the N content has registered a sudden rise. In other words, the fall in N content is the direct result of increase in yields.

The analysis of the first year shows a more or less progressive increase in the amount of available $P_2O_5$ with increased doses of lime. No phosphatic fertiliser had been applied directly to the crop but super phosphate had been applied to the plot at rates varying from 100 to 150 lb. per acre during the three seasons preceding the experiment. This aspect of the action of lime in the soil gains added importance from the fact that "ninety per cent of the soils of the district are deficient in phosphoric acid" (5). It may be questioned, however, why, as in the case of N content the available $P_2O_5$ also does not progressively fall with increases in yields. While one has to admit that soil reactions are complex and often baffling, the explanation may lie in the fact that the available $P_2O_5$ found in the analysis may represent the portion rendered available during the period between the harvest of of the crop in January and the taking of soil samples in April. A more remote possibility is that the $P_2O_5$ rendered available is in excess of the requirements of the crop.

Unlike in the case of most other manures including green leaf, residual effects of liming are observed even after the very first application. This aspect of the question deserves further study as it is possible that the effects may continue for a few years.

The economic aspect of the application of lime is a point which, may be mentioned in passing. The cost of 2,000 lb. of lime at the local rate works out to about Rs. 80/- and the average ryot may rightly be unwilling to invest this amount, considering that it is out of proportion to the advantage gained. The sale of lime at a subsidised rate for manurial purposes in South Kanara is a subject that may be fruitfully considered. It may also be possible for well-to-do landlords to invest some capital for two or three years in the shape of liming and make them fertile in the long run.

**Conclusion:** The trials conducted so far indicate the decisive role played by lime in increasing paddy yields. Several aspects of the application of lime require fuller investigation. The trial was conducted in the double crop area and effect of application to single crop areas remains to be seen. Even in single crop areas, it is worth considering whether lime is best applied directly to the paddy crop or indirectly by being applied to the pulse crop preceding paddy. The effect of liming on soil retentivity and the effect on cattle of straw and grass grown over limed plots are worth investigation. An experiment has been started at the station to investigate the deleterious effects, if any, of the continuous application of ammonium sulphate to the soils of South Kanara. Since the chief argument against the use of ammonium sulphate is that it depletes the soil of its lime content, it would be worth investigating how far using ammonium sulphate (indirectly) in conjunction with lime would set off the bad effects.

It may be of interest to know that in an experiment conducted on similar lines at Woburn, the application of ammonium sulphate at the rate of 2 cwts. per acre for several years in succession made the soil absolutely barren, the result being attributed to the acidification of the soil. With the same treatment, excellent crops were obtained throughout the period on adjoining plots to which lime was added. Despite the fact that the soils of South Kanara are highly deficient in phosphoric acid, the use of superphosphate on these soils does not ordinarily produce marked improvements in yields, the poor response being attributed to the low lime status of the soils which results in the conversion of the soluble phosphates into phosphates of iron and alumina. An experiment to assess the value of lime in increasing the effectiveness of phosphatic manures would therefore be useful. The above two problems assume special importance today since the use of artificial manures offers one of the quickest methods of increasing food production.

## REFERENCES

1. Madras Agricultural Station Reports 1933—34.
2. ,, ,, ,, ,, 1934—35.
3. ,, ,, ,, ,, 1935—36.
4. Venkataramiah, P. Soils of Madras Presidency. Madras Agricultural Journal, Vol. 32, p. 197.
5. Viswanath, B. — Principles of manuring Paddy. Madras Agricultural Journal (1928).
6. Wadia, D. N. — Soils of India. Madras Agricultural Journal, Vol. 3, p. 79.
7. The Science of Soils and Manures — by J. Alan Murray. Pages 84 to 90 and 193.

TABLE I

*Summary of Residual Effects of Lime*

(i)—Doses of lime.

| Particulars. | | 0 | 1000 lb. | 2000 lb. | 3000 lb. | General Mean | 'Z' Test Satisfied or not | Critical Difference. |
|---|---|---|---|---|---|---|---|---|
| Acre Yield in lbs. | 1949–'50 | 1974 | 2024 | 2138 | 2143 | 2070 | Yes. | 112·6 |
| do. | 1950–'51 | 2428 | 2496 | 2571 | 2620 | 2529 | Yes. | 106·0 |
| Percentage on Control | 1949–'50 | 100 | 102·5 | 109·6 | 110·2 | 105·6 | Yes. | |
| do. | 1950–'51 | 100 | 102·8 | 106·0 | 108·0 | 104·2 | Yes. | |

(ii) Interactions.

| Particulars. | | No Leaf Series Lime at (lb./acre) | | | | Leaf Series Lime at (lb./acre) | | | | General Mean. | 'Z' Test Satisfied or not. | Critical Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1000 | 2000 | 3000 | 0 | 1000 | 2000 | 3000 | | | |
| Acre yield in lb. | 1949–'50 | 1929 | 1985 | 2175 | 2161 | 2020 | 2063 | 2154 | 2189 | 2085 | No | ... |
| do. | 1950–'51 | 2344 | 2450 | 2541 | 2564 | 2511 | 2541 | 2602 | 2677 | ... | ... | ... |
| Percentage on General Mean. | 1949–'50 | 92·6 | 95·3 | 104·4 | 103·8 | 97·0 | 99·0 | 103·5 | 105·0 | 100·0 | No | ... |
| do. | 1950–'51 | 92·7 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |

TABLE I-(a.)

(i)—DOSES OF LIME.

| Particulars. | | 0 | 1000 lb. per acre | 2000 lb. per acre | 3000 lb. per acre | General Mean. | 'Z' Test Satisfied or not | Critical Difference |
|---|---|---|---|---|---|---|---|---|
| Acre yield in lb. | 1948–'49 | 1833 | 1895 | 1955 | 1980 | 1916 | Yes. | 75·23 |
| do. | 1949–'50 | 1878 | 2091 | 2171 | 2279 | 2105 | Yes. | 110·7 |
| do. | 1950–'51 | 1485·4 | 1621 | 1652 | 1755 | 1628 | Yes. | 113·63 |
| Percentage on Control | 1948–'49 | 1007 | 103·4 | 106·7 | 108·1 | 104·6 | Yes. | ... |
| do. | 1949–'50 | 100 | 111·4 | 115·6 | 121·4 | 112·4 | Yes. | ... |
| do. | 1950–'51 | 100 | 109·1 | 111·2 | 118·2 | 109·6 | Yes. | ... |

(ii) INTERACTIONS.

| Particulars. | | *No Leaf Series.* Lime at (lb./acre) 0 | 1000 | 2000 | 3000 | *Leaf Series.* Lime at (lb./acre) 0 | 1000 | 2000 | 3000 | General Mean | 'Z' Test Satisfied or not | Critical Difference. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acre Yield in lb. | 1948–'49 | 1697 | 1832 | 1874 | 1887 | 1968 | 1958 | 2035 | 2074 | 1916 | No | |
| do. | 1949–'50 | 1681 | 1966 | 2069 | 2274 | 2074 | 2217 | 2274 | 2285 | 2105 | Yes. | 156. |
| do. | 1950–'51 | 1281 | 1408 | 1519 | 1549 | 1690 | 1835 | 1789 | 1962 | 1629·1 | No | |
| Percentage on General Mean. | 1948–'49 | 88·6 | 95·6 | 97·8 | 98·5 | 102·7 | 102·2 | 106·3 | 108·3 | 100·0 | No | |
| do. | 1949–'49 | 79·9 | 93·4 | 98·3 | 108·0 | 98·6 | 105·3 | 108·0 | 108·6 | 100·0 | Yes. | 7·43 |
| do. | 1950–'51 | 78·6 | 86·4 | 93·2 | 95·1 | 103·7 | 112·6 | 109·0 | 120·4 | 100·0 | No | |

TABLE II.

*Chemical analysis of soil samples taken from different treatments during the period—1948 to 1951.*

| Heads of Analysis | No Leaf Series. Lime at (lb /acre) 0 | 1000 | 2000 | 3000 | Leaf Series. Lime at (lb./acre) 0 | 1000 | 2000 | 3000 | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| pH—Before Trial | 6·21 | | | | | | | | |
| pH—After first application | 5·61 | 5·54 | 5·47 | 5·64 | 5·64 | 5·57 | 5·40 | 5·74 | Samples taken after Harvest; April '49 |
| pH—After second application | 5·97 | 6·48 | 6 75 | 7·01 | 6·88 | 6·71 | 6·94 | 7·11 | do. March '50 |
| pH—After third application | 6·14 | 6·92 | 8·08 | 8·16 | 5·88 | 6·94 | 7·98 | 8·18 | do. March '51 |
| Total lime before trial | 0·066% | | | | | | | | |
| do. After third application, | 0·101 | 0·1563 | 0·2867 | 0·3133 | 0·0652 | 0·165 | 0·2179 | 0·3987 | Samples taken after Harvest. |
| Available $P_2O_5$ after first application | 0·0075 | 0·0069 | 0·0080 | 0·0096 | 0·0070 | 0·0081 | 0·0088 | 0 0095 | do. |
| Nitrogen % after third application | 0·1812 | 0·1525 | 0·1427 | 0·1313 | 0·1626 | 0·1542 | 0·1584 | 0·1584 | do. |

# Manurial Experiments on Rice in W. Godavari, (District Trials)

*By*

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To maintain the food supply for an ever-increasing population, every endeavour will have to be made for conserving soil fertility. The productive power of soils is steadily reduced when successive crops are grown and no adequate manuring is made. The chief food crop in Madras, paddy, (occupying nearly 11 million acres in the State) removes from an acre of soil, 48 lb. of Nitrogen, 23 lb. of Phosphoric acid and 41 lb. of Potash Nitrogen and Phosphoric acid are the two important elements that are required for paddy, as our soils are sufficiently rich in Potash. The main sources of manure for agricultural purpose is farm-yard manure, compost, green manures, "Patti mannu", and oil cakes. The availability of these manures to the area cropped is insufficient. To meet our immediate needs, the only way is to go in for chemical manures — ammonium sulphate and superphophate — which supply the two main elements required for the paddy crop.

The results of a large number of field experiments showed that concentrated nitrogenous manures and phosphatic fertilisers have given increased yields of paddy. They are advocated to be applied in conjunction with organic manures, like cattle manure, green manure, compost and tank silt.

In a review of the experiments conducted since 1930, the Department of Agriculture have clearly shown that increased yields of paddy are secured by judicious doses of fertilisers.

**Measures taken by the Agricultural Department in increasing production, through manuring paddy:** The Madras Government sanctioned a Scheme to supply chemical manures to a tune of 60 lakhs of rupees through interest-free loans for manuring first crop paddy in all districts, where water supply is assured. The Scheme commenced with the manuring period of the first crop paddy in ten districts.

The benefits derived by the ryot were:

1. 100 lb. of ammonium sulphate and 50 lb. of Superphosphate valued at about Rs. 25/- are supplied for each acre.
2. A maximum amount of Rs. 200/- is given to a ryot if he possesses eight acres.
3. Superphosphate is supplied at half cost.
4. Manures are supplied through manure depots within a short distance of each village.

5. Loans are free of interest, repayable in March, 1951, after the harvest and sale of the 1st crop paddy.

6. Ryots who took loans in cash and in kind previously, were not debarred from the manure loans.

The normal area under paddy in West Godavari is 7,00,000 acres irrigated and 39,700 acres rain-fed. The average yield is 2,000 lb. per acre. Manuring of paddy on a limited scale. An intensive drive to give the maximum help to the ryot in a short time was launched. 7,557 ryots were supplied with 2,066 tons ammonium sulphate and 327 tons of superphosphate on loans. Besides the above, nearly 6,000 ryots were supplied with 1,471 tons of ammonium sulphate and 98 tons of superphosphate on cash payment between July last week and October. The total cost worked out to 15 lakhs and covered 700 villages, with an area of 80,000 acres.

To assess the increased yield obtained by the application of chemical manures alone and in conjunction with organic manures over no manure, experimental plots were laid out at the rate of 5 villages per each firka to a total number of about 150 experiments. A summary of results of these experiments is given below. They are in conformity with the yield obtained from the manured fields, other than the experimental plots, all over the district.

1. Ammonium sulphate at 100 lb. with superphosphate at 50 lb. per acre an increased yield of 3 to 5 bags per acre. [Each bag of paddy weight 150 lb.].

2. Ammonium sulphate alone at 100 lb. per acre recorded 2 to 3 bags per acre.

3. Superphosphate alone at 100 lb. per acre and cakes at 320 lb. per acre, gave 1 to 2 bags increased yields in rich soils.

4. One bag of cake and 50 lb. of ammonium sulphate gave 3 bags of increased yield.

5. Green leaf (60 bundles each weighing 50 lb.) when applied with 100 lb. of ammonium sulphate gave 5 bags increase.

6. Application of ammonium sulphate at 100 lb. and superphosphate at 50 lb. in alkaline and saline lands gave 4 to 8 bags increased yields.

7. In areas where there was a good vegetative growth but poor-sized earheads with chaffy grains, superphosphate alone when applied at doses of 25 to 100 lb. per acre gave increased yields of 2 to 5 bags. In such lands the application of superphosphate alone is better than ammonium sulphate alone or a mixture of ammonium sulphate and superphosphate.

8. The percentage in increased yields due to chemical manuring was comparatively higher in loamy and sandy soils than in black *regur*, the difference in increased yield being 2 to 4 bags.

9. Chemical manures applied twice in equal doses, one at the time of weeding and the other at the time of boot stage gave one bag increased yield over plots manured with the same quantity of manures in one dose, at the time of weeding.

10. Application of ammonium sulphate of 100 lb. even at boot stage, to *Basangi* crop (M. T. U. 3) gave an increased yield of 240 lb. to 320 lb.

11. The emergence of the panicle and flowering was uniform and was completed a weeks earlier in the manured plots than in unmanured plots.

12. Plots manured a week before they were submerged due to heavy rains recorded 2 to 3 bags increased yields over unmanured plots.

13. Seedlings raised from manured nursery are of good growth but do not contribute to increased yield if the main field is left unmanured.

14. Application of chemical manures at 100 lb. ammonium sulphate and 50 lb. superphosphate recorded a net profit of Rs. 18/- to Rs. 50/- per acre.

15. Every pound of ammonium sulphate applied resulted in 3 to 7 lb. increased yields of paddy.

# Economic Dose of Groundnut Cake (as Manure) for Enhancing Yields of Irrigated Ragi,

*By*

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In the Grow More Food Campaign one of the ways recommended for stepping up production is manuring of crops. *Ragi* is an important crop among millets grown under irrigated conditions and as a staple food crop it is important in districts like Salem, Visakhapatnam, Chicacole and Coimbatore, where the crop is cultivated extensively. This grain crop is usually manured either with farmyard manure, or by sheep penning. But in these methods due to limited availability of the manures, either increasing the dosage or extending the area of application possible beyond is a certain limit. As an alternative groundnut cake is being advocated by the Agricultural Department, since large quantities of the same are available in districts growing groundnut and having oil-extracting mills. With the idea of finding out the economic dose of this manure to *ragi* grown under irrigated conditions, investigations were done at the Sugarcane Research Station, Anakapalle, during the period 1946 to 1949 and the results are summarised in this note.

In Visakhapatnam dirstrict *ragi* is grown in all the three seasons of the year, (viz) "Early" (*Punasa*, May – August) "Main" (*Pedda panta*, August – December) and "late" (*Pyru*, December – April). The first season crop is grown under partly irrigated and partly rainfed conditions taking advantage of the rains received during this season and supplementing by lift irrigation, while the next is entirely grown rainfed. It is only in the "late" season that a purely irrigated crop is raised and therefore the investigations were confined to this season only. Groundnut cake was applied on nitrogen basis at four levels supplying, (1) 50 lb.-N, (2) 40 lb.-N, (3) 30 lb.-N and (4) 20 lb.-N per acre. These were compared with farmyard manure applied in two doses, (1) 10 tons per acre and (2) 5 tons per acre (taking the last as standard, being the rate at which the ryots apply). The experiment was laid out in randomized plots of 44 x 30 links size (net 40 x 25 links or 1 cent), replicated six times. AKP. 3. *ragi* strain was used for planting and seedlings of about a month in age were planted at $\frac{3}{4} \times \frac{3}{4}$ link spacing. The results are summarised below.

The results show that with progressive increase in the dosage of the manure, there was progressive increase in yield as well; 50 lb.-N gave the best yields closely followed by 40 lb.-N supplied in the form of groundnut cake. But the enhancement in yields is not proportionate to the increased dosages of manure. The rates of grain yield per pound of nitrogen applied in the form of groundnut cake or farmyard manure varied from treatment to treatment. Higher levels of nitrogen gave yields at low rates and lower levels of nitrogen gave high rates of grain yields, in both the kinds of manures. Thus, the response to manure was high in the case of lower levels of manure and diminished as the dosage increased. The extra yields got by additional dosages of manure at higher levels were proportionally low. So at some stage the yields could not compensate the extra cost of manuring. Comparing the net profits got in the case of different levels of manure it can be seen that the margin of profit was the same in both 50 lb. - N and 40 lb. - N treatments and though the former gave higher yields than the latter, the increase of yield was only just sufficient to cover the cost of manure, and left no extra profit. Hence 40 lb. - N supplied in the form of groundnut cake is recommended as the economic dose for irrigated *ragi*, grown under similar conditions as those at Anakapalle. It is considered not profitable to use groundnut cake at higher levels than 50 lb. - N per acre under such conditions.

**MANURIAL TRIALS ON RAGI — SUGARCANE RESEARCH STATION, ANAKAPALLE**

**(1946 - '47 to 1948 - '49)**

SUMMARY OF RESULTS

*Grain and Straw Yields in lb. per acre*

| Treatments (Manure per acre) | 1946—47 | | 1947—48 | | 1948—49 | | Average | | Increased grain yield over control (%) | Net profit over control (%) | Grain yield per pound of N. applied (lb.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw | Grain | Straw | | | |
| *Groundnut cake* | | | | | | | | | | Rs. | lbs. |
| (A) @ 50 lb. N ... | 2088 | 3017 | 1950 | 2933 | 1120 | 1616 | 1719 | 2522 | 42 | 26 | 34·4 |
| (B) @ 40 lb. N ... | 1982 | 2950 | 1779 | 3033 | 1059 | 1467 | 1607 | 2483 | 33 | 24 | 40·2 |
| (C) @ 30 lb. N ... | 1898 | 2700 | 1748 | 2750 | 878 | 1217 | 1508 | 2222 | 24 | 23 | 50·3 |
| (D) @ 20 lb. N ... | 1676 | 2300 | 1671 | 2633 | 781 | 1133 | 1376 | 2022 | 14 | 16 | 68·8 |
| (E) Farmyard manure ... | 1751 | 2733 | 1573 | 2917 | 725 | 1083 | 1340 | 2244 | 11 | 5 | 15·3 |
| (F) F.Y.M. 5 tons (control) ... | 1500 | 2233 | 1389 | 2517 | 746 | 1083 | 1212 | 1944 | ... | ... | 27·7 |
| General mean ... | 1816 | 2655 | 1685 | 2789 | 885 | 1267 | ... | ... | ... | ... | ... |
| Standard Error of the Mean ... | 113 | 168 | 115 | 139 | 36 | 71 | ... | ... | ... | ... | ... |
| If significant by Z test (P=05) | Yes | Yes | Yes | Yes | Yes | Yes | ... | ... | ... | ... | ... |
| Critical Difference (P=·05) ... | 328 | 488 | 334 | ... | 105 | 202 | ... | ... | ... | ... | ... |

# Methods of Increasing Production in Coconut

*By*

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Coconut is an important industrial crop of India and is intimately connected with the economic and domestic life of the inhabitants of the coconut tracts of the country, India ranks third in world acreage and production accounting for about 3,000 million coconuts or 2 lakhs tons of copra from about 1·5 million acres under the coconut. Of India's 1·5 million acres more than a million acres are in Kerala, the remaining being distributed over South Kanara, East Godavari and Tanjore Districts of the Madras State and the States of Mysore, Orissa, Bombay and Bengal.

India has, now become from being an exported of coconut oil 25 years ago, a net importer of coconut oil and copra. This is due to the fall in the production of coconuts and the growing demand for the coconut oil resulting chiefly from the increase in population and improvement in the industrialisation of the country. Unfortunately, the production of coconut has remained more or less static and the imports of copra and coconut oil have been falling steadily. Prolonged prevalence of uneconomic prices for coconut and its products has resulted in neglect of plantations and abandoning of cultural and manurial treatments and consequent deterioration of the condition and yield of trees. These have helped to widen the gulf between the supply and demand for coconuts from year to year. If the coconut industry is to thrive and establish itself as a paying concern and withstand outside competition, maximum production of coconuts at minimum cost and creation of an assured market for them should be aimed at.

There are two important ways of meeting the deficit; one is to obtain, if possible, larger imports and the other is to increase the internal production. The possibility of obtaining increased quantities from foreign sources has to be ruled out as there is a growing world shortage of fats and oils and the small surplus of coconut oil in some of the Eastern countries is hardly sufficient to go round. The need for increasing the production of coconuts in the country is therefore imperative. The coconut is a perennial crop which takes 7 to 10 years to yield nuts. Therefore the possibility of increasing the production by additional land under coconut is a long-term problem. But it should be possible to step up production to some extent immediately by giving the existing trees sufficient care and adopting scientific methods of cultivation.

It may be of interest to note that as much as 95% of the area under coconut in India is located in South India. In South India, Madras State leads in coconut cultivation and therefore it is her duty to increase production of coconuts during times of deficit of this commodity.

Research work connected with coconut improvement was started in Madras in 1916 with the opening of four Research Stations in the South Kanara District. In Madras the coconut crop has been studied more extensiivey than in the other coconut-growing States in India and many useful results of economic importance have been obtained for the benefit of the coconut grower. The results of Research carried out on the different aspects of coconut cultivation such as soils suitable for growing coconut, selection of planting material, depth of planting, mauuring, intercultivation, harvesting of coconuts, and control of diseases and pets, and improved methods of coconut cultivation have not become sufficiently popular among the coconut growers, probably due to want of publicity. There is, therefore, urgent necessity for the dissemination of correct information in coconut culture to the grower as it will greatly help better cultivation and production of coconuts.

# A Note on the Economic Aspects of Manuring Crops

*By*

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The level of manuring is an index of the economic or commercial importance of any crop and the care with which the required quantity and quality of manure is applied directly reflects the esteem in which the crop is held by the farmer. Thus sugarcane, plantains and tobacco among commercial crops, paddy, cholam, ragi maize etc., among grain crops are manured systematically and the farmer pays great attention to this operation.

Since manuring forms one of the important operations in the cultivation of a crop, there is great need to assess accurately the cost involved. In the existing system of farming, our ryots are not in a position to say exactly how much has been spent on each acre of land or for each crop in the shape of manures. At times it is not possible to get at accurate figures of manures applied, particularly of bulky organic manures like farmyard manure, compost or tank silt etc., The use of manures, natural and artificial has become widespread and it is time now that the economic aspect is clearly understood, before large increases in dosages are taken up. What is spent in the shape of manure has to be taken out in increased returns, the value of the increase being considered more than adequate, compared to the cost of manures. In this paper it is proposed to discuss this aspect of the cost in relation to production of crops and increasing of yields.

**Importance of cost**: The importance of assessing the costs involved in the manuring of crops has not been realised fully by the cultivators. The total cost of the manures should always be related to the increase in yields obtained as a result of the application, so that one is in a position to know whether the money has been well spent. It is one thing to apply increased doses of manure and another to judge what increases in yield have been obtained, as a result of the increase in dosages. There are two things involved in this problem; one is the increases in out-turn of the produce, the value of which is easily calculated. The second aspect is the residual effect left in the soil which is likely to give increased yields in the succeding crop or crops. This second point, depends of course, upon the quantity and time of application of organic or inorganic manures. It is supposed that there is no residual effect due to artificial manures. In any case, it should be possible to evaluate the actual cost of of the different manures used and the value of the increased outturn of produce obtained on the basis of unit area, say an acre for each crop raised. Generally the ryot thinks that all the manure applied, including the organic manures, has been utilised by the crop to which such manure had been applied and the value of the increased yields has theefore to be set off fully against the total value of the manures used. It is difficult also to judge how much has been retained and how long the residual effects will last. This depends upon the nature of the soil, time of application and the kind of crops raised. However, it will serve our purpose in the evaluation of costs, if we assume that half the value of the organic manure has been utilised by the crop to which such manures has been applied. Therefore half the cost of the bulky manure may be deducted from the total cost of manure used for any particular crop.

**Limitations:** Various limitations operate in the cource of application of manures, such as quality of manure, irrigation sources, cost, availability, time of application etc., the chief among them being availability and cost. In all parts of our State, both irrigated and unirrigated lands are manured directly or indirectly. While only organic manures such as cattle manure, compost from old sites, tanksilt etc., were applied in the olden days, the need for and the advantages of incorporating heavy doses of organic and artificial fertilisers have of late, been well realised by cultivators and this practice has become a regular feature in farming operations. The manuring of rainfed lands presents many difficulties, connected with season, availability of manure and the economic position of the farmer. Application of organic manures like cattle manure which is not available in adequate quantities in dry land areas, is possible in these areas only once in two or four years. Availability and price of artificial fertilisers form important limiting factors for wetland and gardenland ryots. Judicious application of different manures is of great importance.

**Judging of yields in relation to cost of manures:** Crops in general respond well to manuring. Both rainfed and irrigated crops can be manured with advantage, if adequate moisture is available for the crops. Commonly all agree that the value of the increased yields of crops obtained should at least be equal to the value (or cost) of the manure used. Otherwise loss is inevitable. The increased value should be something over and above the cost spent in the shape of manuring as otherwise there is no incentive for manuring of crops. On the other hand large doses of manures should not also result in serious reduction in value of the yield. Thus an optimum dosage level and judicious method of application should result in maximum economic return from the crop. In recommending application of particular kind and doses of manures, it is necessary to indicate what will be the cost value of the increased return, at the prevailing rates, over and above the cost of manures. In all the manurial experiments in our State the economic aspects of of manuring should be definitely included for consideration,. It is usual to indicate that such and such an improvement gives so much increase in percentage over control in yield. The point to be considered is whether this increase noted as percentage in yield can be a sufficient incentive to take up the improvement or it is only of academic interest. The increase should be appreciable and worth the trouble. One of the main handicaps to agricultural improvement is that the increased return from manuring may not be sufficient to warrant the pains taken.

**Law of diminishing returns:—** The classic example of this law is really the application of increased doses of manure to an unlimited extent and recording of yields due to every increase. After a stage, further additions of manure begin to give proportionately decreased yield and thereby it becomes uneconomical to continue any more applications. This point is to be remembered by over-zealous cultivators in the continuously cultivated areas of sugarcane, vegetables and orchards, as there is a tendency on their part to dump heavy doses of manures without relation to the possible or actual increases in yield as a result of such manuring practices. Instances of uneconomic returns due to the increased doses of manure may be illustrated in the statements, given below with reference to sugarcane.

**Anakapalle Research Station—Manurial Experiments 1946-47.**

| Quantity of Manure. | Cost of cultivation per acre Rs. | Net profit per acre. Rs. | Increase of profit over control Rs. | Value of manure. Rs. |
|---|---|---|---|---|
| 0 lb. of N. ... | 1050-10-0 | 302—5-0 | ... | ... |
| 50 lb. of N. ... | 1081-11-0 | 387-15-0 | 15-10-0 | 30-15-0 |
| 100 lb. of N. ... | 1177-15-0 | 491—2-0 | 188-13-0 | 127—5-0 |
| 150 lb. of N. ... | 1189—0-0 | 366—3-0 | 63-14-0 | 148—6-0 |
| 200 lb. of N. ... | 1225-11-0 | 379—7-0 | 77—2-0 | 175—1-0 |
| 250 lb. of N. ... | 1242—3-0 | 288—3-0 | 14—2-0 | 192—9-0 |

For an increase of Rs. 30—15—0 worth of manure, a profit of Rs. 85-10-0 is obtained, Similarly by spending Rs. 127—5—0 of manure, a profit of Rs. 188—13—0 is obtained. But further increase has not given any increase in profit and in fact for every additional dose of 50 lb. of nitrogen, less and less profits are obtained.

This is more marked when the economics of sugarcane and jaggery production are worked out for the same experiment, as given below :—

| Quantity of manure | Average yield of cane (tons) per acre | Yield of jaggery per acre (tons) | Net profit Rs. | Increase over control |
|---|---|---|---|---|
| 0 lb. of N. ... | 40·70 | 4·656 | 220—13—0 | ... |
| 50 lb. of N. ... | 47·06 | 5·177 | 289— 2—0 | 69— 5—0 |
| 100 lb. of N. ... | 52·07 | 6·034 | 396—13—0 | 176— 0—0 |
| 150 lb. of N. ... | 40·99 | 5·673 | 286— 0—0 | 65— 3—0 |
| 200 lb. of N. ... | 49·00 | 5·439 | 270— 3—0 | 49— 6—0 |
| 250 lb. of N. ... | 50·16 | 5·436 | 258—12—0 | 37—15—0 |

The increase over control is the maximum in the case of 100 lb. of nitrogen giving a margin of Rs. 176/- and further doses of manure have given proportionately lower yields. Apart from the decline in yield, application of larger doses of manure tend to lower the quality of cane. Hence it is necessary to work out the economics of manuring for each crop and the optimum dose which will give maximum profit should be advocated.

Variations of this economic dose of manure are noticed from region to region and from variety to variety. The economic dose of nitrogen for sugarcane is indicated as 100 lb. of nitrogen for Anakapalle, 200 lb. of Nitrogen for Palur and Gudiyatham. Although higher yields are obtained with 250 lb. of nitrogen in the latter two stations they are not, however statistically significiant. This is illustrated below :

**Increase of Profit over Control.**

| | | Anakapalle Co. 419 | Palur Co. 261 | Gudiyatham Co. 419 |
|---|---|---|---|---|
| 0 lb. of N. | ... | ... | ... | ... |
| 50 lb. of N. | ... | 68— 5—0 | ... | 323—15—0 |
| 100 lb. of N. | ... | 176— 0—0 | 145—0—0 | 515— 7—0 |
| 150 lb. of N. | ... | 65— 3—0 | 214—0—0 | 650— 5—0 |
| 200 lb. of N. | ... | 49— 6—0 | 278—0—0 | 773— 9—0 |
| 250 lb. of N. | ... | 37—15—0 | 216—0—0 | 796— 1—0 |

Anakapalle with 100 lb. of nitrogen has given a profit of Rs. 176/- and Palur and Gudiyatham gave Rs 276/- and Rs. 773/- respectively with 200 lb. of nitrogen, after which the increase in profit tends to go down with additional doses of manures.

**Economics of manuring of Paddy :** The maximum economic return varies from from variety to variety of the same crop. In paddy also, no two varieties give similar returns for the same quantity of manure applied. An experiment conducted at the Paddy Breeding Station, Coimbatore, with similar quantities of manure to different varieties or strains indicated that Co. 12 paddy had given the maximum return of Rs. 318—4—0 or 2808 lb. of paddy when compared with Co. 26 and Co. 19. But while assessing the extra money value for the cost of manure which works out to Rs. 72—2—0 (i.e. 2,000 lb. of green leaf at Rs. 6/- ; 400 lb. of G. N. cake at Rs. 45/- ; 112 lb. of super at Rs. 12—8—0 and 50 of ammonium sulphate at Rs. 8—10—0) it is found that the net income or profit over unmanured plots is only Rs. 73—4—0 i.e. the extra yield obtained only just covers the cost of manure applied. Among the varieties Co. 12 has given Rs. 12—1—0 worth of paddy more over Co. 19 and Rs. 7—14—0 over Co. 26. Again, among varieties, the level of the fields have a great influence over the yield of the crop between manured and unmanured plots.

| | High level | Low level | Difference | Cost |
|---|---|---|---|---|
| Co. 12 | 2808 lb. | 2414 lb. | 394 lb. | Rs. 45/- |
| Co. 13 | 2254 lb. | 1535 lb. | 719 lb. | Rs. 82/- |

With the application of the same manure, plots in the higher level give a larger margin of profit than the plots in the lower level and this is seen both in the crop grown in the main season and second season. When similar manures are applied to paddy crop for different seasons (main and second) the profit obtained is greater in the case of main crop than in the case of second crop. This is illustrated in the statement shown below :

*(Manures 40 lb. of Nitrogen applied at different times)*

| | Main crop | Second crop |
|---|---|---|
| Excess yield | Rs. 51—14—9 | Rs. 39— 6—0 |
| Cost of manure | Rs. 28—10—8 | Rs. 28—10—8 |
| Profit ... | Rs. 23— 4—1 | Rs. 10—11—4 |

Thus it is clear that economics of manuring differ widely with regard to season, varieties and regions. Any improvement suggested should bear specific indications of the net return obtained under particular conditions.

**Green Manuring**: Special mention has to be made of green manures from the economic point of view, particularly with reference to paddy. It is possible to raise a green manure crop in the field itself with a small expenditure of Rs. 10/- or less per acre, and the value obtained as green manure is anything from Rs. 50/- to Rs. 70/-. This can give an increase in yield by 10 to 15% over at least two acres. It has been estimated that 15 lb. of green manure is able to give an increase of 1 lb. of grain i. e. by spending about half an anna for production of green manure in the field we will be able to get about two annas worth of extra grain. Economically this is most sound and can be adopted whenever facilities exist. The same argument will hold good for application of green manure to other crops under irrigation like sugarcane, vegetables and fruits, inclusive of coconuts.

