DIRECTOR OF AGRICULTURE

PROCEEDINGS OF THE FIRST ANNUAL SESSION OF THE ACADEMY OF AGRICULTURAL SCIENCES HELD IN THE AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE COIMBATORE

ON 22nd AUGUST 1960

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PROCEEDINGS OF THE FIRST ANNUAL SESSION OF THE ACADEMY OF AGRICULTURAL SCIENCES, HELD ON 22ND AUGUST 1960 AT THE AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE, COIMBATORE.

The First Annual Session of the Academy of Agricultural Sciences was inaugurated by the Hon'ble M. Bhakthavatsalam, Minister for Home and Agriculture, Government of Madras. Shri N. R. BHAT, Director, Sugarcane Breeding Institute, Coimbatore, presided over the Conference. It was attended by scientific workers of this Institute and other officers in Coimbatore and officers deputed to attend the College Day and Conference.

Opening remarks by the Chairman of the Academy.

Dr. S. Krishnamurthi, Dean and Additional Director of Agriculture, Coimbatore, welcoming the Honourable Minister, President, delegates and officers of the Agricultural Department said :

It is with good deal of gratitude that I thank our Minister for Agriculture on behalf of the Academy of Agricultural Sciences for sparing the time to be present with us here to-day to inaugurate the new Academy of Agricultural Sciences, Coimbatore. In this connection, I would like only to say a few words on the genesis of this new Academy of Agricultural Sciences, Coimbatore. As every one is aware, ever since this Institute was established more than 50 years ago, it was not only a mere Agricultural College for training students for the B.Sc. (Ag.) Degree but from the very beginning, it has also been a Research Institute. In other words, besides teaching work, there has always been intensive research work going on alongside. As our Honourable Minister explained yesterday in his speech, the Agricultural College and Research Institute, started just with Agriculture, Botany and Chemistry sections. In those days, the Botany section used to be called as the Economic Botany Section and as you are all aware, with the advancement in plant breeding and genetics, this got divided into several specialisations particularly on individual crops like rice, cotton, millets, pulses, etc. With the development of the Agricultural College and Research Institute, and its expansion of activities, there was no doubt a filllip to experimestal work and dissemination of results of research both through popular articles and scientific publications. We should certainly pay our tribute to those who were responsible for establishing traditions in this Institute and for having started the Madras Agricultural Journal as one of the chief activities of the Madras Agricultural Students' Union, a very difficult task which no other institution can undertake. So it happens from the year 1911, within about four years of the establishment of the Institute, a monthly publication had been started to give an opportunity to our scintific workers to publish their results of research both as scientific material and as popular material. It is a matter of gratification that this Madras Agricultural Journal through its succeeding attempts has been maintaining its tradition of continued publication and has been appearing regularly every month throughout these 47 years except during brief temporary breaks both during World War I and II.

Apart from that, there was another effort made in the early years to form an association of the Economic Biologist and for this association we had Sir T. S. Venkataraman and Dr. B. V. Nath and others who were the sponsors

and real work was done by the Association of the Economic Biologists by bringing together the research work of the Sugarcane Breeding Institute and the Agricultural College under one platform. Somehow or other, this association did not last very long.

In 1950, this institute began to organize the Scientific Workers' Conference at the time of the Annual Agricultural College Day and Conference. That was meant to bring together our own research workers in one platform and particularly to encourage the younger scientists working with us here to present their papers on original research. This has been going on for the last ten years, and the Government have been pleased to assist the Scientific Workers' Conference by giving grants for the publication of its proceedings. Another activity of this Institute has been the conduct of the Study Group, a group meeting held every week during the year in which scientific and technical papers are presented by our research workers here. We have had opportunity of inviting very eminent scientists from abroad whenever they happen to come here, for this study group and we have had during this year a series of good scientists to meet the members of the Study group and addressing them.

The Research Council which has been organising these study groups had to review the whole situation with regard to what has been done in encouraging and promoting the research work to an even higher quality and to promote the exchange of ideas among the scientific workers in agricultural research. As it is, we have been confining these activities to our own workers in this State—in this Institute and the Regional Research Stations. It is always better that in such Conferences, we associate ourselves with scientific workers from outside atleast occasionally, so that there is a free exchange of ideas and so that our scientists' work can be critically reviewed and appraised through presentation by the scientists who come from outside. At the same time they would get an idea of the work, which we are doing in this institute. To promote all these objectives and help in this manner to upgrade the scientific research work in this Research Institute and all other regional stations, this organization namely the Academy of Agricultural Sciences has been established. The coming into being of this Academy would not have been possible but for the very sincere encouragement which was given in the first instance by the Director of Agriculture who thought that this was a good idea, and for the appreciation of the objectives of this Association by the Secretary, Food and Agriculture and our Honourable Minister for Agriculture who has never denied an opportunity for our scientific workers to do advanced and progressive work. That in short is the genesis of the Academy of Agricultural Science.

In these modern days, opportunities for scientific workers in many fields to come together are becoming better and better. The opportunities and co-operation that we can get from internal and external organizations or bodies like UNESCO, FAO and others are becoming practicable and possible. As an example, I can point out to you that within about three months of my having gone to the Indian Agricultural Research Institute, I contacted the representative of the UNESCO and within about six or seven months I was in a position to sponsor with the help of the UNESCO, a World Conference or Horticultural Seminar on fruit-breeding and the UNESCO was kind enough to see that foreign scientists from England, U.S.A., Ceylon, Indonesia, and elsewhere were brought in with us in the Conference. Such opportunities are becoming greater and greater. I have the hope that with the encourage-

ment of the Government of Madras under the Leadership of the Honourable Minister for Agriculture who is in-charge of Agriculture, we would receive both his blessings and the blessings of Government for financial assistance whenever required for such a laudable work for the benefit of the State Agriculture itself. We do accept that this organization will be of some use particularly to our junior scientific workers to upgrade their quality of work. I request the Honourable Minister for Agriculture to kindly inaugurate the Academy of Agricultural Sciences

Inaugural Speech by the Honourable Minister for Home and Agriculture.

I am indeed very happy to associate myself with the establishment of this Academy of Agricultural Sciences. I have great pleasure to inaugurate this academy. This academy is no doubt new but it is not altogether a new organization. But when you establish such an Academy of Agricultural Sciences, it should emphasize that you will devote particular attention to Scientific study and research reaching to the various problems confronting agriculture. During my tour to Russia, I came across with a number of Academy of Agricultural Sciences. They are called Research Academies of Agricultural Sciences. These academies devote themselves to scientific study and research and also training of students. We are indeed proud and happy that the strength of this Premier College has been raised to 162. In one Academy of Agricultural Science in Russia they were having as many as 6,200 students and 500 farmers' children undergoing training. In another institution, they pointed out that there were 5,000 to 6,000 students who were attending classes in agriculture and an equal number being trained by correspondence. They said that with regard to admission as many as 6,000 to 7,000 students, they have to make a selection which means more applicants come forward to join the institution for similar training. I came across with another institution which they called as the Union Institute of Plant. Industry. I saw very eminent scientists there. They had collected plants from India. I could see very many useful publications, but they were all in Russian Language. I could see that one publication on potato which would be useful to us also. They told us that they would like to have contacts with us and others in India and that they would render all co-operation in extending to our country the knowledge that they had derived.

I have listend with interest to the account which the Dean has given of the manner in which this Academy has come into existence. From the very inception, a great tradition has been built up for constructive reasearch work at the Agricultural College and Research Institute. As I have already expressed at the time of opening of the Post-Graduate Block and the inauguration of College Day and Conference, one of my particular observations in Russia was that the scientists in that country were intensely devoted to their work. The result of such devotion is reflected in the results of application of science to agriculture. Russia is a vast country, having a variety of climates, regions and problems in agriculture, just as India. But by a proper organisation of scientific research, Russia has achieved solutions to their many problems. The Academy of Agricultural Sciences at Coimbatore is mainly intended to bring sicentific research in agriculture under a proper organization, to bring scientific workers in the several fields of agriculture under one common platform and to promote contacts of our scientists with scientists from outside the State and abroad. This is a laudable object, and I am aware of the significance of the ultimate impact of the work of this Academy on the general standard of research in our Department of Agriculture.

It is generally true in science that research for the sake of research does lead to immense ultimate benefit. If all scientists were to think every time only of the immediate utility of their experimental work, neither science could have made headway nor great fundamental discoveries could have been possible. Therefore I do agree that all scientists must be given an opportunity to take up fundamental research in their own fields so as to encourage building up of knowledge step after step. This is the reason why there has been a recommendation made by the Food Production Committee of which I was the Chairman that every specialist in the Department of Agriculture should be given some special staff for continuing certain amount of sound fundamental research. This principle has been accepted by the Government and it is learnt that proposals from the Dean and Additional Director of Agriculture for appointing Research Assistants under the Specialists and Heads of Sections to help them in fundamental research are under the active consideration of the Government

While this is one aspect of the scientific work in the Department of Agriculture, there is another more important aspect of research which requires even more emphasis in the context of conditions existing in India. There are at present numerous concrete problems in agriculture which have defied solution. Moreover, when old problems have been solved, new problems continuously arise. Moreover in our country, the most imperative need at present is to raise agricultural production. It is not a question of increasing food production alone. This is no doubt the greatest single problem. But to a large extent the industries in our country are based on agricultural economy. In this Coimbatore City, which we call as the "Manchester of India" the vast textile industry depends, for its very basis of existance, on the agricultural crop, cotton. The same thing holds good with regard to large scale industries in India such as the sugar factories, the tobacco industry, the plantation industry, the jute industry and many other industries of which you as agricultural scientists are thoroughly familiar. For all our foreign exchange which is most essentially required at the present time for us to build up our heavy industries, we have to mainly depend for exports on agriculture and agricultural products. Thus, the economy of our country is so much tied up with agriculture that to accelerate the development of agriculture in all aspects, is a matter of life and death for the country as a whole. There may perhaps be some extent of land which is not cultivated at present but which could be brought under cultivation. However, the eventual increase in production which we can envisage from this addition of land is not likely to cover up our gap in agricultural production. The development of irrigation projects, large and small, is no doubt one of the most important factors for increased production. While all these are important, we have to depend upon agricultural research to give a significant answer to the bulk of the problems of agriculture. Many pests and diseases still damage our crops, often making every other effort towards growing profitable crops futile. I am no doubt happy that this Department of Agriculture has been able to find methods of control of number of pests and diseases of numerous agricultural crops, but there are still many pests and diseases which have defied the efforts of our agricultural scientists. I am told that the group of virus diseases alone are today becoming a menace in the case of many food and commercial crops. Also the solution to infestation of several crops by nematodes has still now not been satisfactory. There are several fields of research work which are still untouched by our agricultural scientists. The Government of

Madras have sufficient realisation of the need for giving every facility to our scientific workers to be trained in advanced countries under eminent scientists. It is for this reason we deputed one of our men from the Research Institute for the study of virology in U.S.A. and the Rockefeller Foundation has been pleased to award handsome grants for equipping a new Virological section for the Agricultural College and Research Institute at present. In the same manner another specialist has been deputed for the study of nematology and in this field also the Rockefeller Foundation has come forward to assist us with grants for setting up suitable laboratores. When we have sent our scientists abroad, I do look forward to their showing concrete results which would benefit the agriculturists at large A two pronged programmes which the Government of Madras has adopted is intended to benefit a number of our scientists in this Institute. One part of the programme is the new opportunities which the Government have afforded by the establishment of the Post-Graduate Centre, for our men in the department to equip themselves for higher degrees such as M.Sc. and Ph.D. The Government as you are aware have encouraged the men of the Department who have joined the Post-Graduate Centre by every means, by granting them study leave, exempting them from tuition fees, and providing extra remunerations in the shape of monthly allowances or stipends. I do hope that these scientists whom we have sponsored for such training in our own Institute here will not only benefit themselves in their future career, but also put their shoulders to the wheel with their higher training, to eventually place agriculture on solid foundation by their deep devotion to research. The other programme which the Government have adopted for a number of years now, is to encourage our scientists to go abroad, through several foreign aid plans such as the T.C.M., the Rockefeller Foundation and the Colombo Plan, etc. As I have already said in their case also, we expect them on their return to apply themselves intensely to their work after their training.

The Government have been sparing no pains to see that the laboratories at this Research Institute are well equipped. If there is any gap in the matter of modernising the laboratories of our Institute or in any facilities which are lacking for furthering agricultural research, I would always be glad to listen to concrete proposals and assist in the implementation of such proposals.

Any scientific work in agriculture proves its value eventually by its actual profitable application The sum total of achievements of our Institute here will be guaged eventually by the benefit which agriculture in the State particularly and in the country generally has derived from the findings of research. Every scientific investigation, therefore, should be properly programmed, critically scrutinised, and promptly implemented so that concrete results will be achieved, which can stand the test of time. It is for this reason that a Research Council has been established in this Institute. The duties of the Research Council are to stand guard over the experimental work conducted in the Institute and its connected 31 experimental stations spread all over the State. I am glad that the Research Council has been helpful in guiding the research programmes so that they are linked up with real problems of farmers. One of the ways by which the quality of scientific investigations can be guaged is for the investigator to present his findings and observations before a scientific body whose critical appraisal will upgrade the quality of his work. I have listened with interest to a description of the

ways and means by which this Institute has been tackling this problem of improving the scientific work of this Institute. The Association of Economic Biologists for a time did useful service. The Annual Scientific Workers' Conference conducted by the Research Council for the last 10 years has also promoted active scientific work. However, the Scientific Workers' Conference has been confining its activity to the Research work done only in the Agricultural College and Research Institute, here and its connected research stations. But in scientific work it also is necessary that fresh winds from outside are allowed to blow into the portals of our Institute and research stations. A critical evaluation of our scientific work frequently through conferences by the association of agricultural scientists from outside, would be for the benefit of not only the Scientific Workers themselves, but for the agricultural research as a whole in the State. I am therefore very happy that the Research Council has now organized an Academy of Agricultural Sciences to promote measures for improving the quality of scientific work in our Institute and the research stations and to provide exchange of ideas between research workers of this State and outside. I am also glad to see that it is intended to hold seminars or Scientific conferences of an All-India nature pertaining to agricultural research and if possible to organise once in a while International seminars in chosen fields of agricultural research. In organizing such seminars which eventually would be useful in upgrading our own work in this State, I would like to assure you all that when concrete proposals are placed before the Government, we will be glad to consider them favourably. The assistance of International Organizations such as the UNESCO and the Food and Agricultural Organization should also be obtained wherever it is possible.

It will be with interest that I will be watching the progress of your well thought out organisation, this Academy of Agricultural Sciences.

Presidential Speech—

Dr. N. R. Bhat, Director, Sugarcane Breeding Institute, Coimbatore expressed his thankfulness for offering him to be the President of the First Academy of Agricultural Sciences. He selected four out of thirteen papers selected for the Academy. The other paper were read and presented in the monthly Academy of Agricultural Sciences meetings.

Presentation of papers and discussions—

(i) ROLE OF LEGUMES IN ROTATIONAL CROPPING OF GARDEN LANDS OF COIMBATORE.

By

Sri T. NATARAJAN, B.A., B.SC. (Ag.), Agronomist and Associate Professor of Agronomy.

Sri M D. PRABHU, B.SC. (Ag.), Lecturer in Agriculture.

Sri R. SUBRAMANIAN. B.SC. (Ag.), Assistant Lecturer in Agronomy.

Sri T. SRINIVASAN, B.SC. (Ag.), L.T. Assistant Lecturer in Agronomy

Introduction.—Crop rotation or crop sequence is a practice well known in India and has been in existence from ancient times. The object of this agronomic practice is to secure higher productivity and income from land. Though the principles involved in crop rotation practices are understood, no scientific data has accumulated to justify the several and varied rotation practices in vogue in the country.

When prices of any commodity rise farmers are tempted to grow that particular crop over and over again disregarding the usual rotations. One such instance is the continuous raising of cambodia cotton crop in the garden lands of Coimbatore year after year in the winter season preceded by an irrigated millet crop either summer cholam or ragi without a sufficient fallow period.

The role of legumes in rotation of crops for maintaining soil fertility and increasing the productivity of grain crops which follow, has been stressed by many workers in India and abroad. Rotation experiments conducted in this State and elsewhere in dry lands indicate that cereals following legumes do better than when they follow cereals. Rotation experiments are few and fewer still are rotation experiments conducted under garden land conditions

Acharya, *etal* (1952), in an experiment on rotation at the Indian Agricultural Research Institute, Delhi found that when berseem was grown in rotation with cowpea and wheat, yields of wheat were higher after berseem raised adequately manured with superphosphate. In another series of experiments at Indian Agricultural Research Institute, Bains (1957) recorded that fertilizing the legume crop in the rotation with phosphate alone or phosphate with nitrogen, increased the yields of legume which in turn had a favourable effect on the yields of subsequent unmanured crops in the rotation. Application of super phosphte at 20 lb. $P_{2}O_{5}$ per acre to the previous crop of Jowar, redgram and groundnut, increased the kapas yield of succeeding cotton crop at Indore. In rotational trials with Cambodia cotton at Cotton Breeding Station, Coimbatore, higher yields of cotton were got when it was rotated with groundnut, sunnhemp or including a summer fallow.

Materials and methods.—With the object of studying the effect of two different rotations, one including a legume and the other without, on the productivity and soil fertility in the garden lands of Coimbatore, an experiment was laid out in 1954, in fields No. 52 A and 52 B of the Central Farm, Coimbatore. The following are the particulars of the rotation treatments adopted :—

Rotation I—(Less intensive legume rotation)—

Summer cholam	March—July.
Irrigated cotton ..	September—March.
Ragi	June—September.
Green manure (Sesbania speciosa).	October—January.

Rotation II—(Intensive rotation)—

Summer cholam	March—July.
Irrigated cotton	September—March.
Ragi	April—August.
Irrigated cotton	September—March.

The more intensive cropping in Rotation II is compared with the less intensive Rotation I in all aspects.

There were 5 treatments randomised and replicated 4 times in plots of 3 cents each as shown below :—

Treatment 1.—Rotation I.—All the crops excepting green manure received 5 tons farm yard manure per acre.

Treatment 2.—Rotation II.—All the crops received 5 tons of farmyard manure per acre.

Treatment 3.—Rotation II.—All the crops received 5 tons of farmyard manure as a basal dose and a top dressing of 25 lb. N. as ammonium sulphate.

Treatment 4.—Rotation 1.—The green manure crop alone received 100 lb. P_2O_5 per acre as super while the other crops received 5 tons farmyard manure per acre.

Treatment 5—*Rotation II.*—All crops received 5 tons farmyard manure and 25 lb. P_2O_5 as Super as a basal dose and a top dressing of 25 lb. of N. as ammonium sulphate.

The experiment was started in 52A with Ragi (Co. 1) crop in June 1954 while in 52B, an irrigated cotton (MCU-1) was sown in September 1954. The experiment was laid out in the fields 52A and 52B to have both the phases of the two year rotation in the same year to offset seasonal effects.

Results.—The first cycle of rotation was completed in the first series in Field 52A by April 1956 and in the second series in Field No. 52B by August 1956. The monetary values of the crops in the two rotations were statistically analysed and it was found in the 2nd series, the intensive rotation, i.e., Rotation II gave significantly higher monetary value than Rotation I, there being no differences between the different treatments of the same rotation.

The 2nd cycle was completed in 1958 April in I series and July 1958 in II series. The differences in the monetary values of the two rotations were not significant.

The third cycle was completed in the first series in April 1960 with an irrigated cotton and in the second series in July 1960 with summer cholam. The first series results did not show any significant differences. In the second series, the intensive rotation, i.e., Rotation II gave significantly higher monetary value than the Rotation I. In the Rotation II plots, those which received fertilizers gave significantly higher monetary value than those which received only farmyard manure as a basal dose. Regarding Rotation I, the differences between the two treatments were not significant. But the treatment 4 where the green manure received 100 lb. P_2O_5 per acre was found to be on par with the treatment II, the plot which did not receive any fertilizer in the intensive rotation. The results are furnished in Table I appended.

Discussion of results.—The monetary value of a rotation depends upon the yields of individual crops and also the residual effects of one crop on the other. Yield data of the individual crops were analysed for the different manurial levels and rotational effect.

Summer Cholam.—This crop follows green manure in Rotation I and can be sown in proper time, i.e., Ist week of March. In the IInd rotation, it follows irrigated cotton and the sowing could be done only 3 or 4 weeks later. The differences in grain yield were significantly higher in favour of Rotation I, in 4 out of 6 seasons, while the straw yields were significantly more in the II rotation. This indicates that seasonal factors have a decisive influence on grain yields. The average grain and straw yields for 6 seasons are furnished in Table II appended.

Cotton.—This follows sorghum in the I year in both rotations but in the second year it follows ragi in the II rotation only while a green manure is raised in the I rotation in the same season. Yield differences of kapas were significant only in one season in the second series, when the yields in Rotation I plots were significantly higher than those of Rotation II. Cotton following ragi is sown only 3 or 4 weeks later than first week of September which is the usual best season for winter cambodia in Coimbatore and yield of kapas in the case of cotton after ragi was appreciably less than when it followed sorghum. Average yields of Cotton for 6 seasons are furnished in Table II appended.

Ragi.—Yield differences of ragi were significant only in one season when both grain and straw yields of Rotation II, were significantly higher than Rotation I. Treatment No. 4 of the First Rotation, where the green manure received 100 lb. P_2O_5 was on par with treatment of 2 of Rotation II, the unfertilized plot, in respect of grain and on par with treatments 5 and 2 in respect of straw. The average ragi yields for 6 seasons are furnished in Table II appended.

Green Manure (*Sesbania speciosa*).—The yield of green matter from plots receiving super was always greater than unmanured plots, though not significant. Sesbania yields are given in Table II appended.

So far three cycles of rotations have been completed. The monetary value of the intensive rotation was significantly higher than the less intensive rotation only in the first and third cycles of the second series. Further, the yields of ragi and cotton in the plots of treatment 4, where the green manure received 100 lb. P_2O_5, were higher than the unfertilized plots of both the rotation and sometimes even on par with the fertilized plots of the intensive rotation. This confirms the results of research elsewhere in India, that the fertilization of the legume crop in the rotation has a favourable effect on the yields of subsequent unmanured crops. Application of fertilizers to the green manure crop itself or to the succeeding grain and cash crops as is done in the intensive rotation, may result in higher yields of crops and also more effectively maintain the soil fertility in the long run. This requires confirmation by further continuance of the experiment with suitable modifications.

Summary and conclusions.—A rotation experiment in the garden lands of Coimbatore with two types of two-year rotations, one less-intensive including a legume, namely, cholam, cotton, ragi, followed by green manure as followed by Central Farm, Coimbatore and another, an intensive type with four crops, viz., cholam, cotton, ragi and cotton, as practised by most farmers was conducted for a period of six years. The results indicate that the monetary value of the produce obtained in the intensive rotation was significantly higher in the 1st and third cycles while both were on par in the second cycle of rotation. The green manure crop which received 100 lb. P_2O_5 in a rotation produced not only higher yields of green matter but increased the yields of the succeeding crops in the two year rotation. Over long years inclusion of legume helps to keep up soil fertility.

Acknowledgment.—The experiment was initiated as a Three-year Programme of work by Sri P. A. Venkateswara Iver when he was Agronomist and Professor of Agriculture, Agricultural College, Coimbatore. The authors acknowledge the help of other workers in the section who were connected with the experiment over a series of years.

References—

(1) Acharya, C. N., etal. (1952)—Influence of legumes on crop rotation, Sci. & Cul. 18 (6) : 86.

(2) Bains, S. S. (1957) Fertilize that legume crop in the rotation, Indian farming : 7 (2) : 28-31.

(3) Balasubramaniam, R. and Sundararaman, S. (1947)—A review of experiments with legumes preceding cotton in the Madras Province, Indian Cotton Growers' Review 1 : 87-95.

(4) Co-ordination of Agricultural Research in India I.C.A.R. Agronomy Vols. 1 and III (1955 and 1957).

(5) Mirchandani, T. J. and Sen, S. (1953)—Crop rotations in India, I.C.A.R. Review series.

TABLE I.

Monetary value from a 3 cent plot in two years.

Rotation.	Treatment.	I Cycle. Monetary value.	I Cycle. Percentage on G.M.	II Cycle. Monetary value.	II Cycle. Percentage on G.M.	III Cycle. Monetary value.	III Cycle. Percentage on G.M.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1st Series.							
Rot. I	I	36·88	99·4	24·82	92·9	37·97	93·5
	IV	37·13	100·1	26·28	98·3	37·81	93·1
Rot. II	II	36·94	99·6	25·67	96·0	41·46	102·0
	III	37·44	100·9	29·02	108·6	42·59	104·9
	V	37·15	100·2	28·03	104·9	43·39	106·8
General mean	..	37·09	100·0	26·73	100·0	40·63	100·0
Significant or not	..	No.		No.		No.	
II Series.							
Rot. I	I	23·81	74·1	32·63	98·1	25·69	70·4
	IV	24·56	76·5	34·65	104·2	30·22	82·7
Rot. II	II	35·63	110·9	32·19	96·8	39·85	109·1
	III	39·19	122·0	34·29	103·1	42·66	116·9
	V	37·44	116·6	32·55	97·9	44·16	120·9
General Mean	..	32·12	100·0	33·26	100·0	36·51	100·0
Significant or not	..	Yes.		No.		Yes.	
Critical Difference	..	3·357		—		3·67	
Conclusion		3, 5, 2, 4, 1.		..		5, 3, 2, 4, 1	

TABLE II.

Average acre yields of crops—cont.

(Six seasons)

		Treatment.	Summer cholam.	Cotton (Irrigated) kapas.	Ragi (Irrigated).	Cotton (Irrigated) kapas.	Sesbania speciosa (Green manure).
Rot. I	..	I	1630·4 grain 5109·4 straw.	1085·5	2151·2 grain 5608·5 straw.		20976·0
Rot. I	..	IV	1539·2 Grain 5047·7 straw.	1124·4	2393.4 grain 6026·0 straw.		22095.0
Rot. II	..	II	677·9 grain 5817·1 straw.	1005·7	2371·0 grain 5819·3 straw.	660·6	
Rot. II	..	III	772·4 grain 5679·4 straw	1066·2	2643·3 grain 7112·1 straw.	644.7	
Rot. II	..	V	749·9 grain 5579·9 straw	1036·7	2548·9 grain 6479·9 straw	701·6	

N.B.—The yields of cholam in Rotation II were always lower because the sowing dates were invariably later than in Rotation I.

(i) ROLE OF LEGUMES IN ROTATIONAL CROPPING OF GARDEN LANDS OF COIMBATORE.

BY T. NATARAJAN, M. D. PRABHU, R. SUBRAMANIAM AND T. SRINIVASAN.
PRESENTED BY : SRI M. D. PRABHU.

Dr. N. R. Bhat, Director, Central Sugarcane Institute, Coimbatore, asked the following querries :—

(1) The experiment is of a feeder type and the conclusions will not be sufficiently sound.

(2)The growth period in the two rotations are not the same. Why it should be so?

(3) Analysis is done on the basis of monetary values which is likely to vary with fluctuations in price. How far will such fluctuations will affect the differences between the two rotations?

The author replied that the growth period has necessarily to be different since a green manure crop intervenes. The points raised will be borne in mind in our future work. The rotation is taken as a whole and hence the monetary value is taken.

Sri Vasudeva Menon, Assistant Agricultural Chemist, Analytical Wing.

1. How was P_2O_5 applied? 2. What is the difference in the yields between the plots fertilized with phosphates and those not applied with phosphates?

The author replied that the yields were always greater in the case of crops applied with phosphate. The phosphates were always applied 2 inches below the surface of the soil.

Sri C. Balasubramaniam, Agricultural Meteorologist. It is better soil moisture data is collected for different treatments. In all agronomic experiments the causative factors for the yield may be determined.

The author replied that the soil moisture will be arranged to be determined in future.

Sri Kuppusamy Iyengar, Assistant in Chemistry section. Whether the soil was analysed before and after the experiments.

The author replied that the soils before and after the experiment are being analysed and the analytical data is not yet ready.

Sri Kaliyappa, P. G. trainee. The cholam crop in the two rotations were at different seasons and the lower yield of the one may be due to seasonal changes or due to late sowing.

The yield of crops vary due to a number of factors. Early sowings are usually better. But it cannot be said that the season of sowing alone is responsible for the difference in yield. Other environmental factors may be also responsible.

Sri S. Lakshmanan, Assistant Lecturer in Agronomy. It has been found by experience by the ryots in Coimbatore district that a cotton or any other crop after ragi or cumbu is always good in yield. Hence it is suggested that along with green manure in a rotation a cumbu crop may be introduced so that the yield of the crop both after ragi, green manure and cumbu can be compared.

The author replied that this experiment has been designed for green manure and other crop like cumbu also may be tried if facilities are available in the future.

Sri M. V. Jayaraman. Ryots in Coimbatore are not using leguminous crop. They are applying no cart loads of silt and are growing Tobacco in the rotation after ragi.

The experiment is only to show how far by introducing a leguminous crop the monetary value is increased in the long run. Hence introducing another crop like tobacco or application of tank silt do not arise. Moreover Tobacco cannot be grown under all conditions of soil and water and tank silt also cannot be available in all places.

Sri Seshu Ayyar. The planning of the experiment should be better planned. In rotation 1. green manure without F.Y.M. and in rotation. 2. Green manure with 100 lb. P_2O_5 is applied. The errors are maximised.

These will be borne in mind and the plan rearranged in future.

Sri Varadarajan, Lecturer in Chemistry. The title of the experiments can be put in a more dramatic way putting importance on leguminous crops than on rotation crops.

Since the effects on the rotation of crops is being studied the title has been put up like this. Any way this will be borne in mind in future.

Sri G. V. Ramana, M.SC., student. In the experiment, cotton follows cholam and cotton follows ragi in another case. Since the effects will be different on both cases on cotton and comparison of the yield cannot show the correct picture.

Since effect of a legume is studied the other factors are not given any importance.

(ii) A PRELIMINARY STUDY ON SOME TREATMENTS OF BANANA SUCKERS PRIOR TO PLANTING

R. Bettai Gowder, C. M. Bhakthacathsalu, M. C. Appaiyan and S. Sambandamurthi—*Central Banana Research Station, Aduthurai, Tanjore district.*

Introduction.—The banana, a popular food-fruit of the millions in the tropics is one of the most important of fruits in India, occupying about 20 percent of the total area under fruits and especially in Madras, banana leads the rest of the fruits, in area covering about 79,000 acres. The plant is propagated vegetatively from its underground bulbous stem, botanically termed 'corm'. The corm has swollen buds in the axils of the scale leaves which are capable of giving rise to many daughter plants called 'suckers'. These suckers in course of time develop their own underground stems which are amenable for easy separation from the mother corm. Normally sword suckers are preferred for raising new banana groves due to their inherent vigour. In addition, there is in vogue the practice of administering certain treatments to banana suckers prior to planting, in order to bring about early fruiting and higher yield. The methods mainly recommended for adoption, are heading back or topping the pseudostem, drying or storing the suckers and smearing a thick suspension of cowdung in water over the corm. Naik (1949) refers to the varied practices of topping the suckers to three to four inches above the corm, storing for four to six days under shade and drying of suckers in the sun for a while after lifting, prior to setting out in the field. Jacob (1952) and Nayar (1954) also have reported the existence of such practices. Mudaliyar (1956) has stated that suckers of Nendran are wilted for a fortnight after smearing with ash and a thick coating of cowdung before planting. There is, however, no precise information or experimental evidence in support of the views expressed by the above workers. The purport of this investigation conducted at the Central Banana Research Station, Aduthurai, therefore, is to study empirically the effects of factors like lopping and drying of pseudostem and dipping or smearing thick cowdung solution over the corm, on the final performance and yield of the leading commercial banana variety Poovan.

Material and methods.—The trial was planned with the following treatment combinations designed on a randomised block lay-out with four replications.

(A) Sword suckers headed back to six inches from the corm.

(B) Sword suckers headed back to six inches from the corm and dried in the sun for 15 days.

(C) Sword suckers headed back to six inches from the corm, dried in the sun for 15 days and smeared with thick cowdung solution.

(D) Unlopped sword suckers dried in the sun for 15 days.

(E) Unlopped sword suckers dried in the sun for 15 days and smeared with thick cowdung solution.

(F) Unlopped sword suckers smeared with thick cowdung solution without any drying.

(G) Sword suckers headed back to six inches from the corm and smeared with thick cowdung solution without any drying.

(H) Sword suckers without any treatment-control.

In short, the planting material of sword suckers of uniform age of three months old Poovan banana variety was subjected to the following three main treatments or factors each at two levels.

The main treatments or factors are—

(i) cutting or heading back the pseudostem

(ii) drying in the sun, and

(iii) smearing a thick suspension of cowdung in water

Following the conventional adoption of notations, the above factors can be represented as C, D and S respectively, the second level of each factor being zero. The combinations therefore, to correspond to the treatment details set out above, are as follows :—

A.	C1	D0	S0
B.	C1	D1	S0
C.	C1	D1	S1
D.	C0	D1	S0
E.	C0	D1	S1
F.	C0	D0	S1
G.	C1	D0	S1
H.	C0	D0	S0

Hence the trial can be deemed a $2 \times 2 \times 2$ factorial experiment.

In the case of treatments B, C, D and E where drying for a fortnight was adopted as one of the treatments, the selection of plant material was so adjusted that the suckers selected for the purpose were three months old at the time of uprooting. To ensure uniformity in age, the suckers intended for other treatments were marked out a fortnight later so that they may also be of the same age (i.e., three months), while subsequently uprooting and planting in the field. The trial under wet land conditions was started during November, 1957 and completed in May, 1959. During its progress routine cultural and manurial practices were adopted as per schedule. The influence of the treatments was measured according to differentials in (1) time of flowering, and (2) weight of the bunch.

Results.—The yield data were statistically analysed and the results presented in Table 1 below indicate no significant difference in bunch weight among the various treatments adopted.

TABLE I.

Analysis of variance of the yield data (weight of bunch in lb.)

Source.	*d.f.*	*S.S.*	*Variance.*	*F.* 5 percent. 3·07
Blocks ..	3	22·96	8·99	1·54
Treatment ..	7	22·48	3·21	Not significant.
Error ..	21	122·02	5·81	..
Total ..	31	167·46	..	..

S. E. of treatment means : 1·204 lb., critical difference : 3·54 lb.

Treatments :	A	B	C	D	E	F	G	H
Mean bunch weight in lb.	24·08	24·20	24·82	23·20	24·08	25·82	24·08	26·05

It is evident from the above analysis that the application of the aforesaid treatments to Poovan suckers prior to planting, does not conduce for better yield.

Next, the data on pre-bunching period (number of days from planting to shooting of the inflorescence) were examined with a view to finding out the effect, if any, of the treatments in modifying the pre-bunching period of the variety Poovan under wet lands conditions at Aduthurai.

The results of the analysis are furnished in Tables II and III below :-

TABLE II.

Analysis of variance of the data on pre-bunching period in days.

(Randomised block in a 2^3 factorial set up.)

Source.	*D. F.*	*S. S.*	*Variance.*	*F.*	*F.* (from tables)
Block	3	816	272		
Treatments	7	5,862	837	3·93†	5 per cent : 2·19 1 per cent : 3·65
Between C	1	443	443		
Between S	1	536	536		
Between D	1	5	5		
Interaction CS	1	132	132		
Interaction CD	1	3,140	3,140	14·7†	5 per cent : 4·22 1 per cent : 8·02
Interaction SD	1	1,070	1,070	5·0*	
Interaction CSD	1	536	536		
Error	21	4,472	213		
Total ..	31	11,150			

† Highly significant.
* Significant.

General mean : 337·6 or 338 days.
S.E. of treatment means : 7·30 days.

There appears to be significant difference in the pre-bunching period of the crop, due to the application of treatments to suckers, prior to planting, even though no such effect was discernable among the main treatments of cutting, drying and smearing with cowdung solution. Two 2-factor interactions, CD and SD have come out significant and the particulars are furnished below :—

TABLE III.

Two way tables of mean duration of the pre-bunching age (in days):

a. *Interaction C×D:*

	D_1	D_0
C_1	331·8	350·8
C_0	344.1	323.5

b. *Interaction S×D:*

	S_1	S_0
D_1	339·6	336·3
D_0	327·3	347·0

C_1 : Cutting or heading back.
C_0 : No cutting.
D_1 : Drying.
D_0 : No drying.
S_1 : Smearing cow dung.
S_0 : No smearing.

S. E. of the difference between any two items in the body of the two way table : 5·16 days

Critical difference at 5 per cent level : 15 days

Critical difference at 1 per cent level : 21 days

The interaction C×D is highly significant and S×D is significant at 5 per cent level.

This indicates that there is highly significant differential response between lopped and unlopped suckers with reference to their being fresh or dried while planting, in modifying the pre-bunching period. Similar significant response is also observed between the suckers smeared and unsmeared with cowdung solution when used as fresh material and dried suckers for planting purposes.

Discussion.—Even though the varied practices of treating the suckers before planting failed to evoke any response in respect of increase in yield of the crop, the following inferences are inescapable :—

(1) The sword suckers can be planted as a whole or headed back to six inches from the corm without in any way affecting the ultimate crop yield. The suckers that are headed back have the added advantage of facilitating easy and economic transport to distant planting sites.

(2) The drying of suckers up to 15 days before planting, has in no way impaired the crop yield. This information is of value in long distant transport of suckers when certain amount of drying up can hardly be helped. Further it may aid in tiding over some unforeseen exigencies which delay planting due to labour difficulties, vagaries of weather and such other unfavourable circumstances.

(3) Smearing a thick solution of cowdung on the corm has not proved beneficial in bringing about enhanced crop yield.

As regards drying of suckers in the sun, Naik (1949) also has expressed doubt as to the benefits of such a system of curing but the same author has reported that growth in the plant from dried suckers was more robust than those of fresh suckers.

It may safely be assumed that such vigour in initial growth is likely to hasten flowering. In other words presumably the pre-bunching period is inversely proportional to the initial growth in vigour.

The analysis of the data on the pre-bunching period in the present study has thrown some light on this point (Table II).

The significant interaction between cutting and drying of suckers (CD) and drying and smearing thick cowdung solution (SD) as given in Table III bring out the following facts, with reference to the modification of the pre-bunching period.

Drying of banana suckers as a practice, prior to planting either lopped or unlopped has nothing much to commend itself in inducing earlier flowering. But the suckers that are to be transported elsewhere for planting may with advantage be cut for easy transport and in consequence if any drying up is unavoidable, it will only be more beneficial than harmful, in hastening the pre-bunching phase. In other words, the suckers that are lopped are perforce to be dried for better performance, in that they tend to flower earlier; whereas it is detrimental to allow the unlopped sword suckers to dry up since such a process is found to prolong the duration of flowering.

In places where the source of supply of planting material is closeby, it appears to be advisable to uproot healthy sword suckers of three months age without lopping or heading back and plant them afresh *in situ* preferably

after dipping in thick cowdung solution, to induce early flowering. When heading back and consequent drying is unavoidable in long distant transport of suckers, dipping in thick cowdung solution will be superfluous as a practice to hasten early growth and flowering.

Wright (1950) and Gregory (1952) have pointed out that in planting sword suckers, it used to be the common Jamaican practice to cut them back and plant on the slant but recent investigations have shown that this practice, so far from being good, may actually be harmful. They are now recommended to be planted erect and uncut.

The above discussion suggests tentatively that control of cropping in bananas in an achievable proposition depending of course on the efficacy of the treatments applied to the planting material. In this context it is worthwhile to remember that the climate is an important factor to be reckoned with, which is not of much relative importance in the tropics when compared to sub-tropical claims, where their modifying influence is the greatest on bananas

Control of cropping in bananas from the growers point of view is of vital importance and means to secure such a control through the pretreatment of planting material remains to be fully explored.

Summary and conclusions.—This study has revealed that though there is not to be gained by way of increased crop yield in banana variety Poovan by the application of certain treatments to suckers like heading back the pseudostem, drying and smearing with thick cowdung paste, prior to planting, there is a definite indication that such practices in certain combinations tend to reduce the pre-bunching age of the crop, which in itself is of potent significance from the growers' point of view for securing control of cropping in bananas and thereby ensuring good returns at the market. There is therefore, an imperative need for launching further trials on pre-treatment of banana suckers as a means to secure not only higher yields but also early cropping in important commercial varieties by the application of growth regulators. etc.

Acknowledgment.—This investigation forms part of the scheme of Banana Research underway at Aduthurai, which is financed jointly by the Indian Council of Agricultural Research and the Madras State Government to whom the authors are thankful for affording facilities for this study.

References.

(1) Gregory, E. J. (1952) Investigations. *Dep. Agric. Jamica Bull.* 49 (original not seen).

(2) Jacob, K. C. (1952) *Madras bananas—A Monograph* : pp. 137 Superintendent, Government Press, Madras.

(3) Mudaliyar, V. T. S. (1956) *Banana*, pp. 3, Amudha Nilayam Limited, Madras.

(4) Naik, K. C. (1949) *South Indian Fruits and their Culture*; pp. 259, P. Varadhachari and Co., Madras.

(5) Nayar, T. G. (1954) *Banana, Bull. Dep. Agric.* Mad as : pp. 3.

(6) Wright, J. (1950) Investigations. *Dep. Agric. Jamaica Bull* 45 (original not seen).

A PRELIMINARY STUDY ON SOME TREATMENTS OF BANANA SUCKERS PRIOR TO PLANTING.

By R. Bettai Gowder, C. M. Bhakthavathsalu, M.C. Appaiyan and S. Sambandamurthi.

Presented by: Sri V. N. Madhava Rao, *Reader in Horticulture.*

Sri V. N. Madhava Rao, Reader in Horticulture stated that in the introduction portion, the first six lines may be omitted and the paper may commence with the subject proper. He also added that the summary of the paper should give more idea of the treatments employed, results achieved and then the conclusions.

The author replied that the remarks are accepted. Since an abstract has been given in the beginning of the paper the last paragraph may be considered as conclusion only.

Sri K. R. Raman, Assistant Horticulturist (Vegetable Scheme) stated that there is a practice prevalent in Wynaad to trim the roots of the suckers after removal, smear them with wood ash and dry in the sun prior to planting. This is said to reduce the prebearing age. This may be included as one of the treatments for future study if possible.

The author replied that the suggestions were noted for guidance when such studies are undertaken in future.

Sri Sethumadhavan, Post-Graduates student wished to know whether any observation has been made on the effect of drying on the extent of suckering since it is reported that the extent of suckering is reduced by drying.

The author replied that this is a worthy suggestion and will be taken into account in future studies.

Sri Natarajan, stated that for local plantings, planting of sword suckers is recommended without lopping or drying. Since the experiment has shown definite advantage in lopping and drying before planting, he wished to know why such a practice cannot be recommended for local plantings also.

No specific advantage is noticed in lopping and drying before planting *in situ* locally, over the method of planting sword suckers without lopping or drying. When suckers are lopped they are perforce to be dried and hence it is not worth while recommending for local plantings but such a practice may be advantageous for transporting suckers for planting at distant sites.

(iii) HYBRID VIGOUR IN CASTOR (*RICINUS COMMUNIS LINN*).

S. G. Aiyadurai, K. Navakodi and P. Krishnaswamy,
Oil Seeds Section.

Introduction.—Increased production of castor which is gaining industrial importance can be achieved by bringing more area under cultivation, adopting improved agronomic methods and growing hybrid strains. The breeding and distribution of hybrid corn in the United States of America have revolutionised maize production. In Madras State, hybrid vigour has

been harnessed in *Bajra* and hybrid strains X1, X2 and X3 capable of giving 40 per cent increased yields over local varieties have been released for cultivation. Similarly an attempt was made to explore the possibility of exploiting hybrid vigour in castor which has a natural cross pollination of 14 per cent and this paper presents the result of investigations in this regard.

High yielding F1 hybrid seeds have been reported to be produced by crossing male-sterile plants of N. 145-4 with an inbred variety as pollinator. Hybrids out-yielded commercial varieties by 15 to 20 per cent. The hybrids produced by crossing N. 145-4 with numerous inbred types also gave higher yields than the parents. Results of work carried on the exploitation of hybrid vigour in castor in U.P. has been encouraging.

Material and method.—Normally the inflorescene in castor bean plant is monoecious, having pistilate flowers on the upper 30 to 50 per cent of the racemes and staminate flowers on the lower 50 to 70 per cent. There are a number of variations from the normal raceme. One such variation is the expression of interspersed pistillate and staminate flowers throughout the entire length of the raceme. Another variation expressed is the presence of only pistillate flowers along the entire length of the raceme. Strain TMV. 1. is a variety possessing high percentage of pistillate flowers in the inflorescence. There are more than 140 inbred types of castor maintained at the Agricultural Research Station, Tindivanam for nearly 15 years. Strain TMV. 1. as female parent and ten high yielding inbred types as pollen parents were employed. The technique of crossing involved was as follows :—TMV. 1. was sown 3 feet apart in alternate rows with ten inbred types. Inflorescence in selected plants in TMV. 1. line were bagged with close meshed cloth bags after the removal of the club-shaped staminate buds, Similarly inflorescences in the inbred lines were also bagged before opening of the flowers. Actual cross pollination was done between 3 and 4-30 p.m., when the anthesis and pollen production was at the maximum. Pollination was carried out daily till the stigma showed signs of drying and it took nearly 20 days to complete pollination of each inflorescence. Three individual crosses were made between TMV. 1. and each of the ten selected inbred types during 1955–56 and 1956–57 and the 30 hybrids were compared with TMV. 1. in compact family block trial during 1956–57 and 1957–58 rainfed seasons respectively. Though the trials failed during both the seasons due to seasonal failures, there was a general indication that the cross involving Russian inbred, R.C. 820 and Egyptian inbred, R.C. 840 gave increased yields of 16.0 and 9.1 percent over strain TMV. 1. In 1957–58, the same set of ten crosses were again effected and 30 hybrids from 10 families with three sibs in each family were compared with TMV. 1. in compact family block trial. The hybrid seeds left over after sowing compact family block trial were also pooled and tried in replicated row tests. The trial was repeated during 1959–60 rainfed season also. The plot size measured 18 feet × 3 feet or 1/806.7 acres (gross and net) and 45 feet x 3 feet or 1/322.7. acre (gross and net) in compact family block trial and replicated row tests respectively. The sowings were done in the first week of August in the first year of trial (1958–59) and in the second week of August in the second year of trial (1959–60).