**Optimum economic doses indicated from previous experiments:** The Department has been conducting manurial experiments in different Research Stations on various crops. The optimum economic dose of manures that may be recommended are indicated below for paddy and millets.

**Paddy:** An ideal prescription for obtaining both sustained increases in yield would be a basal dressing of 5,000 lb. of leaf and super or bonemeal at 20 lb. of phosphoric acid, followed by a top dressing of 100 lb. of ammonium sulphate. Cost of manure for this prescription works out to Rs. 45/- and the extra yield that can be obtained on an average may be reckoned at 705 lb. over the normal of 1,795 lb. This leaves a good margin of Rs. 36/- per acre over the expenditure for manure. Since 15 lb. of green leaf are expected to give one pound of grain, the normal dose of 5,000 lb. of green leaf will result in an increased yield of 333 lb. which may be valued at Rs. 38/- apart from improving the condition of the soil.

**Millets:** The economic dose of nitrogen, phosphoric acid and potash that are to be applied to different types of crops vary considerably and have to be fixed with reference to soil and climatic conditions. Application of fertilisers to supply 30 lb. of nitrogen (it is concluded that ammonium sulphate is best for millets and about the same amount of phosphoric acid are adequate for rain-fed crops and 50% more for irrigated crops in the State. Ragi alone requires heavy dosage of potash. The yields recorded in the various Research Stations in the State vary from 14% to 160% in rainfed crops and 90 to 206% in irrigated crops. Taking the average for these as 87% for rainfed crops and 148% for irrigated, the value of grain may be worked out to see how far these manures are economical.

**Dryland Crops:**

| | Normal yield lb. | 87% increase lb. | Value Rs. | Profit Rs. |
|---|---|---|---|---|
| Ragi ... | 720 | 626 | 66—0—0 | 21—8—0 |
| Cholam ... | 575 | 328 | 35—8—0 | — 9—0—0 |
| Cumbu ... | 555 | 483 | 53-12—0 | 8—4—0 |

(Cost of manure is calculated as Rs. 44—8—0)

It is uneconomic to manure dry land crops directly for higher yields.

**Irrigated Crops:**

| | Normal yield lb. | 148% increase lb. | Value Rs. | Profit Rs. |
|---|---|---|---|---|
| Ragi ... | 1,500 | 2,250 | 236 | 169—4—0 |
| Cholam ... | 1,500 | 2,250 | 243 | 176—4—0 |
| Cumbu ... | 1,200 | 1,800 | 200 | 133—4—0 |

(Cost of manure is calculated at 50% more over rainfed crops i. e., Rs. 66—12—0)

Of course yields differ widely, depending upon moisture available and the season in which the crop is grown, although we have taken into consideration the increased average yield at 87% for rainfed and 148% for irrigated crops. Thus it will be seen that a better return is obtained from millets under irrigated conditions than under rainfed conditions. For rainfed crops which depend upon the seasonal success it is not safe to advocate manuring.

**Conclusions:** Consideration of the economic aspects of manuring is of paramount importance under modern conditions of farming. Cost of production of crops, though it always includes cost of manuring does not show how it far had been worthwhile. When attempts are being made to reduce the cost of production by improved methods, the use of optimum economic doses of manure is also a necessity to keep down costs in relation to yields. The great advantage in this is the large gain that may accrue to the ryot when prices of manures are kept down by controls. If normally prices of manure are kept down in parity with those for the produce, then the advantage gained is not much. The test of efficiency of manures is their capacity to multiply the yields several times in terms of money value. This is really important in the case of commercial crops. The ryots do not generally take into account or consider the actual increase in value obtained by particular instalments of the manure applied, because they do not keep proper accounts. Hence it is necessary to evaluate manures and their economic capacities in relation to increased yields and to judge the returns in the proper prospective, keeping in mind the cost involved in manuring and the relation it bears to the increased returns.

# Essential Oil Yielding Grasses and their Possibilities in Madras State

*By*

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**Introduction :** Most of the food grains which man consumes as food, such as paddy, wheat and millets belong to the family of grasses. There are ,however, certain members of the Gramineae, which are put to other economic uses. Many of the grasses yield oils of different compositions, some of which are credited with medicinal properties while certain others are very useful in perfumery and soap making. The commercially important essential oils are mainly derived from the genus *Cymbopogon*, Hack. There are about 10 species which are common in South India; many of them occur in the wild state, while a few of them are cultivated in limited areas in certain parts of the province. Another valuable grass which yields a scented oil is *Vetiveria zizanioides*, Nash, which is well known in Suth India. The essential oils exported from our country to Europe and U. S. A. during 1949—1950 amount to one lakh of gallons, fetching about 66 lakhs of rupees ; the export reached a peak figure of one crore and 14 lakhs in 1946 — '47. The possibilities of developing the trade are enormous, but no systematic efforts are being made to exploit these grasses. There are no large - scale distilleries in South India ; but a few enterprising people have started small - scale distilleries and much of the essential oils are the outcome of cottage industries.

Most of these aromatic grasses are indigenous to India and Ceylon and thrive in many parts of South India. Varieties of these grasses are cultivated in Ceylon, Burma, Java, Philippines, Madagascar, West Indies and certain parts of India. The climate of certain parts of our State is very congenial to the proper growth of these grasses. The oil content of individual grasses vary and the yield and composition of even the same species grown in different soils and climatic conditions differs. Attempts have been made to collect some of these grasses and plant them in the Botanic Garden at Coimbatore. This paper deals with some of the important species in the State.

From early times these grasses have been utilised in medicine, in various religious rites and in making perfumes. Of late a taste for these oil grasses has developed and regular industries are developing in small scale in South India as well as Ceylon. There are great possibilities for developing this industry in South India where there are about a dozen species, out of which a few could be worked commercially at present. Others can be made equally serviceable by carrying out trials in different localities, to study the suitability of the grasses to the soils.

Several authors have recorded the trials of these grasses in their countries with details of cultivation, yield, oil content and suitability to the soils. Sudborough (1918) stressed the need for careful experiments regarding growing of economic species, and for evolving an effective method for extracting the oil. Rhind (1930) examined three *Cymbopogon* species from Burma and discussed the economic importance of these grasses. David (1940) studied the performance of *Cymbopogon nardus*, Rendle, and mentioned that no significant difference seems to occur between the oil content of leaves cut from plants which produced flowers and other plants which had no flowers. George (1924) discussed the soil conditions, yield of oil and cultivation methods of *Lemon grass* (*Cymbopogon flexuosus*, Wats.) and *Citronella grass* (*Cymbopogon nardus*, Rendle). Casgrove (1946), Comber and Casgrove (1947) mention the yield and period of cutting lemon grass. Luthra (1941) suggested methods of raising suitable profitable grasses. Menon and Ittyachan (1947) recognised the importance of *Vetiver* grass and urged the need for more intensive work to study the yield, oil content, aroma, etc.

The following paragraphs give an account of seven grasses from which essential oils are extracted. The distribution of these grasses in South India, their soil preferences, the quality of oil and their uses are described, assessing their value and possibilities of development.

1. *Cymbopogon nardus*, Rendle (*Andropogon nardus*, L. Citronella grass): Citronella grass, is extensivelly grown in Ceylon and Java for the extraction of the Citronella oil. In South India it grows wild in the Nilgiris and Salem districts. It is reported to thrive well in sandy loams. The grass is propagated by culms or suckers more easily than by seeds. Harvesting could be done thrice a year; leaves which are neither too old or too young yield the best quality oil. No significant difference has been noticed in the oil content of leaves gathered before and after flowering, but oil extracted from dried leaves was poor in quality.

Citronella for export should contain not less than 85% "geraniol". Java Citronella oil is considered to be of the best quality in the U. S. A.

2. *Cymbopogon citratus*, Stapf. (Lemon grass)

| | |
|---|---|
| Telugu: | *Vasana gaddi, Chippa gaddi.* |
| Tamil: | *Vasana pillu.* |
| Malayalam: | *Vasana pullu.* |

Lemon grass is mostly cultivated in tropical countries such as Ceylon, Burma, Java, Mauritius and Malay Peninsula preferably at low altitudes. The grass makes rapid growth on good, well-drained soils. Propagation of the grass is effected by the division of clumps, The spacing and cultural practices differ from place to place, according to soil and climatic conditions. Prior to planting, the land is to be ploughed well and manured and then the culms are planted before the monsoon rains. During the early stages of growth the furrows should be frequently hoed to eradicate weeds, which often give an undesirable odour to the oil. The grass will be fit for harvest after 4 to 5 months, depending on the climatic conditions and fertility of the soil. The number of cuttings per year varies from 5 to 9 and the maximum number of cuttings could be had during the second year of cultivation. After three or four years it is found necessary to replant the area. The lemon grass oil extracted from the grass has a lemon-like odour and taste. The Citral content in the oil various from 70 to 85%. It is largely employed in perfumery and for the preparation of Ionone.

3. *Cymbopogon flexuosus*, Stapf. (Andropogon nardus, L.)
"The Ginger grass" or "Malabar or Cochin lemon grass".

Tamil: *Chukkunari pul.*
Malayalam: *Chukkunari pullu.*
Kanarese: *Anthi balai*

The grass is indigenous to india and is found growing wild in almost all the districts of the Province. Two main types are recognised in Travancore and Cochin, the red-stemmed variety and the white-stemmed variety. The grass grows best in a well-drained sandy loam or on light, sandy soils. In Travancore State the grass is cultivated in the northern district, in hill slopes and forest clearings. In Nilambur (Malabar) this is grown in an appreciable area and a small distillery is managed by a private owner for extracting the oil.

Propagation is generally done by means of seeds which are scattered at random on ploughed ground in March–April. The grass is ready for harvest by June after which cuttings can be had at intervals of 30–40 days. Replanting has to be done every 6 or 8 years.

The "Malabar or Cochin Lemon-grass oil" is exported to Europe and America and a small quantity is also consumed locally.

*Export of Oil from India to Europe and U. S. A.* *

| Year | Gallons | Value in Rupees |
|---|---|---|
| 1944—1945 | 1.21,629 | 32,12,243 |
| 1945—1946 | 1,50,790 | 7.013,862 |
| 1946—1947 | 1,33,390 | 1,07,45,131 |
| 1947—1948 | 84,053 | 36,56,595 |
| 1948—1949 | 95,824 | 24,07.677 |
| 1949—1950 | 82,166 | 42,07,165 |

*From Wealth of India, Vol. 1., 1950.

India has been the principal country producing this Lemon-grass oil. In the recent years other countries as Gautemala and Honduras have started the cultivation and production of this oil. In India there is great scope for increasing the area under this grass and expanding our exports.

4. *Cymbopogon coloratus*, Stapf.

Telugu: *Botha gaddi*
Tamil: *Manda pillu*
Kanarese: *Badai hullu*

This grass is not known to be in cultivation anywhere. The species is distributed as a wild grass from Tinnevelly to Anamalais. It is highly aromatic and comes up well in dry areas. The oil extracted from this grass is reported to be inferior to that of lemon grass, but the oil yield is more than in lemon grass. Isolation of superior quality strains in this species might be possible, as this grass has a very extensive natural distribution in the dry areas of the South.

5. *Cymbopogon martini*, Wats.
"Rosha grass" or "Geranium grass".

Telugu: *Kache gaddi*
Tamil: *Kavattam pillu*
Kanarese: *Kasi hullu,*

Occurs very commonly in South India and thrives well to an elevation of 5,000 feet. Two varieties are recognised, *Motia* and *Sofia* which are morphologically indistinguishable. The *Motia* variety is not gregarious but *Sofia* variety covers extensive areas. The commercially important *Palmarosa oil* is derived from the *Motia* variety which is also known as *Rusa oil* or *East Indian geranuim oil*. *Sofia* variety yields *Ginger grass oil*, which, though not as valuable as the former, is also important commercially. In India *Motia* grass is cultivated in several centres like Lyalpur, Malghat, Betul, Numar, Khandesh and Bombay. The *Sofia* variety is produced in Madras, Punjab and Bengal.

The *Palmarosa oil* is extensively used in India in adulterating Attar. Large quantities are, exported to Europe for use in perfumery. The grass is valued as a remedy for lumbago, skin diseases and stiff joints.

*Export of Palmarosa oil* *

| Year | Quantity. (gallons) | Value (Rupees) |
|---|---|---|
| 1944—'45 | 7,061 | 12,10,883 |
| 1945—'46 | 9,263 | 12,97,433 |
| 1946—'47 | 3,802 | 7,19,438 |
| 1947—'48 | 2,708 | 9,93,385 |
| 1948—'49 | 7,950 | 10,05,473 |
| 1949—'50 | 14,075 | 23,88,279 |

* From Wealth of India, 1950, Vol. I.

6. *Cymbopogon caesius*, Stapf (Kachi grass)

Telugu : *Kamanchi gaddi*
Tamil : *Kamakshi pull*
Kanarese : *Kamancha hullu*
Malayalam : *Inchipul*

It resembles ginger grass in fragrance and properties. More than the leaves the flower heads are rich in oil content. The grass is found wild in South India and is not cultivated. It is distributed throughout the State upto an elevation of 2,500 feet. A small quantity of the oil is exported from India.

There are three more species of *Cymbopogon* occuring in South India, viz. *C. Confertiflorus*, stapf., *C. polyneuros*, stapf. and *C. gidarba*, Haines, which are not very common. But these grasses also yield similar oils and can be tried on a larger scale to study their suitability in the essential oil industry.

*Vetiveria zizanioides*, Stapf.

*Vetiver grass*, Khus-khus grass.

Telugu : *Veltiveru*
Tamil : *Vetiveru*
Kanarese : *Lavancha*
Malayalam : *Ramecham*

This well-known grass is cultivated in parts of Tanjore, South Arcot District and Malabar for their aromatic roots. Besides the extraction of essential oil the roots are used for making fans and window mats. This gives a pleasant cool fragrance in the hot summer months.

The cultivation of this grass differs from place to place; but it comes up in all soils, particularly in well-drained soils and sandy loams. The rooted slips are planted 18″ apart on raised bunds which are 3′ apart. Harvesting is done after 14—16 months when the roots are dug out of the soil, and sent for distillation. The oil is highly valued in perfumery and the soap industry. Medicinally the oil is regarded as a stimulant, diaphoretic and refrigerant. The grass covers large tracts in Punjab and Cuttack; and is cultivated in Rajaputana, Chota Nagpur and in South India in Tanjore, South Arcot and Malabar.

**Summary and Conclusions:** No development of essential oil industry is possible in India, until as a first step a systematic search is carried out on the available resources in aromatic raw materials. The identification and classification is difficult, as a number of forms are met with. Morphologically indistinguishable grasses yield oils differing in oil content and quality. Regarding the nomenclature of these grasses, some difficulty is experienced due to the uncertainty of specific characters. A detailed investigation of the taxonomy of this genus (Cymbopogon) is therefore essential, in the interest of the grass oil industry,

To establish the industry on a firm basis it is also necessary to cultivate the grasses in different climatic conditions, to select economic and profitable strains.

Till recently Travancore and Cochin were the principal producers in the world of oils like the *Palmarosa oil* and *Lemon grass oil*. But of late other countries have taken to the cultivation of these grasses and before they become our competitors, the cultivation of these in India has to be taken up on a large scale. At present small distilleries are owned in certain parts of Travancore, Cochin and Malabar and the oils that are exported do not appear to be as pure as those received from other countries; it is essential that purity of the oil must be aimed at for creating a market in foreign countries. Large distilleries have to be installed for extracting the oils. By systematic surveys, trials, cultivation and scientific distillation methods, the industry can be developed much more extensively.

## BIBLIOGRAPHY


1. Arber, A (1920) Gramineae.
2. Comber, H. E. and Cosgrove, D. J., (1947) — Lemongrass oil from Tanganyika, Bull. Imp Inst. Vol. 45, page 36.
3. Cosgrove, D. J., (1943) Lemongrass from Trinidad, Bull. Imp. Inst. Vol. 44, pp 290 — 292.
4. David, A., (1940) — Trial culture of Citronella grass. Phil. Agriculturist, Vol. 29, p. 507 — 517.
5. Gamble, J. S., (1935) Flora of Madras Presidency, Vol. 10.
6. Georgi, C. D. V., (1924) — Lemon grass oil, Malayan Agriculture, Vol. 12.
7. Luthra, J. C., (1941) — Rosha grass oil, Indian Forester, Vol. 67, p. 555 — 558.
8. Menon, A. K. and Ittyerian, C. T., (1947) — Indian Vetiver and its oil. Jour. Sc. Ind. Res. Vol. 6, p. 214.
9. Rhind, D. (1930) — Note on three oil-bearing grasses from Burma — Agrl. Jour. Ind. Vol. 25, p. 329.
10. Sudborough, (1918) — Indian essential oils. Proc. Ind. Sc. Cong p. 101.
11. Wealth of India, (1950) — Vol. I.

# Distribution of Silica in Relation to Resistance to 'Blast' Disease in Rice

*By*

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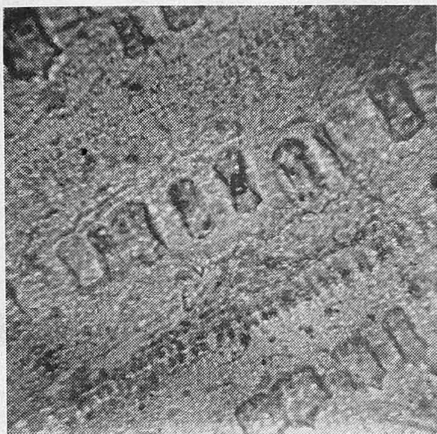
**Introduction:** 'Blast' disease of rice caused by *Piricularia oryzae* Cav. is known to occur in almost all the rice-growing countries of the world. It is by far the most important disease in the Madras State, causing severe losses to cultivators in the years when the seasonal conditions are favourable for the infection and spread of the disease. The only effective method of combating this disease so far known is by growing resistant varieties. The problem of disease-resistance in plants has aroused much interest among workers in the field of plant pathology and numerous investigations have been carried out on the morphological characters of the plant in relation to its resistance to diseases.

Cobb (1892) was the first to find that the resistance to rust of wheat varieties was correlated with morphological characters. Hursh (1924) found out that the resistance of wheat to *Puccinia graminis* was correlated with the relative proportion of sclerenchyma to collenchyma. Willaman and others (1925) reported that the varieties of plum that are resistant to disease have a higher crude fibre content, tougher skin and firmer flesh than the susceptible ones. Melhender and Craigie (1927) found that a correlation exists between the resistance of barberry leaves to stem rust and the thickness of the leaf as well as the resistance to puncture of the outer walls of the epidermal cells. Lutman (1919) found that the thickness of the skin determined the resistance of potato tubers to scab.

Studies on the relation of morphological characters to the susceptibility of the rice plant to disease have been made mostly by Japanese workers. Miyaki and Aachi (1922) found that the silica content of rice plant is correlated with the resistance of the plant to 'Blast' disease. This was confirmed by Kawashima (1927), Seki (1927), Ikari and Kubota (1930) and Miyake and Ikeda (1932). Onoder (1917) found that the silica content of healthy leaves of rice plants was larger than that of leaves affected by *Piricularia oryzae*. Nagai and Imamura (1930) found out that the varieties of rice plant that are susceptible to 'Blast' disease had a larger number of stomata on the epidermis of the pedicels of the spikes, than the resistant ones and that excessive nitrogen fertilization tends to lessen the amount of mechanical tissues in the pedicel thus enhancing susceptibility of the plant to the disease. Hashio Suzuki (1935) made exhaustive studies on the anatomical features of the rice plant and their reaction to 'Blast' and *Helminthosporium* diseases on dry and flooded soils in Japan with resistant and susceptible varieties and concluded that the thickness of the outer walls and the silicated outermost layer of the epidermal cells and the number of silicated bulliform cells, silicated long and short cells and silicated stomata are greater in resistant than in susceptible varieties and in the leaves of rice plants grown on the flooded than on the dry soil, while the number of stomata does not appear to be



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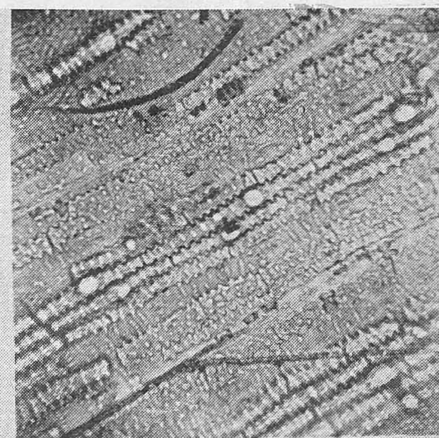

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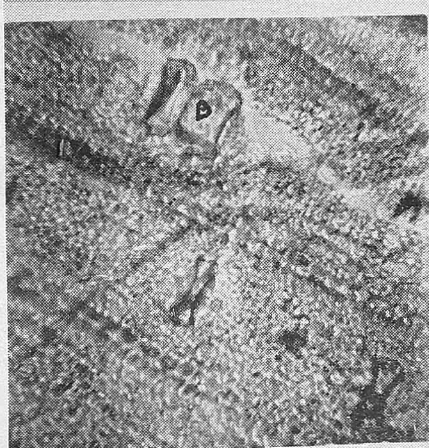

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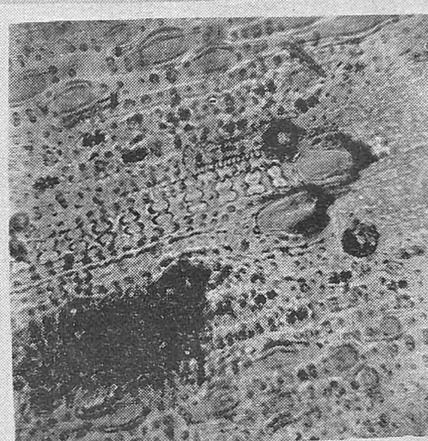

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correlated with the susceptibility to disease. He also reported that the number of silicated epidermal cells per unit area of the leaf could safely be used as a criterion in comparing the degree of silicification of the epidermal tissues of the plant. Akai (1939) concluded from a comparison of the ash figures for leaves of rice plants from humid and arid nursery beds that the number of silicated bulliform cells per unit area was greater in plants from the humid beds than in those from the arid beds and also that the bulliform cells are more easily penetrated by the fungus than the long and short cells and it is possibly significant that the number of silicated bulliform cells varies in accordance with these different conditions in the seedling stage.

There is thus considerable evidence to show that the resistance of the rice plant to 'Blast' disease is correlated with the silicification of epidermal tissues. Studies on varietal resistance of rice to 'Blast' disease was started in Madras in the year 1930 and Thomas and Krishnaswami (1947) have reported on the wide range of susceptibility to 'Blast' disease of different varieties of paddy evolved by the Madras Agricultural Department. Studies relating to the estimation of silicated epidermal long cells and the silicated epidermal bulliform cells in the leaves of the seedlings of 20 cultures of paddy of varying grades of susceptibility to the 'Blast' disease were made by the authors and also the effect of graded doses of nitrogenous fertiliser on the number of silicated epidermal long cells and the silicated epidermal bulliform cells per unit area of the leaf in the three establised highly resistant varieties and one known highly susceptible variety was studied and the results obtained are reported in this paper.

**Material and Method:** *Material:* Twenty cultures of paddy of varying grades of susceptibility to 'Blast' disease were selected for the study and seedlings were raised in pots in paddy soil. The third leaf, counted from the top, from each variety was cut on the 15th day and on the 30th day after sowing and preserved in Formalin-acetic-alcohol. The leaf was divided into three equal parts and only the middle one-third of the leaf was selected for the purpose of estimation.

To estimate the effect of nitrogenous fertiliser on the number of silicated long and bulliform cells per unit area of the leaf, material was collected from the field manurial experimental plots laid out in 'O' Block, Central Farm Wetlands, Coimbatore. The material comprised four varieties (Co. 4, Co. 26, Co 25 and Adt. 10) and 4 treatments (Ammonium sulphate to supply 40 lb., 80 lb., and 120 lb. of Nitrogen per acre and control – no manure). The leaf material required for the estimation was selected at random from each of the treatments on 14–12–1950 i. e., 142 days after sowing and 60 days after application of the fertiliser. The third leaf from the top was cut, the middle third portion of the leaf was selected as before and preserved in the Formalin-acetic-alcohol.

*Method:* (1) *Silicated epidermal long cells:* The leaf was cut into small bits of about half an inch in length and kept in test tubes and macerated by Schultze's maceration method *. Concentrated nitric acid was poured into the tubes to cover the leaf bits and a few crystals of potassium

*Chamberlain, C. J. (1924) Method in Plant Histology P. 137. The University of Chicago, Illinois.

chlorate added and then gently heated until bubbles were evolved and the reagents acted to make the material white. The contents of the tube were then poured into a dish of cold water and thoroughly washed. The peels were selected and stained with Safranin when only the non-silicated structures took the stain and the silicated cells were seen bright. Counts of the silicated long cells were made under the microscope. (Leitz - eyepiece 4 and objective 8). Twenty fields were counted for each variety and the mean number of silicated epidermal long cells per unit area was calculated.

(2) *Silicated epidermal bulliform cells:* The silicated epidermal bulliform cells were estimated by the 'Spodogram' method *. Pieces of the leaf material of approximately 2 x 5 m.m. were cut from the sides of the midrib and placed in porcelain dishes. They were then subject to slow continuous heat over rosette burner for 4 to 6 hours i. e., until the leaf bits turned to ash. The dishes were allowed to cool and the leaf bits removed carefully with a camel hair brush dipped in xylol and mounted on glass slides in pure xylol . The silicated bulliform cells in unit area were counted under the microscope. Twenty readings were taken in each case and mean number per unit area was calculated.

## RESULTS

**I. Silicification of epidermal cells in resistant and susceptible varieties:** The results of the estimation of the silicated epidermal long cells and the silicated epidermal bulliform cells in the leaves of the seedlings of twenty cultures of paddy of varying grades of susceptibility to the disease are given in Table I along with their maximum neck infection percentages recorded in the fields so far since 1943 in order to give a comparative idea of their degree of resistance or susceptibility to the disease with their relative silicification of the epidermal cells. It can be seen from the table that most of the varieties which have shown high degree of susceptibility to the disease contain comparatively lesser number of silicated epidermal long cells and silicated epidermal bulliform cells per unit area of the leaf. The varieties Co. 4 and Co. 26 which are noted for their high degree of resistance have shown a significantly greater number of silicated cells per unit area.

**II. The effect of nitrogenous fertilizer on the silicification of epidermal cells.** It is generally observed that the application of increased doses of nitrogen to the soil tends to increase the incidence of 'Blast' disease in the paddy plant. In order to find out whether there is any change in the degree of silicification of epidermal long cells and epidermal bulliform cells due to application of nitrogenous fertilizer, leaf material was collected from different treatments in the manurial experimental plots as described already and the silicated epidermal cells were estimated as before and the results obtained are given in Table II. The average percentage of neck infections of the plants due to the disease in different treatments as recorded in the same field during the season are also given against each treatment.

* Warner, O. (1928) Biologia generalis IV, 403—446.

TABLE I—Silicification of epidermal cells in twenty cultures of rice of varying grades of susceptibility to 'Blast' disease.

| S. No. | Variety or culture. | Percentage of Neck infection | Mean No. of silicated epidermal long cells per unit area. | | Mean no. of silicated epidermal bulliform cells per unit are. | |
|---|---|---|---|---|---|---|
| | | | 15 days old | 30 days old | 15 days old | 30 days old |
| 1. | Co. 4 | 0·0 | 6 35 | 15·45 | 19·20 | 19·95 |
| 2. | Co. 26 | 1·5 | 5.65 | 8·25 | 19·40 | 18·50 |
| 3. | 3185 | 2·2 | 3·70 | 6·20 | 8·15 | 13·90 |
| 4. | 8036 | 2·2 | 2·40 | 8·70 | 5·70 | 15·80 |
| 5. | 3273 | 2·4 | 1·70 | 6 00 | 4·00 | 13·55 |
| 6. | 2554 | 2·9 | 4·10 | 4·85 | 12·95 | 13·45 |
| 7. | 2552 | 3 0 | 4·55 | 5·70 | 18·50 | 13 05 |
| 8. | 2380 | 3·10 | 1·50 | 7·30 | 14 50 | 14·65 |
| 9. | 2744 | 3·60 | 4·50 | 4·45 | 15·95 | 17·55 |
| 10. | Co. 25 | 4·5 | 3 00 | 6·00 | 14·60 | 15·85 |
| 11. | GEB· 24 | 14·9 | 5 05 | 5 05 | 18·15 | 10·00 |
| 12. | Adt. 4 | 17 9 | 0 95 | 2·45 | 6·05 | 5·95 |
| 13. | Co. 2 | 20·7 | 1·70 | 2·65 | 1·35 | 4·90 |
| 14. | Adt. 6 | 23·1 | 1·90 | 3·20 | 5·50 | 7·50 |
| 15. | Co. 20 | 31·9 | 1·15 | 3·45 | 9·65 | 3·95 |
| 16. | Co. 10 | 34·3 | 2·50 | 1·70 | 4·85 | 3·75 |
| 17. | Ptb. 10 | 45·1 | 1·30 | 2·95 | 10·30 | 7 00 |
| 18. | Co. 13 | 53·1 | 1·85 | 1·65 | 5·90 | 4·10 |
| 19. | Co. 19 | 82·5 | 3·10 | 2·95 | 7·70 | 5·10 |
| 20. | Adt. 10 | 100·00 | 1·40 | 1·70 | 3·55 | 3·90 |

TABLE II—The effect of nitrogenous fertilizer on the silicification of epidermal cells.

| S. No. | Treatments. | Co. 4 | | | Co. 26 | | | Co. 25 | | | Adt. 10. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | A | B | C | A | B | C | A | B | C |
| 1. | No manure (Control) | 0·00 | 19·20 | 21·80 | 0·00 | 14·90 | 17·00 | 0·00 | 13 10 | 20·40 | 63·4 | 2·30 | 3·70 |
| 2. | Ammonium sulphate 40 lb. N per acre | 0·00 | 14·40 | 19·40 | 0·00 | 12·75 | 18 90 | 0·00 | 11·95 | 15·00 | 82·4 | 1·60 | 2·50 |
| 3. | Ammonium sulphate 80 lb. N per acre | 0·00 | 12·05 | 18·00 | 0·01 | 10·30 | 15·00 | 0·00 | 10·95 | 13·90 | 87·5 | 1·70 | 2·10 |
| 4. | Ammonium sulphate 120 lb. N per acre | 0·00 | 10·80 | 15·10 | 0·00 | 9·65 | 12·70 | 0·02 | 9·60 | 13·50 | 90·3 | 1·70 | 2·30 |

A — Percentage of neck infection due to the disease as recorded in the field.
B — Mean number of silicated epidermal long cells per unit area of the leaf.
C — Mean number of silicated epidermal bulliform cells per unit area of the leaf.

The results obtained indicate that there is a tendency for reduction in the silicification of epidermal long and bulliform cells in both resistant and susceptible varieties due to the application of nitrogenous fertilizer. There was a significant reduction in the degree of silicification in all the three resistant varieties when higher doses of ammonium sulphate was applied, However in the susceptible variety Adt. 10 the average number of silicated epidermal long and bulliform cells per unit area was so small that the reductions due to application of manures were found to be insignificant even at higher manure levels.

**Discussion.** The data obtained in the above studies indicate that a correlation exists between the degree of disease resistance in the rice plant and the distribution of silica in its epidermal tissues. Except in a few cases, in all varieties there was a corresponding decrease in the degree of silicification with an increase in the susceptibility to the disease, the decrease in the number of silicated epidermal long cells and silicated epidermal bulliform cells running parallel to each other. Maximum silicification was observed in the varieties Co. 4 and Co. 26, which are noted for their high degree of resistance to the disease, the most susceptible varieties like Co. 10, Co. 13 and Adt. 10 showing the minimum amount and the rest ranging between these two levels. The lessening in the degree of silicification due to the application of nitrogenous fertilizer may be due to profuse vegetative growth of the plant and want of corresponding increase in the intake of silica to maintain the original level of silicification.

It is generally observed that the leaf infection is correlated with the neck infection of the plant due to the disease. Leaf infection takes place both through the stomata and by piercing the cuticle, Yoshi (1933). Whether the resistance is due to the physical obstruction offered by the silicated cells or to the chemical composition of the sap is a point to be investigated by further studies.

**Summary and Conclusion.** Studies relating to the estimation of silicated epidermal long cells and the silicated epidermal bulliform cells in the leaves of the seedlings of twenty cultures of rice of varying grades of susceptibility to 'Blast' disease were made to find out whether there is any correlation between the number of silicated cells in unit area of the leaf and the susceptibility of the seedlings to the disease. The effect of application of nitrogenous fertilizer on the silicification of the epidermal cells in the leaves of three known resistant and one known susceptible variety of rice was also studied.

(i) It was observed that in the leaves of all known susceptible varieties there were fewer silicated epidermal long cells and silicated epidermal bulliform cells than in the resistant varieties.