Observations.—During the crop season, five plants were selected at random in each plot and the following measurements were recorded : (i) height of stem upto main spike, (ii) stem thickness in the region of the 7th node, (iii) length of the main spike, (iv) number of nodes upto the main spike, (v) the length of the male and female portions of the spike, (vi) total number

of capsules set in the main spike, (vii) total number of capsules produced in the secondary and tertiary spikes and (viii) total number of spikes produced per plant. Qualitative tests were also conducted on the produce obtained. The results of these tests are presented in Table I

It was observed during crop growth that the hybrids were vigorous and robust. This was clearly expressed in hybrids X 247, X 248 and X 244, i.e., in crosses involving Russian and Egyptian parents. The qualitative characters like height of stem upto main spike, stem thickness in the region of seventh node, length of main spike, length of the male and female portions of the spike, number of nodes upto main spike, total number of capsules set in the main spike and number of spikes produced per plant were intermediate between the parents, while branching number and order and total number of capsules produced in the secondary and tertiary spikes showed an increase over both the male and female parents. The hybrids commonly produced three terminal branches with third order, while the parents produced 2 to 3 terminal branches with second order. The hybrids except X 246, X 251 and X 252 on an average produced 33 capsules more than both the parents in the rest of seven hybrids. It is interesting to note that the production of capsules is more, i.e., 26 to 38 in crosses involving Egyptian and Russian parents. From the qualitative tests conducted there is no appreciable difference between the hybrids and the parents.

The yield data in respect of compact family block and replicated row tests are presented in Tables II to IV appended for the years 1958-59 and 1959-60. The yield differences due to the variants were significant for both the years for sib analysis and replicated row tests. The yield differences were significant for family analysis in one of the years, viz., during 1959-60. In the family analysis, the average of two years results indicate that eight out of ten hybrids have given increased yields ranging from 2.4 to 18.0 percent over TMV. 1, the high yielding female parent. Crosses X 248, X 247 and X 244 have registered 18.0, 16.1 and 15.5 percent increase respectively over strain TMV. 1. In the sib analysis also, 16 of the 21 sibs have given increased yields ranging from 4.0 to 34.3 percent over TMV. 1. Sibs X 251/3, X 248/1, X 247/3, X 250/1, X 244/2 and X 244/1 have recorded 34.3, 29.3, 29.3, 28.7, 26.6 and 22.0 per cent increase respectively over TMV. 1, the standard. In the replicated row tests also, all the hybrids except X 243 have given increased yields ranging from 2.1 to 34.2 percent over TMV. 1. The increased yield recorded by hybrids X 247, X 250, X 248 and X 244 over the standard are 34.2, 30.3, 27.2 and 13.6 respectively. It is gratifying to note that these four hybrids have given consistently higher yields over TMV. 1. both in compact family and replicated row trials.

Summary and conclusion.—To study the expression of heterosis in castor, ten crosses were effected between strain TMV. 1. with ten high yielding inbreds during 1955–56, 1956–57, 1957–58 and 1958–59 monsoon season. Three plants representing sibs were used as male parents in each of the ten crosses and all the 30 hybrids from ten families of crosses were compared with strain TMV. 1. in compact family block trials during 1956–57, 1957–58, 1958–59 and 1959-60 rainfed seasons. The average of two years results during 1958-59 and 1959–60 reveal that in the family analysis, all excepting the hybrids involving Kanpur and Rajampet have given increased yield ranging from 2.4 to 18.0 per cent over control. In the sib analysis, 16 out of 21 sibs registered increased yields ranging from 4.0 to 34.3 percent over strain TMV. 1. In replicated

row tests, 9 hybrids recorded increased yields ranging from 2.1 34.2 per cent over strain TMV. 1. It is interesting to note that the four hybrids, viz., X 247, X 248, X 244 and X 250 have consistently given higher yields than TMV. 1. in both compact family block and replicated row trials.

The results indicate the possibilities of utilising hybrid vigour in this crop for enhancing the yield. Systematic tests for selection of inbreds will have to be conducted to choose those with high combining ability and to keep them in a pure condition. The variability with regard to combining ability within the inbred lines themselves as expressed by the differences in the yield of the hybrids involving different sibs of the same male parent line suggests scope for further selection within them.

Reference—

(1) Anubavanarayanan, Production of hybrid castor in UP. Indian oil seeds J. 11 : 92.

(2) Hybrids boost castor bean yields, Plant Breeding Abstract 549 : 1954.

(3) Hybrids boost castor bean yields to be ready for growers. Plant Breeding Abstract 2341 : 1954.

Table I.

Quantitative.

(Average of 80 plants taken at random.)

Particulars.	*TMV.* 1.	*Hybrid, X.* 243.	*R.C.* 817.	*Hybrid, X.* 244.	*R.C.* 833.	*Hybrid, X.* 245,	*R.C.* 835.	*Hybrid, X.* 246.	*R.C.* 847.	*Hybrid, X.* 247.	*R.C.* 820.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1 Height upto main spike in cm.	106	89	82	106	110	104	81	100	89	107	125
2 Stem thickness in cm.	2·6	2·5	2·3	2·8	2	2·8	2·2	2·7	2·3	2·6	·2
3 Number of nodes upto main spike	17	16	13	17	19	16	15	17	15	17	23
4 Branching number and order	T2-I-II	T2-4 I-III	T2-3 I-II	T2-3 III	T2 I-II	T2-3 I-II	T2-3 II	T2-3 II-III	T3-4 II	T2-3 II-III	T2-3 I-II
5 Length of main spike	59	48	32	57	61	57	49	58	42	57	35
6 Female/male Regions in cm.	50/9	35/13	23/10	48/9	45/16	43/14	28/21	46/12	17/25	17/10	28/7
7 Number of spike produced per plant	4	5	8	5	7	5	9	5	8	5	4
8 Number of capsules produced in the main spike	94	59	16	79	41	86	29	84	25	86	18
9 Total number of capsules produced in secondary and tertiary spikes.	106	138	82	130	89	115	91	121	152	160	90
10 Total number of capsules produced per plant	200	197	98	209	130	201	120	205	177	246	108
11 Natural test weight of 1 M. M. of beans in grams	1,172	1,166	1,116	1,138	1,074	1,172	1,173	1,172	1,178	1,172	1,173
12 Number of beans per lb.	1,964	1,782	1,996	1,675	1,418	1,831	1,558	1,691	1,462	1,963	1,632

Particulars.	*X.* 248.	*R.C.* 825,	*X.* 249.	*R.C.* 826.	*X.* 250,	*R.C.* 840,	*X.* 251	*R.C.* 842,	*X.* 252,	*R C* 882,
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
1 Height upto main spike in cm.	98	102	90	65	92	72	92	176	94	74
2 Stem thickness in cm.	2·8	3	2·7	2·2	2·4	2·2	2·6	1·5	2·5	2·2
3 Number of nodes upto main spike	16	16	16	14	17	17	18	23	17	14
4 Branching number and order	T2-3 I-III	T2-3 II-III	T2-3 I-II	T2-3 II	T2-3 I-III	T2-3 II	T2-3 I-II	T2-3 I	T2-3 I-III	T2-3 II-III
5 Length of main spike	56	49	55	44	54	45	57	49	55	50
6 Female/male Regions in cm.	43/14	24/25	44/11	26/18	42/12	24/21	44/13	47/2	45/10	40/10
7 Number of spike produced per plant	5	8	5	9	5	8	4	4	5	9
8 Number of capsules produced in the main spike	79	23	74	23	75	27	74	150	79	41
9 Total number of capsules produced in secondary and tertiary spikes.	132	116	138	104	143	141	129	180	108	124
10 Total number of capsules produced per plant	211	139	212	127	218	168	203	330	187	165
11 Natural test weight of 1 M.M. of beans in grams	1,131	1,104	1,157	1,151	1,160	1,141	1,141	1,104	1,160	1,126
12 Number of beans per lb.	1,535	1,171	1,761	1,345	1,611	1,515	1,342	1,231	1,733	1,593

TABLE II.

Yield data—Family Analysis.

Cross number.	*Female Parent.*	*Male parent.*
(1)	(2)	(3)
X·243	TMV. 1	R.C.817—Koilpatti
X·244	,,	R.C.833—Egypt 4.
X·245	,,	R.C.835—Kanpur.
X·246	,,	R.C.847—Vinukonda.
X·247	,,	R.C.820—Russian 13.
X·248	,,	R.C.825—Russian 22.
X·249	,,	R.C.826—Russian 22.
X·250	,,	R.C.840—Egypt 2.
X·251	,,	R.C.842—Cuddapah.
X·252	,,	R.C.882—Rajempet small.

Parents and Hybrids.	1959–60.		1958–59.		*Average of two years.*	
	Acre yield in lb.	*Percentage on control.*	*Acre yield in lb.*	*Percentage on control.*	*Acre yield in lb.*	*Percentage on control.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
TMV.1	1228	100·0	509	100·0	869	100·0
X.243	1353	110·4	640	126·7	997	114·8
X.244	1553	126·5	452	88·8	1003	115·5
X.245	1234	100·5	497	97·7	866	99·7
X.246	1337	108·9	442	86·7	890	102·4
X.247	1603	130·5	415	81·3	1009	116·1
X.248	1461	119·0	591	116·1	1025	118·0
X.249	1346	109·6	451	88·6	899	103·5
X.250	1346	109·6	507	99·6	957	110·1
X.251	1373	111·8	579	113·8	976	112·3
X.252	1282	102·0	442	86·8	847	97·5
Standard error ..	79·7	6·5	66·5	13·0		
Critical difference ..	230·3	19·0				
Whether significant or not	P=0·05	Yes.	No.			

Conclusion: 1959–60

1

from ×·248 ×·247, ×·244, ×·248, ×·251, ×·243, ×·249, ×·250, ×·246, ×.252, ×·246 TMV

TABLE III.

Yield data—Sib Analysis.

Parents and Hybrids.	1959–60. Acre yield in lb.	1959–60. Percentage on control.	1958–59. Acre yield in lb.	1958–59. Percentage on control.	Average of two years. Acre yield in lb.	Average of two years. Percentage on control.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 TMV. 1	1,227	100·0	509	100·0	868	100·0
2 X. 243/1*	1,402	114·2	576	113·2	989	114·0
3 X. 243/2	1,368	111·4	722	141·9	1,045	120·4
4 X. 243/3	1,297	105·2	622	108·0	960	110·6
5 X. 244/1	1,526	124·4	592	102·8	1,059	122·0
6 X. 244/2	1,821	148·8	374	64·9	1,098	126·6
7 X. 244/3	1,316	107·3	391	66·3	854	98·4
8 X. 245/1	1,261	102·8	409	80·4	835	96·2
9 X. 245/2	1,211	98·7	592	116·3	902	104·0
10 X. 245/3	1,228	101·6	489	96·1	859	99·0
11 X 246/1	1,245	101·5				
12 X. 246/2	1,314	107·1				
13 X. 246/3	1,450	118·1				
14 X. 247/1	1,503	122·5	363	71·3	933	107·5
15 X 247/2	1,424	116·1	518	101·7	971	111·9
16 X 247/3	1,878	153·0	365	71·7	1,122	129·3
17 X. 248/1	1,412	115·1	832	163·5	1,122	129·3
18 X. 248/2	1,348	109·8	569	111·8	959	110·5
19 X. 248/3	1,625	132·4	372	73·1	999	115·1
20 X. 249/1	1,376	112·1				
21 X. 249/2	1,458	118·9				
22 X. 249/3	1,206	98·3				
23 X. 250/1	1,659	135·2	576	113·2	1,118	128·7
24 X. 250/2	934	76·1	482	94·7	708	81·6
25 X. 250/3	1,447	118·0	462	90·7	955	110·0
26 X. 251/1	1,214	99·0	381	74·9	798	91·4
27 X. 251/2	1,245	101·5	686	134·8	966	111·3
28 X. 251/3	1,661	135·4	669	131·4	1,165	134·3
29 X. 252/1	1,363	110·9				
30 X. 252/2	1,357	107·4				
31 X. 252/3	1,247	101·6				
Whether significant or not	Yes.	P=0·05	Yes.			
Standard error	133·2	10·9	64·5	12·6		
Critical differences ..	369·3	30·1	178·8	35·1		

* As in family analysis.

Conclusion 1959–60.

16, 6, 24, 23, 19, 5, 14, 21, 13, 25, 15, 17, 2, 20, 3, 18, 30, 7, 12, 4, 8, 31, 10, 11, 27, 29,

1, 26, 9, 22, 28,

1958–59.

17, 3, 27, 28, 9, 23, 2, 18, 4, 5, 15, TMV 1, 10, 24, 25, 8, 26, 19, 16, 14, 7, 6.

TABLE IV.

Yield data—Replicated row tests.

(1)	1959–60. Acre yield in lb (2)	1959–60. Percentage on control (3)	1958–59. Acre yield in lb. (4)	1958–59. Percentage on control. (5)	Average of two years. Acre yield in lb. (6)	Average of two years. Percentage on control. (7)
1. TMV. 1	878	100·0	586	100·0	732	100.0
2. X. 243*	945	107·6	324	55·3	635	86·8
3. X. 244	1017	115·8	648	110·6	833	113·8
4. X. 245	966	110·0	790	134·8	878	119·9
5. X. 246	1030	117 3	464	79·2	747	102·1
6. X. 247	1370	156·1	594	101·4	982	134·2
7. X. 248	1174	133·8	688	117 4	931	127·2
8. X. 249	972	110·9	532	90 8	752	102·8
9. X. 250	1090	124·2	817	139·4	954	130·3
10. X. 251	954	108·6	626	106·9	790	107·9
11. X. 252	1244	141·7	314	53·6	779	106·4
Whether significant or not P = 0·05	yes.		yes.			
Standard error	68·8	7·8	47·1	8·1		
Critical difference	198·7	22·6	135·8	23·2		

* As in Family analysis.

Conclusions: 1959—60.

× 249, × 252, × 248, × 250, × 246, × 244, × 249, × 245, × 251, × 243, TMV. 1

1958–59.

× 250, × 245, × 248, × 244, × 251, × 247, TMV. I, × 249, × 246, × 223, × 232.

HYBRID VIGOUR IN CASTOR–*Ricinus communis* Linn.

By S. G. AIYADURAI, K. NAVAKODI AND P. KRISHNASWAMY.

Presented by: SRI M. STEPHEN DORAIRAJ, *Assistant in Oilseeds.*

No discussion.

(iv) AFFINITY BETWEEN GRAIN AND LEAF CHARACTERS IN *ELEUSINE* SPS.

By K. DIVAKARAN.

Globular or round grain shape was considered as the only type of Ragi grain till 1952 when the occurence reniform (i.e.) kidney shaped grain shape was reported (5). This type has since been designated the *Eleusine reniformis* Divak (4). Wide leaf with predominance of bent lamina, toppling and horizontal coleoptile are some of the other characters associated with reniform Ragi. The inheritance of toppling has recently been recorded (3) and in this article the genetics of the leaf and grain character is reported. As *E. coracana* has narrow leaf and globular grains and *E. reniformis* has wide leaf and reniform grains the inheritance of the characters could be simultaneously pursued.

Materials and method:—E.C. 593 a pure line selection of *E. coracana* and E.C. 4608 a pure line selection of *E. reniformis* were the types used for the study. *E. coracana* was the female parent. The expression of the characters in F1 and segregation in F2 studied. The F1 was back crossed to the double

recessive parent viz. *E. coracana* and segregation in back cross F2 studied to confirm the linkage observed between leaf and grain characters. Visual observation was found to be sufficient to separate the narrow leaf from the wide leaf and globular grain from the kidney shaped grain. The association of bent lamina with the wide leaf also served as a guidance in taking the observation.

The studies which spread over six years were initiated at Millets Breeding Station, Coimbatore in the year 1953. In 1955 the venue of work was shifted to the Agricultural Research Station, Kovilpatti where the investigations were completed in 1959.

Observations.—The important characters of the parents and F1 are as follows.—

TABLE I—*Characters of parents and* F1.

Selection No. and species.	*Characters.*		*Pigment.*
	Grain.	*Leaf.*	
(1)	(2)	(3)	(4)
1. E.C. 593 *E. coracana.*	Globular.	Lamina, narrow, straight.	Green.
2. E.C. 4608 *E. reniformis.*	Reniform.	Lamina, wide bent.	Purple.
3. F1 of E. coracana X reniformis.	Reniform.	Lamina, wide, bent.	Purple.

The F1 as may be seen resembled the reniform type.

The segregation for leaf and grain characters in F2 of *E. coracana* X *E. reniformis* are presented in the following table :—

TABLE II—*F2 Segregation in E coracona XE. reniforms and linkage value between leaf and grain characters.*

TABLE.

Selection number.	*Total.*	*Frequency.*	*Wide reni-form.*	*Wide glo-bular.*	*Nar-row reni-form.*	*Nar-row globu-lar.*	*Linka-ge value.*	*Proba-bility.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
E. C. 4831	445	Observed	275	40	47	83	20·7	0·015
		Expected	249	83	83	26		
E. C. 4832	342	Observed	219	30	39	54	21·9	0·016
		Expected	189	63	63	21		
E. C. 4838	346	Observed	221	31	38	56	21·7	0·016
		Expected	196	63	65	22		
E. C. 4840	564	Observed	358	50	62	94	20·7	0·013
		Expected	317	106	106	35		

The above table shows that wide leaf and reniform grain shaps were simple monogenic dominants over narrow leaf and globular grain. But independent assortment for the two factors were not observed. The leaf and grain character showed a linkage value of 21.2 at 0.15 probability level.

Another observation though not of importance to the subject under study was also recorded. The F1 was normal and fully fertile. In F2 occasional sterility was apparent whilst in the F3 it ranged between 30 to 35 percent. This aspect needs to be tackled separately.

Summary and conclusion.—The inheritance and interaction of the characters of grain shape and leaf width are reported. It was observed that the characters are linked with a linkage value of 20 to 22 percent.

Acknowledgment.—The valuable help and guidance rendered by Sri A. K. Nagaratnam, Superintendent, Agricultural Research Station, Kovilpatti and Sri S. G. Ayyadurai, Millets and Pulses Specialists, Coimbatore in presenting the work are greatfully acknowledged.

References.—

1 Ayyangar G. N. (1934) .. .. .. Anthesis and Pollination in Ragi, Indian Journal of Agricultural Science 2 ; 386-393.

2 Babcock E.B. and Clausen R. E. (1927). Genetics in relation to Agriculture, Megraw Hill Book Company Inc. New York.

3 Divakaran, K. (1960) .. .. .. Inheritance of toppling in *E. coracana* Madras Agricultural Journal 47 : 74-75.

4 Divakaran K. (1959) .. .. .. A new species of *Eleusine*, Madras Agricultural Journal 46 : 485-486.

5 Divakaran, K. and Krishna Rao P. (1952) Reniform grain shape in *E. coracana* Madras Agricultural Journal 39 : 523-24.

6 Immer, F. R. (1930) .. .. .. Formula and table for calculating linkage intensities Genetics 15.

AFFINITY BETWEEN GRAIN AND LEAF CHARACTER IN *ELEUSINE* SPS.

By K. Divakaran.

Presented by : Srimathi K. Samathuvam.

No remarks.

(v) EVALUATION OF SORGHUM TYPES FOR ECONOMIC UTILITY.

By Messrs. A. Subramaniam, K. Meenakshi, K. Venkataraman and L. Sivagnanam, Millets Breeding Station, Coimbatore.

Introduction.—Classification and standardisation are the pre-requisities for the evaluation of utility. At the present time, when there is a vast flew of liaison between scientists of different countries, standardised expression of values mutually and commonly dealt with, is of immense help in the correct appraisal of the utility of results. Exchange of plant material between breeders of the world has now become a regular feature and consequentialy it has also become increasingly necessary to have a standardised schedule of breeding values to evaluate the merits of new types frequently received from several sources. Breeding of plants being directed more towards the economic improvement of crops, the exact utility of any introuced type needs be assessed at the first instance. A detailed study would of course, bring out ultimate potentialities. But when handling hundreds of types under pressure of time, it hardly becomes possible to make a detailed study of all the types handled. At the Millet Breeding Station, Coimbatore, where several hundreds of sorghum types are maintained, not to speak of the stores of fresh ones being periodically received, the difficulty of picking out types with the desired combination of economic characters, particularly at short notice, was keenly felt. By way of getting over this difficulty, a new method of evaluating and indexing the economic attributes with reference to Sorghum types was formulated, the details of which are embodied in this paper.

Materials and Methods.—In summer 1960, over six hundred types, most of which had recently been received from the United States, were raised at the Millet Breeding Station, Coimbatore. This crop provided the material for the present study. A schedule of characters of economic value expected in a Sorghum crop was drawn up and an ideal combination of such characters was bestowed a maximum of 100 marks. The total numerical value was split up among individual characters and further among the degrees of expression of such characters as shown below :—

TABLE I.

Item number economic quality. (1)	*Degree of expression.* (2)	*Individual marks.* (3)	*Total marks.* (4)
I. General acceptance	..	10	10
II. Grain yield	.. 2000 lb. & over per acre.	30	30
	1500–2000	20–30	
	1000–1500	10–20	
	500–1000	5–10	
	Less than 500	0	
III. Straw yield	.. Height over 8 feet.	10	10
	6–8 feet.	8	
	4–6 ,,	6	
	2–4 ,,	4	
	Less than 2 feet.	0	
IV. Duration of Maturity (Seed to seed) ..	.. 80 days and less 10	10	10
	85 ,, 8		
	90 ,, 7		
	95 ,, 6		
	100 ,, 5		
	105 ,, 4		
	110 ,, 3		
	115 ,, 2		
	120 ,, 4		
V. Quality of grain	.. Acceptable colour—pearly, bold round, free from blotches or tannin, good starchy taste.	15	15
VI. Quality of straw	.. Sweet, juicy, reddish purple sheath, leafy.	10	10
VII. Special attributes	.. Drought resistance, striga resistance, pest resistance, disease resistance, non-lodging, tillering and any other specially noticeable character.	10	10
VIII. Over all value	.. Economic 5 Academic 3 Mere maintenance 2	5	5
	Total ..	100	

It may be seen from table I that the attributes of grain and straw gain a maximum of 65 out of 100 by themselves, since they are the most economic factors in sorghum breeding. The marks under the head " general acceptance " were awarded on the basis of ocular appeal and the first impression that the types gives even on a casual inspection. This was provided because, the tempo of spread of improved strains largely depends on the farmers '

first reaction to an economic type, based on the general appearance it presents on the field. Since the quantity and quality of grain and the duration of maturity are also included in the evaluation, it would be obvious that the economic assessment can be conducted only at the stage of maturity. The estimation of grain yield was by eye judgment only, taking an average earhead in the population as a leading clue. In the last item 'overall value', an economic type was bestowed an additional five marks while any type which, showed an interesting qualitative character like purple midrib, yellow endosperm, etc., was awarded three marks. Types which were of neither economic nor acedemic interest were given two marks only.

The several hundred types evaluated as detailed above, consisted of both foreign and indigenous types, belonging to different sub-species of the genus sorghum. Improved strains of known economic value were also raised besides the types to serve as comparision and these were also evaluated without bias, strictly conforming to the schedule of assessment.

Results.—As it would be too cumbersome to present the tabulation of individual scores given to over six hundred types, figures for the types grown in one representative block alone are furnished (in Table II) by way of illustrating the evaluations made.

TABLE II.

Serial number and types.	*Evaluation heads and scores in each.*								*Total.*
	I	II	III	IV	V.	VI	VII	VIII	
1. N. K. 300	5	20	6	8	5	6	2	5	57
2. Texas 610	3	17	4	8	4	6	2	5	49
3. Sarsiya, Bihar	4	8	8	8	10	7	2	3	50
4 N. 4	7	10	9	4	8	8	3	4	53
5. R. S. 301	3	9	6	7	5	7	2	2	41
6. N. K. 140	2	9	5	10	6	7	2	2	43
7. Atlas U. S. A.	5	8	6	7	10	8	2	2	48
8. M. 35-1	7	9	8	5	12	8	2	2	53
9. M. 47-3	7	11	8	4	14	8	2	3	57
10. G. 1	7	7	8	3	10	5	2	4	46
11 Honey U.S.A.	2	6	5	4	4	9	2	3	35
12. K. 3	8	8	10	3	10	5	2	4	50
13. N. J. 53	7	12	7	6	10	8	2	4	56
14. G. 2	7	10	7	6	10	8	2	4	54
15. E. J. 4. R	6	5	7	6	12	8	2	2	48
16. D. 340	7	15	7	7	12	8	2	5	63
17. N. 1.6	6	6	8	5	10	8	2	4	49
18. P. J. 3-R	5	10	8	4	12	8	2	4	53
19. N. 5	6	8	10	5	10	8	2	4	53
20 Texas black Kafir ..	7	12	6	7	8	7	2	3	52
21. N. 3	6	6	8	5	10	8	2	4	49
22. Co. 18.	8	18	7	6	10	9	3	5	66

Discussion.—It may be seen from the data presented that strain Co. 18 scores the maximum number of marks among the types, which is only in fitness of things, since the strain is by far the best evolved at the Millet Breeding Station, Coimbatore. However, what is equally interesting is the fact that certain other types also have scored good marks, very nearly approaching the standard in aggregate. For example, types N. K. 300, M. 47-3, N.J. 53 and D. 340 have scored within ten marks of the aggregate of the standard strain. These selections automatically standard for further direct consideration in regular yield trials for such economic characters as they possess.

In actual practise, the time taken to evaluate a single type on the field, according to the schedule presented in this paper is about a couple of minutes only and can indeed be done more quickly with experience. The only speculative item in the evaluation is the grain yield, which however can easily be judged by any experienced sorghum breeder in mental comparison with standard strains of known yielding capacity. This method of evaluation has proved to be fairly efficacious, as can be seen from Table III, where the marks awarded on the field by eye judgment are compared with the marks due on the basis of actual recorded yield. The closeness between the two valuation is too apparent to be stressed, and since the grain yield is the most important and the only aspect in the schedule that carries the maximum number of marks, a reasonably correct estimation of that aspect enhances the reliability of the evaluation.

TABLE III.

Type. (1)	*Actual yield of grain in lb. per acre by threshing.* (2)	*Marks to be awarded by schedule.* (3)	*Marks actually awarded by eye adjustment on the field.* (4)
N. K. 300	2178	30	26
Texas 610	1743	24	26
Sariaya Bihar	726	7	8
N. 4	1016	10	11
R. S. 301	871	9	9
N. K. 140	1307	16	15
Atlas	871	9	10
M. 35-1	871	9	9
M. 47-3	1162	14	10
G. 1	871	9	10
Honey	291	3	5
K. 3	871	9	8
N. J. 53	1016	10	10
G. 2	1016	10	9
E. J. 4-R	291	9	5
D. 340	1597	22	20
N. 1-6	581	6	8
P.J. 3-R	436	4	5
N. 5	726	7	9
Texas Black Kafir	1,307	16	14
N. 3	436	4	7
Co. 18	1743	24	25

The main utility of this new method of evaluation of sorghum types, is the rapidity with which a large number of types can be systematically screened for further economic work. It is not designed so much to eliminate any of the conventional routine steps in advancing a promising type, as to provide a better and precise foundation at the initial appraisal of the type. It is also by no means contended that the schedule given would suit the sorghum crop grown in different seasons and countries. Since the desired economic characters and their degree of expression vary between different locations and seasons, the schedule has to be duly modified for adoption elsewhere or in other seasons. For example, in the schedule presented in this paper, an increasing score has been provided for increase in plant height, since the outturn of plant matter (fodder) is of paramount importance to our country. In an American sorghum, the same factor would be a disadvantage since taller types would create problems in combine harvesting. Furthermore, sorghum fodder is not as much valuable in the United States as it is in this country. Hence the

schedule may need to be modified for United States, providing greater marks for shortness of height and longer peduncle since both factors would be assets for mechanical harvesting. Similarly the schedule (which as given in this paper is suited only for summer crop) would need modifications under the heads of grain yield, straw yield and duration of maturity if it is to be used for the monsoon season crop, since the average values for a monsoon season (long duration) crop largely differ from those for the summer crop.

The schedule can be applied with best results in the crop raised at the proper season and in fields of at least average fertility. In such cases, even in the absence of a standard strain for comparison, any type that scores not less than 60 marks in aggregate can automatically be isolated, as promising. If the crop had been raised out of season or in a field of poor fertility, a correct reading of the values cannot be obtained without a standard strain of known economic worth also being included in the crop. In these circumstances, however poor may be the crop, the individual component types would be sharing the same agronomic conditions and hence the scores between the standard and the types would become comparable however low they may be. Such types as showing proximity in aggregate scores with the standard can even then be picked out for regular trials under better agronomic conditions.

As it has already been pointed out, every important sorghum growing territory in the world can have a rated schedule for economic crop characters, similar to the one presented in this paper, with due modifications. In exchange of seed materials between these territories, if a score card is provided along with each sample, it will succinctly convey a fund of information, which sometimes may take long to gather otherwise. For example, a score card of 8–20–7–6–10–9–3–5 accompanying an Indian sorghum sample, would convey that it is a robustly growing economic type, high yielder in the range of 2,000 lb. per acre, about six feet in height, taking 95 days for maturity, with grain and straw of good quality and also possessing some special attribute. In every breeding station such score cards can be maintained for every type and would be highly useful in effecting rapid selection for specific purposes like complying with an indent embodying stipulated requirements. For example, if a fodder programme in sorghum is to be instituted and suitable material is to be selected from the germ plasm bank, a perusal of the compilation of score cards, particularly with reference to items 3 and 6 (fodder attributes) would easily show out those types that may be harnessed for the programme. It may thus be seen that the schedule of evaluation is in effect and function, not only a rapid screening medium but also a ready reference and index where hundreds of types are handled for study. Considering the practical utility of this schedule to the sorghum breeder, as experienced at the Millet Breeding Station, Coimbatore, it may perhaps be mentioned that similar schedules, if formulated in respect of other suitable economic crops, may also come in handy.

Summary.—A highly utilitarian schedule of evaluation of economic characters in sorghum has been formulated and discussed. With slight modifications, it can be used to assess the economic worth of sorghum types grown in any part of the world. It is particularly useful in making a preliminary and rapid screening when a large number of types is to be handed.

Acknowledgment.—The authors are grateful to Sri S. G. Aiyadurai, Millets and Pulses Specialist, for his guidance and encouragement in getting up this article.

(V) EVALUATION OF SORGHUM TYPES FOR ECONOMIC UTILITY.

By

A. SUBRAMANIAM, K. MEENAKSHI, K. VENKATARAMAN AND L. SIVAGNANAM.

Presented by SRI L. SIVAGNANAM.

In the discussion that followed Sri Subramaniam, Assistant in Chemistry, wanted to know whether chemical analysis of straw was done; and the Professor of Plant Breeding and Genetics said that marks were allotted for the sugar content of straw.

Sri Seshu Ayyar, Statistical Assistant, stressed on the importance of fitting a multiple regression equation in regard to phenotypic values of characters and a discriminant function in regard to the genotypic values of the characters. The Professor said that in future work these points will be borne in mind.

Sri T. Nataraj, Agronomist and Asst. Professor of Agronomy said that personal factor plays in such evaluation work. He also talked of his experience in trying to evaluate butter.

Sri V. Gobinathan, P. G. Student wanted the individual effects to be worked out for which the Professor said that the same will be borne in mind in future studies.

Sri Narayanan Nayar, Cotton Technologist said that there are more efficient and latest methods have been formulated to assess the worth of the types correctly and quickly.

To a query by Dr. K. Ramakrishnan, Professor of Mycology that all this is a complicated procedure for the man in the field, Sri Seshu Ayyar replied that the mathematical part is attended to by the Statistician and the breeder is given a simple formula which he uses instead of the arbitrary system of weighing now being resorted to.

(VI) THE EVALUATION OF CROP PLANTS FOR SOIL MOISTURE STRESS WITH PARTICULAR REFERENCE TO RICE CROP.

K. RAJAGOPALAN, A. SHANMUGASUNDARAM AND A. ABDUL SAMAD, AGRICULTURAL RESEARCH INSTITUTE, COIMBATORE.

Introduction.—Soil drought, heat and cold are major environmental factors that adversely affect crop production and resistance to these factors are important objectives in the breeding of many field crops. As far as the arid regions of the tropical countries are concerned soil drought is more important and the present discussion will be confined to this aspect in field crops with particular reference to rice.

In Madras State, the rainfed crop of rice extending to about four lakhs of acres has to withstand moisture stress at one stage or other of the crop growth. This crop after seeding in July-August remains dry for a period of about two months till the fields receive irrigation water. Apart from this, the crop is likely to be susceptible to moisture stress at more vulnerable stages like ear formation. Hence breeding of rice varieties that will withstand moisture stress in the early stage as well as late stages of crop growth is important for this State. With this objective a project with partial financial assistance of the Indian Council of Agricultural Research was commenced in 1955 with Coimbatore and Tirurkuppam as the two centres of research.

Review of literature.—Ashton (1948) has adequately reviewed the work on the breeding of crops for drought resistance and the various techniques adopted in evaluating for drought resistance. These investigations relate to the direct method of testing in the field or by pot experiments and drought chambers since, for breeding purposes, many of the morphological and physiological factors have been found an uncertain index.

Studies on varietal resistance to drought and hybridization between varieties and species have been reported in wheat, oats and barley from the U.S.A. and U.S.S.R. The F1 hybrids between *Triticum* and *Agropyron* called *Agrotricums* which resembled *Agropyron* showed resistance to drought and were found to suspend growth at the time of moisture stress but new tillers were formed when the moisture status was restored. Backcrossing the F1 to wheat yielded promising resistant types. Inheritance of heat tolerance was found to be intermediate or partially dominant in the F1 of crosses between corn inbred lines and in barley more resistant forms were obtained by crossing parents showing complementary drought resistance as regards stage of growth. In rice, comparison of height of plants under upland and lowland conditions was considered an indication of varietal drought resistance. Certain types of wild rice, *Oryza sativa* var. *spontanea* was found to thrive well in rice fields in years of drought than in normal years.

Physiological characters such as water requirements, transpiration rates, bound water content, osmotic pressure in germinating seed and cell sap and viscosity have been studied intensively. Osmotic pressure of germinating seed has been found to be a valuable basis for selection in breeding work. Thimann (1954) found D-mannitol a suitable chemical in studies to limit water uptake in plants without affecting their metabolic action. The chemical composition of plants gets materially modified by internal water deficit and high level of nitrogen metabolism was observed in plants grown with deficient soil moisture (Kramer, 1949). Black (1957) has also pointed out that the nitrate content of plants is high under conditions of drought. The balance of enzyme activity under wilting conditions and viscosity were also found associated to drought resistance which could be used as a means of varietal estimate. Levitt (1956) has discussed the various physiological and biochemical characters that are associated with hardiness of crops.

In a study with two corn varieties, that differed in their reaction to drought for certain physiological attributes the following results were obtained (Rajagopalan, 1961.) The percentage germination and survival of corn varieties in D-mannitol solution of 13 atmospheres of osmotic pressure during a period of seven days test was found to be a suitable index in distinguishing the drought resistant type from the susceptible ones. Growth rates of plants at 15 percent, 20 percent and 25 percent moisture levels for a period of 10 weeks indicated that the resistant variety had superior emergence and quick rate of growth up to four weeks in 15 percent and 20 percent moisture levels. The resistant variety showed less of leaf water content, more of dry matter and less of water requirement. There was a gradual increase in soluable protein nitrogen in the shoot as the moisture stress increased and the resistant variety showed increased values.

Materials and Methods.—Breeding for drought resistance in rice in Madras was started in 1947-48 with a programme of hybridization between wild rice, *O. Sativa* var. *spontanea*, which readily intercross with cultivated

rices and high yielding rice strains. Eleven progenies of cross between *O. sativa and O. perennis* isolated by Srinivasan *et al* (1941) were also included in the study. Later, hybrids among rainfed and semi-dry rice varieties TKM. 2, BAM. 3 and MTU. 4 and between rainfed variety and wild *spontanea* were also effected with the object of isolating resistant types with desirable grain quality. In one cross combination Karsnodar, a Russian drought resistant variety formed one of the parents.

Hence a wide range of material was on hand for screening at the commencement of the scheme for evolution of drought resistant strains of paddy, during 1955-56. The programme under the project consisted of testing these progenies for their reaction to drought in fields under rainfed as well as restricted irrigations and isolation of superior selections. Collection of rainfed and semi-dry rices, testing for drought resistance and exploitation of the promising ones by breeding superior varieties formed another item of work. As an adjunct to the breeding programme, investigations on size and frequency of stomata and root development in resistant and susceptible varieties under field condition were also undertaken.

The material was evaluated for drought resistance by ordinary field testing. The crop was subjected to moisture stress by controlled irrigation except at critical stages such as ear formation and grain setting. Selection of superior types was done based on grain yields under moisture stress. Various attributes like tillers, height, ear length, number of grains and chaff and weight of 1,000 grains were also taken into consideration for screening purposes. Testing of the material under wet condition was done to fix types that perform well under both upland and lowland conditions. Root development was studied by growing plants in earthen rings buried in field and examining the plants for tops and root growth at flowering.

Results and Discussion.—A total collection of 294 varieties grown under upland conditions in the State has been made and studied. Of these the most promising ones are Pisini (TKM. 1), Sembalai (TKM. 2) and Vadansamba (ADT. 22) of the north-eastern districts and Kuruvakalayan (ASD. 4), Urundaikar, Ariyan and Chitraikar of the southern districts. TKM. 1 stands foremost in resistance to drought and it showed remarkable resistance to *Helminthosporium* disease which occurred regularly under droughty condition. Quick germination and early start, restricted growth under moisture stress are important features in the growth phase of the resistant strains. The resistant types are coarse grained, possess dark red rice and their glumes develop into brown colouration on ripening.

Twenty-five promising types were tested for their adaptability and yield under upland and lowland conditions for three seasons ending with 1959-60. The results of 13 varieties flowering in 120 days (Table 1) showed that ASD. 4 was superior, both under dry and wet conditions while variety MTU. 18 was high yielding under upland condition only. In another yield trial with 12 varieties flowering within 130 days, variety TKM. 1 was outstanding under dry condition followed by Aruniothi and Patrainisini. Both these varieties resemble the reputed drought resistant strain TKM. 1. Aruniothi, TKM. 1 and ADT. 22 are the promising ones under wet condition.

Hybrid progenies from 11 sets of crosses between cultivated and wild rices have been screened for their resistance and yields. The resistant progenies exhibited quick emergence and steady growth under moisture stress and quick growth under favourable conditions. The hybrids tested for yield showed

positive correlation between F-3 and F-4 yields (Rajagopalan, 1957). Hybrids involving *O. sativa* and *O. perennis* (GEB. 24 X T. 260) were outstanding while hybrids between *O. Sativa* and *O. Spontanea* gave varying performance Early maturing hybrids namely, Co. 13 X T. 129 and Co. 13 X T. 469 gave encouraging results. This has indicated that all *spontanea* forms do not reach similarly towards drought showing thereby that a thorough testing of the *spontanea* parents, both in the field and laboratory conditions would be necessary before resorting to hybridization. Hybrids among rainfed and semidry rices namely TKM. 2, BAM. 3 and MTU. 4 effected with the object of obtaining progenies showing complementary resistance were promising to the extent of combining the good rice quality of BAM. 3 parent.

Results of studies with 11 progenies of cross GEB. 24 X T. 260 along with TKM. 1, TKM. 2 and BAM. 3 under dry and wet conditions at the two centres, Coimbatore and Tirukuppam during 1956-57 to 1959-60 are presented in table 3. A comparison of the yields under lowland and upland conditions shows that cultures 8405, 8409, 8417 and 9754 have high yield potential under the two environments. Hence it is significant that certain hybrids yield well both under upland and lowland conditions. These outstanding hybrids have been sent for testing in different locations in the districts.

The results of root studies showed that the rainfed variety TKM. 1, wild species *O. latifolia* and *O. minuta* and hybrids 8405 and 9754 have greater depth of penetration and length of root system than the wet rice GEB. 24 and *O. sativa* var. *spontanea* (T. 1702). More tillers survived due to the efficient conducting system in the resistant types and these showed greater root to shoot ratio. The data obtained from wet land field confirmed the hereditary potentiality of the resistant types in having deeper penetration, greater length and higher root to shoot ratio.

The stomatal studies revealed no difference in the stomatal size and frequency between the resistant and susceptible types, though some of the resistant types have smaller sized stomata. But in these cases when the size was small the number was greater.

The above results show that by continued testing under field condition it is possible to isolate superior resistant types from varieties and hybrids. Testing of the material both under purely dry condition and under restricted irrigations appears necessary to isolate progenies that will do well under bad and good years. But under field observations it is rather difficult to separate the adverse effect of drought from that of other environmental factors. For this reason, attempts should be made to measure resistance to these adversities in the laboratory by various means. Wilting tests by withholding water are useful in these studies. Adequate previous hardening of the plants is essential if differential killing is to be obtained. Hence suitable devices such as drought chambers wherein plants grown in pots or flats could be subjected to drought are necessary.

Work done in other countries shows that physicochemical factors are more important than morphological and anatomical factors. Determination of osmotic pressure in germinating seeds by D-mannitol is reported to be an easily repeated test for screening material in breeding purposes (Dotzenko and Haus, 1960). Sugar content is an important factor since variation in osmotic pressure is partly due to changes in carbohydrate content (Meyer and Anderson, 1952). Since water deficit modifies the chemical composition of

plants and interferes with protein synthesis, determination of the soluble protein nitrogen fraction during hardening and dehardening might be useful. Amino acid content of the soluble protein is important. Adenine has been found to be associated with drought hardiness in plants. Potash content is also important since it is found to increase in hardened plants in leaf and crown tissues. Content of ascorbic acid and mitochondria in the cells are found to be more in hardened material.

Summary.—Breeding of rice varieties resistant to soil drought is in progress in Madras State from 1955 in a project partly financed by the Indian Council of Agricultural Research.

A total of 294 varieties grown under upland conditions in the State has been collected and studied for their reaction to drought under field conditions. Varieties Pisini (TKM. 1), Sembalai (TKM. 2), Vadansamba (ADT. 22), Kuruvakalayan (ASD. 4), Ariyan, Urundaikar, Chitraikar are promising of which Pisini is outstanding.

Twenty-five promising types were tested for adaptability and yield under upland and lowland conditions during three seasons and the results showed that ASD. 4, Arunjothy, TKM. 1 and Patraipisini are promising under both conditions.

Screening of large number of hybrids between wild and cultivated rices for their resistance and yield under upland conditions showed that hybrids between *O. sativa and O. perennis* are outstanding while that of *O. sativa* and *O. sativa* var. *spontanea* gave varying results. Hybrids among rainfed and semi-dry rices were promising to the extent of combining the good rice quality of one of the parents. Hybrid cultures 8405, 8409, 8417 and 9754 of cross GEB. 24 x T. 260 showed high yield potential under upland and lowland conditions.

The results of root studies under dry and wet conditions showed that TKM. 1, *O. latifolia O. minuta* and hybrids 8405 and 9754 have greater depth of penetration, length of root system and greater root to shoot ratio.

No difference in stomatal size and frequency between resistant and susceptible types has been observed.

Though it is possible to breed suitable resistant types from varieties and hybrids by continuous testing under upland conditions, a thorough understanding of this complex problem of drought resistance in rice can be made only by initiating research in certain physiological and biochemical changes that take place during hardening and dehardening under soil moisture stress.

References.

Ashton, T. Technique of breeding for drought resistance in crops. Technical Communication No. 14, *Commonwealth Bureau of Plant Breeding and Genetics*, 1948.

Black C. A. *Soil-plant relationships.* John Wiley and Sons, Inc. New York, 193-95. 1957.

Dotzenko, A.D., and Haus T.E. Selection of Alfaalfa lines for their ability to germinate under high osmotic pressure. Agron. J. 52 : 200-201. 1960.

Kramer, P. J., *Plant and Soil water relationship.* McGraw-Hill Book Co., Inc., New York, 1949.

Levitt, J. *The hardiness of plants* Academic Press Inc. New York, 141-184. 1956.

Meyer, B. S., and Anderson, D. B., *Plant Physiology*, D. Van Nostrand Company, Inc., New York. 1952.

Rajagopalan, K., Studies on drought resistance in rice. *Madras Agric. J.* 44 : 5 194-215. 1957.

Rajagopalan, K. Studies on two corn hybrids differing in their resistance to drought. *Madras agric. J.*, 48 : 327-336, 1961.

Srinivasan, C. R., Parthasarathy, N. and Ramaswamy, K. Interspecific hybridization in rice. *Proc. 28th Ind. Sci. Cong.* Abs. 37 (Agri.) 1941.

Thimann, K. V. The Physiology of growth in plant tissues. *Am. Sci.* 42 : 589-606. 1954.

Table I.

Yields of varieties (flowering in 120 days) under upland and lowland conditions. (Mean for three years).