(ii) In two highly resistant varieties, Co. 4 and Co. 26, maximum number of silicated cells were recorded,

(iii) There was a tendency for reduction in the number of silicated epidermal long cells and silicated epidermal bulliform cells per unit area in both resistant and susceptible varieties when higher doses of nitrogenous fertilizer was supplied.

(iv) In the susceptible variety Adt 10, the number of silicated cells per unit area of the leaf was so small that the reduction due to the application of manure was found to be insignificant even at higher manure levels.

The results obtained confirm the findings of other workers elsewhere, and may be helpful to the breeder in selection of the material for 'Blast' resistance.

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## PLATES

1. Photomicrograph of spodogram material of Co. 4 showing silicated epidermal bulliform cells.
2. ,, ,, of epidermal peelings of Co. 4 showing silicated epidermal long cells.
3. ,, ,, of spodogram material of Adt. 10 showing silicated epidermal bulliform cells.
4. ,, ,, of epidermal peelings of Adt. 10 showing silicated epidermal long cells.
5. ,, ,, of spodogram material of Co. 26 showing silicated epidermal bulliform cells.
6. ,, ,, of spodogram material of Co. 25 showing silicated epidermal bulliform cells.

*Note :* B : Silicated epidermal Bulliform Cell.
L : Silicated epidermal Long Cell.

## REFERENCES

1. Akai, S. (1939) Ash figures of rice plants transplanted from different kinds of nursery beds and their susceptibility. Ann. Phyto. Soc. Jap. IX. *4*, 223 - 235. (From R. A. M. XIX P 362, 1940).
2. Cobb. N. A. (1892) Contribution to an economic knowledge of the Australian rusts. Agri. Gaz. N. S. Wales III, 181 - 102. (From Hursh, C. R.)
3. Hashio Suzuki. (1934) Studies on the influences of some environmental factors on the susceptibility of rice plant to 'Blast' and Helminthosporium diseases and on Anatom'cal characters of the plant.
I. Influence of differences in soil moisture. J. Coll. Agri. Tokyo XIII, *1*, 45 - 108.
4. ,, ,, (1935) II. Influence of differences in soil moisture and in the amount of nitrogenous fertilizer given. J. Coll. Agri. Tokyo XIII, *3*, 235 - 275.

5. ,, ,, (1935) III. Influence of differences in soil moisturo and in the amounts of fertilizer and silica given. J. Coll. Agri. Tokyo XIII, *3*, 277 - 331.

6. Hursh, C. R. (1924) Morphological and physiological studies on the resistance of wheat to *Puccinia graminis tritici*. J. Agri. Res. XXVII, 381 - 409.

7. Lutman, B. F. (1919) Resistance of potato tubers to scab. Vt. Agri. Expt. Sta. Bul. 215, 1 - 30 (From Hashio Suzuki).

8. Melhender, L. W. and Craigie, J. H. (1927) Nature of resistance of *Barberris* spp. to *Puccinia greminis*, Phytopath. XVII, 95 - 114.

9. Nagai, I, and Imamura, S. (1935) Morphology of the neck of the panicles as related to resistance against blast of rice. Jap. J. of Bot. (abstract) V, *4*, (101) - (102).

10. Thomas, K. M. and Krishnaswami, C. S. (1947) The control of chief diseases of rice as a means of increasing production. Mad. Agri, J, XXXIV, 147 - 154.

11. Willaman, J. J., (1925) Pervier, N. C., and Triebold, H. O. Biochemistry of plant diseases V. Relationship between susceptibility to brownrot in plums and physical properties. Bot. Gaz. LXXX, 121 - 144.

12. Yoshi, H. (1933) How does *Piricularia oryzae* penetrate into the host? J. Plant. Prot. *20*, 841 — 844. (Abstract in Jap. J. Bot. VII 1934 — 35 p. 29).

# Influence of Nitrogen, Phosphorus and Potash on the incidence of Blast disease of Rice

*By*

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**Introduction:** The blast disease of rice caused by *Piricularia oryzae* Cav. is a disease of great economic importance in South India. The intensity of its incidence and the severity of the damage caused by it are profoundly influenced, apart from the varietal susceptibilty, by several environmental factors. Among these, the factor relating to the nutrition of the host plant is of considerable practical importance to the rice grower. Previous investigations in Coimbatore by Thomas (1932) and in Japan by Suzuki (1335) and Sawada (1937) have shown that application of heavy doses of nitrogenous manures is conducive to the development of the disease. With a view to obtaining further information relating to this aspect a series of field experiments were carried out as part of the programme of a special scheme sponsored by the Indian Council of Agricultural Research for the investigation of blast and foot-rot disease of rice in the Madras State. In this paper an account is given of the experiments carried out during the last seven years with the object af determining the effect of application of varying levels of nitrogen phosphorus and potash on the incidence of blast in different varieties of rice.

**Experimental.** *Venue:* The field experiments were carried out in the Central Farm wetlands, Coimbatore under channel irrigated conditions over a period of seven years.

**Material and Methods.** *Series I—Influence of nitrogen on the incidence of blast disease.*

*Material. Rice varieties:* The five varieties tested were pure line selections and comprised the following types: (a) Highly susceptible to blast — Adt. 10, (b) Moderately susceptible—Co. 11 and (c) Resistant — Co. 4, Co. 25 and Co. 26. All the five are long duration varieties.

*Manures:* Two nitrogenous manures were used namely, ammonium sulphate and groundnut cake, at three levels. The quantity of the manures at each level varied according to the nature of the experiment in different years and is mentioned in the table corresponding to each year. All the experimental plots including the outskirts received a basal dressing of 5,000 pounds of green leaf per acre.

*Layout:* Randomized block (Split plot), replicated. Details are furnished in the appended tables.

*Method:* Seedlings were raised in separate nursery plots and transplanted after an interval of forty to fortyfive days in rows one foot apart and with a spacing of 6 inches between plants in the row. Care was taken to see that equal number of plants were planted in each sub-plot. After the plants were well established, the plots were bunded on all sides to prevent irrigation water from passing from one plot to another. The manures were applied one month after transplanting, as a top dressing.

*Observations:* Periodic observations were recorded on the incidence of disease. Observations for leaf incidence were recorded for forty random selected plants in each plot, as light, medium and beavy as per a guide chart and arithmetical values were assigned to these categories when computing data. Neck infection was recorded for each tiller as a unit and computed as a percentage. Each sub-plot was harvested separàtely and the yield of grain and straw recorded.

## RESULTS.

### TABLE I.

**Effect of varying levels of nitrogen on incidence of disease, 1944–45.**

Layout: Randomised block (Split plot).

*Treatments:*

(1) Amm. sulphate at 1 cwt. per acre
(2) ,, ,, 2 cwt. ,,
(3) ,, ,, 3 cwt. ,,
(4) Groundnut cake 3 cwt ,,
(5) ,, ,, 6 cwt. ,,
(6) ,, ;, 9 cwt. ,,
(7) Control (No Manure).

*Varieties tested:*

(1) Adt. 10 (Susceptible).
(2) Co. 4 (Resistant).

Replications: 6.
Area of plot: 20' x 10'
Area of sub-plot: 20' x 5'.
Spacing between rows: 1 foot.
Spacing between plants in rows: 6 inches.

| S. No. | Treatments | Incidence of leaf infection (Category values assigned) | | Incidence of neck infection (in percentage) | | Yield of grain in ounces | |
|---|---|---|---|---|---|---|---|
| | | Adt. 10 | Co. 4 | Adt. 10 | Co. 4 | Adt. 10 | Co. 4 |
| 1 | Ammonium sulphate 1 cwt. | 142·2 | 0.0 | 47·36 | 8·34 | 52·8 | 101·9 |
| 2 | ,, ,, 2 cwt. | 226 5 | 0·0 | 58·78 | 4·85 | 47·4 | 103·8 |
| 3 | ,, ,, 3 cwt. | 270·5 | 0·0 | 60·85 | 3·70 | 49·1 | 113·0 |
| 4 | Groundnut cake 3 cwt. | 164·5 | 0 0 | 47·28 | 5·67 | 55·8 | 100 9 |
| 5 | ,, ,, 6 cwt. | 175·2 | 0·0 | 54·13 | 4·43 | 49·2 | 105·7 |
| 6 | ,, ,, 9 cwt. | 154·3 | 0·0 | 61·02 | 6·41 | 56·8 | 124·6 |
| 7 | Control (No manure) | 145·7 | 0·0 | 53·89 | 6·14 | 41·5 | 109·4 |
| | Standard Error: | 20 9 | | | | | |
| | Critical difference: | 60·3 | | | | | |
| | Significance at 5 per cent level | | | | | | |

### TABLE II.

**Effect of varying levels of nitrogen on incidence of disease, 1945–46.**

Details as in Table I.

| S. No. | Treatments | Incidence of leaf infection (Category values assigned) | | Incidence of neck infection (in percentage) | | Yield of grain in ounces | |
|---|---|---|---|---|---|---|---|
| | | Adt. 10 | Co. 4 | Adt. 10 | Co. 4 | Adt. 10 | Co. 4 |
| 1 | Ammonium sulphate 1 cwt. | 76·2 | 0 0 | 13·6 | 0·0 | 94·5 | 102·5 |
| 2 | ,, ,, 2 cwt. | 99·7 | 0·0 | 15·1 | 0·0 | 108·7 | 112 3 |
| 3 | ,, ,, 3 cwt. | 138·0 | 0·0 | 21·8 | 0·0 | 116·8 | 132·2 |
| 4 | Graundnut cake 3 cwt. | 69·2 | 0 0 | 12·8 | 0 0 | 97·8 | 97·2 |
| 5 | ,, ,, 6 cwt. | 107·5 | 0·0 | 18·8 | 0·0 | 103·8 | 113 0 |
| 6 | ,, ,, 9 cwt. | 121·3 | 0·0 | 18·8 | 0·0 | 108·0 | 110·0 |
| 7 | Control (No manure) | 53·0 | 0·0 | 13·9 | 0·0 | 92·7 | 105·4 |
| | Standard Error: | | | 0·9 | | 3·6 | |
| | Critical difference: | | | 2·6 | | 10·4 | |
| | Significance at 5 percent level | | No | Yes | | Yes | |

### TABLE III.

**Effect of varying levels of nitrogen on incidence of disease, 1946–47.**

Layout: Randomised block (split plot).

*Treatments*:

(1) Ammonium sulphate 1 cwt. per acre
(2) ,, ,, 2 cwt. ,,
(3) ,, ,, 3 cwt. ,,
(4) Groundnut cake 3 cwt. ,,
(5) ,, ,, 6 cwt. ,,
(6) ,, ,, 9 cwt. ,,
(7) Control (No manure)

*Varieties tested:*

(1) Adt. 10 (Susceptible).
(2) Co. 11 (Moderately resistant)

Replications 6.
Area of plot: 20' x 10'.
Area of sub-plot: 20' x 5'.
Spacing between rows: 1 foot.
Spacing between plants in rows: 6 inches.

| S. No. | Treatments | Incidence of leaf infection (Category values assigned) | | Incidence of neck infection (in percentage) | | Yield of grain in ounces | |
|---|---|---|---|---|---|---|---|
| | | Adt. 10 | Co. 11 | Adt. 10 | Co. 11 | Adt. 10 | Co. 11 |
| 1 | Ammonium sulphate 1 cwt. per acre | 139·7 | 59 0 | 33·4 | 3·9 | 73·5 | 87·5 |
| 2 | ,, ,, 2 cwt. ,, | 254·3 | 93·8 | 36·7 | 6·1 | 66 8 | 103·0 |
| 3 | ,, ,, 3 cwt. ,, | 312·7 | 125·8 | 48·2 | 7·7 | 60·7 | 109·0 |
| 4 | Groundnut cake 3 cwt. ,, | 114·5 | 55·2 | 38·2 | 5·9 | 70·7 | 94·1 |
| 5 | ,, ,, 6 cwt. ,, | 206·3 | 69 8 | 43·1 | 7·7 | 73·0 | 108·5 |
| 6 | ,, ,, 9 cwt. ,, | 268 0 | 87·5 | 47·2 | 16 5 | 69·0 | 102.0 |
| 7 | Control (No manure) ,, | 100·7 | 31·7 | 30·6 | 6·5 | 64·3 | 78·7 |
| | Standard Error: | 13·3 | | 2·1 | | 3·6 | |
| | Critical difference: | 37 1 | | 6·2 | | 10·6 | |
| | Significance at 5 percent level | Yes | | Yes | | Yes | |

### TABLE IV.

**Effect of varying levels of nitrogen on the incidence of disease, 1947–48**

Layout: Randomized blocks (split plot).

*Treatments*:

(1) Amm. sulphate 2 cwt. per acre.
(2) ,, 3 cwt. per acre.
(3) ,, 4 cwt. ,,
(4) Groundnut cake 6 cwt. ,,
(5) ,, 9 cwt. ,,
(6) ,, 12 cwt. ,,
(7) Control (No manure)

*Varieties tested:*

(1) Adt. 10 (Susceptible)
(2) Co. 11 (Moderately resistant)

Replications: 6
Size of main plot: 20' x 10'
Size of sub-plot: 20' x 5'
Spacing between rows: one foot.
Spacing between plants in rows: 6 inches.

| S. No. | Treatments | Incidence of leaf infection (Category values assigned) | | Incidence of neck infection (in percentage). | | Yield of grain in ounces | |
|---|---|---|---|---|---|---|---|
| | | Adt. 10 | Co. 11 | Adt. 10 | Co. 11 | Adt. 10 | Co. 11 |
| 1. | Amm. sulphate 2 cwt. | 30·0 | 0 0 | 6·5 | 0·2 | 119·2 | 121·0 |
| 2. | ,, ,, 3 cwt. | 52·0 | 3·7 | 13·0 | 0·0 | 133·3 | 124·5 |
| 3. | ,, ,, 4 cwt. | 120·5 | 4·7 | 19·7 | 0·2 | 132·3 | 134·0 |
| 4. | Groundnut cake 6 cwt. | 35·1 | 0 0 | 6·1 | 0·2 | 123·7 | 124·7 |
| 5. | ,, 9 cwt. | 46·5 | 3·3 | 11·3 | 0 1 | 134·5 | 125·8 |
| 6. | ,, 12 cwt. | 102·3 | 4 0 | 20·6 | 0·2 | 137·0 | 149·7 |
| 7. | Control (No manure) | 27·5 | 0·0 | 7·0 | 0·1 | 103·0 | 111·8 |
| | Standard Error: | 6 9 | | 1·1 | | 4·1 | |
| | Critical difference: | 20·4 | | 3·2 | | 12·0 | |
| | Significance at 5 percent level: | Yes | | Yes | | Yes | |

## TABLE V.

**Effect of varying levels of nitrogen on the incidence of disease, 1948-49.**

Layout: Split plot design (Randomized block)

*Treatments:*

(1) Amm. sulphate 2 cwt. per acre.
(2) ,, 4 cwt. ,,
(3) ,, 6 cwt. ,,
(4) Groundnut cake 6 cwt. ,,
(5) ,, 12 cwt. ,,
(6) ,, 18 cwt. ,,
(7) Control (No manure)

*Varieties tested:*

(1) Adt. 10 Susceptible)
(2) Co. 4 (Resistant)
(3) Co. 25 ,,
(4) Co, 26 ,,

Replications: 4
Area of plot: 18' x 8'.
Spacing between rows: one foot.
Spacing between plants in rows: 6 inches

| S. No. | Treatments | Incidence of leaf infection (Category values assigned.) | | | | Incidence of neck infection (in percentage.) | | | | Yield of grain in ounces. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Adt. 10 | Co. 4 | Co. 25 | Co. 26 | Adt. 10 | Co. 4 | Co. 25 | Co. 26 | Adt. 10 | Co. 4 | Co. 25 | Co. 26 |
| 1. | Amm. sulphate 2 cwt. | 0 0 | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0 0 | 160·8 | 181·5 | 187·5 | 161.5 |
| 2. | ,, 4 cwt. | 0·0 | 0 0 | 0·0 | 0·0 | 0 0 | 0·0 | 0 0 | 0 0 | 198·8 | 210·0 | 211·8 | 216·3 |
| 3. | ,, 6 cwt. | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0 0 | 0 0 | 259·8 | 222·3 | 219·8 | 284·5 |
| 4. | Grundnut cake 6 cwt. | 0 0 | 0·0 | 0·0 | 0 0 | 0·0 | 0 0 | 0 0 | 0 0 | 164·8 | 175·0 | 189·3 | 180·0 |
| 5. | ,, 12 cwt. | 0·0 | 0·0 | 0 0 | 0·0 | 0·0 | 0·0 | 0 0 | 0 0 | 234·3 | 217·3 | 240·8 | 219·0 |
| 6. | ,, 18 cwt. | 0·0 | 0 0 | 0·0 | 0·0 | 0·0 | 0 0 | 0·0 | 0·0 | 302 8 | 223·8 | 281·0 | 268·0 |
| 7. | Control (No manure) | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 113·0 | 151·0 | 136·5 | 121·9 |
| | Standard Error: | | | | | | | | | | 6·06 | | |
| | Critical difference: | | | | | | | | | | 17·09 | | |
| | Significant at 5 percent level | | | | | | | | | | Yes. | | |

The leaf and neck infection in both susceptible and resistant varieties was negligible this year owing to unfavourable weather conditions.

## TABLE VI.

**Effect of varying levels of nitrogen on the incidence of disease, 1949—'50**

Layout: Split plot design (Randomized blocks)

*Treatments:*

(1) Ammonium sulphate 2 cwt. per acre.
(2) ,, 4 cwt. per acre.
(3) ,, 6 cwt. ,,
(4) Groundnut cake 6 cwt. ,,
(5) ,, 12 cwt. ,,
(6) ,, 18 cwt. ,,
(7) Control (No manure)

*Varieties tested:*

(1) Adt. 10 (Susceptible)
(2) Co. 4 (Resistant)
(3) Co. 25 ,,
(4) Co. 26 ,,

Replications: 4.
Size of plot: 18' x 8'.
Spacing between rows: one foot.
Spacing between plants in rows: 6 inches.

| S. No. | Treatments | Incidence of leaf infection (Category values assigned) | | | | Incidence of neck infection (in percentage | | | | Yield of grain in pounds | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Adt. 10 | Co. 4 | Co. 25 | Co. 26 | Adt. 10 | Co. 4 | Co. 25 | Co. 26 | Adt. 10 | Co. 4 | Co. 25 | Co. 26 |
| 1. | Amm. sulphate 2 cwt. | 0·0 | 0 0 | 0·0 | 0·0 | 0 0 | 0 0 | 0·0 | 0·0 | 12·3 | 13·5 | 14·9 | 14·9 |
| 2. | ,, ,, 4 cwt. | 0·0 | 0 0 | 0·0 | 0·0 | 0·0 | 0·0 | 0 0 | 0·0 | 12·8 | 13 6 | 17·3 | 15·5 |
| 3. | ,, ,, 6 cwt. | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 0 0 | 13·8 | 14·6 | 17·8 | 17·3 |
| 4. | Groundnut cake 6 cwt. | 0·0 | 0·0 | 0·0 | 0·0 | 0 0 | 0 0 | 0·0 | 0·0 | 12·6 | 13·6 | 14·8 | 15·3 |
| 5. | ,, ,, 12 cwt. | 0·0 | 0·0 | 0·0 | 0 0 | 0·0 | 0·0 | 0 0 | 0 0 | 14·7 | 14·7 | 15 8 | 15·7 |
| 6. | ,, ,, 18 cwt. | 0·0 | 0·0 | 0·0 | 0·0 | 0 0 | 0 0 | 0·0 | 0·0 | 15·8 | 15·0 | 18·6 | 16·4 |
| 7. | Control (No manure) | 0·0 | 0 0 | 0·0 | 0 0 | 0·0 | 0·0 | 0·0 | 0·0 | 1·2 | 12·0 | 13·7 | 14·2 |

| | |
|---|---|
| Standard Error: | 0·43 |
| Critical difference: | 1·21 |
| Significance at 5 per cent level | Yes |

The leaf and neck infection in both the susceptible and resistant varieties was negligible this year owing to unfavourable weather conditions.

**TABLE VII.**

**Effect of varying levels of nitrogen on the incidence of disease, 1950—'51**

Details as in Table VI above.

| S. No. | Treatments | Incidence of leaf infection (Category values assigned) | | | | Incidence of neck infection (in percentage) | | | | Yield of grain in pounds | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Adt. 10 | Co. 4 | Co. 25 | Co. 26 | Adt. 10 | Co. 4 | Co. 25 | Co. 26 | Adt. 10 | Co. 4 | Co. 25 | Co. 26 |
| 1. | Amm. sulphate 2 cwt. | 293·5 | 0·0 | 2·0 | 2·0 | 82·4 | 0·0 | 0·0 | 0·0 | 3·3 | 16·1 | 18·3 | 17·7 |
| 2. | ,, ,, 4 cwt. | 352·5 | 0·0 | 4·5 | 3·0 | 87·5 | 0 0 | 0·0 | 0·0 | 2·3 | 18·1 | 20·9 | 19·6 |
| 3. | ,, ,, 6 cwt. | 420·0 | 0·0 | 13·0 | 12·0 | 90·3 | 0·0 | 0·02 | 0·0 | 1·7 | 17 9 | 19·5 | 20·0 |
| 4. | Groundnut cake 6 cwt. | 235·5 | 0·0 | 5·0 | 3·0 | 70·9 | 0·0 | 0·0 | 0·01 | 5·5 | 15·0 | 17·5 | 15·9 |
| 5. | ,, 12 cwt. | 357·5 | 0·0 | 0·0 | 5·0 | 85·3 | 0·0 | 0·0 | 0·0 | 2·3 | 17·9 | 19 8 | 18·3 |
| 6. | ,, 18 cwt. | 410·0 | 0·0 | 8·0 | 7·5 | 89·3 | 0 0 | 0 0 | 0·01 | 2·4 | 18·2 | 20·5 | 19·5 |
| 7. | Control (No manure) | 193·0 | 0·0 | 0 0 | 0·5 | 63·4 | 0·0 | 0·0 | 0·0 | 6·0 | 14·4 | 18·2 | 16·9 |

*Analysis of neck infection:*

Critical difference: 3·0 (For comparing manures with in Adt. 10 alone)
Critical difference: 2·24 (For comparing varieties)
Critical difference: 3·25 (For comparing any two manures)

In this experiment there is infection only in Adt. 10; in the other three resistant varieties the infection is practically nil. Therefore the results of the Adt. 10 alone are analysed and given separately and this may be taken as valid.

**Conclusions:** The main plot treatments, namely, the manurial treatments appear to be significant with respect to neck infection. When this is broken up into different components:

(1) Overall response to manure is found to be highly significant, indicating that manuring with nitrogenous manures induces the disease.

(2) 'Form of manure' is not significant, indicating that there is no difference between the two forms of manures namely, ammonium sulphate and groundnut cake.

(3) The significant effect due to levels of nitrogen was broken up into linear and quadratic effects. The linear effect being significant, it may be concluded that the disease increases in a linear fashion with the increase in levels of nitrogen, irrespective of the form in which it is applied.

*Analysis of Adt. 10 only as randomised block design:*

Critical difference: 13·1.

*Bar diagram*

| Control | A. S. 2 cwt, | A. S. 4 cwt. | A. S. 6 cwt. |
|---|---|---|---|
| 63·4 | 82·4 | 87·5 | 90·3 |

The conclusion from this analysis is the same as given above, where it is analysed on the basis of split plot design.

*Analysis of grain yield:* Critical difference: 0·96 (for comparing varietal means).

**Conclusion:** The differences due to manures are not significant. This may be due to the higher incidence of neck infection at higher levels of nitrogen, which consequently reduces the yield in the susceptible variety Adt. 10.

*Series II – Effect of application of varying levels of potash and phosphorus alone and in combination with each other.*

The object of the experiment was to find out if the application of corresponding levels of potash and phosphorus will offset the effect of application of excessive doses of nitrogen, which results in increased incidence of blast.

The preliminary experiments relating to this aspect were first carried out in pots but as it was found that the spread of disease was erratic, the experiments were later laid out in the field where conditions were more favourable for uniform spread of the disease in all the experimental plots. The experiments were carried out for three years.

**Material and Methods:** The variety chosen for this experiment was Adt. 10, a variety highly susceptible to blast disease. The manures applied were ammonium sulphate at three levels to supply 20, 40 and 60 pounds of nitrogen and potassium sulphate at three levels to supply 43, 86 and 129 pounds of $K_2O$ and superphosphate at three levels to supply 22, 44 and 66 pounds of $P_2O_5$, per acre.

## RESULTS.

### TABLE VIII.

**Effect of varying levels of nitrogen, potash and phosphorus on the incidence of blast disease and grain yield, 1948—49.**

Layout: Randomized blocks.
*Treatments*: 19
Replications: 8
Variety: Adt. 10.
Area of plots: 4' x 3'
Spacing between rows: one foot.
Spacing between plants in rows: 3 inches.

| S. No. | Treatments | Incidence of leaf infection. | Percentage of neck infection. | Yield of grain in ounces. |
|---|---|---|---|---|
| 1. | Amm. sulphate 1 cwt. per acre. | 0·0 | 0·0 | 36·4 |
| 2. | ,, 2 cwt. ,, | 0·0 | 0·0 | 36·4 |
| 3. | ,, 3 cwt. ,, | 0·0 | 0·0 | 43·1 |
| 4. | Potassium sulphate 1 cwt. per acre | 0·0 | 0·0 | 33·9 |
| 5. | ,, 2 ,, | 0·0 | 0·0 | 31·5 |
| 6. | ,, 3 ,, | 0·0 | 0·0 | 31·9 |
| 7. | Superphosphate 1 cwt. per acre | 0·0 | 0·0 | 32·1 |
| 8. | ,, 2 ,, | 0·0 | 0.0 | 33·0 |
| 9. | ,, 3 ,, | 0·0 | 0·0 | 32·8 |
| 10. | N3 K1 | 0·0 | 0·0 | 41·5 |
| 11. | N3 K2 | 0·0 | 0·0 | 39·8 |
| 12. | N3 K3 | 0·0 | 0·0 | 37·8 |
| 13. | N3 P1 | 0·0 | 0·0 | 40·4 |
| 14. | N3 P2 | 0·0 | 0·0 | 43·5 |
| 15. | N3 P3 | 0·0 | 0·0 | 36·8 |
| 16. | $N_3$ $K_1$ $P_1$ | 0·0 | 0·0 | 34·8 |
| 17. | N3 K2 P2 | 0·0 | 0·0 | 35·5 |
| 18. | N3 K3 P3 | 0·0 | 0·0 | 39·1 |
| 19. | Control (No manure) | 0·0 | 0·0 | 27·0 |
| | Standard Error; | | | 3·47 |
| | Critical difference: | | | 6·91 |
| | Significance at 5 per cent level. | | | Yes. |

The leaf and neck infection was negligible owing to unfavourable weather conditions this year.

## TABLE IX.

**Effect of varying levels of nitrogen, potash and phosphorus on the incidence of blast and grain yield, 1949—50.**

Details as given in Table VIII.

| S. No. | Treatments | Incidence of leaf infection | Percentage of neck infection | Yield of grain in ounces |
|---|---|---|---|---|
| 1 | Amm. sulphate 1 cwt. per acre | 0·0 | 0 0 | 33·8 |
| 2 | ,, ,, 2 cwt. ,, | 0 0 | 0·0 | 39·4 |
| 3 | ,, ,, 3 cwt. ,, | 0·0 | 0·0 | 38·5 |
| 4 | Potassium sulphate 1 cwt. per acre | 0·0 | 0·0 | 35·8 |
| 5 | ,, ,, 2 cwt. per acre | 0·0 | 0·0 | 31·5 |
| 6 | ,, ,, 3 cwt. per acre | 0 0 | 0·0 | 33·5 |
| 7 | Superphosphate 1 cwt. ,, | 0·0 | 0·0 | 34·4 |
| 8 | ,, ,, 2 cwt. ,, | 0·0 | 0 0 | 35·0 |
| 9 | ,, ,, 3 cwt. ,, | 0·0 | 0·0 | 35·8 |
| 10 | N3 K1 | 0·0 | 0 0 | 40·8 |
| 11 | N3 K2 | 0·0 | 0·0 | 40·3 |
| 12 | N3 K3 | 0·0 | 0 0 | 39·0 |
| 13 | N3 P1 | 0·0 | 0·0 | 43·1 |
| 14 | N3 P2 | 0·0 | 0 0 | 36·9 |
| 15 | N3 P3 | 0·0 | 0 0 | 41·5 |
| 16 | N3 K1 P1 | 0 0 | 0 0 | 41·9 |
| 17 | N3 K2 P2 | 0·0 | 0·0 | 40·0 |
| 18 | N3 K3 P3 | 0·0 | 0·0 | 44·0 |
| 19 | Control (No manure) | 0·0 | 0 0 | 34·0 |
| | Standard Error: | | | 2·54 |
| | Critical difference : | | | 7·10 |
| | Significance at 5 per cent level : | | | YES |

The leaf and neck infection was negligible this year, owing to weather conditions that were unfavourable for the development of the fungal parasite.

## TABLE X.

**Effect of varying levels of nitrogen, potash and phosphorus on the incidence of blast and grain yield, 1950—51.**

Details given as in Table IX.

| S. No. | Treatments | Incidence of leaf (Category values assigned) | Percentage of neck infection | Yield of grain in ounces |
|---|---|---|---|---|
| 1 | Ammonium sulphate 1 cwt. per acre | 249 | 51·8 | 14·1 |
| 2 | ,, ,, 2 cwt. ,, | 475 | 51·8 | 13·9 |
| 3 | ,, ,, 3 cwt. ,, | 720 | 71·3 | 13 3 |
| 4 | Potassium sulphate 1 cwt. ,, | 249 | 45·0 | 15·9 |
| 5 | ,, ,, 2 cwt. ,, | 306 | 48·0 | 11·7 |
| 6 | ,, ,, 3 cwt. ,, | 252 | 50·9 | 13·9 |
| 7 | Superphosphate 1 cwt. ,, | 275 | 46·9 | 13·4 |
| 8 | ,, ,, 2 cwt. ,, | 271 | 45·3 | 15·8 |
| 9 | ,, ,, 3 cwt. ,, | 291 | 54·7 | 11·9 |
| 10 | N3 K1 | 631 | 70·5 | 12·3 |
| 11 | N3 K2 | 740 | 68·8 | 13·1 |
| 12 | N3 K3 | 679 | 72·0 | 12·3 |
| 13 | N3 P1 | 717 | 72·4 | 13·9 |
| 14 | N3 P2 | 705 | 61·8 | 18·2 |
| 15 | N3 P3 | 727 | 61·4 | 15·2 |
| 16 | N3 K1 P1 | 745 | 64·0. | 13·2 |
| 17 | N3 K2 P2 | 735 | 66·6 | 12·5 |
| 18 | N3 K3 P3 | 765 | 67·5 | 15·4 |
| 19 | Control (No manure) | 222 | 48·8 | 14·9 |
| | Critical difference : | | 10·0 | 2·17 |
| | Significance at 5 per cent level | | Yes | Yes |

**Bar diagram for neck infection.**

N3 P1, N3 K3, N3 N3 K1, N3 K2, N3 K3 P3, N3 K2 P2, N3 K1 P1, N3 P2, N3 P3, K3, N2.
72·4 72·0 71·3 70·5 68·8 67·5 66·6 64·0 61·8 61·4 54·7 51·8
(1) (3)
(2)
(4)
(5)

N1, P3, Control, P2, K1, K2, P1.
51·8 50·9 48·8 48·0 46·9 45·3 45·0
(3)
(4)
(5)

**Discussion.** The results of the above experiments show that in years when the disease is absent increase in yields due to manuring is seen in both the susceptible and resistant varieties. In years of heavy infection the application of increasing levels of nitrogen beyond a certain level increases the incidence of blast in the susceptible variety Adt. 10. In the case of moderately susceptible varieties the same tendency is noticed but in respect of the three resistant varieties it is noteworthy that even in years when heavy incidence was recorded in the control variety, a dosage of 120 pounds of nitrogen per acre over a basal dressing of 5000 pounds of green leaf had no effect in breaking down their resistance. Under the conditions of the experiment, potash and phosphorus do not seem to exert any influence on the incidence of the disease nor there is any indication that they are able to off-set the effects of excessive nitrogenous manuring.

Stakman and Aamodt (1924) carried out experiments on the effect of various soil nutrients in relation to the incidence of stem rust of wheat (*Puccinia graminis triticii*). Their results showed increased incidence of disease in plots receiving higher doses of nitrogenous fertilisers under certain conditions. In their experiments the harmful effects of excessive nitrogenous fertilization were not counteracted either by acid phosphate or by potassium. They concluded from these observations, that nitrogenous fertilizers did not alter the inherent resistance or susceptibility of the host plant but only altered the external conditions which favoured the development of the disease. Nitrogenous manuring favoured vegetative growth which increased the density of the stand, providing favourable microclimatic conditions for the development of the disease. It also delayed the maturity of the plants allowing for a longer period of exposure to infection. Hursh (1924) as a result of his anatomical studies of material grown under varying manurial treatments, came to the conclusion that nitrogen has the effect of reducing the sclerenchyma and increasing the collenchyma tissues of the plant which result in increasing the susceptibility of the plant to the disease. Gassner and Hassebrank (1931) found that nitrogen promoted the development of rust, especially when it was applied in excess of potash and phosphoric acid. Phosphoric acid in excess over potash and nitrogen was condusive in increasing the resistance to rust. Sawada (1937) found profound anatomical changes in the leaf and stem as a result of excessive nitrogenous manuring which had the effect of increased susceptibility of the plants to infection.