Serial number and name of varieties.	Upland (Dry).		Low land (Wet).	
	Grain yield per acre in lb	Percentage on general mean.	Grain yield per acre in lb	Percentage on general mean.
(1)	(2)	(3)	(4)	(5)
1. ASD. 4	1,187	157·00	2,591	205·20
2. PTB. 28	551	72·90	1,036	85·00
3. MTU. 18	1,210	160·10	1,275	104·60
4. CH. 62	661	87·30	1,781	146·10
5. Kullakar	412	54·50	738	60·56
6. Palliyan	810	107·20	1,334	109·50
7. Chakkarakayama ..	782	103·50	715	58·66
8. Navara	642	84·92	1,077	88·39
9. Vaya' karutha erukkan	643	85·16	871	71·47
10. Chomala	1,045	138·20	1,105	90·65
11. Chenkeerayan	750	99·22	1,117	91·62
12. Monthakunhi	597	78·98	957	78·52
13. Lalnakanda	536	70·91	1,334	109·50
Grand mean	756	..	1,219	..

Table II.

Yields of varieties (flowering in 130 days) under upland and lowland conditions. (Mean for three years.)

Serial number and name of varieties.	Upland (Dry).		Lowland (Wet).	
	Grain yield per acre in lb.	Percentage on general mean.	Grain yield per acre in lb.	Percentage on general mean.
(1)	(2)	(3)	(4)	(5)
1 TKM. 1	1,870	184·30	2,963	139·20
2 BAM. 3	781	76·96	2,629	120·70
3 ADT. 22	1,089	107·40	3,470	159·30
4 Peddakonda (hill paddy) ..	1,061	104·60	2,049	94·06
5 Patraipisini	1,280	126·10	2,520	115·70
6 Rajakayama	944	93·08	734	33·70
7 Kappakar	1,157	116·60	1,738	79·79
8 Velumbala	729	71·83	2,288	105·10
9 Arunjothi	1,720	169·40	2,872	131·80
10 Vellaichoman	360	35·47	2,551	117·10
11 Vangi Samba	769	75·77	1,385	63·59
12 Punam Kuruvi kanni	418	41·19	932	42·79
Grand mean ..	1,015		2,177	

TABLE III.

Yields of hybrid cultures from cross GEB. 24×T. 260 (O. perennis).

(Under Upland and Lowland conditions).

Serial number.	Culture number.	Coimbatore (Mean of four years). Upland (Dry). Grain yield per acre in lb.	Coimbatore (Mean of four years). Upland (Dry). Percentage of General mean.	Coimbatore (Mean of four years). Lowland (Wet). Grain yield per acre in lb.	Coimbatore (Mean of four years). Lowland (Wet). Percentage on General mean.	Tirurkuppam (Mean of three years). Upland (Dry). Grain yield per acre in lb.	Tirurkuppam (Mean of three years). Upland (Dry). Percentage on General mean.	Tirurkuppam (Mean of three years). Lowland (Wet). Grain yield per acre in lb.	Tirurkuppam (Mean of three years). Lowland (Wet). Percentage on General mean.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	8401	799	89·55	2,877	147·99	605	92·22	2,160	118·16
2	8405	1,397	156·97	2,136	109·88	703	107·16	2,000	109·41
3	8409	463	52·02	2,383	122·58	735	112·04	2,262	123·74
4	8412	1,039	116·74	1,827	93·98	589	89·79	1,702	93·11
5	8417	842	94·6	1,721	88·53	851	129·72	2,144	121·66
6	8439	585	65·73	2,571	132·25	640	97·56	2,211	120·95
7	9729	465	52·70	2,438	125·41	527	80.34	2,127	116·35
8	9754	1,217	136·74	1,911	98·3	855	130·34	1,993	109·03
9	9756	1,179	132·47	1,640	84·36	568	86·58	1,714	93·76
10	9761	1,168	131·24	1,846	94·96	597	91·0	1,803	98·63
11	9776	1,320	148·31	1,816	93·41	603	91·92	1,652	90·37
12	TKM. 1	1,060	119·1	1,677	86·26	858	130·79	1,704	93·21
13	TKM. 2	433	48·65	959	49·33	434	66·16	744	40·07
14	BAM. 3	487	54·72	1,410	72·53	617	94·05	1,380	75·49
	Grand mean	890		1,944		656		1,828	

THE EVALUATION OF CROP PLANTS FOR SOIL MOISTURE STRESS WITH PARTICULAR REFERENCE TO RICE CROP

By K. RAJAGOPALAN, A. SHANMUGASUNDARAM AND A. ABDUL SAMAD.
Presented by SRI K. RAJAGOPALAN, AN ASSISTANT PADDY SPECIALIST, DROUGHT RESISTANCE SCHEME.

1. Dr. K. Ramakrishnan, Professor of Plant Pathology wanted to know the meaning of the term ' drought resistance ' and whether it indicates the ability of the plant to survive and produce grains under droughty conditions. He cited that in the case of perennial rye the plants do not die off because of the rhizomatous habit. He also wanted to know the technique adopted in evaluating the material for drought resistance.

The author replied that in the present studies the ability of the plant to survive and produce grains as well as yield well under droughty conditions was taken as the criterian for isolation of drought resistant types. Regarding the terminology of ' drought resistance ', Dr. Levitt has defined " resistance as the ability to survive the unfavourable external environment " while ' hardiness is its ability to survive an unfavourable internal environment '. The technique adopted for evaluating the material was ordinary field testing and the basis for selection was yield under droughty conditions.

2. Sri C. Balasubramaniam, Agricultural Meteorologist stated that the Food Production Committee has pointed out the importance of the problem of drought resistance in crop plants. He suggested that data regarding soil

moisture and microclimate could be collected in these studies and in addition to soil drought, aerial drought also should be taken into consideration. He also stated that an assessment of the critical phase of crop growth has to be made.

In reply the author stated that the critical stages consist of the early tillering phase and the stage of flower initiation and grain formation. But it is the later stage that is more important since the metabolic activity in the plant is maximum at that stage. Testing for aerial drought can be effectively carried out in controlled drought and heat chambers which have, " walk in " facilities and such chambers are in use in the U.S.A. in drought and heat resistance studies.

3. Dr. D. Daniel Sundararaj, Systematic Botanist and Associate Professor of Botany stressed the need for more intensive work in physiological and anatomical aspects. He wanted to know how certain hybrid cultures have done well under Upland and Lowland conditions while usually the varieties that do well under lowland conditions do not yield high under upland condition.

The author replied that in the present studies the material was tested under both Upland and Lowland conditions in order to determine their response to the two different environments and to work out the upland lowland ratio. Plant height and yield were recorded and the data presented in the table show that the hybrid cultures 8405, 9754 and 9776 and drought resistant strain TKM 1 have greater upland lowland ratio in respect of yield. Hence these varieties are expected to have good performance under lowland as well as upland conditions and will be useful in good and bad years.

4. Dr. B. W. X. Ponniah, Associate Dean and Professor of Plant Breeding and Genetics, indicated the association of silica deposition in roots of *Graminae* such as *Panicum antidotale* to their drought resistance. Spodogram technique was suggested as useful in silica determination.

5. Sri T. Nataraj, Agronomist and Associate Professor of Agronomy, elicited information regarding the adaptability of the drought resistant rice varieties under upland conditions existing in Chingleput district as under droughty conditions there will be no upward movement of capillary water.

It was replied that among the morphological and physiological attributes that were studied, development of the root system, namely, depth of penetration and higher root shoot ratio was found to be associated with reference to drought.

6. Sri Charles Ratnaswamy, Assistant in Millets, pointed out some of the structural adaptations for drought resistance in Millets, namely, well developed stele, vascular bundle, hypodermal layer and silicated cells in the leaf sheath and leaf lamina.

7. Dr. N. R. Bhat, Director, Central Sugarcane Breeding Institute, Coimbatore, wanted clarification whether all the drought resistant strains, species and hybrid progenies possess deeper root system.

Sri K. Rajagopalan replied that from the studies carried out so far it was found that the reputed drought resistant strain TKM 1, hybrid cultures 8405 and 9754 and wild species *O. minuta* and *O. latifolia* showed greater root development. The study is being continued.

8. Sri Ramanujam, Assistant in Cotton, referred to the method of evaluating for drought resistance in pine varieties by studying the chlorophyll stability index.

9. Sri Samuel, Assistant Agricultural Chemist, wanted to know whether there is any difference among the different drought resistant varieties in their content of reserve carbohydrate material.

It was replied that this aspect has not been studied so far.

(vii) STUDIES IN GREEN LEAVES—III BUFFERING EFFECT OF GREEN LEAVES IN SOILS.

By K. S. SHETTY AND S. VARADARAJAN.

(Chemistry Section, Agricultural College and Research Institute, Coimbatore.)

Introduction.—The application of green leaves to soils is an age-old practice and the beneficial effects conferred by them are neither doubted nor disputed. It is well known that the usefulness of plant materials applied to the soil depends on their nitrogen and carbon contents. Therefore the enhancement of yields of crops due to green-leaf manuring is a multiple function performed by the green matter, namely, (1) that due to the physico-chemical effect on the soil; and (2) that due to biological effect and the release of plant nutrients in an available form. The extent to which green leaves would alter the soil reaction was attracting the attention of the authors, since the sap of the different green leaves has different hydrogen-ion concentration. The publication of results of experiments conducted by the workers of the National Botanical Gardens, Lucknow, gave an added impetus to these studies indicated below.

The Lucknow workers have reported that they had successfully reclaimed *usar* lands with the common wasteland weed, *Argemone mexicana*. In the studies undertaken by the authors it was sought to find out if the plant materials added in the form of any particular plant leaves had any buffering effect on the soil reaction and if so which of the leaves would be most suitable for use as soil amendment.

Experimental results.—For the investigation five different green leaves were collected and the following aspects were studied. The leaves were : (1) Sesbania speciosa; (2) Gliricidia maculata; (3) Tamarindus indica; (4) Argemone mexicana; (5) Pongamia glabra :—

(1) *Determination of the pH of the crushed fresh leaves.*—For assessing the hydrogen-ion concentration of the fresh green leaves, 10g. samples of leaves were crushed with 5g. washed sand and 50 ml. of distilled water in a porcelain mortar. This was extracted with a further quantity of distilled water and the entire volume made up to 300 ml. The results are given in Table I. From the table it will be seen that the pH of the different green leaves varies from 3·2 in the case of Tamarind to 7·2 in the case of Glyricidia. Thus the pH of green leaf materials is from strongly acid to slightly alkaline range.

The extent to which the original pH of the different green leaf extracts gets altered when treated with dilute acid and alkali was found. The results are presented in Tables II and III. It is seen that there is change in the case of the extracts of all the green leaves except Tamarind. In the case of Argemone mexicana leaf the change is the lowest.

The above inference led to the idea of the probable buffering capacity of the leaf-extracts and in order to determine the inherent potency of the extracts to withstand the addition of different quantities of acid and alkali the leaf extracts were treated with different amounts of acids and alkalies and the pH determined. The results are presented in Table IV and the summary of results in Table V. The amount of acid required to alter the pH by 0·2 in the case of Sesbania was 2·5 ml. N/100 H_2SO_4 while it was 1·5 ml. in the case of Pungam. The leaves which reacted better were Argemone mexicana and Tamarind. In the case of Argemone mexicana the amount of N/100 acid required was 15 ml. and in the case of Tamarind 30 ml. Similarly with N/100 alkali, Argemone extract required only 4·0 ml. to change pH by 0·2 units which Tamarind required about 25 ml. to alter its pH to that degree. Thus it is apparent that Tamarind leaf has a comparatively better buffering effect than any other green leaf and, of the leaves studied, Argemone mexicana can be considered a close second.

When green leaves are allowed to undergo fermentation the changes that result in the pH at different periods are given in Table VI. The pH of all the green leaves at start was on the acidic range and within seven days Argemone reached the neutral point. All other plants reached the alkaline range within a month excepting the Tamarind. Even after sixty days of fermentation Tamarind leaves gave a pH in the acid region (5·8). Thus it seems that Tamarind leaves contain more of organic and mineral substances inherently acidic.

(2) *Green leaves and removal of soil alkalinity.*—The next series of experiments conducted were to test the capacity of the different green leaves to counter the alkalinity of soil and the period to which they were capable of retaining the altered hydrogen-ion reaction of the soil. This faculty of the respective green leaves would be a very useful factor in the choice of green leaves for the reclamation of alkalinity, permanently or as a temporary measure for the duration of crop growth.

To 100 gm. of soil samples of known alkalinity 5 gm. of crushed green leaves were added and the pH estimated at different intervals. The results are presented in Table VII.

The soil reaction at the start was pH 8·0 which in the course of 60 days got reduced to 7·9 when water was added. This is probably due to the decomposition of the soil organic matter and the activity of micro-organism producing carbonic acid. In the case of green leaf treatments the pH of the soil got reduced considerably with lowest value around 6·4 in the case of Tamarind and Sesbania, while Argemone gave a pH of 6·8 to the same soil. The pH recorded during definite intervals showed a steady increase in all the treatments but yet Tamarind maintained the lowest value.

Discussion.—Experiments to compare different forms of green manures, as well as to find out the optimum quantity of green manure to be applied were conducted at several places in the country. The largest number of experiments with green manures was conducted at the several Agricultural Research Stations in the Madras State. The general findings are that green manure is as efficient as ammonium sulphate, and that about 6,000 to 8,000 lb. of leaves per acre appear to be the optimum quantity and that different green manures when compared on equal nitrogen basis gave more or less the same response with a few exceptions. A few trials were also carried out at

several places on reclamation of alkaline soils by green manure. The trials at Mettumarudur in the Kattalai High Level Channel area to reclaim the typically alkaline soils, daincha was used as an adjunct with gypsum and sulphur, because daincha is able to withstand slight alkalinity. But no trial was done on the use of green manure alone for ameliorating the alkaline condition of soils. In the trials carried out at Nagercoil for three years (1932—35) different leaves, which are sour, were tried at 4,000 lb. per acre to verify the validity of the claim made by farmers of the area that sour leaves reclaim alkaline soils. Of the six different leaves tried, leaves of nelli (Phyllanthus emblica) were most effective in neutralizing the alkali followed by tamarind. The trials carried out at the research stations of Mysore (Irwin Canal Farm and Babbur) showed that all the leaves were effective generally. However, sunnhemp at Babbur and lantana and tirucally at Irwin Canal Farm were the best. It was generally found that there was a fall in pH after treatment with green manure in all cases. Daniel and Karunakar (1950) found that the pH of green manured plots was slightly higher than the unmanured control plots. The difference in pH between the green manure treated plots themselves was not pronounced. But the variations in pH value with time was found to be much greater than that obtained with even such drastic treatments as incorporation of organic and or inorganic manures in the soil medium. They averred that the growth of the rice plant caused the changes in the reaction of the medium on which it grew. They themselves expressed the view that unfortunately there were no fallow plots with treatments from which comparisons could be made in regard to variations in pH in cropped and fallow soil. Kelly (1923) showed that pH changed very little during one year period. Later studies by Karunakar *et al* (1950), the drainage water analysed for pH showed very little difference in the different rounds of analysis done. There was no difference between the plots receiving 5,000 lb. of green manure and uncropped and those receiving the same dose but with a crop of paddy. There was also not much difference due to application of double dose of green manure (10,000 lb.).

So far no detailed study seems to have been made in regard to the buffering capacity of green leaves when applied to an alkaline soil. The present investigation in the laboratory revealed that some of the leaves have definite buffering capacity when applied to the soil. When tamarind leaf was applied at a low level to a soil of pH 8·0 it was able to maintain the soil around a favourable pH for a longer period than the other leaves compared. In case considerable quantities of tamarind leaves are applied it may be possible that the effect may be felt for a longer period. The point referred to by Sethi *et al* (1952) that sour leaves are popularly used to reclaim alkaline soils and that nelli and tamarind leaves are generally used seems to have support in these investigations. Besides the tamarind, the claims made for Argemone by workers elsewhere seems to be due to factors other than their buffering effect. It may be pointed out here that the mineral matter content of Argemone is considerable and over 40 percent of the ash material is composed of calcium. Further work is warranted to find the mechanism of reclamation brought about by green leaves.

Summary and conclusions.—(1) Studies were carried out with different green leaves as to their buffering capacity in presence of acid and alkali. It was found that tamarind leaf is able to withstand a greater amount of acid and alkali without much change in the pH followed by Argemone mexicana.

(2) Of the different leaves applied to an alkaline soil, they all brought the pH to the acidic side but the effect was only for a short time compared to that produced by tamarind leaf.

(3) The studies reveal that inherently sour leaves have better effect on alkalies and further work is needed to appreciate their usefulness in this regard.

References—

(1) Joshi, A. B., Sing, H. P., Joshi, B. S. (1960), Indian Farming, Vol. 10, 1.

(2) Kelly, A. P. (1923) Soil Sci. 16, 41-54.

(3) Sethi, R. L., Ramaiah, K., and Abraham, T. P. (1962)—Manuring of Rice in India, Bull. No. 38, I.C.A.R.

(4) Varadarajan, S. and Sanyasi Raju, M. (1956), Madras Agri. J. 43 : 59-68.

(5) Karunakar, P. D., Sanyasi Raju, M. S., and Verghese, E. J. (1951). —Studies on green manuring of paddy—Proc. of First Scientific Workers Conference, Agricultural College and Research Institute, Coimbatore.

(6) Karunakar, P. D. and Daniel, F. L. (1950)—Preliminary studies on pH fluctuations in Rice soils—Indian J. Agric. Sci. XX pt. II 173-184.

Glossary.

Daincha—Sesbania aculeata.
Sesbania—Sesbania speciosa.
Pungam—Pongamia glabra.
Tamarind—Tamarindus indica.
Argemone—Argemone mexicana.

TABLE I.

pH of green leaf extract.

Name of the leaf.	*pH value.*
1 Sesbania	6·8—6·8
2 Glyricidia	7·0—7·6
3 Tamarind	3·1—3·3
4 Argemone mexicana	5·6—6·3
5 Pungam	6·3—6·5
6 Water	6·6—6·8

TABLE II.

pH values of the green leaf extracts treated with acid and alkali.

Name of the leaf (75 ccs. only).	*Original pH*	*pH values.*			
		N/100 H_2SO_4		*N*/100 *KOH*	
		5 ml.	10 ml.	5 ml.	10 ml.
1 Sesbania	6·3	5·4	4·9	6·8	7·4
2 Glyricidia	7·4	6·5	5·7	7·9	8·2
3 Tamarind	3·1	—	No change.	—	—
4 Agemona mexicana	5·8	5·6	5·5	6·2	6·6
5 Pungam	6·4	5·8	5·8	6·8	7·3

TABLE III.

The fluctuation in pH value of the green leaf extract treated with acid and alkali.

Name of the leaf.	Change in pH			
	N/100 H_2SO_4		N/100 KOH	
	5 ml.	10 ml.	5 ml.	10 ml.
1 Sesbania	0·9	1·4	0·5	1·1
2 Glyricidia	0·9	1·7	0·5	0·8
3 Tamarind		No change		
4 Argemone mexicana	0·2	0·3	0·4	0·8
5 Pungam	0·6	1·1	0·4	0·9

TABLE IV.

Buffering effect of the green leaves.

Name of the leaf.	pH						
	N/100 H_2SO_4						
	Original pH	0·5 ml.	1·0 ml.	1·5 ml.	2·0 ml.	2·5 ml.	3·0 ml.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 Sesbania	6·4	6·4	6·4	6·3	6·3	6·2	6·1
2 Glyricidia	7·0	7·0	6·9	6·9	6·9	6·8	6·7
3 Tamarind	3·2	3·2	3·2	3·2	3·2	3·2	3·2
4 Argemone mexicana	5·6	5·6	5·6	5·6	5·6	5·6	5·6
5 Pungam	6·4	6·4	6·3	6·2	6·2	6·1	6·1
6 Water	6·7	..	4·2	..	3·8	..	3·6

	pH					
	3·5 ml.	4·0 ml.	5·0 ml.	10·0 ml.	20·0 ml.	30·0 ml.
	(9)	(10)	(11)	(12)	(13)	(14)
1 Sesbania	6·1	6·0	..	..	..	..
2 Glyricidia	6·5	6·5	6·4	..	..	..
3 Tamarind	3·2	3·2	3·2	3·2	3·1	3·0
4 Argemone mexicana	5·5	5·5	5·5	5·5	5·3	5·1
5 Pungam	6·1	6·1	6·0	..	..	..
6 Water	..	..	3·4	3·1	2·8	2·6

	N/100 KOH					
	0·5 ml.	1·0 ml.	1·5 ml.	2·0 ml.	2·5 ml.	3·0 ml.
1 Sesbania	6·4	6·5	6·5	6·6	..	6·7
2 Glyricidia	7·1	7·1	7·3	..	..	..
3 Tamarind	3·2	3·2	3·2	3·2	3·2	3·2
4 Argemone mexicana	5·6	5·7	5·7	5·7	5·7	5·7
5 Pungam	6·4	6·5	6·5	6·5	6·5	6·6
6 Water	..	9·2	..	9·7	..	9·9

	N/100 KOH					
	3·5 ml.	4·0 ml.	5·0 ml.	10·0 ml.	20·0 ml.	30·0 ml.
1 Sesbania	..	6·9	7·0	..	..	..
2 Glyricidia	..	..	7·6	..	..	..
3 Tamarind	3·2	3·2	3·2	3·2	3·3	3·5
4 Argemone mexicana	5·7	5·8	5·9	..	..	..
5 Pungam	..	6·7	6·8	7·3	..	..
6 Water	..	..	10·2	10·5	10·8	..

To produce 0·2 unit change Argemone required 15 ml. N/100 H_2SO_4
Tamarind required 25 ml. N/100 KOH

Table V.

The quantity of acid and alkali required to change the pH by 0·2 of the leaf extracts.

Name of the green leaf.	N/100 acid to change the pH by—0·2. ml.	N/100 Alkali to change the pH by—0·2. ml.
(1)	(2)	(3)
1 Sesbania	2·5	2·0
2 Glyricidia	2·5	1·5
3 Tamarind	30·0	25·0
4 Argemone mexicana	15·0	4·0
5 Pungam	2·0	3·0

Table VI.

The pH of the green leaves during decomposition in distilled water.

Name of the leaf.	pH at different intervals					
	4 days	7 days	15 days	30 days	45 days	60 days
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 Sesbania	4·9	5·2	6·7	8·1	8·3	8·4
2 Glyricidia	4·9	4 8	6·6	7·2	7·6	7·8
3 Tamarind	3·2	3·3	3·6	4·8	5·6	5·8
4 Argemone mexicana ..	6·2	7·0	7·8	8·2	8·2	8·5
5 Pungam	5·4	6·1	7·2	7·8	8·0	8·2

Table VII.

Decomposition of green leaves and soil pH.