Anatomical studies made at Coimbatore by the writer and his colleagues have showed that the number of silicated epidermal cells tends to get reduced with increasing levels of nitrogen applied. It is also possible that C/N ratio is altered with a higher nitrogen content of the cells, which favours the development of the disease. But further studies in this direction are indicated. It would appear therefore that increased susceptibility induced by nitrogen is at least partly due to the structural alteration of the host plant which modifies its resistance to penetration and development of the pathogen.

As regards the practical importance of the findings, it is evident that great care should be exercised in the application of nitrogenous manures in tracts where the disease is prevalent and susceptible varieties are grown. The results of the above experiments show that excessive nitrogen, irrespective of the form in which it is applied, either organic or inorganic, has the effect of increasing the incidence in the susceptible variety. In the resistant varieties, even very high doses of nitrogen do not appreciably alter their powers of resistance and the safety limit is beyond the quantity of nitrogen that is likely to be applied to the rice crop under South Indian conditions.

**Summary:** A series of field experiments were carried out at Coimbatore with the object of ascertaining the effect of application of varying levels of nitrogen, phosphorus and potash on the incidence of 'blast' disease of rice caused by *Piricularia oryzae* Cav. The results of the experiments showed that application of increasing levels of nitrogen increased the incidence of disease in the susceptible variety Adt. 10. Plots receiving a dose of 20 pounds of nitrogen per acre over a basal dose of 5,000 pounds of green leaf however did not show higher incidence than the control plots which received only the basal dose of manure. The effect of application of nitrogen either in the form of ammonium sulphate or groundnut cake were more or less the same in all the experiments. In the resistant vearieties namely, Co. 4, Co. 25 and Co. 26 the application of nitrogen upto 120 pounds per acre did not result in increased incidence of the disease. Under the conditions of the experiment, potash and phosphorus did not appear to exert any appreciable influence on blast disease, either by themselves or in combination with nitrogen.

**Acknowledgements:** The scheme under which the above work was done is partly financed by the Indian Council of Agricultural Research and partly by the Government of Madras and the author wishes to express his indebtedness to both of them for the facilities provided. Acknowledgements are due to the Statistician, Indian Council of Agricultural Research for the scrutiny of the statistical analyses and the staff of the Paddy Blast Scheme for help rendered in laying out the experiments and in recording observations and to Mr. K. M. Thomas and Sri. D. Marudarajan, for helpful suggestions.

## REFERENCE :

1. Gassner, G. and Hassebrank, K. (1931) Investigations of the relations between mineral salt nutrition and reaction of cereal plants to rust. Phytopath. Zeitschr. iii, 6, 535—617, (From abstract R. A. M, XI. 98, 1932)

2. Hursh, C. R. (1924) Morphological and physiological studies on the resistance of wheat to *Puccinia graminis tritici* Erikss and Henn. Journl. Agri. Res. XXVII, 381—411.

3. Sawada, K. (1937) Rice blast disease and manuring. Agric. Rep. Formosa XXXV 22—31, 111—118, 182—189, 251—259, 383—387, 444—449, 655—656,

4. Stakman, E. C., and Aamodt, O. S. (1924) The effect of fertilizers on the development of stem rust of wheat. Journl. Agric. Res. XXVII, 6, 347—379,

5. Suzuki, H. (1935) Studies on the influence of some experimental factors on the suscepitibility of rice plant to blast and Helminthosporium diseases. T. coll. Agri. Page, XIII, 3, 277—331,

6. Thomas, K. M. (1931) Some aspects of the control of blast disease of paddy Madras Agri. Jour. XVIII, 12, 9 pp, .

# Westerns 1. Cotton — Its Status and Work in Progress for its Spread

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**Introduction:** Cotton is one of the major commercial crops grown in the Ceded Districts. It occupies nearly a third of the area under cultivation specially in black cotton soil tracts. In recent years groundnut also is raised over extensive areas on account of the high prices. Generally the rainfall and the time of receipt of rains decide the crop (cotton or groundnut) that will be raised. The Westerns tract, comprises the black soil areas of Bellary, and Anantapur districts, and portions of Pattikonda taluk of Kurnool district and Pulivendla, Proddatur, Jammalamadugu taluks of Cuddapah district. The total area grown to cotton in this zone is about 6½ lakhs of acres. During war time there was a slight fall in the area under cotton on account of the Grow More Food Campaign and also due to the restrictions placed on growing commercial crops. With the partition of India we fell short of cotton. To cover up the deficiency and meet the demand we had to divert more area to cotton and extension work assumed importance. Effective schemes had to be put into operation so that the country might produce sufficient cotton for its needs.

There are two main seasons in the tract known as "*Mungari* and *Hingari*". Mungari is the early season commencing from May-June and Hingari the late season commencing from August-September. This tract is mainly rainfed. An Arboreum type of cotton locally known as "*Sokda*" is raised in the early season. This is a short-stapled type with a ginning percentage of 33 and coarse to the touch, with a low spinning count and is inferior to the Westerns. This variety has a high yielding capacity ranging from 500 to 800 lb. of kapas per acre.

The variety raised in the Westerns zone in the late season is a Herbaceum type, H. 1., evolved at the Agricultural Station, Hagari. It has a staple of 13/16″ with an average ginning percentage of 28 and can spin up to 26 counts. It has a very good gloss, is white in colour and silky.

In recent years it is reported that Mysore-American cotton is extending in Harpanahalli, Hadagalli and Kudligi taluks of Bellary district where the average rainfall is slightly higher. The Hyderabad American (H. A. 11.) is also spreading in Siruguppa taluk along the banks of the Tungabhadra and in the valley portions of Tekkalakota firka.

**Previous Work:** The strain H. 1. was a selection from H. 25 of the Agricultural Station, Hagari and was given for distribution as early as 1924. The initial work of seed multiplication was taken up round about Hagari and later expanded to Bellary taluk. This strain has been very popular with ryots and almost the entire area under Westerns has been now covered. When the demand increased the headquarters of the Special Agricultural Demonstrator was fixed at Guntakal from 1926 onwards. From about 200 to 250 acres the area has now been extended to 6,500 acres. The following table gives the areas of the seed farms from 1942 onwards.

| Years. | Area under seed farms |
|---|---|
| 1942—'43 | 3,000 acres |
| 1943—'44 | 3,000 ,, |
| 1944—'45 | 3,000 ,, |
| 1945—'46 | 5,000 ,, |
| 1946—'47 | 4,984 ,, |
| 1947—'48 | 4,935 ,, |
| 1948—'49 | 5,000 ,, |
| 1949—'50 | 3,735 ,, |
| 1950—'51 | 6,500 ,, |

Previously the ryots were being given the pure seed received from the Agricultural Research Station, Hagari free of cost at the beginning of the sowing season, with a definite understanding that they should cart kapas to the selected gin and return the seeds in equal quantities or at 1¼ times to that supplied originally. The rest of the seeds was purchased at the prevailing market rates. This system has been now replaced by an outright sale of seed to the ryots. Cultivation advances ranging from Rs. 10 to 20 per acre are also given, and all other conditions are the same as in previous years. The seed farm villages mostly comprise the black soil areas of Bellary and Anantapur districts round about Guntakal, within a radius of 10 miles. This area was selected on account of a more assured rainfall than in Bellary taluk and Guntakal being a centrally situated place the transport of seeds was easier. In this area the Mungari cotton is generally not grown in the vicinity of seed farms. Thus the possibility of mixing the inferior *mungari*, variety with the Westerns is avoided. The Guntakal market is reputed for the purity of lint and seed and is maintaining its reputation.

In the Westerns zone, the I. C. C. C. started a scheme in 1932 for a period of two years for quickening the spread of the strain in the zone and aiming at covering the entire Westerns zone by this strain. This scheme commenced in May 1933 but had to be given up after one year due to the difficulty of securing the co-operation of the local co-operative sale societies who were not themselves in a strong position for want of sufficient capital. However, due to the great demand for pure H. 1. cotton seed, a scheme was sanctioned with financial assistance from the Indian Central Cotton Committee for a period of five years from 1942—'43 at a cost of Rs. 1,01,000/-. According to this revised scheme outer seed farms had to be run by the Agricultural Department, at three centres, Bellary, Adoni and Guntakal.

| | Seed farm area for each centre. |
|---|---|
| 1st Year | 2,000 acres |
| 2nd ,, | 5,000 ,, |
| 3rd ,, | 7,500 ,, |
| 4th ,, | 10,000 ,, |
| 5th ,, | ... |

The 3,000-acre seed farm at Guntakal is to work as an inner area for supplying seed material to the outer seed farms. Seeds produced on the outer seed farms had to be purchased by the co-operative societies in the three centres and sold to ryots. This scheme also had to be closed in 1946, after running for four years due to various practical difficulties. Since then the seed farms at Guntakal have become the main source for production and supply of pure H. 1. seeds in this area.

There has been an increasing demand for the supply of H. 1. cotton seeds and the work of seed multiplication at Guntakal may be divided into zones so that the ginning and distribution of seed is effected in time. In order to gin the kapas quickly and to maintain the purity of the seed a departmental ginnnery may be opened with advantage. The seed for sowing may be issued free at the first instance and later recovered in kind at ginning time so that more yots could have the benefit of the scheme. The purchase of seed farm kapas by the Government and ginning it in a departmental gin would help the production of greater quantities of seeds and also maintain the purity. The payment of premium for seed farm lint by the purchasing firms, if announced prior to the sowing period, would act as an inducement for more ryots in the seed farm sphere, resulting in the larger production of seed. The quantity of nucleus seed supplied by the Agricultural Station is inadequate to cover the entire primary seed farm area and as such the seeds procured from the first crop have also to be used for sowing seed farms. Arrangements to have greater supplies of nucleus seed would be welcome. Any loss in the purchase price of cotton seed intended for sowing purposes due to market fluctuations at the time of procurement and sowing periods should be subsidised by the Government. Picking of kapas is usually done in this tract during midday, when the bracts would have dried up, making clean picking impossible. Pickings if attended to during the early hours of the day would avoid dried-up leaves, dust and dirt getting mixed up with the kapas. To enhance the reputation of the Westerns, clean pickings should be insisted upon and every mill owner should have a kapas opener so that the blowroom loss in the mills is reduced which is now reported to 5 to be 6%. In order to cover the entire area in quick time the system of exchange of seeds of of H. 1. with the sowing material of ryots which is usually admixed with all kinds of seeds is suggested, provided any loss in this is indemnified by the Government.

**Results:** The strains released by the Agricultural Station, Hagari are being tried in the districts but so far no variety that is suited to the tract and could compete with the Westerns has been released for large-scale distribution. A variety, 2800, was sent out for trials and it was noted that though the yield was slightly greater and of better colour, there was no improvement in staple or ginning. The American varieties M. A. 11 and G. IX Co. 2 were tried with H. 1. as control. M. A. 11. gave an yield of 330 lb., G. IX Co. 2. 220 lb. and H. 1. 200 lb. per acre. The ryots are not favour of the American types as these have to be sown by the middle of August and are attacked with Jassids and Blackarm disease. Hence, the possibility of introducing the American types in these areas is to be re-examined, and confined to low-lying areas and in places where the rainfall is better.

# Manuring of Ratoons in Sugarcane

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**Introduction:** The practice of ratooning sugarcane is common in most of the sugar-producing countries of the world. In India too, it has become a common practice, in view of its advantages like reduction in cost of cultivation and earliness in maturity. With the introduction of Coimbatore canes this practice has established itself in this State.

Experiments on the ratooning of sugarcane were in progress at the various research stations in this State. These indicated that ratoons should be manured for getting good yields but the increased dose of nitrogen to be applied over that of plant crop was not indicated. The results of investigations made to evolve a suitable manuring schedule for ratoons, for getting high yields with good juice quality, are presented in this paper.

2. **Material and Methods:** An experiment was laid out with the popular variety Co. 419, in a split-plot design with plant crop, first ratoon, and second ratoon as major treatments and nine manurial doses as minor treatments. The doses of manure consisted of 100 lb., 150 lb., and 200 lb. nitrogen, in combination with 0 lb., 50 lb., and 100 lb. $P_2O_5$ per acre. The nitrogen was supplied in the form of groundnut cake and ammonium sulphate, in the ratio of 2 1 on nitrogen basis. $P_2O_5$ was supplied in the form of superphosphate. The manures were applied in two equal doses, half at planting and the other half at earthing-up time in June. All the treatments received a basal dressing of 10 tons of farmyard manure per acre.

3. **Results:** (i) *Height:* The data of periodical heights in plant crops, first and second ratoons are presented in Tables 1 & 2. The results show that first ratoons showed more initial vigour upto July–August but the plant crop made better progress and attained equal height with the first ratoons. In the treatments receiving higher doses of Nitrogen than 100 lb. Nitrogen, the first ratoon showed better height and was even slightly more than 100 lb. Nitrogen treatment of plant crop. In the case of second ratoons however, there was no increase in crop height even with higher doses of Nitrogen. Comparing the crop height of first ratoon with that of plant crop there was a slight difference in favour of the plant crop but the second ratoon was far below the plant crop.

(ii) *Population:* The total number of canes is an important factor in the yields of plant and ratoon crops. The effect of increased doses of manures on the population was not seen in the case of plant crops but in ratoons and particularly in second ratoons there was a marked increase in population with increased doses of manure. Between 150 lb. and 200 lb. Nitrogen however, there was no appreciable difference in population in the first and second ratoon crops. There was no difference due to differences in $P_2O_5$ doses. The data are presented in Table 3.

(iii) *Weight of single cane:* There is a gradual fall in the weight of individual cane from plant crop to first ratoon and from first to second ratoon. There is increase in weight of cane in the case of plant and ratoon crops from 100 lb. to 150 lb. Nitrogen treatments. But between 150 lb. and 200 lb. Nitrogen there was no such increase. The weight of single canes of first ratoons under high doses of Nitrogen was almost equal to the weight of single canes of plant crop from 100 lb. Nitrogen treatment. The second ratoon crop, though somewhat improved with increased doses of manure could not come up to the level of plant crop or first ratoon. The data are presented in Table 4.

(iv) *Yield:* Plant crops recorded significantly higher yields than first and second ratoons and first ratoons yielded significantly more than second ratoons. There is increase in yield upto 100 lb. Nitrogen but between 150 lb. and 200 lb. Nitrogen treatments there was no increase. The increase in yield was more pronounced in the case of ratoon crops than in plant crops. The yield of first ratoon crop with 150 lb. Nitrogen treatment was found to be on a par with the yield of cane of plant crop in 100 lb. Nitrogen treatment. The second ratoon were always poorer than plant and first ratoon crops. Varying doses of phosphoric manures did not influence the yield in any of the three crops.

(v) *Arrowing:* There is increase in arrowing from plant crop to first ratoon and from first to second ratoons (Table 6). With increase in dose of nitrogenous manure there is decrease in percentage of arrowing. There are no differences due to doses of phosphatic manure in any of the three crops.

(vi) *Juice quality:* Juice analysis of the three crops in the different manurial treatments was conducted from November to February and the results are presented in Tables 7 & 8. Ratoons in general record a richer juice quality earlier in the season than plant crops. Increased doses of Nitrogen reduced the sucrose content of the juice in plant crop while in first and second ratoons there was no such marked reduction. Phosphates did not show any influence on juice quality in any of the crops. The difference in quality of juice between 100 and 150 lb. Nitrogen treatments was not so wide as between 100 and 200 lb. Nitrogen treatments.

(vii) *Sugar recovery:* Vasudeva Rao and Lakshmikantham (1946) found that ratoons gave less recovery of sugar than plant crops. For comparison they gave sugar recovery figures of earlier months of ratoon crops and those of plant crops of later months. The data indicate higher sugar per cent in ratoons upto February. The data are furnished below :—

| | C. C. S. % during Nov. | Dec. | Jan. | Feb. |
|---|---|---|---|---|
| Plant crop | 8·06 | 10·21 | 11·53 | 12·79 |
| First Ratoon | 7·80 | 10·96 | 12 05 | 12·88 |
| Second ratoon | 9·24 | 12·05 | 13·49 | 13·52 |

(viii) *Glucose:* The percentage of glucose of the three crops in different months, from November to February was also studied. No specific differences in glucose percent could be seen between the three crops:

| | Glucose % during Nov. | Dec. | Jan. | Feb. |
|---|---|---|---|---|
| Plant crop | 1·71 | 1·31 | 1·25 | 3·67 |
| First ratoon | 1·84 | 0·97 | 1·22 | 0·69 |
| Second ratoon | 1·99 | 0 91 | 0·96 | 0·96 |

4. **Discussion:** Data gathered on different aspects like height, population, weight of single cane, arrowing, yield and juice quality of the three crops as influenced by the different doses of nitrogenous and phophatic manures showed differences between the plant and ratoon crops. The height of cane was less in ratoons when compared with plant crops. The weight of single cane was in the descending order in plant, 1st and 2nd ratoon crops. The yields of plant crops were significanty, more than 1st ratoon and those of 1st ratoon significantly superior to 2nd ratoon. With increase in dose of nitrogen over 100 lb. there was no significant increase in yield in plant crops. First ratoon with 150 lb. Nitrogen dose gave yields significantly on a par with plant crop receiving 100 lb. Nitrogen. Increase in yield in 2nd ratoon, with increased doses of Nitrogen, did not put pull it up to the level of plant or 1st ratoon crop. 100 lb. of Nitrogen is judged as optimum for plant crops. In the case of 1st and 2nd ratoons there is significant increase in yield upto 150 lb. Nitrogen per acre.

The effect of phosphoric acid was not seen, in influencing yield or juice quality on either plant or ratoon crops.

Studies on the physiology of ratoons indicated that ratoons have lower hydration than plant crops and have less of root forming zones in the basal portions of shoots. The analyses of cane plant, leaf samples and juices in plant crops 1st and 2nd ratoons showed that ratoons under normal manuring showed less nitrogen content than plant crops. This indicates that ratoons are less efficient in the absorption of nitrogen than plantcrops and that they require a higher concentration of nitrogen. There was no increase in phosphoric acid content with increasing doses of $P_2O_5$ in the juice of all the three crops and this shows that there was no additional utilisation of this element even in ratoons, with increased doses of $P_2O_5$. The counts of smut whips show increase in incidence of smut with successive ratooning.

5. **Summary and Conclusions:** Ratoons are inferior to plant crops and they also become worse by successive ratooning. Ratoons require

more manure and water than a plant cropand there is greater response to increased doses of nitrogen. The following are the conclusions.

(1) Yield of ratoons are less than plant crops under the same cultural and manurial treatments.

(2) The optimum doses of nitrogenous manure is higher in ratoons than plant crop and it is 50 lb. nitrogen per acre over the optimum dose of plant crop.

(3) There is no effect of increased doses of $P_2O_5$, either in yield or juice quality, in plant as well as ratoon crops.

(4) Ratoons are richer in juice quality than plant crops earlier in the season.

(5) There is no difference in glucose percent between the juice of plant and ratoon crops.

(6) There is more arrowing in ratoons than plant crops and it is less with increase in dose of nitrogenous manure.

(7) There is increase in incidence of smut with successive ratooning.

7. **Future lines of work:** (1) Time of manuring a ratoon crop has to be investigated to see if by earlier manuring more growth of the crop can be induced. For preventing arrowing which causes cessation of growth, prolonged application of manure may be helpful.

(2) The populations of ratoons crops vary, due to varietal differences, but the possibility of improving the population by suitable cultural operations has to be investigated.

(4) Since ratoon crops appear inferior in metabolism to the plant crop, the optimum combination of water, manure and cultural operations to improve the nutrition of the plant has to be investigated, so that a suitable schedule can be designed.

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## BIBLIOGRAPHY

1. Vasudeva Rao, R. and Lakshmikantham, M. (1946) On ratooning in Sugarcane; Madras Agricultural Journal, Vol. No. XXXIV, No. 1, 2 and 3.

2. Ekambaram, C. (1949). Some aspects of ratooning in Sugarcane; Madras Agricultural Journal, January, 1949.

3. Annual Reports of the Agricultural Station 1934 – 35, 1940 – 43 and Annual Report of Sugarcane Research Station, Anakapalle, 1949 – 50.

4. Dutt, N. L. (1946). Report on Survey Sugarcane Research in India.

5. Report of work done on sugarcane ratooning scheme at Kalai (1939 – 49) of Sahajahanpur, (1950).

6. Lakshmikantham, M. and Sankaram, A. (1949). Optimum Nitrogen requirements of sugarcane in Anakapalle tract; Madras Agricultural Journal, Jan. 1949.

**TABLE I — Height measurements.**

| S. No. | Treatments | November, 1949-50 Plant crop Height in inches | | 1st Ratoon crop Height in inches | | 2nd Ratoon crop Height in inches | | 1948—49 Plant crop Height in January (inches) | | 1st Ratoon Height in January (inches) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 N+0 P | 125 | | 125 | | 115 | | 123 | | 121 | |
| 2 | 100 N+50 P | 123 | 125 | 124 | 124 | 121 | 118 | 104 | 119 | 128 | 117 |
| 3 | 100 N+100 P | 126 | | 120 | | 118 | | 131 | | 123 | |
| 4 | 150N+0 P | 825 | | 128 | | 117 | | 126 | | 124 | |
| 5 | 150N+50 P | 125 | 125 | 129 | 127 | 119 | 118 | 130 | 127 | 126 | 126 |
| 6 | 150N+100 P | 126 | | 125 | | 117 | | 125 | | 128 | |
| 7 | 200 N+0 P | 126 | | 123 | | 116 | | 129 | | 122 | |
| 8 | 200 N+50 P | 125 | 125 | 120 | 122 | 117 | 116 | 123 | 126 | 126 | 125 |
| 9 | 300 N+100 P | 123 | | 124 | | 116 | | 125 | | 124 | |
| | Average | | 125 | | 124 | | 117 | | 124 | | 123 |

**TABLE II—Periodical Height of crop (in inches) 1949—50.**

| Nitrogen treatments | Plant crop July | Plant crop Aug. | Plant crop Sep. | Plant crop Nov. | 1st Ratoon July | 1st Ratoon Aug. | 1st Ratoon Sep. | 1st Ratoon Nov. | 2nd Ratoon July | 2nd Ratoon Aug. | 2nd Ratoon Sep. | 2nd Ratoon Nov. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 lb. N | 47 | 77 | 101 | 125 | 53 | 79 | 105 | 124 | 42 | 68 | 92 | 118 |
| 150 lb. N | 47 | 77 | 104 | 125 | 54 | 81 | 105 | 127 | 48 | 64 | 96 | 118 |
| 200 lb. N | 50 | 80 | 105 | 125 | 53 | 79 | 104 | 122 | 48 | 75 | 96 | 116 |
| Average | 48 | 78 | 103 | 125 | 53 | 80 | 105 | 124 | 46 | 70 | 95 | 117 |

**1948—49.**

| Nitrogen treatments | Plant crop July | Plant crop Aug. | Plant crop Sep. | Plant crop Nov. | Plant crop Jan. | 1st Ratoon July | 1st Ratoon Aug. | 1st Ratoon Sep. | 1st Ratoon Nov. | 1st Ratoon Jan. |
|---|---|---|---|---|---|---|---|---|---|---|
| 100 lb. N | 28 | 41 | 68 | 98 | 119 | 35 | 47 | 70 | 91 | 117 |
| 150 lt. N | 29 | 43 | 71 | 103 | 127 | 38 | 51 | 76 | 104 | 126 |
| 200 lb. N | 30 | 44 | 72 | 101 | 126 | 39 | 52 | 78 | 105 | 125 |
| Average | 29 | 43 | 70 | 101 | 124 | 37 | 50 | 74 | 100 | 125 |

**TABLE III—No. of canes at harvest per acre; 1949–50.**

| Treatments | Plant crop | Average | 1st Ratoon | Average | 2nd Ratoon | Average. |
|---|---|---|---|---|---|---|
| 100 N+0 P | 35,714 | | 25.714 | | 23,834 | |
| 100 N+50 P | 32,331 | 33,885 | 31,805 | 29,449 | 30,150 | 26,466 |
| 100 N+100 P | 33,610 | | 30.977 | | 25,413 | |
| 150 N+0 P | 34.736 | | 32,331 | | 30,977 | |
| 150 N+50 P | 34,060 | 33,909 | 30,000 | 31,303 | 30,601 | 31,102 |
| 150 N+100 P | 32,931 | | 31,578 | | 31,728 | |
| 200 N+0 P | 37,369 | | 29,925 | | 26,541 | |
| 200 N+50 P | 32,481 | 33.995 | 31,127 | 30,902 | 31,127 | 29,774 |
| 200 N+100 P | 34,135 | | 31,653 | | 31,653 | |
| | Average per acre. | 33,930 | | 30,568 | | 29,114, |

**TABLE IV—Weight of single cane in lb.; 1949—50.**

| S. No. | Treatments | Plant crop | | 1st Ratoon | | 2nd Ratoon | |
|---|---|---|---|---|---|---|---|
| 1 | 100 N + 0 P | 2·87 | | 2·82 | | 2·27 | |
| 2 | 100 N + 50 P | 2·82 | 2·89 | 2·72 | 2·73 | 2·19 | 2·29 |
| 3 | 100 N + 100 P | 2·97 | | 2·65 | | 2·40 | |
| 4 | 150 N + 0 P | 2·87 | | 2·84 | | 2·61 | |
| 5 | 150 N + 50 P | 3·08 | 3·07 | 3·39 | 2·98 | 2·58 | 2·57 |
| 6 | 150 N + 100 P | 3·26 | | 2·71 | | 2·52 | |
| 7 | 200 N + 0 P | 2·88 | | 2·77 | | 2·58 | |
| 8 | 200 N + 50 P | 3·29 | 3·07 | 2·85 | 2·84 | 2·54 | 2·56 |
| 9 | 200 N + 100 P | 3·03 | | 2·89 | | 2·57 | |
| | Average. | | 3·01 | | 2·85 | | 2·47 |

**TABLE V—Yield of cane in tons per acre; 1949—50.**

| S. No. | Treatments | Plants crop | | 1st Ratoon | | 2nd Ratoon. | |
|---|---|---|---|---|---|---|---|
| 1 | 100 N + 0 P | 45·79 | | 32·42 | | 24·15 | |
| 2 | 100 N + 50 P | 46·72 | 43·71 | 38·36 | 35·86 | 29·45 | 26·94 |
| 3 | 100 N + 100 P | 44·60 | | 29·05 | | 27·21 | |
| 4 | 150 N + 0 P | 44·60 | | 40·90 | | 30 07 | |
| 5 | 150 N + 50 P | 46·87 | 46·47 | 38·87 | 39·31 | 35 24 | 35·65 |
| 6 | 150 N + 100 P | 47·94 | | 38·15 | | 35·88 | |
| 7 | 200 N + 0 P | 47·95 | | 36·97 | | 30·56 | |
| 8 | 200 N + 50 P | 46·52 | 46·87 | 39·52 | 39·11 | 35·28 | 33·51 |
| 9 | 200 N + 100 P | 46·12 | | 40·87 | | 34·71 | |
| | Average. | | 45·68 | | 38·10 | | 32·04 |
| | **Effect of phosphoric acid.** | | | | | | |
| | 0 lb P | | 46·11 | | 36·76 | | 28·26 |
| | 50 lb P | | 44·70 | | 38·92 | | 33·32 |
| | 100 lb P | | 46·22 | | 36 02 | | 32·51 |

**TABLE VI—Arrowing in Ratoons.**

| S. No. | Treatments | Plant crop | Average | 1st Ratoon | Average | 2nd Ratoon | Average | Average of three crops |
|---|---|---|---|---|---|---|---|---|
| 1 | 100 N+0 P | 14·8 | | 17·4 | | 37·6 | | |
| 2 | 100 N+50 P | 15·0 | 15·67 | 14·3 | 17·1 | 32·9 | 34·8 | 22·5 |
| 3 | 100 N+100 P | 17·2 | | 19·6 | | 33.8 | | |
| 4 | 150 N+0 P | 7·7 | | 11·1 | | 15·7 | | |
| 5 | 150 N+50 P | 13·1 | 11·07 | 12·2 | 12·8 | 18·8 | 16·1 | 13·2 |
| 6 | 150 N+100 P | 13·4 | | 14·2 | | 13·8 | | |
| 7 | 200 N+0 P | 11·6 | | 8·1 | | 14·4 | | |
| 8 | 200 N+50 P | 4·5 | 7·70 | 7·3 | 7·2 | 13·4 | 15·9 | 10·3 |
| 9 | 200 N+100 P | 7·0 | | 6·1 | | 20·0 | | |
| | Average | 11·47 | | 12·25 | | 22·26 | | |

### TABLE VII.

#### Juice quality — Effect of nitrogen.

| | 100 lb. N per acre | | | | | | 150 lb. N per acre | | | | | | 200 lb. N per acre | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plant crop | | 1st ratoon | | 2nd ratoon | | Plant crop | | 1st ratoon | | 2nd ratoon | | Plant crop | | 1st ratoon | | 2nd ratioon | |
| | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity |
| November | 14·26 | 83 73 | 14·25 | 83·98 | 15·56 | 84·81 | 13·93 | 82·90 | 14·55 | 86·09 | 14·63 | 85·15 | 13·13 | 82·07 | 14·09 | 84·04 | 14·20 | 83·94 |
| December | 16·16 | 87·80 | 16·08 | 84·90 | 16·39 | 87·99 | 15·19 | 85·51 | 16·03 | 85·28 | 15·38 | 83·06 | 15·57 | 86·49 | 15 04 | 82·09 | 15·41 | 84·01 |
| January | 17.04 | 89·29 | 16·90 | 88·75 | 18·29 | 90·64 | 17·78 | 88·09 | 16·45 | 86·75 | 17·55 | 90·58 | 16·91 | 88·54 | 17·25 | 88·77 | 18·36 | 91·58 |
| February | 17·71 | 88·29 | 18·46 | 90·34 | 18·80 | 90·08 | 17·69 | 88·34 | 17·92 | 88·71 | 17·30 | 88·23 | 16.43 | 86·96 | 18·08 | 90 81 | 18·43 | 90·19 |
| **1948 — '1949.** | | | | | | | | | | | | | | | | | | |
| December | 14·52 | 84·82 | 14·31 | 86·04 | ... | ... | 13·34 | 81·21 | 12·98 | 80·67 | ... | ... | 12·93 | 80·37 | 13·40 | 81·40 | ... | ... |
| January | 15·98 | 88·05 | 16·07 | 86·66 | ... | ... | 16·01 | 85·02 | 16·16 | 86·21 | ... | ... | 16·02 | 87·29 | 15·51 | 85·17 | ... | ... |

### TABLE VIII.

#### Juice Quality — Effect of Phosphoric Acid.

| | 0 lb. $P_2O_5$ | | | | | | 50 lb. $P_2O_5$ | | | | | | 100 lb. $P_2O_5$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plant crop | | 1st ratoon | | 2nd ratoon | | Plant crop | | 1st ratoon | | 2nd ratoon | | Plant crop | | 1st ratioon | | 2nd ratoon | |
| | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity | Sucrose | Purity |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| November | 13·66 | 82·13 | 14·74 | 84·03 | 15·10 | 84·03 | 13·84 | 83·15 | 13·86 | 84·18 | 14·56 | 83·70 | 13·82 | 83.73 | 17·63 | 85 63 | 18·06 | 85·40 |
| December | 15·31 | 85 91 | 15·90 | 84·32 | 15·41 | 85·54 | 15·09 | 86·41 | 15·49 | 84·06 | 15·68 | 84·26 | 15·93 | 87·49 | 15·83 | 84·48 | 16·08 | 85·26 |
| January | 17·70 | 88·87 | 17·28 | 89·31 | 17 90 | 90 48 | 16·72 | 88·30 | 16·39 | 85·46 | 16·94 | 89·50 | 17·31 | 88·75 | 17 94 | 89·50 | 18·20 | 91·82 |
| February | 17·18 | 87·65 | 18·66 | 90·41 | 18·05 | 89·51 | 17·54 | 88·03 | 18·42 | 90·15 | 18·32 | 89·42 | 17·12 | 87·91 | 17·38 | 89·30 | 18·16 | 89·71 |

# Some Practical Aspects of Application of Bulky Organic Manures to Sugarcane in Madras

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**Introduction:** Maximisation of production is the need of the day. Manuring crops is perhaps the easiest way of stepping up production. Commercial crops always receive better attention in the matter of manuring, in view of the more lucrative prices that can be secured. Concentrated manures are invariably applied to these crops for increasing production. Groundnut cake is the largest produced oil cake in this State and sulphate of ammonia, the most popular fertiliser applied to sugarcane.

Experiments to find out the dose and time of application of these manures to sugarcane, either alone or in combination with other organic and inorganic concentrates were few and far between in this State. It is proposed to present in this paper, a review of the results of experiments so far conducted on sugarcane, using bulky organic manures, alone or in combination with other manures.

Among plant nutrients Nitrogen is the chief limiting factor of sugarcane yields. Hence the efficiency of these manures is mainly considered with reference to their nitrogen supply and its time of availability. Their influence on the physical condition of the soil is also dealt with incidentally.

**2. Review of Experiments in Madras:** (a) *Farmyard manure:* Of all the bulky organic manures, farmyard manure received the greatest attention in experiments in this State. Samalkot was the earliest to conduct these experiments which extended over a period of 16 years from 1902 to 1917. In none of these experiments was this manure compared with cakes or artificials on a nitrogen basis. In the first few years the cost of manures compared was kept constant ( Rs. 40/- per acre ) irrespective of its quantity or quality. In certain years the quality of farmyard manure applied was not noted and at times it was noted in terms of cartloads. Thus 60 cart loads, 30 tons, 10 tons, 47,250 lb. and 56,000 lb. were the doses tried. These were compared with ten bags of castor cake, (noted as weighing 1,640 lb. in earlier years and 1,660 lb. later on), which was considered as the standared dose of manure for sugarcane in those years. The analysis figures of castor cake and farmyard manure were reported in some years and nitrogen content of the former varied from 6·05% to 6·34%, while that of the latter ranged between 0·24% to 0·29%.

Assuming one cartload to be equal to ½ a ton, the following data are computed from the results available.

| Year | N supplied Farmyard manure per acre lb. | Yield of cane in lb. | N supplied as castor cake (10 bags per acre) | Yield of cane in lb. |
|---|---|---|---|---|
| 1902—03 | 194·88 | 32,200 | 102·83 | 65,500 |
| 1905—06 | 151·2 | 78,848 | 103·98 | 111,440 |
| Total ... | 346·08 | 111,048 | 206·81 | 176,840 |
| Yield per pound of N. | | 321 lb. | | 856 lb. |

**Yield of jaggery in lb. per acre.**

| | 10 tons Farmyard manure. | 10 bags castor cake (1660 lb.) |
|---|---|---|
| 1909—10 | 7,050 | 11,858 |
| 1910—11 | 4,220 | 7,460 |
| 1911—12 | 2,767 | 7,167 |
| Total ... | 14,037 | 26,485 |
| Average ... | 4,678 | 8,828·8 |

**Yield in Farmyard manure treatment as percent of that in cake treatment was 53%.**

| | 30 tons Farmyard manure. | Groundnut cake 10 bags. |
|---|---|---|
| 1912—13 | 10,166 | 9,463 |
| 1913—14 | 9,355 | 13,599 |
| Total ... | 19,521 | 23,062 |
| Average ... | 9,760·5 | 11,531 |

Yield from Farmyard manure treatment as % of that from groundnnt cake ... ... ... } 80%

Experiments comparing cattle manure alone with other manures were not conducted at any of the other Research Stations of the State. Varieties tried in the experiments cited above are now extinct and the results are at best only indicative.

Experiments including cattle manure supplemented with other manures were conducted at Samalkot, Anakapalli and Palur. Results from Samalkot are furnished below :

| Year | 10 tons cattle manure + 820 lb. castor cake. | | 10 bags of castor cake per acre (1640 lb.) | |
|---|---|---|---|---|
| | Yield of cane lb. | Yield of jaggery lb. | Yield of cane lb. | Yield of jaggery lb. |
| 1914—15 | 62,687 | 8440 | 73,174 | 10,827 |
| 1915—16 | 53,432 | 7240 | 65,788 | 9,242 |

Average yield of jaggery from farmyard manure + cake treatment as % of that from cake alone. } 78%

| Year | 10 tons farmyard manure + 1230 lb. castor cake | | 1640 lb. castor cake | |
|---|---|---|---|---|
| | Cane yield lb, | Jaggery yield lb. | Cane yield lb. | Jaggery yield lb. |
| 1916—17 | 96,711 | 11,475 | 87,177 | 10,269 |
| 1917—18 | 93,850 | 10,693 | 88,065 | 10,193 |

Average yield of jaggery from farmyard manure + cake treatment as % of that from cake alone. } 108%

By substituting 410 lb. of castor cake with ten tons of farmyard manure, 8% increased yield was realised. By supplementing 10 tons farmyard manure with 820 lb. of castor cake, 78% of the yield of control could be realised (12).

At Anakapalli the value of farmyard manure as a basal dressing at ten tons per acre to supply about 80 lb. N, was tested during 1944—'47 along with six graded doses of N going up to 250 lb. per acre supplied in the form of groundnut cake. The variety used was Co. 419.

Application of farmyard manure did not influence the different phases of crop performance to any appreciable extent. Under extreme oonditions of drought its beneficial influence was more pronounced (9).

The results are summarised below ;

| Nitrogen. | Yield of cane in tons per acre. | | | | | |
|---|---|---|---|---|---|---|
| | 0 lb. | 50 lb. | 100 lb. | 150 lb. | 200 lb. | 250 lb. |
| With basal dressing | 41·38 | 49·97 | 52·99 | 49·78 | 49·19 | 51·90 |
| Without do | 40·03 | 44·14 | 51·18 | 50·20 | 50·41 | 48·43 |
| | *Percent sucrose in juice.* | | | | | |
| With basal dressing | 17·29 | 16·13 | 17·10 | 16·64 | 16·13 | 16·24 |
| Without do | 17·51 | 17·26 | 16·50 | 17·02 | 15·93 | 15·91 |

At Palur a similar experiment was conducted during the same period but on two different varieties viz : Co. 281 and Co. 349. The results indicated that there was no significant difference between yields or juice quality in by the crop raised with basal treatment and that which did not receive it (10). Nitrogen supplied by the basal dressing was 60 lb. per acre. Yield data are furnished below :

*Yield of cane in tons per acre.*

| Variety. | 0 lb. | 100 lb. | 150 lb. | 200 lb. | 250 lb. | |
|---|---|---|---|---|---|---|
| Co. 281 | 27·76 | 29·54 | 27·80 | 29·75 | 34·67 | (Basal dressing) |
| | 18·22 | 29·98 | 30·78 | 34·91 | 33·62 | (Without do ) |
| Co. 349 | 23·26 | 31·12 | 36·64 | 39·71 | 41·18 | (Basal dressing) |
| | 24·60 | 33·19 | 32·76 | 35·63 | 42·38 | (No do ) |

In an experiment at Anakapalli with farmyard manure and wild indigo leaf as basal dressings, application of 260 lb. of sulphate of ammonia and 640 lb. groundnut cake in place of 17,665 lb. of farmyard manure, resulted in increased yields of 11,175 lb. and 4,321 lb. of cane per acre respectively (8).

(b) *Green manures:* Sowing a green manure crop prior to planting sugarcane is a common practice in some localities of Visakhapatnam and Godavari districts. But experiments to evaluate the actual nitrogen supplied by the green manure crop and compare it with other manures were not laid out in any of the research stations. Only experiments to compare oil-cakes, cattle manure & sulphate of of ammonia supplemented with green or green leaf manure were conducted at Anakapalli and Palur.

The results of a trial carried out from 1916–17 to 1918–19 at Anakapalli, indicated that 30 cartloads of farmyard manure with 820 lb. castor cake per acre was as good as 2,000 lb. of wild indigo with 1,640 lb. castor cake in wetlands. In garden lands the former treatment gave an appreciable increase in yield, indicating that farmyard manure is better applied to garden lands and green manures to wetlands (10).

| *Treatments.* | *Average yield of cane in pounds per acre.* *Wetland.* | *Garden land.* |
|---|---|---|
| Cattle manure at 30 cartloads per acre and wild indigo at 2,000 lb. per acre. | 73,061 | 55,666 |
| Farm yard manure 30 cart loads per acre and castor cake 820 lb. | 77,159 | 59,898 |
| 2,000 lb. wild indigo and castor cake 1,640 lb. per acre. | 77,866 | 52,507 |

In an experiment conducted for 9 years at this station from 1923—1932 it was noted that 4,000 lb. wild indigo may be substituted for 7 cwts. of groundnut cake without any appreciable lowering of cane yields.

Average yields of cane in the different treatments are furnished below:

| *Treatments.* | *Yield of cane in lb. per acre.* |
|---|---|
| Groundnut cake 20 cwts. per acre. | 80,734 |
| Groundnut cake 10 cwts. per acre + 2,000 lb. wild indigo. | 72,658 |
| Groundnut cake 15 cwts. | 75,630 |
| Groundnut cake 8 cwts. and 4,000 lb. wild indigo. | 74,850 |

At Palur, application of 4,000 lb. of sunnhemp in addition to 200 lb. N applied three-fourth in the form of groundnut cake and one-fourth as sulphate of ammonia resulted in an increased yield of 0·80 ton per acre over the yield recorded when cake and sulphate of ammonia alone were applied without sunnhemp. The quality of jaggery was not affected by green manuring.

At Samalkot, sunnhemp was found suitable as an inter-crop when sown at first or second hoeing after planting cane. It gave an increased yield of 1890 lb. of jaggery over the crop which received no green dressing.

(c) *Compost:* Manuring with compost was compared with application of castor cake at Samalkot in 1903—54. When 63½ lb. N. per acre was supplied in the form of compost, 567 lb. of cane were realised for each pound of nitrogen supplied against 615 lb. of cane per lb. of N given by castor cake when applied at the rate of 101·68 lb. of N per acre.

Burying cane trash in between cane rows in ratoons was tried at Samalkot in 1906—07 with old noble canes which were susceptible to red rot and the trial was a failure. Hence no data are available with regard to the usefulness or otherwise of composting trash.

3. **Review of experiments in other States:** The results presented in this aspect were culled mainly from two excellent reviews on the subject by Rege and Mukerji. In an experiment conducted Muzzaffarnagar in west U. P. during three years (1934—37), farmyard manure, neem cake and sulphate of ammonia were applied alone and in combination, to supply 120 lb. N per acre. It was noted that for each pound of nitrogen supplied, farmyard manure gave 689 lb. of cane, neem cake 771 lb., sulphate of ammonia 769 lb. and farmyard manure and sulphate of ammonia in equal proportions gave 754 lb. of cane. Thus substitution of half the quantity of N by sulphate of ammonia can be done without practically any lowering of the yields (13.)

In another experiment conducted at the same station for 5 years from 1944—'45 and involving sulphate of ammonia, farmyard manure, press mud etc. each to supply 120 lb. N per acre, the former yielded 849·0 mannds of cane with 56·7 maunds of sugar while farmyard manure gave only 645·2 maunds of cane with 53·4 maunds of sugar (6).

At Shahjahanpur (1932—'35)the inefficiency of N supplied by farmyard manure when compared to that given by cake or sulphate of ammonia alone and in combination with each other was revealed. In an experiment conducted at Risalewala in the Punjab, including 35, 70 & 105 lb. N supplied in the form of *toria* cake, or sulphate of ammonia over a basal dressing of 70 lb. N per acre given as farmyard manure, it was noted that even 35 lb. N supplied as cake or sulphate of ammonia gave higher yields than farmyard manure alone. In an experiment conducted at Pusa during 1934—'35 and 1935—'36, ten tons of farmyard manure gave as much yield as 40 lb. N as rape cake plus 50 lb. $P_2O_5$ as superphosphate, even though the nitrogen and phosphate contents of farmyard manure amounted to 134 lb. and 36 lb. $P_2O_5$ respectively (8).

Certain biological investigations carried out at Shahjahanpur indicated that farmpard manure increased the level of bacterial population over that of sulphate of ammonia. Sulphate of mmonia gave a higher population than control (no manure) (15). Farmyard manure became available after 6 weeks, cakes in about 4 weeks and sulphate of ammonia in about 2 weeks after their application to soil, though according to Mukerji, Pramanik and Misra (1950) the "maximum availability of ammonium sulphate was attained in the 8th week after application, and at this stage while 70·5% of the total nitrogen applied is nitrified in the case of ammonium sulphate and 52·7% in the case of groundnut cake, the quantity of N nitrified in farmyard manure is only 8·53%" (8).

(b) *Green Manure:* Sunnhemp was the main green manure crop which received attention with reference to manuring sugarcane throughout India. Experiments canducted at Shahjanpur indicated 50 days to be the optimum age to plough in sunnhemp, which gave 60 lb. N per acre at the age of about two months. One siginificant result of an experiment conducted from 1933—'34 to 1935—'36 was that on a basal dressing of green manure, top dressing of 60 lb. N as farmyard manure was as good as sulphate of ammonia or cake, but with more sucrose in juice. The yields are furnished below:

| | Yield of cane rn lb. per acre. | Average percent Sucrose. | Average purity. |
|---|---|---|---|
| Green manure | 66,343 | 17·21 | 88 66 |
| Green manure + Ammonium sulphate (60 lb. N) | 75,352 | 16·94 | 88·03 |
| Green manure + Castor cake (60 lb. N). | 74,250 | 16·92 | 87·96 |
| do + Cow dung (60 lb. N) | 75,178 | 17·56 | 87·88 |

In an experiment conducted at Sepaya in Bihar for four years (1932—'36), farmyard manure was superior to green manuring in the matter of cane yield. But the results of an experiment conducted on Padegaon (1636—'38) on black cotton soil, revealed that farmyard manure was inferior to green manure as a basal dressing. The results are furnished below (16).

| Treatments. | Yield of cane per acre in lb. (Co. 431) |
|---|---|
| *Sunnhemp as basal manure* (gave 17,775 lb. and 13,450 lb. in two years respectively. | |
| 150 lb. N per acre. | 70,504 |
| 220 ,, do | 90,093 |
| *Farmyard manure 15,000 lb. per acre as basal manure.* | |
| 150 lb. N per acre. | 65,618 |
| 225 ,, do | 91,067 |
| *Groundnut cake 1 ton per acre as basal manure.* | |
| 150 lb. N per acre. | 93,543 |
| 225 ,, do | 1.00,979 |

(c) *Compost:* There were not many experiments for testing the the efficiency of compost as a basal dressing or as a supplier of nitrogen to cane. In two experiments conducted at Meerut for 4 years and at Hordi for two years in the U. P., no appreciable difference was found between yields recorded by cowdung and compost, applied at 400 maunds per acre. There was, however, an indication that the yields tended to be better when compost was applied. At Padegaon, compost from sugarcane trash was found to be inferior to both farmyard manure and groundnut cake when applied on the basis of equal nitrogen (120 lb. N per acre) (16). The compost in this case had a nitrogen content of 0·41% when compared 0·39% to farmyard manure. In two experiments conducted at Shahjanpur and Muzzafarnagar from 1938—'39 to 1947—'48, the average yields due to application of organic and inorganic manures on the same 'N' basis were recorded. The results are furnished below.

| Treatments. | Average yield in Shahjahanpur. | Maunds per acre Muzzafarnagar. |
|---|---|---|
| Sulphate of ammonia | 792 | 643 |
| Farmyard manure | 754 | 446 |
| Press mud | 788 | 507 |
| Farm compost | 781 | 493 |
| Castor cake | 819 | 851 |

Farm compost in this case was found to be superior to farmyard manure but was slightly inferior to press mud, castor cake and sulphate of ammonia (13).

**Preliminary Trials (1943)** to compost trash in the field itself were made at Padegaon by ploughing it well in advance of planting cane. Ammonium sulphate to supply 0·5 to 0·8% N on the dry weight of trash was sprinkled to bring the C/N ration within favourable limits. Yield data are as below :

| Treatment. | Trash alone | Trash + S. A. | Trash composted | Sanai | Sanai + Trash. |
|---|---|---|---|---|---|
| Yield in tons per acre | 37·7 | 41·6 | 41·5 | 39·6 | 37·7 |

Composted trash recorded the same yield as trash buried in the soil when sulphate of ammonia was applied in adequate quantities to serve as starter and facilitate its quick disintegration (17).

(d) *Bulky Manures as soil improvers with residual effect:* Fifty to 70% or more of N in farmyard manure remained unavailable to the crop (16). The low availability of N during the first year of application suggests that farmyard manure should have residual effects. But yield data from an experiment at Risalewala (1934—'36) with sugarcane, wheat-gram-cotton as rotation crops did not show any residual effect when 16 or 18 tons farmyard manure was applied as basal dressing. Even total N in farmyard manure treated plots was not more than in other fields. Farmyard manure supplied easily decomposable organic matter to the soil. At Padegaon continuous cropping with cane for 5 years with an annual dose of 40,000 lb. of farmyard manure and 150 lb. nitrogen as top dressing showed a loss of 52% of N after making allowance for its uptake by the crop. But in the acid alluvium of Jorhat (Assam) residual effect of farmyard manure was noted (16).

Farmyard manure is considered more as a soil improver, rather than as a supplier of N in Bombay. In an experiment conducted at Padegaon (1933—'36) including Pundia and P. O. J. 2878, the distinct influence of farmyard manure in improving soil tilth and thus benefiting the shallow-rooted Pundia could be clearly noted. However, fertility studies at the same station indicated the danger of indiscriminate, heavy applications of farmyard manure, especially in badly drained soils, as it increased C/N ratio beyond the beneficial limit and had actually reduced the fertility status of the soil. This was also applicable to the black cotton soils of Bombay (2). This aspect of manuring with farmyard manure was not studied in the other parts of the country. Similar studies on compost and green manures may throw more light on the subject.

With regard to economics, sunnhemp green manuring was more profitable than growing a rotation crop in the Deccan canal tract according to the findings of Gadgil in 1937. This dictum may be untenable now, because of the soaring prices of cereal grains which normally come in rotation with sugarcane. However, green manuring was found to be more paying than application of 30 cartloads of farmyard manure. (16). Even now this position remains the same.

In a very important experiment started in 1938—'39 and continued now, continuous annual applications of a basal dressing of 20,000 lb. of compost to sugarcane, planted in rotation in the same plots, was studied in a rotation experiment at Padegaon. The rotation adopted was groundnut, sugarcane and '*Jowar.*' The results of 3 cycles of crops are now available. Sugarcane received 300 lb. N as cake alone and sulphate of ammonia alone and in combinations of both in 2:1, 1:1 and 1:2 proportions. There was a duplicate series without basal dressing.

The data indicated that there was a steady decline in yield in spite of application of compost; the deterioration, however, being less in the case of compost series. The decline in yields in the case of top dressings was highest in sulphate of ammonia alone treatment, and least when cake alone was applied. The results are furnished below :

*Average response to top dressings, in tons of cane per acre.*

WITH COMPOST.

| Cycle | No. top dressing | Cake alone | Cake + S. A. 2:1 | Cake + S. A. 1:1 | Cake + S. A. 1:2 | S. A. alone |
|---|---|---|---|---|---|---|
| I | 17·58 | 56·91 | 58·86 | 58·85 | 56·60 | 55·43 |
| II | 17·11 | 47·35 | 46·08 | 45·30 | 42·22 | 36·39 |
| III | 13·21 | 45·72 | 45·63 | 44·38 | 38·52 | 31·44 |
| III as % of I. | 75·14 | 80·34 | 77·52 | 75·41 | 68·06 | 56·72 |
| | | | WITHOUT COMPOST. | | | |
| I | 18·31 | 54·96 | 57 48 | 56·89 | 55·06 | 43·70 |
| II | 12·18 | 43·87 | 41·28 | 37·17 | 32·15 | 24·13 |
| III | 10·98 | 42·20 | 39·68 | 36·45 | 28·89 | 20·41 |
| III as % of I. | 60·00 | 76·80 | 69·00 | 64·10 | 52·50 | 42 80 |

There was a distinct superiority in the humus & nitrogen content of soils which received compost as basal dressing. The humus content was 0·84% and 0·497% respectively, for compost and no compost series. The total nitrogen in the compost series increased from 0·059 in the I cycle to 0·076 in the III cycle. For the no compost series the figures were 0·057 and 0·071 respectively. The C/N ratio in the plots which received compost was 15·8 against 14·1 of the "no compost" series. There was 25% increase in $P_2O_5$ content of soil in the compost series. The results of two years only of the IV cycle indicated that the downward trend in the yields of all the treatments including the sulphate of ammonia treatment was arrested in the series which received the basal dressing. In fact, there was marked increase in yields of all these treatments over the yields recorded in the 3rd cycle, whereas in the series that did not get the basal dressing, deterioration in cane yields continued in all the treatments. Decline in yields was most marked in the treatment which received sulphate of ammonia alone as top dressing (18).

4. **Practices in other countries:** (a) *Australia:* There was no significant increase in yield due to conservation of trash combined with normal fertiliser applications at Bundaberg in Australia (6). Green manuring is common in this country. Von Stieglitz estimated that a good crop of green manure supplies 120 lb. N and 22 lb. $P_2O_5$ and 110 lb. $K_2O$. Incorporating trash in the soil and sowing a green manure crop for subsequent turning in, is advocated to facilitate decomposition of trash (21).

(b) *Hawaii:* According to Borden, when cane trash is worked into the soil a fallow of at least 8 months is required before planting cane to avoid loss in yield. In this case N is fixed by soil organisms and is available only at a later period (4). Starting with trash with a C/N ratio of 66·1, Borden found that available N decreased in plots to which different quantities of trash were applied together with ammonium nitrate to give up to 150 lb. N per. acre. Only when Ammonium Nitrate was applied at 200 lb. N was there a slight increase in available N, indicating that this 200 lb. N was required to satisfy the needs of soil micro-organisms. He recommended the use of 25 lb. N as N fertiliser per ton of trash, to save the crop from N deficiency.

(c) *Louisiana:* Cane is grown here after a crop of cowpeas *(Vigna unguiculata)* which is ploughed in.

(d) *South Africa:* Writting about preservation of the fertility of cane fields, Dr. Dodds recommended green manuring before growing cane in South Africa. He advocated composting cane trash in the field with filter cake and growing sunnhemp on the compost fields (5). Results of an experiment on burning cane along with trash, versus non-burning, reported by Sherrard indicated that by burning standing cane with trash there was distinct fall in yields, which increased as the number of ratoons increased (10). The yield date are presented below :

| *Plant crop, 1941* | | *Tons cane per acre* | *Sucrose % cane* | *Tons sucrose per acre* |
|---|---|---|---|---|
| Burnt | ... | 39·78 | 15·58 | 6·20 |
| Trashed | ... | 42·18 | 15·18 | 6·40 |
| *First ratoon crop 1943* | | | | |
| Burnt | ... | 52·83 | 12·28 | 6·49 |
| Trashed | ... | 61·13 | 12·47 | 7.62 |
| *Second ratoon crop 1945* | | | | |
| Burnt | ... | 40·26 | 13·69 | 5·51 |
| Trashed | ... | 49·16 | 13·63 | 6·70 |
| *Third ratoon crop 1947* | | | | |
| Brunt | ... | 28·10 | 13·92 | 3·91 |
| Trashed | ... | 41·42 | 13·83 | 5·74 |

(e) *West Indies:* Experiments in Trinidad indicated that pen manure with sulphate of ammonia was more efficient than sulphate of ammonia alone (19).

**5. Some practical aspects of application of organic manures in this State:** A review of results of experiments pertaining to three main bulky organic manures viz: farmyard manure, compost and green manure is made in the foregoing pages. Molasses was not considered in view of the impracticability of its transport and application. Press mud cake, another minor by-product of the sugar factories, received some attention. From this review the following inferences may be drawn.

1. We have not got sufficient data on all aspects of manuring with bulky organic manures to sugarcane in different soils.

2. In the matter of supply of nitrogen as plant food, all the bulky organic manures are inferior to concentrated organic manures like oil cakes as well as to inorganic fertilisers.

3. However there is some beneficial effect in applying these bulky organic manures and that is only indirect. They act as soil improvers.

4. There is an indication that continuous application of these bulky manures like compost will mitigate the adverse effects of continuous application of fertilisers.

5. When there is over irrigation or ill drainage, heavy applications of farmyard manure may lead to increased C/N ratio and depress yields.

6. Response of these bulky organic manures differs with differences in soil types.

7. Generally speaking they do not adversely influence juice quality of sugarcane.

With the background of this information, it is appropriate to consider certain practical aspects of application of these manures in this State; these are discussed below.

(i) *Availability of* (a) *Farmyard manure:* When areas under commercial crops were limited and knowledge of the use of organic concentrates and artificials was not so widespread as at present, cane growers invariably reserved adequate quantities of their farmyard manure to sugarcane. They relied on better preparatory cultivation of the soil and farmyard manure for good crops. And the noble varieties then under cultivation demanded such careful treatment. There are villages like Nadukuru of Srikakulam district, where ryots even now, stick to farmyard manure and never apply any concentrates, organic or inorganic. With the increase in area under sugarcane and other crops, application of farmyard manure in any adequate measure became out of the question. Acharya calculated that only about 120 8 million tons of farmyard manure (containing 50% moisture) is prepared annually and it meant $\frac{2}{5}$ of a ton of manure per acre (1) It can safely be assumed that the position is no better now.

(b) *Compost:* That farm, rural and town wastes can be converted into valuable bulky manures by composting is being realised and getting slowly popularised recently. There is a vast scope for increasing the quantity of compost, provided all the organic waste products are composted. For instance, about 3,35,000 tons of cane trash will be available annually for conversion into compost in this State. Barring a little quantity used for thatching houses, the rest is now being burnt away. If all of this is converted into compost along with other organic wastes, compost will be a valuable and rich source of bulky organic manure. Von Stieglitz (1944) estimated that in Queensland the trash and tops from a 20 ton cane crop, contain 52 lb. N, 22 lb. $P_2O_5$ and 90 lb. $K_2O$ (21). At this rate about 50,000 lb. N. can be supplied from the surplus cane trash and other wastes from the present cane area in this State.

(c) *Green Manure:* The availability of this manure is practically unlimited.

(d) *Pressmud cake:* Among the factory wastes press mud is a good source of organic N as well as phosphate. The average composition of the stuff is as follows:

| | Mushari (fresh) weight percent | Vuyyur percent (fresh) | Queensland (fresh) percent | Natal (airdried) percent |
|---|---|---|---|---|
| Moisture ... | ... | ... | 70·0 | 10·0 |
| Nitrogen ... | 1·0 | 1·17—0·65 | 0·5 | 0·80 |
| $P_2O_5$ ... | 3·0 | 1·001 | 0·5 | 2·50 |
| $K_2O$ ... | 1·0 | 0·58 | 0·06 | 0·02 |
| Lime ... | 8·0 | ... | 0·7 | 14·0 |

The production of press mud in this State is estimated at about 14,000 tons with 60 to 70% moisture.

(ii) *Time and method of application:* Generally speaking, application of bulky manures is recommended to be done well in advance of planting cane.

Farmyard manure has to be ploughed in about a month or earlier prior to planting (15). This is to facilitiate decompostion and availability of plant nutrients to sugarcane shortly after its establishment. While reviewing the results of fertiliser experiments, the apparent inconsistency in the effect of application of farmyard manure was largely attributed, by Dr. Rege, to the differences in the state of its decomposition (which is not mentioned in the reports), not to speak of the influences of the particular soil type. If partly decomposed organic matter, is applied in the name of farmyard manure, it increases the C/N ratio, resulting in loss of nitrogen by bacterial action. There are instances, however, of applying excellently rotted cattle manure top dressing in parts of Visakhapatnam and Godavari districts. That is the ideal state in which it should be applied to the crop to derive maximum benefit.

In green manures we have a source of unlimited supply of bulky organic manures. But their use is conditioned by certain limitations which have to be overcome before they can be more widely popularised.

Ploughing a green manure crop '*in situ*' prior to planting cane is being recommended from many years past. But there should be adequate time for it to distintegrate and become useful to the succeeding cane crop. We have no data in this State on the effect of ploughing in a green manure crop at different periods prior to planting cane.

Even in other States, data are extremely meagre. In the black cotton soils of Bombay–Deccan, sunnhemp is grown as a rotation crop and ploughed in in August and cane is normally planted only in next January. There is thus plenty of time for it to disintegrate, but due to heavy rains in September – October, 25% of the added 'N' was leached away (16). In Madras State sugarcane is mostly rotated with paddy which is harvested in November - December. Sunnhemp or Pillipesara are sown in the standing crops of paddy and after about 2 months, part of the green stuff is utilised for cattle feed and the remaining ploughed in for green manure purposes. So the problem here is proper disintegration of green manure prior to planting cane and not leaching away of nitrates. This is so far as places to which water supply is available till March, are concerned. But in places like parts of Godavari district, Srikakulam district and large areas of Visakhapatnam district, water supply may be available just for planting cane and giving it an irrigation or two, before the canals are reopened or monsoon rains set in. For instance in Chodavaram taluk (growing about 10,000 acre under cane) a large part of the cane area is planted after the receipt of one or two good summer showers only. In such places ploughing in of a green manure crop prior to planting is unthinkable. For overcoming the difficulty of early stoppage of water supply, the cane areas have to be planned just as the second crop paddy area. This planning, can be and has to be done by the cane growers themselves. They should grow an early duration paddy variety in the area proposed to be planted to cane next year. This can be removed from the field in the first week of November and a green manure crop sown in the standing crop of paddy prior to its harvest. By about the end of December it should be ploughed in. Cane planting may be done in February - March after the green manure gets well incorporated into the soil. If this is not systematically done, sunnhemp, which is the most popular green manure crop in this State will get affected by seepage of water from surrounding wetlands having long duration paddy crops. An instance of consolidating cane areas into blocks for facilitating better drainage is available in the Vuyyur Factory area in the Krishna district. In a similar way it should be possible to organise cane areas into blocks and grow short duration paddy followed by a green manure crop prior to planting cane in most of the wetlands of this State.

In areas where there is not enough interval for growing a green manure crop it can be sown as an inter-crop in sugarcane, provided there is a possibility of water supply after about two months. The crop can be buried besides cane rows while earthing them up.

The sunnhemp seed has to be dibbled with the first hoeing to give a satisfactory crop. Where intercultivation with bullock - drawn implements is done the seeds have to be sown close to the cane rows to facilitate working of the implements without uprooting the plants. It is also desirable to adopt 3 feet spacing under such circumstances.

When the intercrop is grown, enough moisture during its growth is necessary, if this is not to make inroads into the moisture required by the main crop during the summer months.

Green manuring is considered the cheapest way of supplying organic nitrogen as well as humus to soils. A crop of sunnhemp aged 50 to 60 days is estimated to supply 60 lb. N per acre (16) Whether increased cane yields and the beneficial effects of green manuring on the physical condition of soil, offset the income that can be derived by alternate crops like pulses or cereals in these days of high prices has to be investigated.

There is yet another aspect that needs consideration when green manuring is proposed prior to planting cane. A thorough preparatory cultivation from the time the previous crop is removed is considered superior to green manuring the land. Progressive cane cultivators in the deltas prefer to plough the land immediately after removing paddy, without taking either a pulse crop or a green manure crop. They feel that by deep cultivation they will be able to improve the moisture-holding capacity of the soil and help the crop to tide over the summer months. In the Central districts the practice of allowing the land to dry up and crack for some time, then letting in water and ploughing the field when in condition is found to give a very good tilth. By doing this, clods will not be formed as in the case of ploughing immediately after paddy. But whether the moisture-holding capacity will in any way be affected by this practice is not known. Thus, whether a thorough preparatory cultivation without growing a green manure crop will be better than green manuring and moderate cultivation needs investigation.

A great handicap which limits composting is the non-availability of vacant spaces near the fields for digging compost pits or putting up compost heaps. If all the surplus cane trash is to be composted, a nearby vacant space is necessary. It will be a costly affair to collect it from the field and cart it to distant places where space might be available. Hence many cane growers adopt the least expensive method of its disposal by burning it. They are thus not only burning away trash but also the roots and other organic material spread over in the top layers of the soil and amounting to about 3,000 lb. per acre (7). To obviate the expensive method of collecting trash and overcome the difficulty of lack of space, composting cane trash in the field itself is recommended. But direct application of trash without proper precautions was found to lower yields, in this and other countries (16,4).

Application of ammonium sulphate at 0·5 to 0·8% on the weight of trash seemed to have kept down the C/N ratio and promoted decomposition of trash without affecting the soil, in Bombay (17).

Pig manure is supposed to quicken disintegration of trash when applied as a starter. Substances like press mud cake are also being tried as starters in place of cow dung-water for composting. In a small-scale trial at Samalkot no adverse effects on the crop (like yellowing of leaves, or scorching of leaf tips) were noted by direct application of trash in summer. There were white ant and rat attacks, which were negligible. It may be of interest to note that to conserve moisture, a light layer of cane trash is spread over the young cane crop beds, in Godavari and Visakhapatnam districts. This trash is collected and removed with the onset of rains. It is recommended that it may be buried besides cane rows in the field itself and the normal manuring with concentrates attended to. The effect of this practice on the nutrition of the cane plant has to be investigated and a method of composting cane trash in the field itself has to be perfected in the interests of economy.

Press-mud cake which is being produced in limited quantities was favoured for application to paddy by ryots in the neighbourhood of sugar factories. Direct application to cane, just like farmyard manure was tried at ten tons (20 cartloads) per acre on the Sugarcane Liaison Farm at Samalkot during 1950—51. It was ploughed in about two weeks before planting cane, and there were no visible adverse effects on the crop like yellowing of leaves etc. It is reported that direct application to sugarcane is also being tried by some cane growers in recent years. One reason why the application of filter press mud has not given any great increase in crop yields, is reported to be its high wax content. (12% on dry weight; 14 to 22% in Cuba). A process has been recently developed by Dr. Owen for extracting this wax with solvents and reinoculating the mud with desirable soil microbial flora before its application as manure (4). The possibility of removing this wax by some such process may be considered in this State to improve the manurial efficiency of press mud cake.