Treatment.	pH at different periods					
	4 days	7 days	15 days	30 days	45 days	60 days
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 Sesbania	6·4	6·7	7·2	7·5	7·6	7·7
2 Glyricidia	6·5	6·7	7·2	7·4	7·6	7·8
3 Tamarind	6·4	6·4	7·1	7·3	7·3	7·5
4 Argemone mexicana ..	6·8	7·0	7·3	7·6	7·6	7·7
5 Pungam	6.6	7·0	7·2	7·3	7·4	7·6
6 Soil (Untreated)	8·0	8·0	7·9	7·9	7·9	7·9

STUDIES IN GREEN LEAF III.

BUFFERING EFFECT OF GREEN LEAVES IN SOILS.

By K. S. Shetty and S. Varadarajan.

Presented by Sri S. Varadarajan.

Sri T. Rajagopala Iyengar, Compost Development Officer wanted to know if any systematic studies on the organic acids liberated during the decomposition of green leaves were made. He also pointed out that the optimum pH for phosphate solubility is between 6.5 and 7.5 and at that pH the phosphates have buffering effects. He further stated that green manures have physical and manurial effects.

Dr. Nijahvan suggested that tamarind seeds improved soil structure and also were useful as food material.

Sri Balasubramania Mudaliar wanted to know whether the tests were made under field conditions. He also suggested that the studies might be concentrated on the Argemone mexicana, since the usefulness of the weed would be a decisive factor to control its spread.

Sri Vasudeva Menon desired to know why the pH values were different in the different tables.

Sri Ramakrishnan wished to know whether the different organic acids produced by the Argemone plant during its growth were identified. He was of the opinion that the organic acids released during the growth of the plant might bring down the pH and thus influence the soil conditions in the rhizosphere region for good-crop growth.

Sri T. Nataraj wanted to know whether the experiments were carried out under irrigated or swampy conditions.

Sri D. M. Samuel said that the presence of saponins might have great effect on the structure of the soils.

Sri Varadarajan replying to the queries raised during the discussion said that nobody doubted or disputed the manurial value of green leaves. It was only in regard to their buffering effect in soils that these studies were directed. He added that the production of various organic acids during the decomposition of organic matter was well-known. Along with the production of organic acids, carbonic acid was also produced, all of which were useful in reducing alkaline reaction. He agreed that phosphates had buffering effects but for the phosphates to be soluble the pH had to be brought to about neutral region and that was possible by the immediate buffering effect of green leaves.

He added that these tests were made in the laboratory and under swampy conditions. The different values found in the different tables were due to the different samples. He said a range of pH of the leaves has been given in Table I.

He concluded that the entire study has indicated that green leaves have buffering effect for shorter or longer periods depending upon the nature of the leaves and that sour leaves seem to have such effects against alkaline soils for a longer period. He said that further study is warranted to throw more light on the usefulness of green leaves in this regard, namely, to keep out the alkaline reaction of a soil for a considerable period during a crop growth.

(viii) The influence of paddy husk, saw dust and tamarind seed powder on some physical properties of soil and on crop growth

By MESSRS. S. KANNAN AND C. N. VENKATARAMAN.

Introduction.—The use of synthetic soil conditioners like Krilium, and Aerotil, is of recent origin. These have been found to assist in soil aggregate formation, water retention, water percolation and soil aeration, as well as in the reclamation of saline and alkaline lands (Hedrick and Mowry, 1952; Allison, 1952; Martin and Jones, 1954). The crop growth in conditioner treated soil has also been found to be improved (Hedrick and Mowry, 1952). These soil conditioners however, have not become quite popular, even in western countries, presumbaly because of the prohibitive cost of these materials.

Several organic compounds, organic refuse and wastes from agricultural products, containing many of the compounds like polyuronoides and polysaccharides, have been tried for their soil conditioning properties by many workers. Soil aggregation and improvement of soil structure were found to be brought about by the application of clarion extract (spent liquor from the production of wood pulp), (Alderfer and Sharp, 1935), wood pulp and wood fragments (Lunt, 1955), and mesquite gum (Martin and Aldrich, 1955). Even bark fibre obtained from popular trees, were found to increase moisture holding capacity of light soil, by Fogg (1954). Hoon *et al* (1955) have suggested that the tamarind seed powder, which could be available in abundance can be utilized as soil conditioner, by suitably processing the product. The experiment described herein was conducted to examine the soil conditioning properties of paddy husk, saw dust, and tamarind-seed powder, and also the effect on the growth of crop grown in such treated soils.

Experimental.—The experiment designed to find out the effects of paddy husk, saw dust, and tamarind seed powder at 3 levels, viz., 2½ percent, 5 per cent and 10 per cent by weight of the soil, was first conducted using red soil, and was taken up later, using black soil, on similar lines.

Besides control, two more treatments with synthetic soil conditioners, namely, Krilium and Aerotil, at 0·1 percent in each case, were also included, in order to have a comparative study. There were altogether twelve treatments, and, two sets in each treatment were run simultaneously. Three kilograms of soil were placed in each pot representing a treatment, and the calculated quantity of the materials at the rates mentioned above, was intimatey mixed with the soil. The soil was then wetted with about 500 ml. of water, periodically, at fortnightly intervals.

The aggregate analysis was done after about 80 days of application, using about 200 gms. of air dry soil samples, following the dry sieving method, and the data are presented in the graph. The soil reaction was determined with a Beckman pH meter. The rate of percolation, water holding capacity, and volume of expansion were estimated and expressed on moisture free basis, *vide* Table 1.

At the end of the experiment, the pots were utilized for growing ragi seedlings, in order to study the effect of the different treatments on crop growth. For this purpose, seedlings about 20 days old, were transplanted in both the sets of pots, 5 plants in each. Cattle-manure at 100 gms. per pot, was applied in one set of pots, before the transplantation of ragi seedlings, as a basal dressing, while the other set did not receive any basal dressing. The relative growth performance of ragi, due to different treatments, can be observed in Fig. 1.

Results—Soil reaction.—The pH of the red soil receiving no treatment, is little higher than the neutral range. While the Krilium and Aerotil have not brought about much change, there is a considerable reduction in all the rest of the treatments. Maximum reduction has resulted following application of tamarind seed powder at 10 per cent level. Among the 3 dosages, viz., 2½ per cent, 5 per cent, and 10 per cent, in each kind of treatment, the larger the dosage, the greater the reduction in pH, in general. The bringing down of the pH from 7·9 to 6·5, by tamarind-seed powder application at 10 per cent level, is quite striking. The effects on black soil by any of the treatments are on more or less similar trend, though not to the same degree.

Rate of percolation.—This was studied in red soil. Krilium and Aerotil have been found to considerably increase the percolation capacity of soil. Paddy husk and saw dust at the doses tried, are less effective than Krilium and Aerotil, though the effects are much better than in control. In these treatments, there is not much of variation resulting from the 3 dosages in each. The effect of tamarind seed powder on percolation rate is interesting. At $2\frac{1}{2}$ percent dose, the rate of percolation is high. At 5 percent, this is almost $2\frac{1}{2}$ times as effective as $2\frac{1}{2}$ percent. At the maximum dose of 10 per cent, the rate of percolation does not increase and is almost the same as at $2\frac{1}{2}$ percent dose.

Volume of expansion.—Krilium is found to cause the maximum expansion in volume following addition of water, in the red soil. Tamarind seed powder at $2\frac{1}{2}$ percent rate, is nearly as effective as Krilium in this regard, while the higher the dosages, the less the degree of volume of expansion At 10 percent rate, it is not effective at all. The volue of expansion in the case of paddy husk, is even less than the control. This is particularly true in the case of paddy husk and saw dust at 10 percent levels. In black soil, Krilium and tamarind seed powder at 10 percent dose, cause the largest volume expansion. The effects of paddy husk and saw dust at all the 3 levels and tamarind seed powder at $2\frac{1}{2}$ percent and 5 percent do not seem to bring about large change in this respect.

Water holding capacity.—In red soil, paddy husk and saw dust at 10 per cent levels, and tamarind seed powder at 5 percent level, are found to increase the water holding capacity more or less to the same extent while the largest increase is seen in tamarind seed powder application at 10 per cent. All the other treatments are almost ineffective in increasing the water holding capacity. In black soil, the water holding capacity is markedly increased by paddy husk and saw dust at 5 percent and 10 percent doses, and by tamarind seed powder at all the levels.

Aggregation.—The effects of the 3 indigenous materials, on aggregation in red soil, are superior to the control, and even to the synthetic soil conditioners Krilium and Aerotil. at the doses tried, particularly, on aggregate sizes greater than 2 mm. The tamarind seed powder treatments at 5 percent and 10 per cent levels, are seen to give maximum aggregation. While this is equally so in black soil, their superiority over the untreated soil is not so great as in the case of red soil.

Crop growth.—In the crop growth in the treated soils, the effects of tamarind seed powder at all the 3 doses, are quite marked. This is specially so, at 10 percent application. The basal dressing with cattle manure is found to improve the crop growth, to a large extent. Thus, the plants in soils which did not receive cattle manure, were stunted and poor. The earhead and grain formation were also poor, in contrast to the plants receiving basal dressing, in general.

Discussion.—The soil is a heterogenous complex system made up of solid, liquid and gaseous material. To make a soil fertile, the solid phase must contain sufficient nutrients that can be released to the plants. The ability of the soil to produce crops however, is dependent not only upon the proper supply of these nutrients, but also upon such air and water relations as will make possible the most efficient usage of available nutrients by plant. The agricultural importance of a good soil structure on which depends the air and water relationship of a soil, therefore, needs no emphasis.

It is observed that by the addition of some of the organic waste materials like paddy husk, saw dust and tamarind seed powder, some of the physical properties like soil reaction, rate of percolation, water holding capacity, and volume of expansion, have all been favourably influenced to varying degrees, in red soil and black soil, which were experimented upon.

In red soil, tamarind seed power at 2½ per cent, 5 per cent and 10 per cent, are seen to bring about considerable reduction in pH ; the higher the dosage, the greater the reduction in pH. The organic acids which are present in tamarind seed in abundance, may perhaps be responsible for the reduction in soil pH. In regard to the rate of percolation, the higher dosage of tamarind seed powder does not proportionately increase it, thereby indicating that application of higher dosages as at 5 and 10 percent, not beneficial for better aeration of soil.

Application of as large doses of paddy husk and saw dust as 10 per cent, are no doubt capable of increasing water holding capacity of both red and black soils; but more or less similar increases are obtained using tamarind seed powder at 2½ percent and 5 percent rates. It is also noted on aggregate analysis by dry seiving, that tamarind seed powder at 5 and 10 per cent give the maximum aggregation, and is superior to paddy husk and saw dust, although the latter two materials are also found to be better than control.

From the results of aggregate analysis, it is observed that the effects of the various materials used, on the soil aggregation, are less pronounced in black soil than in red soil. The presence of greater amounts of clay in the black soil used, may perhaps be responsible for the [illegible] for aggregation, in general. Baver (1935), while studying the effects of organic matter on aggregation of soil, obtained a very high correlation between organic matter and aggregation in soils containing less than 25 percent clay.

In respect of crop growth, maximum growth of ragi is observed in soils treated with tamarind seed powder. It is interesting to note that application of organic matter like cattle manure has enhanced the effects of all the treatments, in general. It is quite possible that given optimum physical conditions in a soil, nutrients from applied manure become available to the plants; to a greater extent.

The use of saw dust has not been found to be much beneficial in both black and red soils, and the crop growth in soils receiving these treatments, was not appreciable. Even a poor growth of plants in soils treated with saw dust has been recorded by Lunt (1955) and is explained to be the result of temporary nitrogen deficiency, caused by saw dust.

Conclusions.—The applications of paddy husk, saw dust and tamarind seed powder at 2½ percent, 5 percent and 10 percent levels, in red and black soils, are seen to bring about considerable improvement on some of the physical properties of soil. There is ample scope for their being used as substitutes for synthetic soil conditioner like Krilium and Aerotil, which are very costly. The beneficial effects of these indigenous materials, are not however so marked in black soil, as in red soil.

Better crop growth can be obtained when basal dressing of cattle manure is given to the soil previously treated with these materials.

The tamarind seed powder is found to be the best of the three materials, tried. Application of tamarind seed powder at 2½ percent level will be much useful, when taken up on a field scale. The duration of the effectiveness of these materials, is however, yet to be examined.

Literature cited.

1 Alderfer, R. B. and Sharp, W.C. 1955 Effect of clarion extract on the physical and chemical characteristics of the soil. Soils and Fertilizers, 18,2721.

2 Allison, L. E. .. .. 1952 Effect of synthetic polyelectrolytes on the structure of saline and alkaline soils. Soil Science. 73 : 443–54.

3 Baver, L. D. .. .. 1935 Factors contributing to the genesis of soil microstructure. Amer. Soil Survey Assoc. Bull, XVI, 55–56.

4 Fogg, H. G. N. .. .. 1954 Bark fibre as a soil improver, Grower, 42, 675.

5 Hedrick, R.M. and Mowry, D.T. 1952 Effect of synthetic polyelectrolytes on aggregation, aeration and water relationships of soils. Soil Science, 73: 427–441.

6 Hoon, R. C. Nadig, H. N. K. and Narira, J. T. 1955 Soil conditioner evolved from tamarind (Tamarindusindica) seed powder, Irrigation and Power, 12, No. 1, 79–89, (Hirakud Res, St., Orissa),

7 Lunt, H. A. .. .. .. 1955 The use of woodchips and other wood fragments as soil amendments. Soils and Fertilizers, 18, 2,716.

8 Martin, J. P. and Aldrich, D. G. 1955 Influence of soil exchangeable cation ratios on the aggregating effect of natural and synthetic soil conditioners. Soil Science Soc. Amer. Proc. 19 : 50–54.

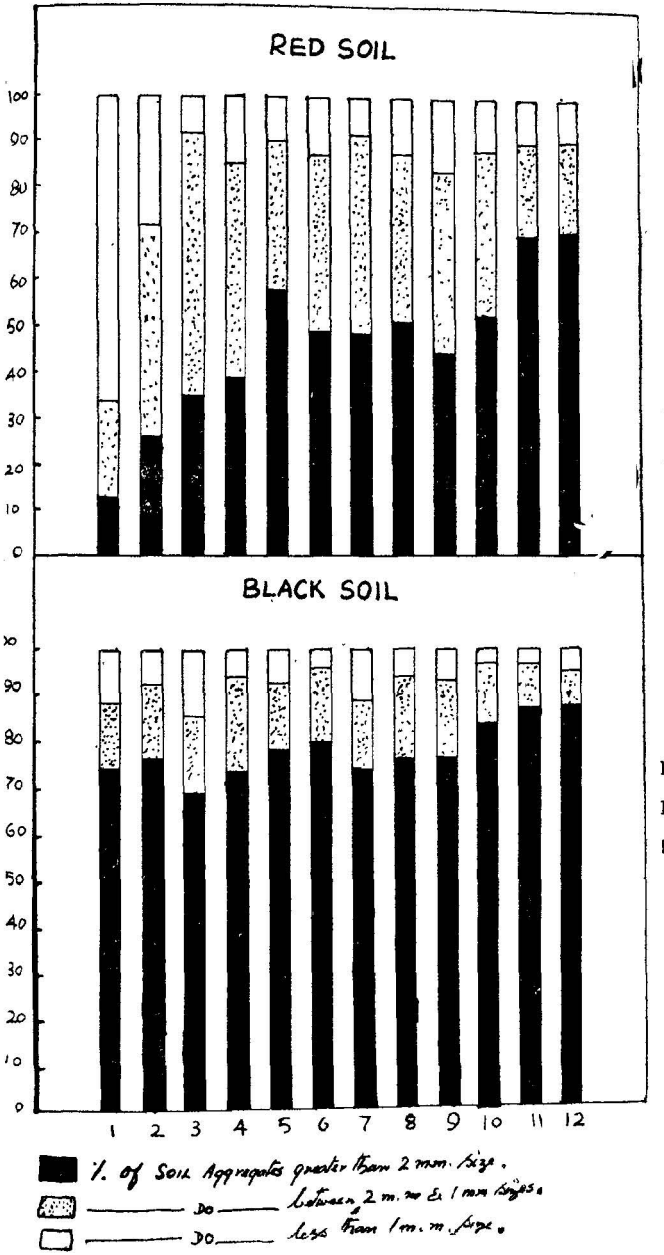
9 Martin, J. P. and Jones, W. W. 1954 Greenhouse plant response to vinyl acetate-maleic acid copolymer in natural soils and in prepared soils containing high percentages of sodium or potassium. Soil Science, 78 : 317–324.

TABLE I.

Effects of paddy husk, saw dust and tamarind seed powder, on soil reaction, rate of percolation, water holding capacity and volume of expansion in red and black soils, as compared with those Krilium and Aerotil.

Treatment.	Soil reaction.		Rate of percolation in Red soil. ml. per hour.	Volume of expansion.		Water holding capacity as per cent.	
	Red soil.	Black soil.		Red soil per cent	Black soil per cent	Red soil.	black soil.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Control ..	7·9	8·1	57	5·99	21·46	63·77	60·04
Krilium 0·1 per cent.	7·95	7·9	660	11·66	33·64	55·13	63 32
Aerotil 0·1 per cent.	8·00	7·9	750	7·50	23·87	55·29	60·47
Paddy husk 2½ per cent.	7·65	7·8	200	4·43	21·72	55·65	57·93
Paddy husk 5 per cent.	7·4	7·7	200	4·53	19·96	55.67	72·81
Paddy husk 10 per cent.	7·0	7·7	103	2·02	24·12	74·59	79·94
Saw dust 2½ per cent.	7·85	7·9	266	6·00	21·51	62·30	66·79
Saw dust 5 per cent.	7·5	7·8	273	6·05	20·67	67·08	79·31
Saw dust 10 per cent.	7·45	7·8	308	2·43	26·07	75·50	79·98
Tamarind seed powder 2½ per cent.	7·3	7·4	347	10·45	24·34	62·47	72·06
Tamarind seed powder 5 per cent	6·8	7·4	333	8·15	27·99	77·43	84·76
Tamarind seed powder 10 per cent.	6·5	7·1	284	5·63	34·70	82·15	82·89

SOIL AGGREGATION FOLLOWING DIFFERENT TREATMENTS.

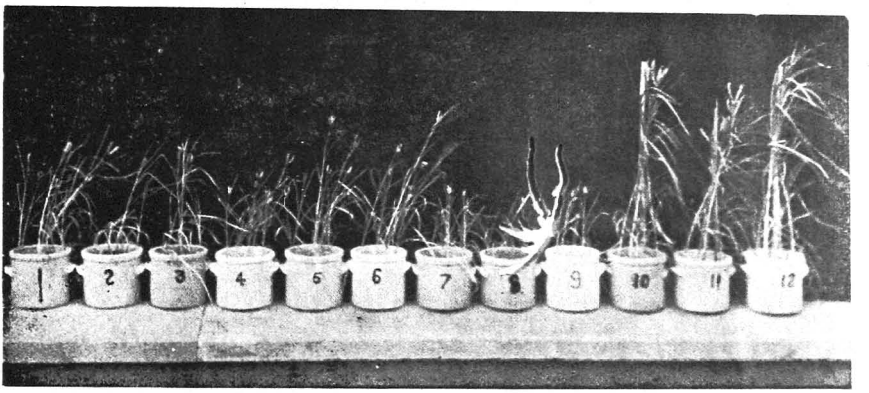


TREATMENTS.

1. Control.
2. Krilium 0·1%
3. Aerotil 0·1%
4. Paddy husk 2½%
5. Do. 5%
6. Do. 10%
7. Saw dust 2½%
8. Do. 5%
9. Do. 10%
10. Tamarind seed powder 2½%
11. Do. 5%
12. Do. 10%

RAGI CROP RESPONSE IN DIFFERENT TREATMENTS

PLATE (A)



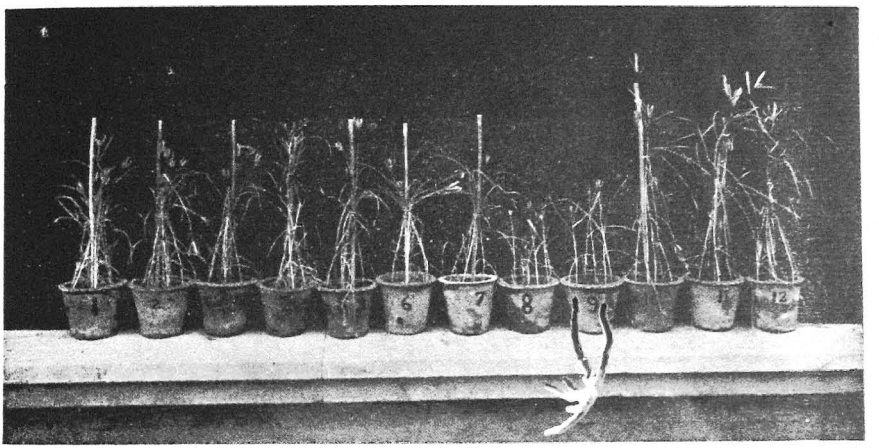
Details of treatments—

Plate (a) No Basal dressing.

1. Control;
2. Krilium 0·1%
3. Aerotil 0·1%
4. Paddy husk 2½%
5. ,, 5%
6. ,, 10%
7. Saw dust 2½%
8. ,, 5%
9. ,, 10%
10. Tamarind seed powder 2½%
11. ,, 5%
12. ,, 10%

RAGI CROP RESPONSE IN DIFFERENT TREATMENTS

PLATE (B)



Details of treatments—

Plate (b) with a basal dressing of cattle manure 100 grm/pot.

1. Control;
2. Krilium 0·1%
3. Aerotil 0·1%
4. Paddy husk 2½%
5. „ 5%
6. „ 10%
7. Saw dust 2½%
8. „ 5%
9. „ 10%
10. Tamarind seed powder 2½%
11. „ 5%
12. „ 10%

INFLUENCE OF PADDY HUSK, SAW DUST AND TAMARIND SEED POWDER ON SOME PROPERTIES OF RED AND BLACK SOIL AND ON CROP GROWTH.

By S. Kannan and C. N. Venkataraman.

Presented by : S. Kannan.

Sri K. Vasudeva Menon, Assistant Chemist, wanted to know whether the application of tarmarind seed powder would be economical in view of the great demand for the same nowadays.

The suggestion was that it would be advantageous to report to this applications wherever it is cheaply obtained.

Sri S. Venkatachalam, Assistant Soil Chemist, wanted to know the mode of action of the synthetic soil conditioners in soil aggregation.

He was informed that the polymer compound has molecules of long structure and these are capable of forming ' bridges ' between two soil particles.

Sri C. Balasubramaniam, Meteorologist, remarked that field trial of these substances would bring out possibly favourable results even in the case of black soil.

The experiment was confined only to pot culture study.

(ix) STUDIES ON CUMBU (*PENNISETUM TYPHOIDES*) RUST.

By C. V. Govindaswamy, K. Ramakrishnan and K. Sambasivan.

(Plant Pathology Section, Agricultural College and Research Institute, Coimbatore.)