Before concluding this paper, one point has to be stressed. There is at present a wrong emphasis in practice on the efficacy of artificials for getting high yields. Many cane growers are adopting this short cut (in their opinion) to get high yields. But a note of warning should be sounded against this practice.

The results of the Bombay experiment on continuous applications of compost (18) should be an eye-opener to them. Moreover, Dr. Baver, (Hawaii) writing about translation of results of research into practical field scale achievements, postulated that there was a deterioration in the natural productive capacity of the soil at a rate almost fast enough to off-set all the improvements in soil and crop management. He suggested that "ascertaining and application of sound basic facts to the problems of increasing soil productivity would make a sizeable contribution to narrowing the gap between science and practice in the sugar industry". (3) Good soil management, including application of bulky organic manures coupled with proper cultural practices, such as provision of better drainage, optimum irrigation and timely intercultivations are essential for stepping up cane production and maintaining soil fertility.

6. **Summary and conclusions:** Sugarcane is a heavy feeder and to increase its production, large doses of nitrogenous concentrates are essential. There is at present acute short supply in organic concentrates like oil cakes. It is necessary to supply inorganic fertilisers in combination with organic concentrates or on a basal dressing of some bulky organic manure like farmyard manure, compost or green manure. The effect of application of these bulky manures with and without concentrates, as revealed by the results of experiments conducted in this and other States was reviewed. Some practical aspects, especially with regard to doses and time of application were dealt with. The available information is definite only about one thing and that is, that a large quantity of nitrogen in the bulky manures remains unavailable to the cane crop during its life period and that though applied on the same nitrogen basis, bulky manures are inferior to concentrates like cakes or inorganic fertilisers. Information with regard to residual effect is not uniform. Heavy applications were beneficial under certain conditions but were harmful when over-irrigation or bad drainage was prevalent in certain soils. Thus there is need for conducting experiments on all aspects of the application of bulky organic

manures to sugarcane, including the economic aspect (of missing a rotation crop, for growing a green manure crop) taking into consideration certain practical difficulties inherent in the different localities. Only then will it be possible to recommend correct methods for utilisation of these bulky manures based on experimental data, instead of in an empirical manner as is being done now, These experiments, designed as they are, for keeping up the fertility status of the soils and producing better crops over a long period, are of vital importance and should claim top priority in schemes of research on sugarcane.

7. **Acknowledgements:** Results of experiments in other States were mainly taken from the bulletin on 'Fertiliser experiments on sugarcane in India by Dr. Rege and from 'Manuring of sugarcane—a critical review' by Mukerji and Verma. Thanks are also due to the Indian Central Sugarcane Committee, who are partly financing the scheme of developmental work on sugarcane in this State.

## REFERENCES


1. Acharya, C. N. (1944) Cattle wastes in India. Ind. Farming; Oct. 1944.
2. Basu, J. K. et al. (1943) Soils of the Deccan Canals. Soil fertility survey on the Nira left bank and Godavari canals. Ind. Jour. Agrl. Sci. Vol. (6) p. 572—586.
3. Baver, L. D. (1949) Hawaii. Plant. Rec. Vol. LIII, No. 1. p. 1-12.
4. Borden, R. J. (1949) Nitrogen fertilisers - Review - Hawaii Plant Rec. Vol. 53, PP 79—88. Original not seen — extract Int, Sug. Jour; Aug. 1950.
5. Dodds, H. H. (1946) Preserving the fertility of cane fields. Extract from Int. Sug. Jour; Aug. 1946.
6. Forty-Fourth Annual Report of the Bureau, of Sug. Expt. Stations, Queensland. 1943.
7. Hardy, F. (1944) Tropical Agriculture, Vol. 21, No. 11, PP. 203-209. Refce. in Sugar, 1945, No. 2.
8. Kapoor, G. P. and Kishore, G. (1951) Comparative efficiency of various organic manures and inorganic fertilisers in West Uttar Pradesh for sugarcane. Proc. 1st. Biennial Conf. Sug. Research workers in the Ind. Union, Part II. I. p. 83—92.
9. Lakshmikantham, M. and Sankaram, A. (1949) Optimum nitrogen requirements of sugarcane in the Anakapalli tract. Mad. Agri. Jour. Vol. XXXVI Jan. 1949.
10. Madras Agricultural Station Reports, Anakapalli. 1916—'17 to 1918—'19.
    do 1920—'21.
    do 1923—'33.
11. do Palur. 1939—'40, 1941—'42. 1946—'47.
12. do Samalkot. 1902—'03 to 1907—'8.
    1909—'10 to 1917—'18.

13. Mukherji. B. K. & Verma, G. (1950) Manuring Sugarcane; A critical review; Proc. 19th Annual convention Sug. Tech. Assoc. of India. Part I. p. 46—49.

14. Owen, L. W. N. (1951) Sugar 46. (1) No. 1 p. 34—36.

15. Pramanik, B. N. & Misra, A. N. (1951) Certain biological investigations carried out at the sugarcane research station, Shajahanpur Proc. 1st Biennial Conf. of Sug. Res. Workers in Ind. Union, Part II. I. p. 97. 108.

16. Rege, R. D. (1941) Fertiliser experiments on sugarcane in India, 1932—'39. Misc. Bulletin 41. of I. C. A. R.

17. Rege, R. D. and Wagle, P. V. (1944) Proc. 12th Con. Sug. Tech. Assoc. Ind. (original not seen). Extract from Int-Sug. Jour. Nov. 1944.

18. Sherrad, C. D. (1949) South African Sug. Jour. Vol. 33 No. 8 P. 533.

19. Rege, R. D. (1951) The place of compost in sugarcane culture in the Bombay Deccan; Proc. 1st Biennial Conf. of Sug. Res. workers in Ind. Union; p. 73—76.

20. Turner, P. E. (1950) Report of recent work in Sugarcane Agriculture. (Original not seen). Extract by H. M. L. in Ind. Sug. Jour., Sep. 1950.

21. Von Stieglitz C. R. (1944) The economic use of fertilisers for sugarcane cultivation in war time. Proc. Queensl. Soc. Sug. Tech, 1944, PP. 73—82 (original not seen) Extract from Int. Sug. Jour., Aug. 1946.

# The Nitrogen Nutrition of Sugarcane

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**Introduction:** Of the major plant food elements, sugarcane responds most to nitrogen. Phosphate and potash are only of local importance depending upon the nature of the soil and its peculiar formation. Nitrogen happens to be the chief problem in the fertiliser programme for sugarcane, and it is the most fugitive of the three elements. The yield and quality are both affected by nitrogen. Low applications result in poor yields while high doses result in canes of poor quality. Also, the climatic conditions and the time at which the nitrogen is applied have all got an effect upon the plant's reaction. Applications made late in the season depress the sugar content and yield of juice, resulting in poor quality jaggery. *It can thus be seen that the nitrogen fertilisation of sugarcane* is an operation which affects the yield, the composition, and quality of sugarcane and the sugar manufacturing and open - pan industries.

Considerable attention has been paid to this problem, which is the foremost in the sugarcane countries of the world. The earliest comprehensive investigation on this aspect is by Das (11) in Hawaii who attempted a detailed physico - chemical study of nitrogen nutrition in the sugarcane plant. The main object of his study was to find out why high nitrogen doses, while giving high yields, reduce the quality of the cane and what changes in the cane plant accompanied this phenomenon. He found that high doses of nitrogen increase the vegetative growth, tillering and yield. They promoted succulence of tissues by increasing the moisture content per gram of dry matter. The sucrose content in the sap was reduced and reducing sugars increased. The characteristic effect is an increase in the total and soluble nitrogen in the tissue with increasing nitrogen doses. From these studies, he hypothesized that application of nitrogen would first increase the absorption of the ash constituents, resulting in a modification of the hydration capacity of the tissue colloids. This alteration in the hydration capacity controls the elaboration of the various carbohydrates in the tissues, presumably through its influence on the organic complex of the plant.

Along with the above workers. Ayres (3) in the same station, studied the absorption of mineral nutrients by sugarcane at successive stages of growth. A knowledge of the changing demands which the growing cane plant makes on the soil at different stages of growth was felt necessary to adopt a more rational fertiliser programme. He found that the different plant nutrients were absorbed at different rates, nitrogen being absorbed earlier than phosphate. The rate of uptake of nitrogen was most rapid upto 6 months, after which there was a marked falling off.

Studies on the nitrogen requirement of sugarcane were done by Borden (5, 6) in Hawaii. This author started with a study of the periodical uptake of nutrients and finally attempted the evolution of an index in the plant itself which could be used for assessing the fertiliser requirements of sugarcane. In a study of the early development and rate of nutrient uptake by sugarcane, Borden (4) attempted to find out the critical stages of the crop when the crop required maximum plant food. He found that the concentration of N, P, K, decreased with increase in age. The most rapid uptake of nitrogen occurred between the 4th and 9th month. The absorption of $P_2O_5$ was constant after the crop was well under way. Such information has been found useful for developing a rational schedule of manuring.

The usual technique of field experimentation by the use of graded quantities of fertilisers has been found to be of limited value by these workers, in solving the manurial requirements of crops. Also, it was found that the results obtained at one particular place or soil were not applicable to a place even nearby. The need for an index, either in the soil or in the plant, was found to be imperative. Soil studies failed to give any satisfactory index for the manurial needs of the plant. By means of careful tests it was found that the leaf was a reliable index of the fertiliser needs of the cane plant. This technique of "foliar diagnosis" has been adopted in Hawaii, Mauritius, Puerto Rico and Jamaica. By this technique the plant is manured only when the need is indicated by an analysis of the leaf. Whenever the leaf nitrogen value falls below an optimum value, the crop is manured. By means of this technique, it has been estimated that Hawaii was able to reduce its manurial dose considerably. Notable among the workers in this line are Borden (5) and Clements (9) in Hawaii and Craig (10) in Mauritius.

In an article on "A search for guidance in the nitrogen fertilisation of sugarcane", Borden (5) found that soil analysis for both total and available nitrogen failed to give any specific guidance when the crop was under way. He found that foliar nitrogen was more reliable and in a growing crop he determined levels of nitrogen in the leaf indicative of deficiency, sufficiency and excess of nitrogen in the soil. In a subsequent study, Borden (7) studied the effect of nitrogen on the yield and composition of sugarcane. By applying graded doses of nitrogen he found that the concentration of nitrogen in all parts of the cane increased with increase in nitrogen added to the soil. The crop was found to show a deficiency of nitrogen at 11 months (in Hawaii sugarcane is a biennial crop) when the nitrogen in total dry weight was only 0·23%, 1·28% in leaf punches, 0·89% in leaf blades. At this stage, it has been found profitable to apply some more nitrogen to effect an increase in final yields. This system of controlled fertilisation was very helpful in economising manurial expenses in Hawaii. Borden (6), extended his studies to second ratoon crops also and found that the indices for the ratoon crops for optimum yield were higher than for the plant crops.

Craig (10) in Mauritius was able to establish a correlation between leaf nitrogen and crop response. In subsequent years, it was possible to control nitrogen fertilisation of sugarcane by means of leaf analysis. Definite levels of N, P and K in the cane leaves were found to be indicative of the manurial requirements of sugarcane. However, there were characteristic levels of nutrients for each variety and hence varietal differences must also be taken into consideration.

Asana (1) working in Bihar, studied the absorption of nitrogen by the sugarcane plant at different stages of growth. He found that the rate of uptake of nitrogen increased to a maximum in about 17 weeks and thereafter there was a steady decline. These studies are of value in indicating the periods of plant food requirements by the crop.

Lakshmikantham and Sankaram (15) sought to determine the optimum nitrogen requirement of sugarcane iu the Anakapalle tract by means of a field experiment with graded doses of nitrogen from 0 to 250 lb. nitrogen. Considering the yield, they found that 100 lb. nitrogen per acre to be the optimum for sugarcane in this tract. The conclusions were based mainly on yield and economics of cultivation and do not indicate the periodical requirements and utilisation of nitrogen by the crop.

Rege (16) at Padegaon studied the nitrogen requirement of sugarcane. Biochemical studies on the crop and the soil revealed 300 lb. nitrogen. to be the optimum in that tract, beyond which it was not economical. In a more recent study. Rege and Sannabhadti (17) studied the physiological behaviour of important cane varieties, with regard to the uptake of the major plant food elements. They found that during the early stages of growth, nutrient absorption takes place at a much greater rate than the elaboration of dry matter. The maximum absorption was found to occur during October – November and later, the cessation of growth brings a reversal in the uptake. These studies have been found useful to draw up different manurial schedules for different varieties without detriment to soil fertility.

Khanna, Prasad and Sinha (14) studied the applicability of foliar diagnosis as an index for optimum fertilisation for sugarcane in Bihar. They found that both the standard leaf and the alcohol extract of the standard leaf were better than the whole plant for assessing nutrient requirements. This was particularly so in the case of phosphates. The maximum uptake of nitrogen was in May and that of phosphates in August.

Work was done in Madras to find out the optimum nitrogen requirements of the cane crop for the different soil and climatic conditions that exist in different cane tracts and tentative schedules were drawn up by field experimentation at the various research stations. This information, valuable as it is, does not give an insight into the behaviour of the cane plant, when the cane crop needs the manure most and whether the applied manure is efficiently utilised. Dutt in his report of sugarcane research in India has stressed the need for recommending the minimum additional dose of fertiliser over and above the farmyard manure the ryot invariably applies, There is also a need to reduce the manure bill for sugarcane. All these require investigations on the cane plant at different stages of growth and detailed investigations were taken up with the object of elucidating :—

(a) the fate of the fertilisers applied to the soil;

(b) the composition and uptake of nitrogen by cane plant at different stages of growth, to determine the 'critical periods' in the life of the cane plant;

(c) the effect of cane growing on soil fertility;

(d) the possibility of finding out an index in cane tissue which can indicate its manurial requirements;

(e) the effect of such fertilisation on the composition of juice and jaggery quality.

Such information is essential to evolve a sound system of manuring, for maintenance of soil fertility at high levels and producing cane of good quality, since the ultimate objective is more sugar and jaggery of good quality.

**Material and Methods:** With the above objects, a field experiment was laid out at this station with graded doses of nitrogen viz., 100, 150 and 200 lb. nitrogen with two varieties, Co. 527 (early) and Co. 419 (late). The layout was a split plot design with six replications. Before planting, the soil of experimental field was analysed to have an idea of the basic fertility level of the soil.

**TABLE I.**

**Initial analysis of the soil.**

| S. No. | Constituents | Results of analysis |
|---|---|---|
| 1 | Moisture% | 3·46% |
| 2 | Total Nitrogen | 0·046% |
| 3 | Nitrate-Nitrogen (mg. per 100 grms soil) | 1·12 mg. |
| 4 | Organic carbon | 0·34% |
| 5 | C/N ratio | 7 7 |
| 6 | pH | 7·4 |

The data reveal that the initial fertility level of the soil is high enough.

Subsequently, soil samples were drawn every month from the different treatments and analysed for nitrate nitrogen and moisture to study the release of nitrogen from the manures under different treatments. Simultaneously, plant samples were drawn to study the composition and uptake of nitrogen per acre. Since the uptake of nitrogen per acre was calculated every month, the "unit length" method of sampling was adopted where one-half of the experimental plots were divided into strips, and alternative strips were taken from each replication and then mixed and a composite sample obtained. These samples were immediately used for moisture determination and another sample oven-dried for nitrogen estimation. From the nitrogen content in the strips taken on fresh basis, the uptake of nitrogen per acre was calculated.

**Results and Discussion:** (a) *Composition of the cane plant:* *Fig.* 1 gives an idea of the effect of nitrogen application upon the composition of the cane plant. The trend of nitrogen concentration in the cane plant is to decrease with age, the youngest plant having the highest concentration. It shows that the formative stage is characterised by higher absorption than utilisation by the plant. As soon as the cane plant starts its "grand period of growth" from June - July, the utilisation proceeds at a faster rate than the absorption of nitrogen which results in what is called a "poverty adjustment" balance, but when the maturity phase sets in, no more nitrogen is required and actually there is a return of nitrogen to the underground portions and the soil by the time the cane is harvested. A clear understanding of this nitrogen metabolism is essential for a rational schedule of manuring for the cane crop. Yuen and Hance (18) in Hawaii believe that the nitrogen concentration must be kept at the higest level, preferably at luxury concentration, in the formative stage along with optimum moisture conditions to enable the plant to tiller well. Failure of this early tillering will result in lesser number of mother shoots, and finally give a lower yield of cane and sugar per acre. When the grand period sets in, there is need to maintain high amounts of availabe nitrogen in the soil to cope with the rapid utilisation by the cane plants. As soon as the maturity phase sets in, there should not be much available nitrogen in the soil, since it has been found that high amounts of nitrogen in the soil helps sugar breakdown rather than accumulation. In the present study also, high amounts of nitrogen in the body of the cane plant resulted in low sucrose content in the cane juice, as seen in Table II.

**TABLE II.**

**Nitrogen in cane tissue and sucrose % in juice.**

| S. No. | Details | August | November | | Harvest | |
|---|---|---|---|---|---|---|
| | | Nitrogen % | Nitrogen % | Sucrose % | Nitrogen % | Sucrose % |
| 1 | Co. 419 : 100 N | 0·75 | 0·42 | 7·63 | 0·29 | 17 04 |
| 2 | ,, : 150 N | 0·83 | 0·57 | 7·13 | 0·20 | 16 58 |
| 3 | ,, : 200 N | 0 95 | 0·56 | 7·26 | 0·36 | 15·85 |
| 4 | Co. 527 : 100 N | 0·85 | 0·55 | 11·37 | 0·42 | 15·14 |
| 5 | ,, : 150 N | 0·94 | 0 55 | 9·62 | 0·42 | 15·14 |
| 6 | ,, : 200 N | 0·97 | 0·60 | 8·74 | 0·46 | 14·66 |

The effect of increasing doses of nitrogen on the composition of the whole plant is given below:

**TABLE III.**

**Total Nitrogen in the whole plant** *(% Oven-dry basis).*

| S. No. | Details | May | June | August | November | Harvest |
|---|---|---|---|---|---|---|
| 1 | Co. 419 : 100 N | 1 71 | 1·05 | 0·76 | 0·42 | 0 29 |
| 2 | ,, : 150 N | 1·83 | 1·09 | 0·83 | 0·57 | 0·29 |
| 3 | ,, : 200 N | 1·85 | 1·30 | 0·95 | 0·56 | 0·36 |
| 4 | Co. 527 : 100 N | 1·85 | 1·09 | 0·85 | 0·55 | 0·42 |
| 5 | ,, : 150 N | 1·88 | 1·12 | 0·94 | 0·55 | 0·42 |
| 6 | ,, : 200 N | 1 89 | 1·25 | 0 97 | 0·60 | 0·46 |

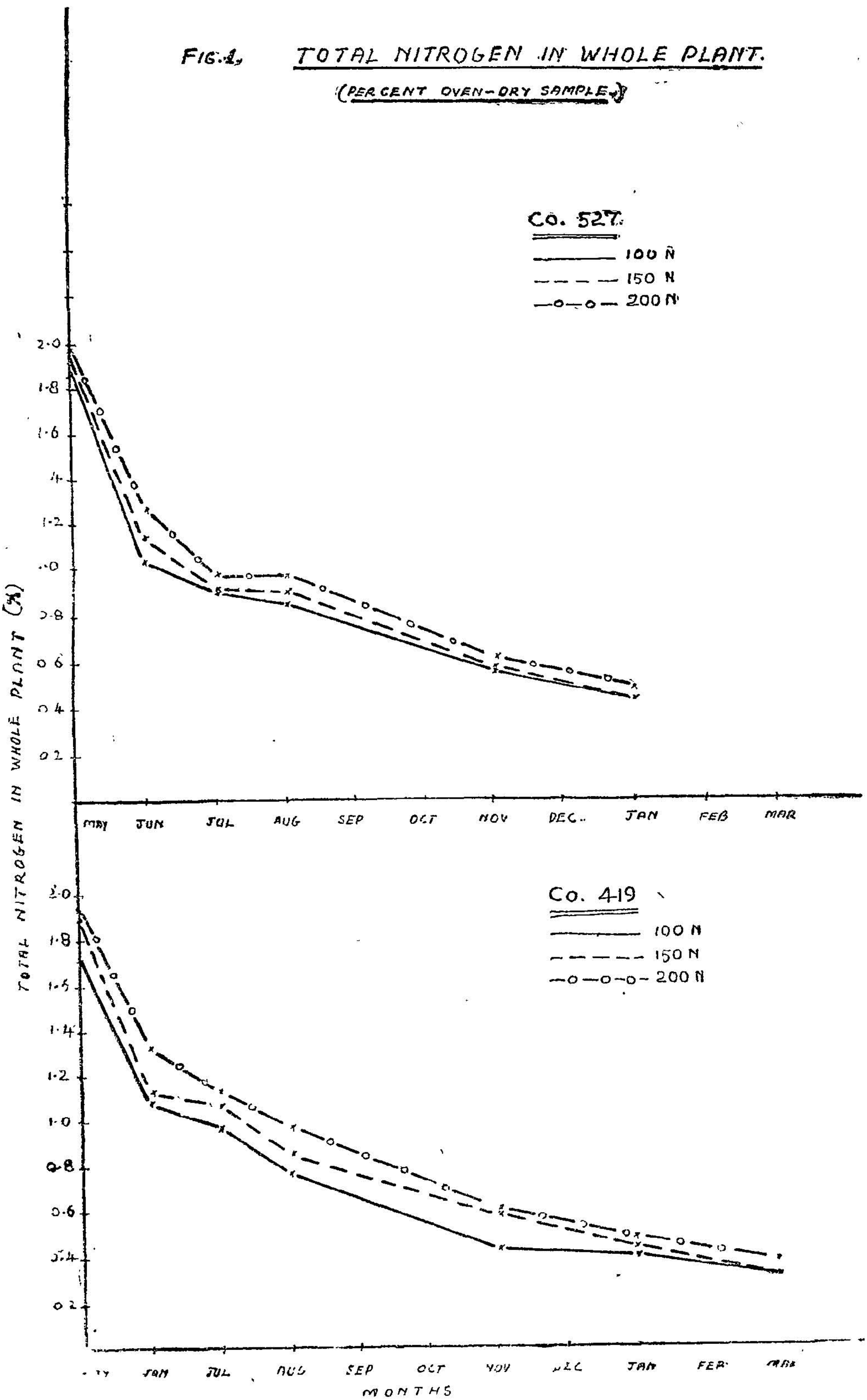
FIG. 1. TOTAL NITROGEN IN WHOLE PLANT.
(PERCENT OVEN-DRY SAMPLE.)
Co. 527.
100 N
150 N
200 N
Co. 419
100 N
150 N
200 N
TOTAL NITROGEN IN WHOLE PLANT (%)
2·0
1·8
1·6
1·4
1·2
1·0
0·8
0·6
0·4
0·2
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC.
JAN
FEB
MAR
MONTHS

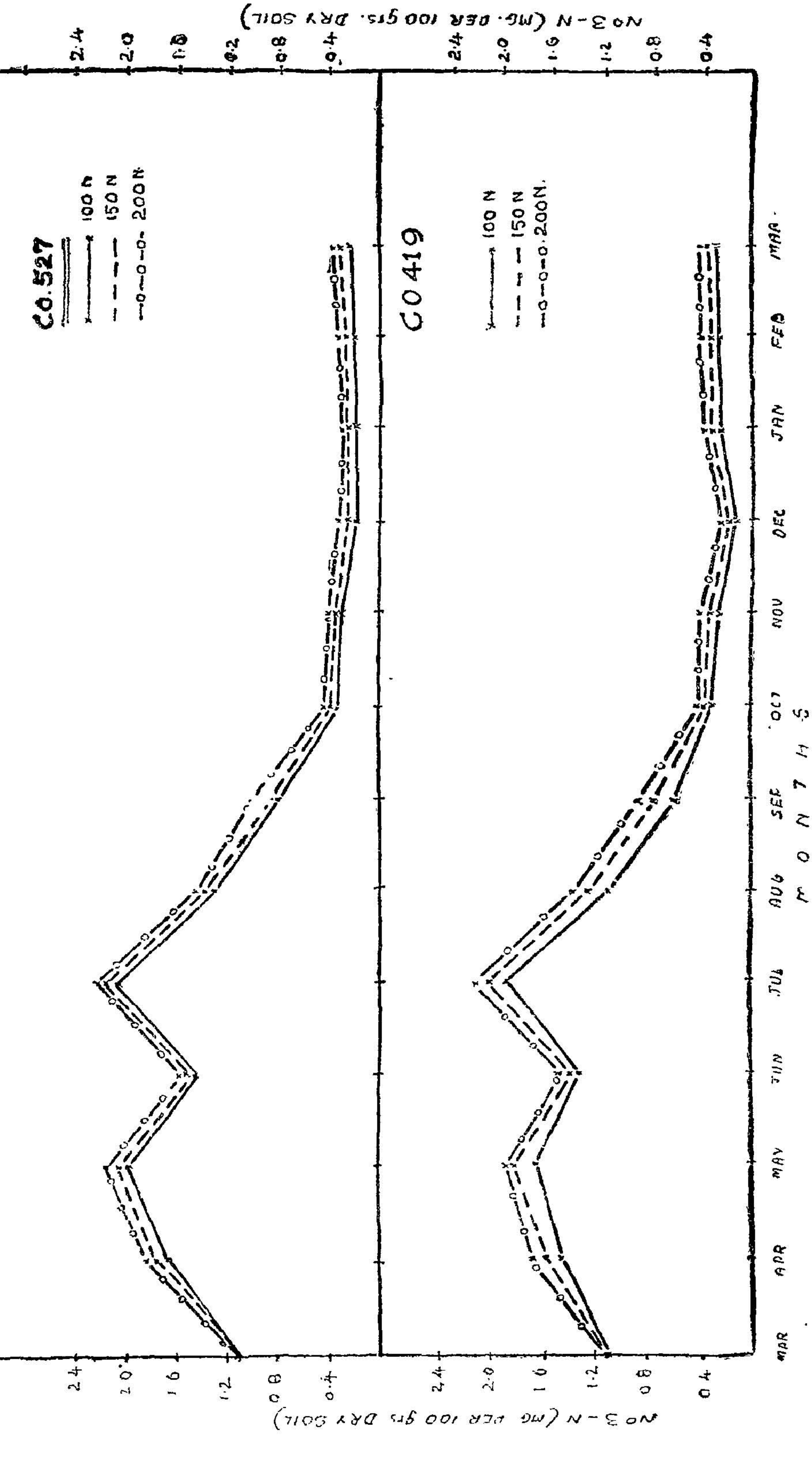


FIG. 3. MONTHLY VARIATION OF NITRATES IN THE SOIL (MG PER 100 grs. DRY SOIL)

It can be seen that there is a slight increase in nitrogen in the cane tissue with an increase in the dose of nitrogen. It is more marked in the early stages of growth and is maintained upto harvest. In the two varieties, taking the lowest dose of 100 lb. N into consideration, it can be seen that Co. 527 throughout records a higher nitrogen content in its tissue than Co. 419, the late varity. The greater detrimental effect of 200 lb. N on juice quality of Co. 527 as shown in table II, may be due to this.

(b) *Uptake of nitrogen per acre:* The periodical uptake of nitrogen by the cane plant as computed by the unit length method of sampling is given in Table IV.

**TABLE IV.**

**Periodical uptake of Nitrogen** *(lb. per acre).*

| | Details: Variety | | Dose of Nitrogen (in lb. per acre) | Formative stage | Early grand period | Maximum uptake (during grand period) | Harvest time |
|---|---|---|---|---|---|---|---|
| 1 | Co. 419 | : | 100 N | 23 5 | 111·7 | 129·0 | 94·0 |
| 2 | Co. 419 | : | 150 N | 36·7 | 152·9 | 178·5 | 96·4 |
| 3 | Co. 419 | : | 200 N | 47·3 | 169·8 | 191·7 | 104·6 |
| 4 | Co. 527 | : | 100 N | 27·7 | 132·5 | 169·6 | 127·7 |
| 5 | Co. 527 | : | 150 N | 34·9 | 145·1 | 246·4 | 134·0 |
| 6 | Co. 527 | : | 200 N | 44·1 | 158·4 | 234·0 | 163·6 |

It can be seen that, in spite of the high nitrogen concentration in the early stages (Table III), the uptake per acre is lowest during the formative stage, showing that under normal conditions, the nitrogen requirement is negligible in the early stage. It can also be seen thst the uptake is more with increased nitrogen doses, but this is not reflected in increased yields of cane. The rate of uptake rapidly increases with the onset of the grand period and during this period as much as three-fourths of the total nitrogen is taken up. By harvest time there is a fall in the nitrogen per acre. Thus the early grand period stage can be taken as the "critical period" in the life of the plant, during which it requires the maximum amount of available nitrogen. The dose and time of manuring should be so adjusted that adequate nitrogen is made available to the plant during this stage. In the case of higher doses of nitrogen, beyond 100 lb. N, the higher accumulation in the plant body without a corresponding increase in yield results in poor juice quality.

(c) *Release of Nitrogen from manures:* The periodical availability of nitrogen from different treatments was studied throughout crop growth. The data are presented in Table V.

TABLE V.

**Nitrate-nitrogen in soil during crop growth** *(Original* $NO_3 = \frac{1 \cdot 12 \text{ mg.}}{100 \text{ gm}}$*)*

| S. No. | Details | April | May | June | July | August | Sept. |
|---|---|---|---|---|---|---|---|
| 1. | Co. 419 : 100 N | 1·54 | 1·69 | 1·33 | 1·92 | 1·10 | 0·56 |
| 2. | ,, 150 N | 1·61 | 1·76 | 1·33 | 2·03 | 1·28 | 0·74 |
| 3. | ,, 200 N | 1·64 | 1·78 | 1·38 | 2·08 | 1·37 | 0·82 |
| 4. | Co. 527 : 100 N | 1·70 | 2·02 | 1 44 | 1·10 | 1 30 | 0·80 |
| 5. | ,, 150 N | 1·74 | 1·97 | 1·43 | 2·14 | 1·35 | 0·70 |
| 6. | ,, 200 N | 1·72 | 2 06 | 1·47 | 2·15 | 1·40 | 0·95 |

| S. No. | Details | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|
| 7. | Co. 419 : 100 N | 0·29 | 0·24 | 0·11 | 0·22 | 0·22 | 0·21 |
| 8. | ,, 150 N | 0·36 | 0·30 | 0·15 | 0·22 | 0·20 | 0·27 |
| 9. | ,, 200 N | 0·36 | 0·30 | 0 20 | 0·22 | 0·19 | 0·27 |
| 10. | Co. 527 : 100 N | 0·36 | 0·30 | 0 18 | 0·22 | 0·19 | 0·23 |
| 11. | ,, 150 N | 0·36 | 0·30 | 0·27 | 0·22 | 0·22 | 0·23 |
| 12. | ,, 200 N | 0·36 | 0·30 | 0·27 | 0·26 | 0 21 | 0·27 |

The analysis of the soil for nitrate-nitrogen shows that higher nitrogen doses did not result in higher availability of that element in proportion to the dose applied, presumably due to some limiting factor operating. By the stage of maturity, however, no difference in the nitrate-nitrogen is noticeable among the different treatments (Fig. II),

The first half of the manure applied at planting time is found to reach peak availability (Fig. II) in about 1½ to 2 months in the case of all treatments. But it was already noted that the nitrogen requirement during this stage is very little and hence the utilisation of the dose is not complete and is likely to be wasted. The second half of the manure given at earthing-up time is found to maintain a higher level of available nitrogen during the grand period. The rapid fall in available nitrogen after July appears to be due to high uptake by the plant.

Thus a comparative study of the uptake of nitrogen by the cane plant and the release of nitrogen from the applied manures has yielded useful data regarding the manurial requirement of the cane crop, The "Early grand period" stage is the most critical perid for nitrogen in the crop. The release of nitrogen from the soil in the different manurial treatments shows that the rate of availability is not conducive to efficient utilisation since the first peak is not fully utilised by the plant when it is in a formative stage of development. These studies warrant the conclusion that for an efficient utilisation of manure, it must be applied 1 to 1½ months after planting. Further studies in this line are in progress.

(d) *Composition and quality of the juice :—* The effect of high nitrogen on the chemical composition of the cane juices was studied through an analysis of the juice, both for sugar and non-sugar constituents. The data are given in Table VI.

**TABLE VI.**

**Effect of nitrogen on juice composition (1949–50)**

| S. No. | Details of analysis. | C. 419 | | Co. 527 | |
|---|---|---|---|---|---|
| | | 100 N | 200 N | 100 N | 200 N |
| 1 | Total solids (by drying) | 20·35 | 20·16 | 16·98 | 16·80 |
| 2 | Sucrose % (True) | 19·20 | 18·80 | 15·38 | 15·16 |
| 3 | Purity % | 94·25 | 93·25 | 90·55 | 90·24 |
| 4 | Glucose % | 0 65 | 0·78 | 0·85 | 0·79 |
| 5 | Glucose ratio | 3 37 | 4·17 | 5·50 | 5·20 |
| 6 | Ash: per 100 c. c. juice | 0·36 | 0 32 | 0·35 | 0·37 |
| | ,, % juice. | 0 33 | 0·30 | 0·33 | 0·35 |
| 7 | Total non-sugars. | 0 50 | 0·55 | 0·75 | 0·85 |
| 8 | Organic non-sugars % | 0 17 | 0·25 | 0·43 | 0·51 |
| 9 | Ash/sucrose % | 1·71 | 1·57 | 2·13 | 2·30 |
| 10 | Organic non-sugars/sucrose % | 0·91 | 1·34 | 2·77 | 3·32 |
| 11 | Ash constituents per 100 c. c. juice | | | | |
| | (a) Lime. | 0·028 | 0·032 | 0·045 | 0·048 |
| | (b) Magnesia | ... | ... | 0·013 | 0·019 |
| | (c) Phosphoric acid | 0·027 | 0·018 | 0·017 | 0·014 |
| 12 | Chlorine per 100 c. c. juice | 0·085 | 0·082 | 0·089 | 0·115 |
| 13 | Total Nitrogen-mgms per 100 c. c. juice | 19 88 | 22·68 | 18 80 | 24·40 |
| 14 | Non-protein N do. | 9·80 | 10·92 | 6·72 | 13·44 |
| 15 | Non-protein—N as % of total Nitrogen | 49·28 | 48·15 | 35·76 | 55·08 |
| 16 | Colloids–per 100 c. c. juice | ... | ... | 0 34 | 0·36 |
| 17 | Pectins | ... | ... | 0·029 | 0·037 |

The data furnish interesting information regarding the quality of the juices. Apart from a lowering of the sucrose content in juice, the main effect of high nitrogen appears to be an increase in the organic non-sugars, specially the harmful nitrogen, colloids and pectins. This is accompanied by a reduction in the phosphate content of the juice showing an antagonism between the nitrogen and phosphate in the ion-intake by the cane plant. It is well-known that an increase in the harmful non-protein nitrogen and colloids result in juices which are difficult to clarify in the factory, increase viscosity of the syrup and prevent uniform crystallisation in the pans. It is also known that a minimum of 30 mgms of $P_2O_5$ per 100 c. c. juice is necessary for efficient clarification and whenever it goes less than this, it should be supplemented artificially. This detrimental effect on juice quality by an increase in the harmlful constituents is felt during the manufacture of jaggery also and the end product is generally of poor quality. The data of analysis of jaggery is given in Table VII.

**TABLE VII.**

**Analysis of Jaggerry samples (1949—50).**

| S. No. | Details of Analysis | Co. 419 | | Co. 527 | |
|---|---|---|---|---|---|
| | | 100 N | 200 N | 100 N | 200 N |
| 1 | Moisture % | 10·77 | 7·91 | 10·42 | 7·93 |
| 2 | Sucrose % | 76·37 | 76·47 | 78·88 | 78·44 |
| 3 | Glucose % | 11·64 | 10·71 | 10·20 | 9·71 |
| 4 | Glucose ratio | 15·24 | 14·00 | 12·70 | 13·38 |
| 5 | Ash % | 1·66 | 1·34 | 2·06 | 2·15 |
| 6 | Total Non-sugars % | 11·97 | 12·82 | 11·10 | 11·85 |
| 7 | Organic Non-sugars % | 10·31 | 11·48 | 9·04 | 9·70 |
| 8 | Chlorine % | 0 30 | 0·34 | 0·48 | 0·42 |
| 9 | *Ash constituents:—* | | | | |
| | (a) Lime % | 0·20 | 0·24 | 0·25 | 0·17 |
| | (b) Phosphoric acid % | 0·13 | 0·09 | 0·10 | 0·08 |
| 10 | Total Nitrogen (mgm. per 100 gms. jaggery) | 31·4 | 38·0 | 68·8 | 118·6 |

Irrespective of the other constituents, the most characteristic effect is the increase in nitrogen content and a depression in the phosphate content of the juice. It can be seen that the effect of high nitrogen doses is a continuous process from an increase in the nitrogen of the plant tissue, then the juice and then the end product, the jaggery.

(e) *Soil Analysis:* To see if there is any depletion in the soil nitrogen in any of the doses of nitrogen by a season's crop growth, the soils from the different treatments were again analysed, after harvest of the experimental canes.

**TABLE VIII.**

**Initial and final soil analysis.**

| S. No. | Details | | Nitrate-N Mgm./100 gms. | Total N % | Carbon % | C/N | pH |
|---|---|---|---|---|---|---|---|
| 1 | Co. 419: | 100 N | 0·21 | 0·059 | 0·62 | 10·6 | 7·5 |
| 2 | ,, : | 150 N | 0·27 | 0·062 | 0·62 | 10·1 | 7·5 |
| 3 | ,, : | 200 N | 0·27 | 0·064 | 0·62 | 9·3 | 7·5 |
| 4 | Co. 527: | 100 N | 0·20 | 0·063 | 0·90 | 14·3 | 7·5 |
| 5 | ,, : | 150 N | 0·22 | 0·064 | 9·90 | 14·0 | 7·5 |
| 6 | ,, : | 200 N | 0·21 | 0·064 | 0·90 | 14·0 | 7·4 |
| | Initial soil analysis | | 1·12 | 0·046 | 0·35 | 7·7 | 7·4 |

The total nitrogen figures for the soil after harvest of the crop reveal that at any level of nitrogen dose applied, the nitrogen in the soil is not depleted below the original level after one season of crop growth. There is practically no change in the pH values, irrespective of the variety or nitrogen dose applied. It is interesting to note that the carbon content has actually increased after one year's crop growth and this is more under Co. 527 than Co. 419. This is probably due to greater contribution of roots in the soil by Co. 527.

(f) *Yield of cane and commercial cane sugar:* The yield of cane from the different treatments, the C. C. S. % and the C. C. S. per acre are given below :

**TABLE IX.**

**Yield and Commercial Cane Sugar.**

| S. No. | Details | | Yield of cane tons/acre | C. C. S. % | C. C. S. per acre tons |
|---|---|---|---|---|---|
| 1 | Co. 419: | 100 N | 42·90 | 11·72 | 5·03 |
| 2 | ,, : | 150 N | 43·49 | 11·60 | 5·05 |
| 3 | ,, : | 200 N | 42·32 | 10·89 | 4·61 |
| 4 | Co. 527; | 100 N | 40·09 | 10·78 | 4·32 |
| 5 | ,, : | 150 N | 41·54 | 10·88 | 4·52 |
| 6 | ,, : | 200 N | 41·88 | 10·39 | 4·35 |

It can be seen that while there is not much difference in yield between the different treatments, the C. C. S. per acre have been depressed in 200 lb. nitrogen.

The above data reveal 100 lb. N to be optimum under the conditions of the trial. But it was already seen that there was likelihood of a part of the manure applied at planting time being wasted since, the cane plant was in need of only small amounts of nitrogen during the formative stage. It was also seen that a higher dose during formative stage as in 200 N did not favourably influence the yield at the end. Accumulation of high amounts of nitrogen in cane tissue due to continued availability late in the season in higher doses, result in poor quality juices. All these point to the possibility of reducing the manure dose without affecting cane yield and soil fertility. The periodical uptake of nitrogen shows that after the grand period stage there is no need for any available nitrogen. The manurial regimen must be timed to suit these conditions. This will not only reduce the manurial bill but also favour sucrose accumulation. That the time and dose of nitrogen must be based upon the knowledge of the "critical period" of a crop plant is in line with the work reported by Hester (13) and Cochran and Olson (9). In these studies it has been proved that the critical period is between 2½ to 5 months. Asana (1) has reported that the rate of uptake and the important period is from 3—6 months. Further experiments have been planned to see if the manurial dose can be reduced and juice quality enhanced by a modification of the schedule, based upon the above investigations.

**Summary and Conclusions:** 1. Studies on the biochemical aspects of the nitrogen of the cane plant have been presented in this paper. The object was to evolve a manurial schedule economical to the cultivator, which is at the same efficiently utilised and not detrimental to soil fertility.

2. Increasing doses of nitrogen increase the concentration of this element in the cane tissue but the effect is not much over 100 lb. N. The concentration shows a downward trend with age.

3. A study of the periodical uptake of nitrogen per acre has shown that the most critical period during which the cane plant requires the maximum amount of nitrogen is from 2½ to 5 months, before which high available nitrogen in the soil is not well utilised and after which high nitrogen depresses the juice quality, jaggery and C. C. S.

4. The analysis of nitrogen showed that the applied manure reaches peak availability in 1½ to 2 months. It is hence necessary that the time of application must be so adjusted so as to synchronise the peak availability with the "critical period" for nitrogen requirement in the cane crop.

5. Nitrogen in higher doses is carried over into extracted juice, with an increase in the colloids and other organic non-sugars, resulting in juices of poor workability. Also, the jaggery from such juices show high nitrogen and poor quality. It is found that the initially high accumulation of nitrogen is carried forward from the most tender plants up to harvest, then to the juice and the jaggery. This is thus a continuous process. High nitrogen is accompanied by low phosphate, which is not favourable for clarification.

6. Under the nitrogen doses applied, the soil nitrogen is not depleted below the initial level by one season's crop growth. The contribution of roots to soil organic matter is quite marked.

7. There was no increase in yield beyond 100 lb. N, but the C.C.S.% and C.C.S./acre decreased in 200 lb. N. dose.

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## LITERATURE CITED.

1. Asana, R. D. (1949) Annals of Rotany. Vol. 13. No. 50, P. 238.
2. Ayres, A. (1936 – 37) Hawaiian Planters' Record, Vol. 40 – 41. p. 335.
3. Association of Official Agricultural Chemists — Official and Tentative methods of analysis, 1935.
4. Borden, R. J. (1944) Hawaiian Planters' Record, Vol. 47, p. 43.
5. ,, (1941 – 42) Hawaiian Planters' Record, Vol. 45 – 46, p. 191.
6. ,, (1946) Hawaiian Planters' Record, Vol. 49. p. 161.
7. ,, (1948) Hawaiian Planters' Record, Vol. 52, p. 1 – 51.
8. Clements, H. F. and Kubota, T. (1942) Hawaiian Planters' Record, Vol. 46. p. p. 17 and 163.
9. Cochran, H. L., and Olson, L. C. (1940) Plant Physiology, Vol. 15, p. 765.
10. Craig, N. (1939) 10th Annual Report of Sugarcane Research Station, Mauritius.
11. Das, U. K. (1936) Plant Physiology, Vol. 11, p. 251.
12. Dutt, N. L. (1946) Survey of Sugarcane Research in India prepared for I. C. A. R.
13. Hester, J. B. (1938) Proc. Amer. Soc. of Horti Science, Vol. 36, p. 720.
14. Khanna, K. L., Prasad, S. H. and Sinha, S. N. (1947) Proc. of the Ind. Sci. Congress.
15. Lakshmikantham, M. and Sankaram, A. (1949), Madras Agri. Jour. Vol. 36.
16. Rege, R. D. (1935 – 40) Annual Reports of the Sugarcane Research Schemes, Padegaon.
17. ,, and Sannabhadti, S. K. (1948) Proc. of Deccan Sugar Tech. Association, Poona.
18. Yuen, Q. H. and Hance, F. E., (1938 – 40) Hawaiian Planters' Record, Vol. 42 – 44, p. 163.

# Quality of Green Manured Rice

*By*

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It has generally been observed—vide Viswanath (1936, 1927 and 1941), Viswanath et al (1927), McCarrison and Viswanath (1926), Howard (1945), Boas (1932), Pfeiffer (1945) Karunakar (1948), Karunakar and Rajagopalan (1948) and others—that cereal crops manured with organic manures are in quality superior to those fertilized with mineral fertilizers. With regard to rice Verghese (1948) found that quality in rice was reflected in the granular size and make-up of rice starch. The present study was undertaken to see how far this property could be made use of to evaluate rice quality vis-a-vis organic and inorganic manures, green manure and ammonium sulphate for example; and a comparison of the feeding values of such differently treated rice, was also included.

**Materials and Methods:** Rice was grown in pot-cultures under the following treatments:

(1) No Manure.

(2) Green Manure at 10,000 lb. per acre.

(3) Ammonium sulphate to contain Nitrogen equivalent to (2).

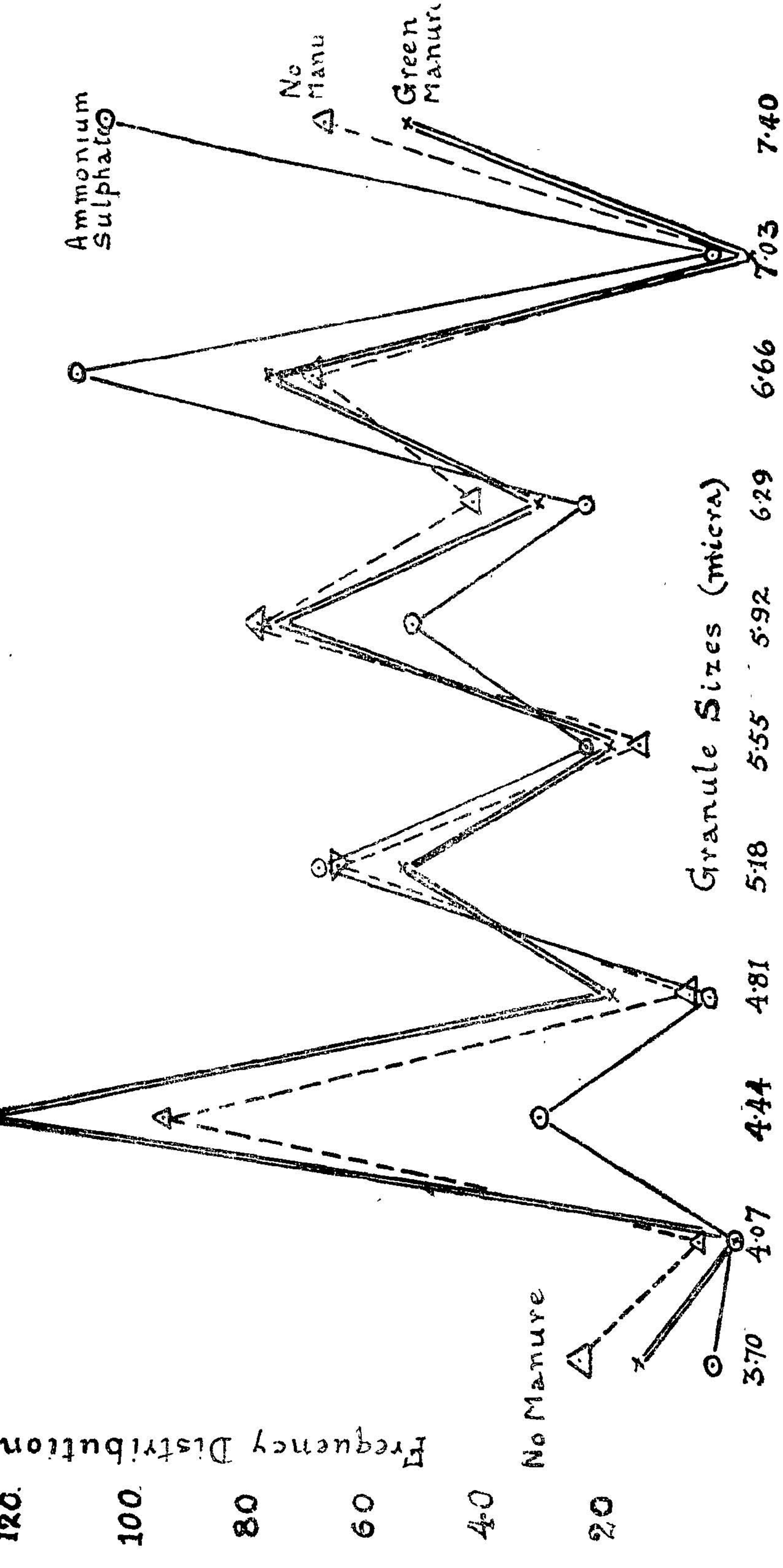
The green manure used was pillipessara, analysing 0·68% nitrogen while the ammonium sulphate contained 21·08% nitrogen.

**Soil and Rice Variety:** The soil used for growing the rice was a nitrogen – starved soil from the old permanent Manurial Plots of the Central Farm, Coimbatore, which has not been receiving any nitrogenous fertilizers for the last four decades. This variety of rice grown was Co. 13, which is known to be a rice of poor quality. Such a poor soil and rice variety were selected for the study so that the response to nitrogen manuring and consequent *improvement in quality*, if any, would then be more marked.

**Pot-Culture Technique:** 10 Kilos of well sampled soil were placed above a two-inch layer of gravel, small pebbles and coarse sand contained in a glazed pot 10″ x 10″. The soil was well puddled and the necessary amount of green manure cut into small bits were thoroughly incorporated into the puddled soil. The green matter was allowed to rot for one week after which rice was transplanted. The calculated amount of ammonium sulphate was added at planting time. In all, 11 pots were used for each treatment.

*After harvest* the grain and straw from each treatment was mixed, and a new composite sample from each lot was taken for analysis.

Fig 1. Starch Granule Size — of Rice CO13 grown under different Manurial Treatments (Frequency Distribution of Starch Granule Sizes).



**Analytical:** 1. *Preparation of starch:* Starch was prepared from the rice by the method outlined by Verghese (1948).

2. *Granule size measurement:* A suspension of the starch was examined under the microscope in glycerine mount according to the method of Garner (1932) and Barham et al (1942, 1944, 1946) and 500 granules were measured.

3. *Feeding Values:* The feeding values of the rice and straw were determined by A. O. A. C. methods.

**Observations:** *Granule size of starch:* The results of the measurements of starch granule size of starches from the differently manured rice are presented in Table I.

A study of Table I discloses the fact that though variations in frequency distribution are fairly uniform throughout the entire step interval of frequencies in all three starches, in green manured rice there is a greater number of granules of lower sizes than in the case of ammonium sulphate and No Manure treatments, with a reversal of this position in the higher sizes. It was found by Verghese (1948) that this phenomenon i. e., a greater preponderance of small-sized granules was the characteristic change when new or freshly harvested rice improved in quality by storage. It may be said therefore, that rice grown under green manure is of superior quality to that under ammonium sulphate treatment. In fact the ammonium sulphate treatment yields rice inferior in quality to "No Manure" itself.

Analysis of the data indicates that in most of the class intervals the number of granules is significantly different in the different samples.

**Feeding Values:** The feeding values of the rice and straw are presented in Table II.

It will be seen that green-manured rice contains more proteins, ether extractives, potash and phosphoric acid. The content of protein, $K_20$, and $P_20_5$ in this case is greater to the extent of 5·8%, 20·%, and 16·4% respectively over the ammonium sulphate manured rice, while in the case of straw the percentage gain in these constituents are 11·7% 43·2% and 30·0% respectively. The effect is thus mere pronounced in the case of straw.

These results are in harmony with the findings of other workers, particularly with regard to phosphoric acid. The function of phosphorus in improving quality of seed has been stressed by Sen (1948) and Karunakar (1948, 1949). Phosphorus, they say, is involved in vital growth processes in plants as it is a constituent of nucleic acids. Phosphorus is also important in seeds and in connection with the metabolism of fats. Compounds of phosphorus are connectde with the processes of respiration and with the efficient functioning and utilization of nitrogen. Phosphorus is also of special interest in root development and the ripening of seeds and fruits, and in human and animal nutrition.

An efficient and effective way to improve the quality of grain and stock feeds for cattle and men is to green manure cereal crops.

It was shown above that rice grown without application of any manure is of better quality than that manured with ammonium sulphate. Comparison of feeding values (Table II) confirms this. "No Manure" yields rice of better feeding value. The question whether intensive manuring with ammonium sulphate would depress crop quality merits a thorough investigation.

**Summary:** A comparative study of rice grown under different manurial treatments has shown that rice manured with an organic manure (green manure) is of superior quality, as judged by the granular make-up of the rice starch and the feeding values of rice and straw, to that fertilized with a mineral fertilizer (ammonium sulphate). Ammonium sulphate manured rice is even inferior in quality to that grown unmanured. The possibility of improving the quality of grain and stock feeds for cattle and man by green manuring is stressed.

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## LITERATURE CITED

Barham, H. N. Wagoner, J.A., and Reed, G.N., (1942.) Indus Engg., Chem., 34. 1490-9.

" " " and William B.M,, ((1944) J. Agr., Res,, 68, 331-45.

Barham, H.N.' and Wagoner, JA., (1946) Jour. Agri. Res., 73, 255-10

Garner, W., (1932) Industrial Microscopy, London.

Howard, Albert., (1945) Farming and Gardening for Health or Disease. Faber and Faber., London.

Karunakar, P. D. (1948). Review of work done on the maintenance of soil fertility in the Madras Province. Government Press, Madras – 1948. 1-6.

" (1949) Madras Agricultural Journal,

" (1948) Madras Information. 2, 18-20.

" and Rajagopalan, T. Tropical Agriculturist CIV, 210–14.

Viswanath, B., (1926) M.A.J., 14, 19.

" (1927). Pusa Memoirs – Chemical Series. 9, 85.

" (1941). Proceedings of National Academy of Sciences.

Mc Carrison and Viswanath., (1926). Indian Journal of Medical Research 14, 351.

Pfeiffer Ehrenfried. 1945. Soil Fertility, Renewal and Preservation, Faber and Faber Ltd., London.

Sen, S. (1948). Proc. I. A. R. I., Crop and Soils Wing.

Verghese. E. J. (1948) Rice Polysaccharides with special reference to quality; M. Sc Thesis, Madras University.

## TABLE I

**Granule size of starches prepared from rice grown under different manurial treatments.**

| Step interval (micra) | I No Manure No. | I Frequency Per-cent | I Accumulated frequency % | II Green manure at 10,000 lb. per acre No. | II Frequency Per-cent | II Accumulated frequency % | III Ammonium sulphate N — that in II No. | III Frequency Per-cent | III Accumulated frequency % |
|---|---|---|---|---|---|---|---|---|---|
| 3·70 | 23 | 4·6 | 4.6 | 16 | 3·2 | 3·2 | 4 | 0·8 | 0 8 |
| 4·07 | 6 | 1·2 | 5·8 | 1 | 0·2 | 3·4 | 1 | 0·2 | 1·0 |
| 4·44 | 97 | 19·4 | 25·2 | 129 | 25·8 | 29·2 | 83 | 16·6 | 17·6 |
| 4·81 | 8 | 1·6 | 26·8 | 21 | 4·2 | 36·4 | 5 | 1·0 | 18 6 |
| 5·18 | 68 | 13·6 | 40·4 | 56 | 11·2 | 44·6 | 71 | 14·2 | 32·8 |
| 5·55 | 17 | 3·4 | 43·8 | 22 | 4·4 | 49·0 | 26 | 5·2 | 38·0 |
| 5·92 | 89 | 17·8 | 61·6 | 81 | 16·2 | 65·2 | 56 | 11·2 | 49·2 |
| 6·29 | 46 | 9·2 | 70·8 | 35 | 7·0 | 72·2 | 27 | 5·4 | 54·6 |
| 6·66 | 74 | 14·8 | 85·6 | 81 | 16·8 | 88·4 | 113 | 22·6 | 77·2 |
| 7·03 | 2 | 0·4 | 86·0 | ... | ... | ... | 5 | 1 0 | 78·2 |
| 7·40 | 70 | 14·0 | 100·0 | 58 | 11·6 | 100 | 109 | 21·8 | 100·0 |
| Total ... | 500 | 100·0 | 100·00 | 500 | 100·0 | 100·0 | 500 | 100·0 | 100·0 |

## TABLE II

**Feeding values of rice and straw obtained from rice grown under No manure, green manure and ammonium sulphate**

| Heads of analysis | Grain No manure | Grain Green manure | Grain Amm. sulphate | Straw No manure | Straw Green manure | Straw Amm. sulphate |
|---|---|---|---|---|---|---|
| Moisture | 11·79 | 11·96 | 11·81 | 6·75 | 6·74 | 6·39 |
| Ash | 1·61 | 1·63 | 1·57 | 16·74 | 17·77 | 17·05 |
| Crude Proteins | 7·09 | 7·33 | 6·93 | 2·31 | 2·38 | 2·13 |
| Ether extractives | 2·91 | 3·48 | 2·97 | 1·57 | 1·54 | 1·53 |
| Crude fibre | 0·68 | 0·52 | 0·61 | 3·16 | 3·15 | 3·15 |
| Carbohydrates (by diff.) | 75·92 | 75·08 | 76·11 | 69·47 | 68·42 | 69·75 |
| Total ... | 100·00 | 100·00 | 100·00 | 100·00 | 100·00 | 100·00 |
| Albuminoids | 6·95 | 7·20 | 6·77 | 2·21 | 2·26 | 1·99 |
| Insolubles % | 0·22 | 0·19 | 0·16 | 15·18 | 15 45 | 15·22 |
| Lime (CaO) % | 0·05 | 0·04 | 0·04 | 0·11 | 0·13 | 0·12 |
| $P_2O_5$ % | 0·72 | 0·78 | 0·67 | 0·29 | 0·13 | 0·10 |
| $K_2O$ % | 0·27 | 0·30 | 0·25 | 0·69 | 1·19 | 0·81 |
| Acid value | 30·54 | 31·03 | 26·20 | 77·35 | 81·25 | 81·25 |

# Climate in Relation to Manuring of Crops

*By*

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**Introduction:** The farmer thinks of applying manures and fertilisers to his soil with the main intention of increasing its fertility. Generally, the productive nature of the soil is taken as an indicator of its fertility, but productivity depends not merely on soil fertility but also on causes external to the soil. The relationship existing between the 'soil climate' and the 'atmospheric climate' has to be understood to enhance the fertility of soils by application of manures.

**Climate and Soil:** Soil is formed as a result of disintegration of the parent rock. This transformation of rock to soil takes several centuries and factors like temperature, rainfall, sunshine, relative humidity, and wind velocity play an important role, in this natural process of soil formation. For the formation of 1″ of top soil the period taken will be anything from 300 to 1,000 years. Further, the climate of a place also determines the type of the soil. A close relationship exists between climate and soil, climate and vegetation, and vegetation and soils. Hence, any attempt to improve the fertility of the soil should also include a study of climate of the locality and its influence on soil fertility.

The term climate is a comprehensive term, which is the sum total of various elements like temperature, rainfall, wind velocity, sunshine, and relative humidity. In dealing with the influence of climate in relation to manuring of crops each of these elements has to be considered with reference to its influence on plant growth and soil fertility.

**Climate in Relation to Manuring:** To get the best out of the manures applied to the soil there should also be an optimum moisture condition in the soil. This leads to the classification of soils according to their moisture-retaining power. Water is essential both for soil fertility and crop production. For successful crop production a clear concept of the natural water cycle of the locality is necessary. The fate of the rain after it touches the soil is to be studied in detail, before attempting the conservation of soil-moisture. Measures which are conducive to soil conservation are equally efficient for moisture conservatiou and in areas of low and uncertain rainfall, the adoption of soil conservation methods is of paramount importance in successful farming.

In addition, a study of the water cycle will show how it is influenced by temperature, relative humidity, wind velocity and sunshine. With a given rainfall, the amount of water left to soak into the soil will be increased with an increase in relative humidity, decrease in temperature and an increase in the duration of the period during which the soil remains under bright sunshine. The distribution of rainfall is also equally important. Further, under leaching conditions, any amount of fertilisers will not produce proportionate benefit to the crop since most of the plant food will be carried away in the drainage water. There is another point also to be considered in this connection. In moist climates proper tillage is necessary to prevent the water in the soil from acting as a source of hindrance to the supply of air to the plant roots. Similarly in arid regions, with hot windy weather, too free a circulation of air through the soil will dry it out too quickly. Further, soils of arid regions are poor in humus content and consequently poor in nitrogen also. For getting the best out of such soils, plenty of nitrogenous manures should be added. Therefore, application of organic manures, especially farmyard manure is recommended for dry lands to improve the soil structure and increase the water-holding capacity of the soil. Apart from suppling nitrogen, farmyard manure also increases the availability of phosphate, potash and other elements by improving the microbiological status of the soil (4).

Next to soil-moisture comes temperature. The temperature of a locality determines the types of crops that can be successfully raised in the locality. Increase in altitude results in a decrease in temperature owing to the speedy rate with which the earth's surface at higher elevations relinquishes the heat absorbed from the sun. Further, the temperature has an important effect on certain physical processes in the soil. For instance, it influences the rate of percolation of water and also the aeration in the soil. Further, low temperature reduces the speed of phosphate fixation in the soil and thus increases its mobility (2). Only the top few inches of soil are affected by atmospheric temperature, and the sub-soil is generally independent of variations in the temperature of the top soil. In almost all soils, the variation in soil temperature due to diurnal changes is very little at depths below two feet. All these facts are to be kept in mind when improvement of soil fertility is thought of.

Closely associated with temperature are the hours of bright sunshine and the dryness or dampness of the air, known otherwise as relative humidity. Whatever may be the good effects of the manures and fertilisers applied to the soil sunshine must be available in plenty if plants are to grow normally, as it is required by plants both for photosynthesis and for transpiration.

Relative humidity of the air influences the rate of transpiration and evaporation of soil moisture. If the relative humidity is high, soil aeration must be properly controlled by incorporating more organic matter, particularly if the soil is compact or water-logged. Further, if the air is moist, transpiration will be low. That means there must be more stimulant applied to the roots by way of fertilisers, to make them more active in drawing up plant foods from the soil.

The velocity of the wind also is an important factor to be considered while applying manures. In the first place fertilisers, if not properly incorporated into the soil, will be carried away by winds. If the wind is hot and high in velocity it is likely to damage the crop even. In fallow fields it is likely to cause soil erosion, especially if the soil is deficient n soil-moisture.

**Conclusion :** A general correlation exists between vegetation maps and climatic maps, although the degree of agreement might vary in different regions and for different vegetation types (3). Any attempt to improve vegetation should therefore take into consideration the climatic factors also. Application of manures to soils is done with the aim of improving vegetation to the advantage of men and cattle. Soil management and maintenance of soil fertility can be successfully tackled only when the climatic features of the locality are clearly understood.

## REFERENCES

1. Kellog C. E. (1941) Climate and soil, U. S. A. Year Book of Agriculture.

2. Dodykin, V. P.—(1950) The influence of soil temperature on the availabiliiy of phosphorus to plants", Soils and Fertilisers, Vol. 13, No. 1.

3. Hartley W.—(1950) The global distribution of the Gramineae in relation to historical and environmental factors, Austral. Jour. of Agric. Res., Vol. 1, No. 4.

4. Basu J. K.—(1951) Presidential Address, 38th Indian Science Congress, Bangalore.

# Soil Conservation with Special Reference to the Nilgiris

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It may be said without fear of contradiction that the problem of soil erosion started when the first man turned the sod in the garden of Eden and began upsetting the equilibrium established by Nature. We are all aware that the native grass that clothes the Earth's surface and the vegetation that springs up spontaneously are the anti-erosion controls of Nature. The cover or canopy effect of vegetation, the mechanical hindrance to the flow of water by stems and roots, the soil-binding property of the roots of plants and the biological effects brought about by the addition of dead and decaying organic matter year after year; all these contribute towards the control of soil erosion.

Soil erosion in the Nilgiris is most marked during the heavy pre-monsoon or post-monsoon showers of the South-West Monsoon and the heavy sporadic rains of the North-East Monsoon. It is least during the main period of the Sout-West Monsoon, when the sky is completely overcast and rains are received in continuous showers for days on end. There are two phases in soil erosion. The first is the breaking up of soil particles into fine silt. The actual loss takes place during the second phase when the fine particles are washed down by the surface flow. American workers have observed that these two phases are negatively correlated. For instance, sand is easily detached by the beat of heavy rain drops, but it is not easily transported, whereas stiff clay is not easily detached but is carried away quite easily by the run-off water. Unfortunately we in this country have no data at all on this subject. From a cursory observation of the colossal soil loss in the Nilgiris, as evidenced by the silt in the run-off water from newly broken land, it is clear that the laterite soils of the district are as easily detached as sand and transported as easily as clay particles.

**Contributory Factors:** From the point of erosion control, the cultivation of potatoes, which occupies a place of honour in the agronomy of the State, with 19,100 acres out of a total area of 19,500 acres in Madras State, is the bane of the Nilgiris district.

Prior to the First World War, the average area under potato was in the vicinity of 7,000 acres. With the end of the first World War the price of potato began to rise and with that started the race for extended cultivation. Steep hill-slopes that were previously left untouched or were planted with blue-gum trees were converted into potato fields without any regard for protection of the soil, either by terracing or levelling. During the Second World War from 1939, the area under potatoes increased once again, reaching the peak of over 20,000 acres in 1945. In this boom period not only were all possible lands brought under cultivation but also the bulk of Government *poramboke* lands not so far assigned to anyone were also leased out and cultivated. The net result was that the evils of soil erosion, which were hitherto insignificant, began to be felt in a serious form. The *sholas* which sheltered the springs disappeared. thereby causing the streams to dry up. The soil particles were washed down to silt up the streams and were carried down even to the plains through the waters of the Moyar and Bhavani rivers. The rains began to fail year after year, the mild and equable climate changed into hot summers and all the greenness disappeared, giving place to bleak and desolate hillsides.