Introduction.—The rust disease on cumbu (*Pennisetum typhoides* Stapf), caused by the fungus *Puccinia penniseti* Zimm. is quit common throughout Madras State. Ramakrishnan and Sundaram (1956) observed that most of the varieties of this crop grown at the Millets Breeding Station, Coimbatore were more or less susceptible to this disease, the intensity of infection ranging from 5—100 (according to Cobb's scale). The cultivators' crop in the State is also affected by this disease, very often in a severe form, but it is generally ignored by them, as there is a general impression that the disease does not materially affect the yield. No data, however, is available on the correlation between rust intensity and yield. It was therefore considered desirable to ascertain whether there was any appreciable loss in yield due to infection by this rust and whether such losses could be averted by fungicidal spraying. With this objective, a field experiment was laid out at the Millets Breeding Station, Coimbatore, for three seasons during the years 1957–59 and the results obtained are reported in this paper.

Materials and methods.—The variety of cumbu used in the experiments was Co. 3., a rust susceptible variety of this crop. During 1957 the crop was raised under rainfed conditions while in the other two years it was irrigated. The experimental treatments were randomised and replicated. The fungicides Dithane Z-78 (Zinc ethylene bis dithiocarbanate) was used in the fungicidal spraying at a concentration of 0·15 percent. It was expected that by adjusting the frequency of sprayings a graduated series of infection

grades could be obtained. These grades could then be compared and correlated with the yields of the respective treatments. The number of sprayings given varied from 5 to 11, the first spraying given 45 days after sowing and the subsequent sprayings at six day intervals.

Observations on the prevalence or intensity of rust infection were recorded just prior to each spraying and the final infection count was taken at the time of harvest. For recording infection counts 100 random plants were examined under each treatment. In each plant five random leaves were examined and the intensity of leaf infection scored according to the modified Cobb's Scale (Chester, 1950). The intensity of leaf infection in each treatment was computed by adding the category values assigned to each grade and the total intensity per treatment was obtained. During 1957 the intensity of leaf infection was not recorded but the percentage of rusted plants per treatment.

Results 1957.—During the 1957 season sowings were done on 18th October 1957. The fungicidal treatments were started when the crop was about 45 days old. The crop received one to five sprayings according to the treatment. Where the sprayings were repeated this was done at six-day intervals. Observations on the prevalence of rust in each of the treatments were made prior to each spraying and also at the close of the experiment. The grain yield in each of the treatments was also recorded. The results are presented in Table I.

TABLE 1.

Percentage prevalence of rust and grain yield in 1957.

Treatments—Number of sprays.	*Disease prevalence percent.*				
	Rep. I	II	III	IV	*Mean.*
	(1)	(2)	(3)	(4)	(5)	(6)
One	86·9	87·8	90.7	86.1	87.9
Two	78.6	82.8	90.2	84·4	84·0
Three	73·7	88·4	89·7	90·9	85·8
Four	79.9	84·7	86.8	89·8	85·3
Five	79.6	88·9	87.5	73.9	82·4
Control	77·4	86·4	89.4	89·0	85.6

	Grain yield in oz.				
	I	II	III	IV	*Mean.*
	(7)	(8)	(9)	(10)	(11)
One	19·5	22·5	15·3	11·3	17·2
Two	20·5	22·2	18.2	20·7	20·4
Three	21 3	26·8	17.8	22.8	22·2
Four	14·5	30.3	24·0	27.0	23·9
Five	21·5	27·0	24·5	27·0	25·0
Control	13·5	16·8	19·0	15·5	16·2

Disease incidence : Z test not satisfied.

Yield differences : Z test satisfied S.E. 1·70; C.D. 4·98

Conclusions 5 4 3 2 1 6

The results indicated that there was no significant difference in percentage prevalence of rust infection between treatments. The yield differences between treatments were, however, statistically significant. On closer examination it was observed that there were considerable differences in the intensity of infection (plant infection) between the different treatments. In the succeeding two years therefore, the experiment was modified by increasing the number of sprays and also by recording the intensity of infection in each treatment instead of percentage prevalence.

1958.—During the 1958 season the crop was raised under irrigated conditions and the sowing was done on 30th May 1958. The treatments ranged from no spraying to 11 sprayings in some of the treatments so as to obtain a sufficient number of differing grades of infection. The intensity of infection and the grain yield were recorded. These are furnished in Table II.

TABLE II.

Intensity of leaf infection (category values) and grain yield during 1958.

Number of sprays.	*Intensity of leaf infection.*				
	Rep. I	II	III	IV	*Mean.*
	(1)	(2)	(3)	(4)	(5)	(6)
One	434	486	455	450	456·3
Two	443	449	446	461	449·8
Three	484	357	411	422	418·5
Four	368	305	349	360	345·5
Five	367	253	443	392	363·8
Six	284	269	334	385	318
Seven	94	149	234	301	194·5
Eight	75	153	30	42	75·0
Nine	35	42	62	54	48·3
Ten	37	33	25	27	30·5
Eleven	27	11	21	25	21·0
Control	385	479	452	492	452·0

	Grain yield in oz.				
	I	II	III	IV	*Mean.*
	(7)	(8)	(9)	(10)	(11)
One	20·5	21·3	15·0	21·8	19·6
Two	17·8	24·0	25·0	18·5	21·3
Three	22·5	20·3	16·8	19·3	22·2
Four	20·5	23·5	21·5	22·0	21·9
Five	12·0	33·0	21·5	22·5	22·3
Six	23·0	27·5	23·5	20·0	23·5
Seven	23·5	30·5	27·5	18·0	24·9
Eight	25·0	22·0	24·0	26·0	24·3
Nine	23·5	32·0	14·5	22·3	23·1
Ten	25·8	24·5	22·5	20·5	23 3
Eleven	26·3	26·5	22·0	19·5	23 6
Control	23·0	22·8	14·5	18·0	19 6

Yield differences : Z test not satisfied.

Disease intensity differences : Z test satisfied ; S.E. 31·1 ; C.D. 89·27

Conclusions :

1 12 2 3 5 4 6 7 8 9 10 11

It is clear from the table that there was considerable variation in the intensity of leaf infection between the treatments. There was, however no statistically significant difference between unsprayed control and plots receiving up to three sprays. Beyond this disease intensity steadily decimed up to six sprayings. From the sixth to the seventh there was a sudden drop; thereafter the disease intensity did not significantly fall, the differences between 8th, 9th, 10th and 11th sprayings being not statistically significant.

The yield differences between treatments were not statistically significant. However a clear trend of increasing yield with increase in number sprays was observed. The mean yield in plots receiving seven sprays was about 24 per cent higher than in plots receiving no sprays.

1959.—During the 1959 season the experiment was repeated on the same lines as in 1958. The results are set out in Table III.

TABLE III.

Intensity of leaf infection (category values) and grain yields during 1959.

Number of sprays.	Intensity of infection.					
	I	II	III	IV	V	Mean.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
One	488	492	479	452	459	474
Two	480	421	439	420	431	438·2
Three	440	461	411	420	419	430·2
Four	284	385	269	334	400	334·4
Five	102	135	120	114	121	118·4
Six	40	52	61	45	59	51·4
Seven	35	42	54	41	45	43·4
Eight	36	40	51	50	49	45·2
Nine	35	31	49	53	36	40·8
Ten	39	38	39	48	39	40·6
Eleven	30	24	21	25	30	26·0
Control	500	500	500	500	500	500

	Grain yield in oz.					
	I	II	III	IV	V	Mean.
	(8)	(9)	(10)	(11)	(12)	(13)
One	9·0	10·5	10·0	10·0	10·0	9·9
Two	9·3	7·0	11·3	11·0	11·0	9·9
Three	8·0	7·8	6·0	12·0	19·5	10·7
Four	9·3	6·0	11·5	13·0	14·5	10·9
Five	11·0	9·5	11·5	11·5	20·0	12·7
Six	8·5	11·0	17·0	15·5	15·0	13·4
Seven..	15·8	10·0	11·5	13·5	18·0	13·8
Eight	13·0	11·0	17·5	10·0	15·5	13·4
Nine	9·0	9·5	8·0	15·0	22·5	12·9
Ten	15·0	12·0	13·0	12·0	10·0	12·4
Eleven	6·0	16·0	8·5	15·0	15·0	12·3
Control	9.0	6·0	6·0	16·8	11·0	9.8

Yield differences: Z test not satisfied.

Disease intensity difference: Z test satisfied; S.E. 10·17; C.D. 28·25.

Conclusions:

12 1 2 3 4 5 6 7 8 9 10 11

The results in 1959 are similar to those of the 1958 experiment. The disease intensity was significantly reduced by four sprayings and over. Six sprayings, however, appeared to be optimum, as over this there was no significant reduction in disease intensity. The yield differences though not varying significantly between treatments, still showed a clear tendency to increase with increasing number of sprays up to six sprayings. In this experiment also the plots receiving the optimum number of sprays showed an increase in yield of 40 percent over unsprayed control.

Discussion.—No information is available on the extent of loss in yield caused by rust incidence on *cumbu*. The spraying or dusting method allows the production of graded degrees of disease intensity by varying the rate, time, frequency and concentration of fungicide application (Chester, 1946). The value of this method has also been emphasised by Yarwood (1945) in the study of copper sulphate as an eradicant spray for powdery mildews. In the present experiments a graduated series of infection grades have been successfully obtained by varying the frequency of sprays. The results showed a clear trend of reduction in disease intensity with increasing number of sprayings. The optimum number of sprayings required to obtain a significant reduction in disease intensity from unsprayed controls varied according to the season and the severity of infection. While in 1958 this was seven sprayings in 1959 six sprayings were required.

Yield differences did not reach the level of statistical significance except during 1957. However, the trend of increase in yield when the disease intensity was reduced by sprayings was quite clear during the 1958 and 1959 seasons. The six times sprayed plots showed an increase of 25—40 percent in yield over unsprayed control. A great deal of work has been done on the assessment of losses caused by rusts on wheat. Mains (1927, 1930) reported increased yield in wheat by dusting with sulphur to control leaf rust of intensity 70—100 percent. The increases ranged from 10.9 to 24.3 per cent. Broadfoot (1931) reported that yield of wheat was raised by 27 per cent when dusted with sulphur to control stem rust. There are numerous other instances of leaf rust control and consequent increase in yield of wheat quoted by Chester (1946).

The present experiments on *cumbu* rust indicated a clear trend of reduced yields with increase in intensity of rust infection. In Madras State *Cumbu* is grown over an area of 1·3 million acres (Rajabhooshanam, 1958). Taking 500 lb. as the average acre yield of cumbu and at a conservative estimate 20 per cent loss in yield due to rust infection a total annual loss of about 60,000 tons of grain worth about Rs. 2.1 crores (grain valued at Rs. 350.00 per ton) may be estimated. This loss in yield cannot obviously be averted by spraying economically in a largely rainfed crop like *cumbu*. Fungicidal control is not considered economical even in a more paying crop like wheat. The experiments however, point to the necessity of evolving rust resistant varieties of *cumbu* so that this heavy potential loss may be averted.

Summary.—An experiment conducted for three seasons indicated that graded intensities of *cumbu* rust infection could be obtained by varying frequency of sprayings of Dithane Z 78. According to the severity of infection and the season 4 to 6 sprays were required to get a significant reduction in rust intensity from unsprayed control. Although yield differences between unsprayed control plots and plots receiving optimum number of sprayings were not statically singification, a trened of increasing yields with decreasing rust intensities was noticed.

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REFERENCES.

Broadfoot, W. C.	1931	Preliminary experiments on the control of cereal rusts by Kolodust, *Phytopathology* 21 : 347–372.
Chester, K. Starr	1946	*The nature and Prevention of cereal rusts as exemplified by the leaf rust of wheat* Waltham Mass., Chronica Botanica, 269 pp.
	1950	Plant disease losses : Their appraisal and interpretation, *Pl. Dis. Repir.* Suppl. 193: 190–362
Mains, E. B.	1927	The effect of leaf rust on the seed production of wheat, Abs. *Phytopathology* 17 : 40
....	1930	Effect of leaf rust (*Puccinia triticina* Ericks.) on yield of wheat, *J. agric Res..*, 40: 417–446
Rajabhooshanam, D. S.	1958	*Season and crop reports of the Madras State for the Agricultural year* 19 6–57 (*July to June*) *Fasli* 1366 Government of Madras, 70 pp.
Ramakrishnan, T. S. and Sundaram, N.V.	1956	Further studies on *Puccinia penniseti* Zimm *Proc. Indian Acad. Sci.* B. 40: 190–196.
Yarwood, C. E.	1945	Copper sulphate as an eradicant spray for powdery mildew, *Phytopathology*, 35 ; 890–994.

STUDIES ON CUMBU RUST.

By C. V. Govindaswamy, K. Ramakrishnan and K. Sambasivan.

Presented by Sri C. V. Govindaswamy, Lecturer in Mycology.

Dr. Bhat, Director, Sugarcane Breeding Institute, who presided over the proceedings wanted to know whether the threshold value has been determined. He also stated that when there is a fall in infection one would expect rise in yield but there is reduced yield with higher number of sprayings. It may perhaps be due to the toxic effect of the fungicide and this may be taken into consideration in the discussion.

The author replied that in 1958 marked reduction in disease intensity was obtained with seven sprayings while in 1959 it was with five sprayings. The threshold value must lie in between these two limits depending upon the severity of the disease. Regarding toxicity, this fungicide is not known to be toxic to plants. Further the results of grain yield during 1958 and 1959 are not statistically significant and the slight differences in yield between treatments at higher levels of sprayings are not real differences.

Sri C. Balasubramania Mudaliar, Agricultural Meteorologist stated that during 1957 the experiment was conducted on a rainfed crop and the results of grain yield were statistically significant while the results of experiment conducted under irrigated conditions during 1958 and 1959 were not statistically significant. This has to be considered because the effect of soil moisture on the disease incidence and grain yield has to be studied carefully.

The author replied that so far as this disease is concerned both dry and irrigated crops are equally susceptible and 100 percent infection could be obtained under favourable environmental conditions for the disease. Dr. K. Ramakrishnan added that in the case of wheat rust, although the disease occurs both on dry and irrigated crops, the effect of disease is more keenly felt in a dry crop.

Sri Ibrahim Ali, Plant Protection Officer, Central Pool, Tiruchirappalli, wanted to know whether these findings have any practical application and also whether the economics of spraying has been worked out.

The author replied that the object of this study was to ascertain whether this disease causes any loss in grain yield and also to develop a technique of obtaining differing grades of disease intensity so that the yields could be correlated with disease intensity. These have been achieved in the investigation. We have ourselves suggested that spraying is not a practical proposition and therefore the need for breeding rust resistant varieties has been emphasised.

Sri N. V. Sundaram, Pathologist, PIRRCOM, Coimbatore, stated that in the life cycle of the rust, it takes about 10 days to produce uredosori. The infection takes place at the time of flowering. The crop is of 90 days duration and spraying are given at 10 days intervals. It is not known how 11 spraying could be given. It is really surprising how there could be so much infection in spite of several sprayings.

The author replied that uredospores are capable of immediate germination and under favourable environmental factors of temperature, relative humidity, etc., it is possible for the fungus to produce uredosori much earlier than 10 days. The first spraying was given as soon as the disease was observed on the crop and this was found to be about 40 days after sowing. Subsequent sprayings were given at six days intervals. The infection was markedly low with six sprayings and above a comparison with disease intensity at lower levels of sprayings. In severe epidemics there will be a continuous release of uredospores and it is almost impossible under field conditions to cover the entire leaf surface of all the plants with the fungicide. Negligible or low intensity of leaf infection is therefore inevitable irrespective of the number of sprayings given.

Dr. Daniel Sundararaj, Systematic Botanist and Associate Professor of Botany, wanted to know the effect of water in the spray fluid on the yield in the case of dry crop.

The author replied that the effect of water present in the spray fluid on the crop is negligible and is generally ignored.

Sri Ambikacharan wanted to know whether the toxic effect of the fungicide has been taken into consideration.

The author replied that this fungicide—Dithane Z.78 has not been found to be toxic to any plant and in fact it has given increased yields in certain crops like turmeric, potato, etc., besides giving effective control of the disease.

(X) THE CONTROL OF EARLY SHOOT BORER, *CHILOTRAEA INFUSCATELLA S.* ON SUGARCANE USING INSECTICIDES.

By T. VENKATARAMAN (*Central Sugarcane Research Station, Cuddalore N.T.*)

Introduction.—Among the various insect pests that attack and cause damage to the Sugarcane crop the early shoot borer, *Chilotraea infuscatella S.* is a serious pest througout Madras State being active from April-May until July-August. The borer larvae enter the young plants and their fillers from the sides by making several holes in the young stalk and bore upwards and downwards. Thus the central leaf sheath is cut off and the connection from the main plant is severed. So, the central shoot dries up, creating what is known as the " Dead-heart ". The dead-heart is greyish white in colour and being completely severed from the parent plant, can be easily pulled out, thereby leaving behind a well defined cavity. The base of the dead heart is completely rotten and evinces an offensive odour. The attack is also noticed into the internodes of the well formed canes, but the infestation ceases as the crop grows and later becomes almost insignificant.

The pest causes outright mortality to the young plants causing gaps in the field in the case of early attacks. When the attack is after the tiller formation stage, the stool is made bushy and grassy where the shoot do not form millable canes as the shoots are killed as and when they emerge. Due to gaps and poor population the yield is affected.

Several attempts have been made to control the menace caused by this major pest in recent years in India and abroad. Experiments on control with cultural methods, mechanical means, insecticides and natural enemies were conducted and some gave encouraging results. But the pest could not be completely eradicated from the cane areas. For controlling this pest an insecticidal trial was laid at the Central Sugarcane Research Station, Cuddalore, using insecticides in the early period of the crop and the results are presented in this paper.

Previous work done.—Rahman (1942) has established that the same larva enters in more than one shoot and kills them causing several deadhearts. Parthasarathy (1953) has proved that the standard of growth is poor in attacked clumps and the loss depends more on the time of occurrence of pest in the field. In 1948–49 and 1949–50 it was found in Madras that partial earthing up was better in controlling the pest. In 1955 at Anakkapalle, the infestation was found to be less in deep trench system of planting than in bed system. Two light earthings one by the end of May and another by middle of June followed by the final earthing during rains were highly beneficial to prevent the shoot borer from damaging the young crop under Northern Indian conditions, as reported by Gupta (1945). Cane trash mulching, in order to mitigate the summer drought in between cane rows has been found to control the pest, by Parthasarathy (1959) In Madras, Basheer (1954) recorded D.D.T. 0.25 percent spray to be better in controlling the pest. Ramachandrachari (1959) has recorded that D.D.T. 0.32 percent spray at 4th, 6th and 9th weeks of age of crop, gives an effective control. Siddiqi (1959) has observed that pure Gamma B.H.C. of Lindane quality at a dose of 1 lb. per acre gave almost control of early shoot borer in addition to checking the attack of Termites.

Materials and methods.—A randomised replicated trial was laid out with four replications with the veriety, Co. 449, a variety which generally records comparatatively high incidence of early shoot borer. The planting was taken up by end of March in each year so that the germination and early stage of the crop will coincide with the peak period of attack by the pest. The following insecticides were tried with the strength indicated to test their efficacy in the control of early shoot border. 1. D.D.T. 0.25 percent, 2. B.H.C. 0.5 percent, 3. Endrin 0.1 percent, 4. Folidol 0.05 percent, 5. Aldrin 0.1 percent, 6. Dieldrin 0.1 percent, 7. Ryania 0.5 percent, 8. Mechanical Control (Spike thrust method), 9. B.H.C. 20 percent E.O. at 5 lb./acre, soil application at planting and 10. Control (No treatment).

Three sprays at tri-weekly intervals, commencing from the early signs of the pest (dead-heart) were given, regulating the quantity of spray material used at 40 to 60 gallons per acre according to the age of the crop. In the treatment mechanical control no chemical spray was given, but the dead-hearts were pulled out and the cavity spike thrusted. In the treatment B.H.C. 20 percent E.C. at 5 lb. per acre no spray was given but the chemical was mixed with 100 gallons of water per acre poured with a gardner's can, on the setts in furrows at planting, and then the setts were planted. Except the chemical treatments, all plots were given the same cultural and manurial operations.

In each plot two rows of 50 links each, in the middle, were marked out and observations recorded. Counts of the infested and healthy shoots were made in all the plots before and after 21 days of each spray and the percentage of incidence assessed.

Results and discussion.—The germination count was recorded in the trial at the age of 5th week and tabulated below.

Serial number.	*Treatments.*	*Average Germination percent.*
(1)	(2)	(3)
1	D.D.T. 0·25 percent	46·3
2	B. H. C. 0·5 percent	43·0
3	Endrin 0·1 percent	44·5
4	Folidol 0·05 percent	43·4
5	Aldrin 0·1 percent	40·8
6	Dieldrin 0·1 percent	44·2
7	Ryania 0·5 percent	46·0
8	Gamma B.H.C., E.C.	53·5
9	Control	42·4

Note.—The treatments 1 to 7 and 9 are practically the control as they have not received any chemical treatment before the germination count is taken.

'Z' test satisfied. Significant at P.=0·01
S. E. 1·93
C. D. 5·40

8, 1, 7, 3, 6, 4, 2, 9, 5.

The plots treated with the chemical Gamma B.H.C. 20 percent E.C. 5 lb./acre at the time of planting on the setts in furrows have recorded higher germination percent which is statistically significant and saperior over others. The other plots which are practically the control (No treatment) as they have not received any chemical treatment before the germination count is taken are on par with one another and inferior to the above chemical treated plots. David (1959) has recorded that the chemical Gamma B.H.C. is effective in increasing germination. In the above trial the germination is enhanced by about 15 percent to 31 percent in the treated plots over control proving the superiority of the chemical in enhancing germination capacity in cane.

The incidence of early shoot borer was recorded in all the plots and the efficacy of the chemicals arrived at. The data are furnished in the following table.

Percentage incidence of early shoot borer—

Serial number.	*Treatments*	*Percentage incidence of early shoot borer.*		
		1958.	1959.	1960.
(1)	(2)	(3)	(4)	(5)
1	D. D. T. 0·25 percent	17·5	42·2	34·4
2	B. H. C. 0·5 percent	9·9	39·6	48·6
3	Endrin 0·1 percent	5·7	30·7	13·5
4	Folidol 0·05 percent	40·7	47·6	38·2
5	Aldrin 0·1 percent	32·9	54·0	22·8
6	Dieldrin 0·1 percent	41·0	41·3	31·3
7	Ryania 0·5 percent	27·8	28·8	42·3
8	Mechanical Control	20·3	45 2	*N I
9	Gamma B.H.C., E.C.	*N I.	25·7	17·7
10	Control (No treatment)	46·1	45·8	59·3

*N.I.=Not included.

Statistical Analysis :—

1958 'Z' test satisfied. P=0·05 S. E. 2·3, C. D. 4·8.

10, 6, 4, 5, 7, 8, 1, 2, 3.

1959 'Z' test satisfied. P=0.05 S.E. 11·6, C. D. 16·97.