Secondly, to make matters worse, the trees existing in Government and private plantations were mercilessly felled, without any attempt at re-afforestation, in order to tide over the fuel shortage. Due to an unfortunate order of the Government that non-agricultural lands in municipal areas should be charged a prohibitive penal assessment, the entire tree growth within municipal areas, nearly a century old, were all ruthlessly eradicated and the lands opened up for potato cultivation.

Thirdly, the ryots who had made enormous profits by potato cultivation, when deprived of their lease lands, rushed for possession of the extensive Toda *patta* lands which for centuries were used as grazing grounds and broke up the area without any regard for anti-erosion methods.

A good bit of the Wenlock Downs, which was retained as a National Park was broken up when it was assigned to the Political Sufferers. Though the methods suggested for prevention of soil erosion were ignored by these assigneess when they occupied the land, it is gratifying to note that the bulk of the area has now been bench-terraced, thereby minimising soil losses.

**Conclusion:** The rape of the Queen of the Hill Stations, brought about by the mad rush for extended potato cultivation in unsuitable sites and the reckless devastation of the forest area for fuel and timber without adequate provision for re-afforestation, has not only resulted in eroding the already poor soil of the district and reduced its productive capacity, but it also threatens to silt up beneficial works such as the Lower Bhavani Reservoir, which is intended to give irrigation for two lakhs of acres of food crops. The only silver lining to this dark cloud is the attempt by a few well-to-do ryots, to adopt soil conservation methods such as terracing, levelling, gully-plugging, and contour planting of potato and the belated awakening of the Government and the people to the dangers of the situation. The position is no doubt bad, but is not hopeless yet, and can be retrieved by the strict enforcement of a ban on assigning lands in the Nilgiris, by encouraging large-scale tree-planting on steep slopes, by judicious granting of kist remissions and large-scale adoption of simple anti-erosion measures like bench-terracing, contour planting and better cultivation.

# Emergency Food Production Camps

*By*

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**Introduction:** This paper proposes to stress the necessity for putting into operation a practical scheme towards increasing food production in as many places as possible in the State.

Concentration on stepping up production on the lands already under cultivation is more essential than attempting to extend cultivation over patches now remaining fallow. Because most of these new areas are agriculturally defective, any attempt towards their reclamation is a tedious process.

The areas proposed to be worked should literally be 'camps' as only then can an atmosphere of grave danger be realised.

It is accepted by all that there is shortage of food. Various schemes have been launched and a number of concessions have been granted by Government to agriculturists to cover the deficit. Half a dozen years hence, if we look back at the achievement it would be found that it had not been a success. There have been adverse seasonal conditions in many tracts, but even in places where an assured supply of water was available, the level of production of crops has not reached increased over the pre-shortage days.

This indicates that the danger has not been fully appreciated and that there is want of heart in the application of methods aimed at growing more food. What is now required is the continuance of concessions to agriculturists and widening of facilities to a greater extent on the part of the Government and in return the farmers should co-operate to a greater extent than at present, in the problems facing the country.

Under the efforts to be put forth by the Government, it is essential that suitable centres should be selected, taken on lease and practically worked to enhance the production under scientific guidance to convince the people that the yielding capacity of the land could be raised. Can any one deny that an ounce of practice is worth a ton of theory? This saying was proved beyond doubt during the war years in producing sufficient vegetables for the military. The Government took lands in suitable tracts, grew vegetables and met the shortage very successfully. If similar efforts are directed towards producing food, it is bound to bear successful results and be an eye-opener to the full productive potentialities of the land.

No obstacle should be considered unsurmountable in taking up beneficial schemes and these schemes have to be worked with a protective purpose rather than earning big returns on the sums invested.

**Objects:** The objects of the scheme described in this paper are :-

1. To make the cultivation of crops which form the staple food of the locality more intensive than what is being done now by the farmers.
2. To increase production of crops by adopting better methods and relieve the acute shortage.
3. The improvements carried out on the lands would serve as permanent objects of demonstration and a lasting asset to the owners of the land.
4. Greater interest will be evinced by the farmers of the locality on the improvements carried out on the lands of some of their own men and they will adopt them with the result that production level will increase in the region as a whole.
5. Besides increased food for the man, fodder for the beasts of the farmer also is increased in quantity.
6. To stir those at present in complacency to a state of real activity.

It is suggested that the scheme be run for five years. The requisites for working the scheme, viz., land, technical staff, labour (including human, mechanical and cattle power), irrigation sources and manure requirements are discussed. Then the cropping scheme which will be most profitable to the tract, the increased out-turn and the extra human and animal units that can be supported are indicated.

**Land:** Each camp can have a minimum area of 200 acres in a block. If one block is not available smaller blocks of 50 acres in extent not far from each other can also be taken up.

Garden and wetlands with assured water supply alone need be taken on lease.

Farmers unable to do effective cultivation for want of sufficient funds, absentee landlords and some who may be attracted by the lease amount offered, may agree to lend their lands on lease. Besides these, lands belonging to temples and charitable institutions may also be available. The lease amount will be on a par with that prevailing in the locality with a small premium added to it. A five-year work on the lands by the technical department will be sufficient.

**Labour:** The following sources of labour can be usefully employed.

1. As much labour as is locally available.
2. Demobilised soldiers willing to take up farming.
3. Labour migrating from famine districts.
4. Able-bodied beggers who are at present idling.

The imported labourers should be provided with sheds as close to the workspot as possible.

Regarding wages, rates similar to local rates can be paid to adults and juvenile labour. A slight modification is suggested, viz., wages can be paid at intervals of a week. Instead of disbursing the whole amount, two-thirds can be paid and the balance credited to his account. This accumulated amount can be utilised at the end of each year to meet the clothing requirements and the balance carried over to the end of the 5th year and disbursed in a lump sum. The underlying object is, that when the scheme is disbanded after 5 years the individual worker is left with a lumpsum which will help him to buy cattle and become a tenant cultivator or to build a house of his own or buy milch cattle and live on milk trade.

The wages vary according to seasons but taking the average to be Rs. 1—4—0 per day per man, 12 annas per woman and 8 annas per boy, the yearly accumulation after disbursement will be Rs. 144/- per man, Rs 84/- per woman and Rs. 57/- per boy. Deducting Rs. 44/- from men, Rs. 34/- from women and Rs. 17/- from boys towards clothing for themselves and their children they are left with Rs. 100/-, Rs. 50/- and Rs. 40/- as net savings each year. At the close of the five-year period each man has to his credit Rs. 500/-, woman Rs. 250/- and boy Rs 200/- disbursed in a lumpsum to be utilised in the best way possible. Regarding implements they can be loaned from the agricultural department and catt e pairs hired locally.

**Staff:** The minimum requirement will be one upper subordinate at a maximum salary of Rs. 220/- and dearness allowance of Rs. 45/-, one fieldman on Rs. 45/- plus 25, one store-keeper on Rs. 45/- plus 25. This comes to Rs. 4.860/- or Rs. 5,000/- for 200 acres per year i. e. Rs. 25/- per every acre to work the scheme at each centre of 200 acres.

This is only a fraction of the extra return realised from the land as explained more fully in the later portion of this paper namely Rs. 130/- per acre in wetlands and Rs. 180/- per acre in garden lands.

**Irrigation Sources:** If the block of land happens to be entirely garden land, and if the existing number of wells are insufficient; a few wells can be dug. If they are in disrepair or with poor springs the department can set them right. The owners of the lands can be charged 50% of the cost of excavation or deepening to be recovered from the lease amount in five annual instalments and the rest treated as subsidy.

In places where facilities exist for getting electric connections electric motors and pumps can be installed for the wells. Otherwise oil engines have to be provided. This will dispense with animal pairs and their high maintenance costs.

At the end of the scheme the engines can be offered to the owners of the wells at a concession rate. If necessary they can be given loans also, to make the purchase. In case there is no demand from the owners of lands who had given them on lease the engines can be auctioned.

Providing wells or deepening them, installing pumps by the Government, and offering them at concession rates is no small help to the farmer since many find these beyond their means.

If wetlands are chosen they should have guaranteed supply of water from an irrigation project. Even here wells have to be provided to raise timely nurseries and give a few irrigations to green manure crops.

**Manures:** If the 200 acres are entirely wetland, except for 20 acres required for nurseries, the rest can be put under a green manure suited to the locality. Even here the dual-purpose green manure viz., pillipesara can be grown, seeds collected from the first flush, fed partly to cattle and the subsequent flush ploughed in.

Planting perennial green manure shrubs such as *Glyricidia* and *Adathoda* on alternate field bunds will provide sufficient leaf and supplement what is obtained by sowing green manure seeds in the fields.

In places where two crops of paddy are raised, the first crop is easily manured with green leaf, but the second crop does not get leaf as the short interval between the two crops does not permit raising a green manure crop on the field. Hence farmers who can afford it, buy artificial manures or oil cakes for the second crop. Other starve their second crop resulting in poor yields. To overcome this difficulty, in easy method of growing leaf is suggested as follows:

A nursery of *Sesbania* seedlings has to be grown at the time of sowing paddy nursery for the first crop. Immediately after transplanting the paddy crop, i. e. by the end of June or July, the *Sesbania* seedlings are pulled out from the nursery and planted in the field touching the bunds, one foot apart or even closer. These seedlings grow very well and commence to flower by September. The paddy crop is harvested by the end of September if it is a short duration variety. Immediately after harvest the land is prepared for the second crop; just at that time the *Sesbania* plants along the bunds are pulled out and pressed into the field. It will give at least 3,000 to 4,000 lbs. of leaf per acre. Where no leaf is available and also where the cost involved in buying oil-cakes is too high this method of supplying leaf comes in very handy.

Experiments have indicated that a complete manuring of paddy. namely leaf, manure, phosphates and ammonium sulphate gives maximum yield. Based on this, adequate artificials have to be applied at an uniform rate of 100 lb. ammonium sulphate and 50 lb. of super phosphate per acre over a basal dressing of 5,000 lb. of leaf.

If garden lands are selected, composts and cattle manure are to be secured from the nearest available sources as maintaining cattle pairs is not contemplated but composts from available waste material can be prepared to a limited extent.

Top dressing with ammonium sulphate and oil cakes will help in obtaining substantial increases in yields.

**Cropping Programme:** Wetlands: Single crop and double crop.

The entire area of 200 acres can be cropped with paddy and then sown with green manures except over 20 acres which may be required for raising nurseries.

If it is a double crop area, the first crop is raised, then the second crop and finally a green manure crop which will be useful for the first crop of the succeeding year.

**Garden lands:** Out of 200 acres, crops can be grown as follows:

| | | |
|---|---|---|
| Cereals | 120 acres | 2 crops to be raised in a year. |
| Vegetables | 50 acres | 2 crops where vegetables of short duration are raised. |
| Root crops | 20 acres | |
| Bananas | 10 acres | |

Vegetables and root crops will rotate with cereals over 70 acres every year and over the rest of the area every alternate year. In the cereal portion, where there is an interval of three months, fodder crops can be grown.

On the area where root crops have been grown (i. e. 20 acres) and where cerals are not alternated with vegetables, the next year, a short-term green manure crop like Sunnhemp can be grown to recuperate the soil.

The above crops provide a variety of food. They give scope to engage the labour throughout the year, and they satisfy the nutritive considerations also by supplying varying amounts of proteins, carbohydrates and minerals, besides vitamins. Vegetables, root crops and bananas yield 6 to 8 times more energy than cereal crops from the same unit area.

A statement is furnished to show the increased out-turn that will result by working a scheme of this nature and how it justifies employment of special staff.

In respect of wetlands a moderate acre yield of 1 $\frac{1}{3}$ tons of paddy and 1$\frac{1}{2}$ tons of straw is anticipated instead of the $\frac{7}{8}$ ton grain and 1 ton of straw now obtained on an average.

In garden lands the cereal acre yield is expected at $\frac{2}{3}$ ton in the place of the present average of $\frac{1}{3}$ ton.

Regarding root crops, vegetables, bananas and fodder crops, an increase of 1 ton per acre alone is aimed at over the 5-ton yield that is being realised now.

The value of the increased yields anticipated as a result of improved methods is computed at very reasonable rates, indicated in the statement.

Every acre of wet land can bring a net increased return to the value of Rs. 130/- over what is normally obtained and in garden land up to Rs. 180/- per acre, as a result of operating a scheme of this nature.

**Conclusion:** A brief account of the methods of increasing food production by starting emergency camps or production centres is discussed. These centres will serve as models for wider application of improved methods. They do not in any way displace those already engaged in the agricultural profession; in fact, other kinds of labour are invited in addition to the locally available ones and their efforts properly diverted towards more production.

Attention devoted towards maximising production in manageable units by technical staff will prove to be effective in solving food shortage in the zones attempted, besides benefiting the State as a whole.

ACRE YIELDS AND PRICES (ASSUMED)

| Crops | Present producton in tons (per acre) | | Expected production in tons (per acre) | | Increased production in tons (per acre) | | Prices assumed. |
|---|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw | |
| Cereals | $\frac{1}{3}$ | $\frac{2}{3}$ | $\frac{2}{3}$ | 1 | $\frac{1}{6}$ | $\frac{1}{3}$ | Rs. 224/- per ton or 0-1-7 per lb. |
| Root crops | 5 (tubers) | | 6 ( tubers) | | 1 | ... | Rs. 210/- per ton or 0-1-6 per lb. |
| Vegetables | 5 | ... | 6 | ... | 1 | ... | Rs. 210/- per ton or 0-1-6 per lb. |
| Bananas | 5 | ... | 6 | ... | 1 | ... | Rs. 280/- per ton or 0-2-[illegible] per lb. |
| Fodders | ... | 4 | ... | 5 | ... | 1 | Rs. 45/- per ton or 0-0-4 per lb. |
| Green manures | ... | ... | ... | 2 | ... | 2 | Rs. 3/- per ton. |

CROPPING ON GARDEN LANDS.

| Nature of crop | Area in acres | Present production (estimated) in tons | | Expected production (estimated) in tons | | Increased production (estimated) in tons | | Value of increased produce | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Grain | Straw | Grain | Straw | Grain | Straw | Grain Rs. | Straw Rs. | Total Rs. |
| Paddy first crop. | 120 | 40 | 80 | 60 | 120 | 20 | 40 | 5600 | 1800 | 7400 |
| ,, second crop. | 120 | 40 | 80 | 60 | 120 | 20 | 40 | 5600 | 1800 | 7400 |
| Root crops | 20 | (100 tubers) | ... | 20 (tubers) | ... | 20 | ... | 4200 | ... | 4200 |
| Bananas | 10 | 50 | ... | 60 | ... | 10 | ... | 2800 | ... | 2800 |
| Vegetables | 50 | 250 | ... | 300 | ... | 50 | ... | 10500 | ... | 10500 |
| Fodders | 75 | ... | 300 (green) | ... | 375 (green) | ... | 75 (green) | ... | 3375 | 3375 |
| Green manure | 70 | ... | ... | ... | 140 (leaf) | ... | 140 (leaf) | 420 | ... | 420 |
| | | | | | | | | | | 36,095 or |

36000 Rs. or Rs. 180/- per acre.

CROPPING ON WETLANDS.

| Nature of the crop. | Area | Present Production | | Expected Production | | Increase | | Value of increased produce. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Grain | Straw | Grain | Straw | Grain | Straw | | | |
| Paddy | 200 acres. | 175 tons. | 200 tons. | 276 tons. | 300 tons. | 92 tons. | 100 tons. | Grain<br>Straw | 20,608/-<br>500/- | Rs. 25,108/- |
| Green manures | 180 acres. | ... | ... | Leaf | 360 tons | ... | ... | ... | ... | 1080/- |
| | | | | | | | | Total. | | 26,188 |
| | | | | | | | | | or | 26;000/- |

| Remarks | Present production | | Expected production | | Increase | |
|---|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | Grain | Straw |
| Acre yield assumed | 7/8 ton. (1680 lb) | 1 ton. | 300 lb. (1-1/3 tons) | 1½ ton | ½ ton | ½ ton. |

i.e., Rs. 130/- acre.

Green leaf. 2 tons per acre.

*Prices:* (assumed)

| | | |
|---|---|---|
| Paddy grain. | Rs. | 224—0—0 per ton |
| Straw | Rs. | 45—0—0 per ton. |
| Green manures. | Rs. | 3—0—0 per ton. |

# Intensification of Agricultural Extension Service

*(A plea for utilisation of services of Teachers in Rural Schools.)*

*By*

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Research and Propaganda are the two limbs of the Department of Agriculture. Both should march hand in hand for a proper solution of the various agricultural problems in the country. At the present moment, emphasis must be more on the side of extension service than on research to meet the present crisis of food shortage.

The magnitude of research work done in our institutes and farms has been applauded by all the eminent visiting scientists from abroad and other parts of India. "The work that is going on here" said the distinguished British scientist Sir John Russell, "offers the prospect of solving to a great extent India's food difficulty. The practical difficulty is to get better materials over to the peasant, to enable him to adopt the methods suggested by agricultural experts. There remains always the practical difficulty of getting these methods adopted and properly carried out." It is this weak link in the chain that needs immediate strengthening. Results of research, however valuable and useful are of little significance unless they are translated into practice in the villages. We have made remarkable progress in evolving strains of various crops suitable to varying conditions of soil and climate in this State. It is true also that we have reliable data pertaining to different cultural practices and manurial improvements. But we have failed to carry the results so gained to the tiller of the soil, to the extent desired. It is for us now to think of the methods we have adopted so far and to devise ways and means of how best these can be enlarged, amended or improved for achieving quick and effective results.

**Drawbacks of uniform policies:** In the enunciation of any policy or formulation of any scheme, it has been our failing to have been led by set patterns of procedure for the entire State, irrespective of local conditions and needs. In the extension side of our Department, a uniform standard from Srikakulam to South Kanara will not work. Each district and taluk has its own special problems which require special treatment, and the least we have to think of is in terms of zones. The West Coast for example cannot normally be clubbed with the rest of the State in the planning of any scheme on a State-wide basis. While an agricultural demonstrator or a fieldman or maistri could normally tackle a couple of villages easily in a day in the Tamilnad or Telugu districts, it will be difficult for him to meet even two ryots of a single village in a West Coast district or taluk in a day. This essential difference should be borne in mind in any policy or procedure affecting the work of the department.

**Planning of extension service and its limitations**: Any scheme devised for a proper organisation of the extension service in a locality should be based on the genius of its people. It is also very necessary to formulate schemes which will have a maximum effect with minimum expenditure from the present financial resources of the country. Surely we can show remarkable progress if we could appoint an Agricultural Demonstrator with a depot for each village, but it will be a dream-although in the ultimate analysis, it may become necessary for a country like India.

In Japan, it is said, for a prefecture of about 500 square miles in area-which is almost the area of one of our taluks here-there is a central experimental station and about 250 technicians-who are either graduates in agriculture or sufficiently trained hands - spread out in the entire prefecture. This works out to a technical man available at the rate of one a village or for an area of 2 to 3 square miles. These men maintain the link between the farmers and the experimental station, passing the results of research to the farmers and bringing to the notice of the research station the problems of farmers for investigaton. It is no wonder then, that Japan can produce 2,350 lb. of rice per acre whereas we in India can obtain only 860 lb. What Japan does, India can do. In contrast with such efficient methods of Japan in extension service, we here, are charged with duties and responsibilities of a Grow-more-food campaign on a three-year plan. Of course our plans are not so ambitious and are limited to our resources of men and material. Indeed, in regard to facilities offered to the staff engaged in extension work we are having a retro-grade movement. While in the old scheme, we had a field man and two maistries for each firka and a minimum of two sales depots for each taluk, we are now having only one depot at taluk headquarters and the field staff is exactly halved in strength. This is a matter for us to pause and ponder.

**Existing limitations of extension service**: Supply of agricultural requisites to the door of the ryot and continuity of contact and maintenance of liaison between the department and the ryot are the two main factors that require immediate solution for making the extension service effective, efficient and useful. Only these two aspects are considered this paper and how this can be achieved effectively at minimum cost. If cost is not the criterion any ambitious scheme can be put up. This aspect has been kept in mind while discussing the possibility of utilising the services of teachers in rural schools for extension service.

**Extension work by fieldmen and demonstration maistries**: It is felt that the amount of work done by the fieldmen and the demonstration maistries under existing conditions cannot take us far. One can just imagine the difficulties of a subordinate who has to go 10 to 15 miles to the interior, along tracts badly connected by public conveyances, with hardly a place to halt and facilities even for a meal. When the holdings are scattered and approaches are through hills, valleys, streams and field bunds, we can imagine the number of ryots that could be contacted and kept in touch to secure some practical results. The anxiety of such subordinate is more to secure a seat in the returning bus, if any, than to stay and do work in a place where he has neither the facility to stay nor to eat. Therefore, the stationing of men as near the work spot as possible is a prime necessity.

Again, the men charged with the duties of extension work should be those that inspire confidence and faith among the ryots and evoke their admiration. The fieldmen and the maistries are hardly the persons that can create these feelings among our ryots and it is for this reason that the idea of utilising the services of teachers in rural schools for organised extension work, is considered as opportune and suitable.

**Status of a teacher in rural parts :** Many higher - grade or secondary grade teachers employed in rural schools come from respectable families, who are also practical agriculturists with a high status in rural life and society. Their contact with students and the parents mark them as very useful persons for extension work. A selection of the best among them should be made.

**Selection, training and employment of school teachers for extension work :** Let us assume that a taluk has about 100 villages. 20 local teachers who are also practical agriculturists and who have an agricultural bias should be selected and deputed for a period of 6 months for intensive training at the nearest agricultural station at State expense. Care should be taken to select teachers from schools located in the centre of a group of 5 villages. On completion of training they are taken back on the staff of the school from which they were drawn and continue to work as teachers for only *half a day* and devote the *other half for* Agricultural extension work under the control and guidance of departmental officers. If he was getting say Rs. 30/- to 40/- per month for working as a full - time teacher he will continue to receive *only half this amount* from the school authorities. For working as an extension officer for half a day each day and during holidays he should be compensated by paying the other half plus an additional allowance of 25 to 50% of his entire pay. It is felt that an additional allowance of 25 to 50% should be a sufficient attraction and encouragement to a teacher to devote himself whole - heartedly to agricultural improvement work. The cost of paying the teacher, half his monthly pay plus allowances, should be met by this department under a scheme of subsidy on 50 – 50 basis between the Goverment of India and the State Government. These teachers should be also entrusted with sale of seeds, insecticides etc. according to local demand by providing themselves with some storage facilities, out of allowances granted.

In a taluk with about 20 such trained teachers stationed at the rate of one for about 5 villages, with facilities to supply the agricultural requirements at as near a place as possible and devoting their time every day among those with whom they are familiar and intimate, it would be possible to achieve remarkable results in a comparatively short time at a low cost. This scheme may be taken up on a five - year plan in some selected taluks of South Kanara and Malabar in the first instance, to be extended, or suitably modified and improved, based on the results achieved and experience gained. The financial implications of the scheme are worked out for a taluk of about 100 villages — where 20 trained teachers are proposed to be employed. A teacher's pay is taken as Rs. 40/- a month.

**Recurring Expenditure.**

| | | Per month | Per year |
|---|---|---|---|
| (1) | 50% of pay that is at Rs. 20/- per month for 20 teachers ... ... | Rs. 400/- | Rs. 4800/- |
| (2) | Allowance at 50% of full pay at Rs. 20/- for 20 teachers ... ... | Rs. 400/- | Rs. 4800/- |
| (3) | Contingencies — Postage and Travelling Expenditure once a month to head-quarters of Taluk at Rs. 5/- per teacher for 20 teachers ... ... | Rs. 100/- | Rs. 1200/- |
| | Total recurring expenditure ... | Rs. 900/- | Rs. 10,800/- |

**Non - Recurring Expenditure :**

Supply of local measures and one Spring-balance etc., — L. S. at Rs. 100/- for each teacher for 20 teachers ... Rs. 2000/-

**For each Taluk :**

| | |
|---|---|
| Recurring ... ... | Rs. 10,800/- |
| Non Recurring ... ... | Rs. 2000/- |

# The Food Problem in Madras

*By*

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The problem of food is becoming a crisis day by day, engaging the best brains and the greatest men of the country. This inadequacy started in 1942 - 43 in the midst of war, due to sudden influx of evacuees from Burma and other States coupled with increased numbers of Military to be fed Inspite of all efforts by the State for increased production, by various concessions such as manures, seeds, mechanical and electrical power and land with irrigation projects and improvements for increased water supply, this deficit is still not made up. The reasons quoted are the failure of crops by excess or shortage of rains, and adverse seasonal effects, but there should also be some underlying root-cause that contributes to this crisis.

1. That the season and weather conditions alone are not the real causes, can be substantiated by the following examples:

(A) In September - October, 1949 there was cyclone and storm in North Circars which devastated the paddy crop to the maximum extent. Yet the prices of rice, or in other words the extent of dearth of food was not so high as what prevailed in October 1950 or March 1951, in Vizag district especially.

(B) Even the drought-affected parts of the province (Chingleput, N. Arcot) and the famine declared state of Cooch Bihar have not felt the soaring up of prices so much as the Andhra districts in March 1951, where the crops (paddy etc.,) harvested were not below normal in many parts. So it is apparent that seasonal effects alone are not responsible for the sudden crisis or inadequacy of food, but there is something else. It is not due to real want of food grains in the locality but want of adequate release and liberal distribution. The reasons for this lock-up or hoarding are as follows:

(i) From the beginning the ryot is unwilling to part with his grain to the State, in spite of rigorous procurement, due to discontent with the controlled price of Rs. 18—6—0 per bag. In 99% of the villages that discontent is not entirely unreasonable. Thus the real agent that produces food is neither friendly to the procuring authorities nor does he thinks of parting with his produce for procurement. Thus leaving aside the unwilling or antagonistic real agent i.e., the ryot, other means like regulations, rules, etc., cannot alter the situation.

(ii) Secondly, the ryot devotes more attention to his commercial crops such as sugarcane, plantains, vegetables, turmeric, onions, chillies etc., on wet lands, cotton groundnut, Deccan Hemp for fibre, etc., on dry lands than food grains, as these fetch much higher prices in the market. For instance (a) from 1 acre wetland if cropped with sugarcane a ryot gets Rs. 2000 —Rs. 800 = Rs. 1200 net profit in the place of Rs. 270—40 plus Rs. 100 = Rs. 330 net per acre of paddy, with *pyru* ragi following.

(b) A ryot growing plantains would realise Rs. 800/- net profit, instead of Rs. 330/- by growing paddy.

(c) A ryot with summer brinjal crop or turmeric would get Rs. 400/- net, in 4½ months, instead of Rs. 220/- on second crop paddy.

(d) A ryot who grows onions or vegetables after paddy harvest (between January and April) would realise Rs. 280/- net profit while his neighbour cropping with *pyru* ragi in the same period would get only Rs. 160/- net profit.

(e) *Dry lands:* He who grows Deccan Hemp for fibre is realising Rs. 400—80 = Rs. 320/- net while his neighbour growing ragi gets only Rs. 150/- net. He who grows groundnut on one acre gets Rs. 290/- net while his neighbour growing ragi gets only Rs. 150/-. He who grows 1 acre cotton on dry land gets Rs. 300/- net in place of Rs. 100/- by cholam. These disparities induce the ryots to go in for commercial crops in preference to food grain crops.

(iii) Thirdly the non-restriction of area under commercial crops leaves the cultivator free to increase the areas under these, to get increased profits. In fact he wants to minimise the area under food crops wherever possible to avoid procurement, with an area to just suffice for his consumption and that of his servants.

(iv) Fourthly, where subsidiary crops can be raised he prefers to grow money crops, rather than food grain crops, to avoid controls.

(v) He resents the control system of grain and its purchases as it is at variance with other controlled agricultural products. For instance, when his paddy price is fixed at Rs. 17—13—0 per bag i.e. at 3¾ times the prices of 1936–37, his sugarcane product (jaggery) is fixed at Rs. 0—11—0 per vis or in other words 8 to 10 times the price in 1936. Similarly when his *ragi* and *cumbu*, prices are fixed now at Rs. 16—8—0 per bag i. e. 4 times the price of 1936, the groundnut product i. e.—cake is fixed at Rs. 14—4—0 per bag, i. e.—14 times the price of 1936 and oil at six times the pre-war prices.

(vi) The ryot's displeasure is not confined to the preference of commercial crops in place of food crops in old lands but the same mentality is exhibited in newly reclaimed lands as well. In the name of growing food crops he takes mechanical aid (tractors, bull-dozers, pump-sets, engines etc.) but uses the land for commercial crops wherever possible.

(vii) His indifference also exends to the growing of green manure crops, where he prefers *punasa* millet crops of small duration. How to turn him into the requisite line or how best to increase food crops is a problem indeed. The incomplete release and consequential soaring up of prices can not be combated either with intensive procurement or in its entire absence as well. In both cases the situation could not be set right. When lakhs of consumers do require procurement for ration supply, others, including small tenants ardently desire the cessation of procurement. As such the problem remains as unsolved as before. A via media policy to satisfy both sections is necessary.

The following suggestions are offered to satisfy both :—

1. To collect all land kist and assessment in the shape of food grains as per the old system, centuries back. There is now much difficulty with regard to collection - weighing, storage, carting etc. The special village official will collect and the contractor will carry and store in town. By this system Rs. 12/- crores worth of food grains (Government and Estate lands) can be collected. The extra trouble is worth shouldering when compared with the immense trouble to approach foreign countries.

2. To levy from all lands above 3 acres one bag per acre in rain-fed lands and shallow tankfed lands (non-deltaic area), while in project areas the usual rates can be insisted on.

3. To levy 4/5ths of the dry and high level wet-lands at the usual rates specified in 1 and 2 above, irrespective of the area actually grown by the ryot with food crops. If he grows food crops in less area he will have to purchase and deliver the grain. This may restrict the area under commercial crops to a fair extent.

4. To insist on the growing of green manure compulsorily in all lands where possible, except in low lands, at least in 1/5th of the area of wetlands by compulsory levy of additional yield for these lands to force the ryot to grow green manures.

5. To levy on non-food crops extra tax, and to show a little concession to ryots growing all food crops in his holding. Some discretion of the local officers is essential and is to be used tactfully.

6. To appoint 4 or 5 leading ryots in every village to form a procurement committee who may be entrusted with the collection and delivery of the levied quantities in full. This committee may be either honorary or a small compensation paid. It is this committee of local influential men that can safely arrange the procurement, that can watch the prices, that can prevent transfer of stocks to outside, and that can unearth concealed stocks.

7. To settle the prices from firka to firka or from taluk to taluk in consultation with this committee from time to time. No hard and fast rules can be enforced for the whole district. In several localities, special circumstances would prevail where high prices would inevitably range.

8. When the rations by local vendors are issued by measurement, let the same measure be used for procurement The ryot resents delivering by weight when his servant purchases from the ration shop by measurement.

9. To fix controlled prices for procurement at a fair level seeing the market for other agricultural produce, comparing both with 1936 prices. The vast disparity in different agricultural produces causes unwillingness to part with his grain to the State or to grow more food crops.

10. To plan from now on to remove the grain control after a time by eventually entrusting it to village committees with members commanding influence over several villages.

The Congress Panchayatdars, the District and Provincial Congress Committee members, the M. L. As. who are all expected to command influence over the public of the locality can sympathise with the hungry millions, join these committees voluntarily, exhibit self-sacrifice and help the situation. The District Collectors can persuade these elected members and other influential leaders to form committees for this purpose. They are to be made to observe strictness, impartiality and loyalty to the State.

11. To guard against the alarming news often published in newspapers (vernacular dailies) about the famine conditions, acute shortage of food and starvation in other places, etc. Similarly, publication of the black market prices of rice and millets prevailing in other localities has also to be guarded; such news causes sudden rise of prices in normal and surplus areas. The sum total of all the above is to court the ryot's friendship, gain his confidence and obtain his co-operation to deliver the goods. For this, elaborate propaganda, appeals to humanity, through papers, books, songs, ballads, cinema shows, dramas, meetings and above all, by voluntary teams of propagandists manned by influential leaders, as was done hitherto in the days of Khadi propaganda, Harijan propaganda, and for enlistment of Congress members.

2. The appeal should also be based on religious sentiments, something like saving of lives from death by moving speeches, since in our country ryots are readily influenced by religious appeals.

3. To write and publish an extra reader for V Class, a text for VIII Standard and a compulsory reader for S. S. L. C. in vernacular languages, considering this food production.

4. To prepare ballads in melodious tunes to be sung by villagers.

5. Village boys are to be taught *Dasara Padyams* or verses for *Dasara Puja* days sung in teams for 15 days in September. Composting, tree-planting, green-manuring, fertiliser application, food production, human sympathy, saving several lakhs of lives of starving people, these can be the subjects of the verses thus sung.

6. Of late *Burra Kadha* has become popular in Andhra districts and *Kathakali* in Malayalam. Items of the above type in story may be put across to rural folk in those regions.

Any amount of preaching or propaganda cannot succeed with the ryot when it is a question of his extra income or money earning, especially when the necessities and luxuries are to be purchased by him at high prices in the market, *e. g.*, cloth, vessels, iron, implements and others.

As such, vigorous and strenuous propaganda and appeals to his sympathy in the name of God and humanity alone, can induce the ryot to unlock his underground cells and granaries.