5, 4, 10, 8, 1, 6, 2, 3, 7, 9.

1960 'Z' test satisfied P=0·01 S.E. 10·27, C.D. 28·75.

10, 2, 7, 4, 1, 6, 5, 9, 3,

It is seen from the above data that the treatments, Endrin, 0.1 percent spray and Gamma B.H.C. 20 percent (E.C.) 5 lb./acre soil application are effective in controlling the early shoot borer as they have recorded significantly lesser incidence consecutively over other chemicals and no treatment.

The incidence is reduced to about 33 percent to 87 percent in the Endrin sprayed plots and 43 percent to 69 percent in the Gamma B.H.C. treated plots over the control.

David (1959) has observed that the incidence of early shoot borer is controlled by the soil applications of 5 lb. B.H.C. per acre. Siddiqi (1959) has recorded that the application of Gamma B.H.C. at 0.75 lb. actual per acre sprayed over setts in furrows at the time of planting considerably reduces shoot borer incidence in the germinating crop. The trials conducted in the Sugarcane Insect Pests Scheme in Madras State for the year 1958-59 showed that Endrin 0.1 percent spray has recorded the least infestation in all the experiments and it is comparatively superior to all other chemical in the control of early shoot borer.

Cost of treatment per acre—

Chemical.	*Quantity.*	*Labour.*	*Total cost.*
1 Endrin	24 oz. (for three sprayings)	2 men at Re. 1. 6 Boys at Re. 0·50 nP.	Rs. 18
2 Gamma B.H.C. ..	1 Gallon	1 man at Re. 1.	Rs. 43

The total cost of treatment works out to Rs. 18 for Endrin and Rs. 43 for Gamma B.H.C.

Summary and conclusion.—A randomised replicated trial was laid out with four replications using the variety Co. 449, to find out the efficacy of the different insecticides in controlling early shoot borer. The crop was planted during the end of March in each year, so that the early stage of the crop will coincide with the peak period of pest activity.

Several chemicals including Endrin 0.1 percent was given as spray thrice at tri-weekly intervals commencing from the early signs of the pest and Gamma B.H.C. 20 percent E.C. 5 lb. of chemical per acre applied at planting on setts in furrows. The incidence was recorded in the middle two rows of 50 links each in all plots before and after 21 days of each spray and percentage of incidence assessed.

The following conclusions are adjudged :—

(1) The chemical Gamma B.H.C. 20 percent E.C. 5 lb. per acre is found to be effective in increasing the germination in sugarcane.

(2) The chemical Endrin 0.1 percent spray thdice at tri-weekly intervals commencing from early signs of pest incidence and Gamma B.H.C. 20 percent E.C. 5lb./acre applied at the time of planting on setts in furrows are effective in controlling the early shoot borer attack.

(3) The total cost of treatment works out to Rs. 18 for Endrin and Rs. 43 for Gamma B.H.C.

(4) Considering the cost the chemical Endrin is found to be more suitable for controlling the pest.

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Bibliography—

(1) Ann. Rep. Sugarcane Insect Pests Scheme in Madras State, 1948–49, 1949–50 and 1958–59.

(2) Ann. Rep. Sugarcane Research Scheme for Andhra State at Aanakkapalle, 1955—P. 121.

(3) Basheer, M., Krishnamurthy, C., and Nagarajan, K. R., 1954, Ind. J. Ent. XVI, 4, pp. 350–361.

(4) David, H., 1959, Indian Sugar, Volume IX, Part 7, pp. 387–388.

(5) Gupta, B. D., 1945, Ind. J. Agric. Sci. XV, 1, pp. 1–7.

(6) Khan A. Rahman and Dalbir Singh, 1942, Ind. J. Ent., Volume IV, No. 1, pp. 77–85.

(7) Parthasarathy, S. V., 1953, the 22nd Proc. of the Sugarcane Tech. Asso. of India, Kanpur, pp. 13–22.

(8) Parthasarathy, S. V., 1959, Ind. J. Sugarcane Res. and Dev., Vol. III, part 3, pp. 151–152.

(9) Ramachandrachari, C., 1959, Ind. J. Sugarcane Res. and Dev. Vol. III part 4, pp. 215-218.

(10) Siddiqi, Z. A., Rajani, V. G., and Singh, o.p., 1959, Ind. J. Sugarcane Res. and Dev. Vol. III, part 4, pp. 227–232.

THE CONTROL OF EARLY SHOOT BORER.

Chilotrea infuscatella, S.

ON SUGARCANE USING INSECTICIDES.

By T. Venkataraman

(*Central Sugarcane Research Station, Cuddalore N.T.*)

Presented by : Sri V. M. Kalyanaraman, *Assistant in Entomology.*

Sri M. V. Jayaraman, Assistant in Meteorology wanted the reason for the variations in the percentage of infestation from year to year and also the explanation for the treated plots recording more incidence than control in the 1959 year experiment.

It was explained that the variation in the percentage of infestation from year to year may be due to various factors such as soil, climatic conditions, etc., prevalent during the years. Regarding the treated plots showing more incidence than control, it was explained that similar findings have been recorded

in some of the experiments conducted at Coimbatore against the early shoot borer and also in the experiments conducted at Pugalur for the control of the top borer. Perhaps the natural enemies are killed in the treated plots allowing the pest to be active unchecked by the natural enemies.

2. Sri K. A. Seshu Ayyar, Statistical Assistant said that it will be worthwhile to have a corresponding yield data given from year to year to know the extent of relation between the percentage of infestation and the yield. It was replied that as this pest affects the crop during the early stage of the crop, it may not be correct to correlate the yield with the percentage of infestation, as this crop is subject to attack by other pests during the growing stage.

Sri K. A. Seshu Ayyar further suggested that it will be useful it the influence of weather factors is correlated with the incidence of the early shoot borer. It was replied that this study is being done at Coimbatore and the statistical findings of 13 years data have indicated that high day temperature and low to moderate humidity are conducive for the multiplication of this borer. The data for the last 18 years have been furnished to the Statistical Assistant for analysis. The above fundamental aspect of study will be continued at Cuddalore when the Sugarcane Insect Pests Scheme is shifted to Cuddalore by 1st April 1961.

(xi) STUDIES ON BREAKING THE DORMANCY IN THE SPREADING VARIETY OF GROUNDNUT.

By S. Gopalakrishnan and A. N. Venkateswaran.

Introduction.—The problem of seed dormancy in groundnut assumes two different aspects in relation to the variety. Two distinct varieties of groundnut differentiated by their habit of growth, viz., the spreading and the bunch, are in cultivation in the Madras State. The seeds of the spreading variety have a dormant period of 2 to 2½ months in contrast to the bunch variety which germinates in the field itself on receipt of a few showers at the harvest stage. (John, C. M. *et al*, 1948). Dormancy in the spreading variety manifests itself as a great problem in the main groundnut growing tracts of the Madras State. This crop has a duration of 4½ months and is grown, both during the main rain-fed season between June and December and the irrigated season between February and August. The seeds from the rainfed crop are used for sowing the succeeding irrigated crop. Under normal seasonal conditions, the interval between the harvest of the rainfed crop and the sowing of the summer crop is just sufficient to complete the rest period of the spreading variety. But, in years when the sowing of the rainfed crop is delayed due to late receipt of rains, the interval between the two crops will be too short for the seeds to overcome the dormancy with the result that such seeds when sown for the irrigated crop, give poor germination and stand, with consequent reduction in yield. The need thus arises for finding out a means of reducing the period of dormancy in the spreading variety. Studies on this problem were taken up to select the best out of a series of treatments for breaking dormancy in the spreading variety.

Review of literature.—Temperature treatments and treatments with hormonal chemicals were perhaps the only methods adopted in the past in overcoming dormancy in groundnut. Hull (1937) found that storage at a low temperature of 3°C increased the dormancy period, while storage at temperatures of 20° to 40° C shortened dormancy. Beattie *et al* (1932) observed greater germination in unshelled, stored groundnut seeds than in shelled and

stored seeds. Seeds stored at low temperatures have been reported to maintain viability for a fairly long period. (Pons *et al*, 1949), Shibuya (1938) reported that indole acetic acid in lanolin (1 to 10) hastened germination when applied to the scratched testa of the seeds. Work done in the past at the oil seeds laboratory at Coimbatore indicated the usefulness of 0.7 per cent solution of ethylene chlorhydrin and the water extract of the non-dormant bunch variety used as pre-soaking treatments in inducing good germination of the spreading variety seeds.

Material and methods.—Three experiments using temperature treatments and one experiment using extract of TMV. 2 groundnut were conducted to overcome dormancy in the spreading varieties TMV. 1 and TMV. 3 groundnut. The particulars of the experiments are presented below :—

Experiment.	*Varieties.*	*Number of days after harvest when shelling was done.*	*Storage temperature used.*
I	T.M.V. 1	(i) 20 days (ii) 30 days	(a) Room temperature (28°C) (b) 0°C (c) 40°C
II	T.M.V. 1	15 days	(a) Room Temperature (28°C) (b) 0°C (c) 40°C (d) 50°C
III	(i) T.M.V. 1 (ii) T.M.V. 3	20 days	(a) Room Temperature (28°C) (b) 40°C (c) 45°C

Samples were drawn from each treatment in duplicate and their germination capacity was tested at the end of 3, 6, 9, 12, 15, 20 and 30 days in storage. The germination counts were taken for a period of three days.

Experiment IV.—Seeds of TMV. 3 variety were soaked in different extracts of the bunch variety TMV. 2 and germinated in petri dishes. The soaking was done for a period of 16 hours keeping the ratio of weight of seed in grams to the volume of extract in ml. as 3 : 1. The treatments consisted of—

(i) *Cold water extract.*—Obtained by shaking 50 gm. of TMV. 2 seeds with 250 C.C. of cold distilled water, for one hour.

(ii) *Hot-water extract.*—Obtained by boiling 50 gm. of TMV. 2 seeds in 250 C.C. of distilled water for one hour and making up the volume to 250 C.C.

(iii *Blended extract in alcohol.*—Obtained by blending 50 gm. of TMV. 2 seeds in 250 C.C. of 80 per cent alcohol in a Waring Blender and filtering the extract through a Buchner filter.

(iv) *Blended extract in cold-water.*—Obtained by blending 50 gm. of TMV. 2 seeds in 250 C.C. of cold water (distilled) and filtering the extract through a Buchner filter.

(v) *Control.*—Unsoaked.

Results.—The data on the percentage of germination obtained under each treatment are furnished in the following tables separately for each experiment :—

Table I.

(Experiment I)

Dormancy studies—Variety TMV. 1.

Data on percentage of germination.

Treatment.	Pods shelled 20 days after harvest and seeds stored for days.					Shelled 30 days after harvest and seeds stored for days.				
	3	6	9	15	30	3	6	9	15	30
Room temperature.	34	56	55	100	100	100	94	100	100	100
0°C	21	42	30	78	78	61	70	96	96	92
40°C	41	69	90	100	100	100	100	100	100	100

Table II.

Dormancy Studies—(Variety TMV. 1) Data on percentage of germination (Initial germinability 25 per cent.)

Treatment.	Percentage of germination at the end of days of storage.						
	3	6	9	12	15	20	30
Room temperature.	19·0	25·0	30·5	54·0	58·5	65·5	87·0
0°C	8·5	16·0	15·0	22 5	24·0	30·0	32·0
40°C	21·0	51·5	55·5	86·0	90·0	87·0	95·0
50°C	38·0	67·5	80·0	81·5	87·0	85·0	88·5

Table III.

Dormancy Studies—(Variety TMV. 1) Data on percentage of germination.

(Initial germination 15 per cent.)

Treatment.	Percentage of germination at the end of days of storage.						
	3	6	9	12	15	20	30
Room temperature ..	28	32	66	69	68	80	93
40°C	82	83	97	100	100	99	100
45°C	79	90	99	99	100	99	99
	Variety TMV. 3, Initial germination 13 per cent.						
Room temperature ..	27	25	65	60	60	78	90
40°C	64	69	92	95	95	97	92
45°C	69	70	93	94	95	94	100

TABLE IV.

Dormancy Studies—(Variety TMV. 1) Data progress of germination per cent.

Treatment.	*Percentage of germination on*	*Number of days in storage:*						
		3 days	6 days	9 days	12 days	15 days	20 days	30 days
Room temp. ..	I day	2·0	2·0	9.0	3·0	5·0	8·0	5·0
	II day	15·0	18·0	46·0	55·0	45·0	64·0	80·0
	III day	11·0	12·0	11·0	11·0	18·0	8·0	8·0
0°C	I day	..	4·0	5·0	3·0	1·0	4·0	7.0
	II day	4·0	11·0	8·0	8 5	19·0	22·0	20·0
	III day	4·5	1·0	2·0	11·0	4·0	4·0	5·0
40°C	I day	13·0	17·0	61·0	50·0	73.0	91 0	96 0
	II day	58·0	63·0	33·0	50·0	24·0	7·0	2·0
	III day	11·0	3·0	3·0	..	3·0	1·0	2·0
45°C	I day	10·0	16·0	65·0	74·0	88·0	95·0	96·0
	II day	50·0	62·0	33·0	25·0	11·0	4·0	3·0
	III day	19·0	12·0	1·0	..	1·0	..	..

* (The data given against this treatment are from experiment II)

TABLE V

Dormancy Studies—(Variety TMV. 3) Data on percentage of germination.

Pre-soaking in Extracts of TMV. 2.

Treatment	*Percentage of germination on.*			
	1st day	*2nd day*	*3rd day*	*Total*
Cold water extract	75	15	2	92
Hot water extract	70	21	..	91
Alcohol extract	..	..	..	..
Cold water blended extract ..	46	36	..	82
Control	8	26	32	66

Discussion.—From the data in Table I, it can be seen that the higher the storage temperature, the better the germination throughout the period of storage. Storage at 0° C has prolonged dormancy. Under room temperature, dormancy is completely broken in about the same period after harvest, irrespective of whether the pods were shelled 20 or 30 days after harvest. This would show that keeping the pods unshelled for a longer period did not improve germination, a finding not in line with that reported by Beattie *et al.* The high temperature of 50°C is not only not superior to 40°C, in breaking dormancy but also some what affected the germination after 9 days of storage even though up to nine days, the rate of germination was higher at 50°C thar at 40°C. It may be of interest to note that storage at 0°C prevented the breaking of dormancy even up to 45 days after harvest, the figure hardly exceeding 32 per cent in contrast to 87 per cent and 95 per cent under room temperature and 40° C. respectively. This phenomenon is contrary to what is observed in many other crops, in which storing the moist seeds at low temperatures accelerates their after-ripening (Crocker, 1948). In the third experiment the unfavourable temperature of 0°C was dropped out and an intermediate temperature (45°C) between 40°C and 50°C was included. The results, presented in Table III, indicate that storage at 40°C or 45° C, in contrast to the room temperature, considerably accelerates the breaking of dormancy in as short a period as 9 days, while at room temperature, it is attained only at the end of 30 days of storage or 50 days after harvest. It may also be seen that there is appreciable difference in germination between 40° and 45°. Further, variety TMV. 3 appears to be more dormant than TMV. 1, but this aspect needs further investigation. Critical analysis on the progress of germination, given Table IV, reveals the importance of

temperature of storage in breaking dormancy. There is a certain percentage of germination in the first day in the control which shoots up on the second day with a steep fall on the third day. The retarding effect 0° C is lost on the second day when the percentage of germination increases. At higher temperatures there is a high percentage of germination on the first day, with a steep fall on the second day and third day which is evident after six days of storage. This pattern in the progress of germination assurance greater intensity with advancing periods of storage.

The cold-water extract of uncrushed TMV. 2 seeds, improved the germination in TMV. 3 variety considerably (92 per cent as against 66 per cent in control). The hot-water extract was equally effective. Crushing seeds with blender, and extracting with cold-water was only inferior to the ordinary extract. The 80 percent alcohol extract seems to have completely killed the seeds thus giving no germination. The principle or the ingredient contained in the cold-water extract of TMV. 2 appears to be hormonal in nature, capable of inducing germinability in the spreading variety noted for its dormancy. The horomone is probably indole acetic acid, which was detected and estimated by soaking freshly harvested TMV. 2 seeds in water (unpublished work of M. V. Jayaraman and S. Gopalakrishnan). The efficacy of hormone-like substances in improving germinability gives scope for investigation to be compared with temperature treatment.

Summary and conclusions.—Studies in the breaking of dormancy of the seeds of groundnut TMV. 1 and TMV. 3 were conducted in order to make possible the use of seeds from the rainfed crop for sowing the succeeding irrigated crop in the Madras State. The studies revealed that a simple temperature treatment of storing the seeds at 40°C or 45°C is effective in breaking the dormancy in about 6 to 9 days as against a period of 30 days after storage required in the normal course. Pre-soaking the seeds in the cold or hot water extract of the seeds of non-dormant bunch variety TMV. 2 was also effective in breaking the dormancy. Storing unshelled pods did not confer any advantage over stored seeds. It was brought out clearly from the studies that the non-dormant bunch groundnut TMV. 2, contains a hormone like substance, similar to IAA, which can be extracted in cold-water and utilised profitably by the cultivators in breaking the dormancy of the seeds of TMV. 1 and TMV. 3 varieties.

Acknowledgment.—The work was carried out under the scheme for research on the physiology of groundnut in the Madras State financed partly by the Indian Central Oil-seeds Committee. The help rendered by the Oil-seeds Specialist in the conduct of the experiments is thankfully acknowledged

Literature—

Beattie, J. H., Jackson, A. M. and Currin, R. E., 1937 : Effect of cold storage and age of seed germination and yield of peanuts, U.S.D.A. Cir., 233.

Crocker, W., 1948 : Growth of plants, Pub. Reinhold Publishing Corporation, New York.

Hull, F. H . 1937 : Inheritance of rest period of seeds and certain other characters in the peanut. Fla. Agr. Exp. Sta. Bul. 314.

Jayaraman, M. V. and Gopalakrishnan, S., Estimation of indole acetic acid by colorimetry (unpublished).

John, C. M., Seshadri, C. R. and Bhavanishanker Rao, M., 1948 : Dormancy of the seed in the groundnut, Madras Agri. J. XXXV, 159.

Shibuya, T.. 1938 : Forcing the germination of dormant seeds by means of growth hormone. Jour Soc. Prop. Agr. (Japan), 10 :1-8.

STUDIES ON BREAKING OF DORMANCY OF SPREADING VARIETY OF GROUNDNUT

By S. Gopalakrishnan and A. N. Venkateswaran.

Paper presented by Sri A. N. Venkateswaran.

Dr. Bhat said that work done at the Tobacco Research Station, Rajamundry revealed that the testa of seeds of the spreading variety groundnut possessed a germination inhibiting substance and that when the same was removed the germination was increased. He desired to know the effect of temperature on this germination inhibiting substance.

Mr. Rajaratnam, Additional Superintendent, Central Farm, Coimbatore suggested the use of carbon disulphide for breaking the dormancy of groundnut seeds as the same was found suitable for breaking the dormancy of potato tubers.

Sri C. R. Seshadri, Joint Director of Agriculture (Planning and Development) complimented the authors for having conducted such a useful piece of work. But he pointed out that it was not correct to allow an unduly long period to elapse after harvest before shelling the pods, as the object of the studies is to break the dormancy of the seeds in as quick a time as possible. Probably just sufficient time could be allowed to facilitate the normal drying and cleaning the produce and studies should be started immediately. Referring to the President's remarks, he pointed out that in certain tracts it was the practice of the ryots to soak the seeds before sowing and it was removed due to soaking actually give poor germination compared to seeds with intact testa.

Sri S S. Nagarajan, Assistant in Groundnut Physiology said that trials conducted in the oil-seeds section were not in line with those carried out at Rajamundry, as it was noted that even after removing the seed coat in the seeds of spreading variety of groundnut the dormancy was not broken as evinced by poor germination.

Sri S. G. Aiyadurai, Millet and Pulses Specialist in charge Oil-seeds Specialist also spoke about the practical difficulty in removing the testa of seeds. He also said that if the testa were to be removed, the kernel would be exposed to fungal attack.

Replying to the remarks made by the various workers Sri A. N. Venkateswaran stated that as already stated removal of testa may not be a practicable proposition when large quantities of seeds are required for sowing and it has also been observed to be not beneficial in inducing germination.

Referring to the suggestion to use carbon disulphide, he mentioned that trials have been conducted in the oil-seeds laboratory using certain chemicals and it was found that at 0.7 per cent solution of ethylene chlorhydrin was

quite effective in breaking the dormancy in TMV. 1 groundnut. Further, carbon disulphide is known to overcome the effect of inhibitors like NAA in potato. Ethylene chlorhydrin does the same thing. Regarding shelling, two stages of shelling were included as treatments in one experiment just to see whether keeping the pods unshelled have got any beneficial effect. In the other experiments pods were shelled 15 days after harvest.

(xii) DEW FORMATION AT COIMBATORE.

C. Balasubramanian and Komalam P. Nayar.

(Agricultural Meteorology Section, Coimbatore.)

Introduction.—Dew formation is an indication of the nature of radiation exchange taking place in the atmospheric layers near the ground surface. It is a form of precipitation, not capable of being measured with an ordinary rain gauge. Nevertheless it is an important source of moisture to vegetation in periods of acute drought, particularly in arid and semi-arid regions.

Agriculturally dew formation has got a great significance. Incidence of some of the plant diseases is surprisingly associated with the nature of dew formation. In Madras State the finding of the research workers on paddy crop is that the incidence of 'Blast' disease on paddy is closely related with the nature of dew formation in the months of December and January. If the dew formation is heavy in these months, the incidence of 'Blast' disease on paddy also gains an alarming proportion.

In consideration of the agricultural significance of dew formation, not only in India, but in other countries as well, attempts were directed to evolve a simple and effective device to measure the amount of dew formation. As early as 1947 *Duvdevani Dew Gauge* was invented and it is now extensively used throughout the world to measure the amount of dew formed in a locality.

At the Central Agricultural Meteorological Observatory at Coimbatore, collection of data on dew formation with Duvdevani Dew Gauge was commenced in December 1958 and is being continued. In this paper the data collected in the years 1958–59 and 1959–60 have been taken up for a statistical scrutiny

Materials and Methods—Materials.—The data collected on dew formation in the periods 10th December 1958 to 12th March 1959 and 6th December 1959 to 22nd March 1960 were compiled along with the corresponding daily data on maximum temperature, gross minimum temperature, screen minimum temperature, morning relative humidity, mean relative humidity, vapour pressure and wind velocity at 4 feet height. In these two periods two hundred and one sets of data were available for statistical scrutiny.

Methods.—(*a*) The dew formation period at Coimbatore starts early in December and ends by about the second or third week of March. The number of dew days with varying amounts of dew formation, ranging from trace to 7·5 were compiled month-var for the dew formation periods in the years 1958–59 and 1959–60. This compilation was taken up with the intention of getting information on the variation in the intensity of dew formation at Coimbatore in the months of December to March (2).

(*b*) Simple correlations were worked out between the amount of dew formation and the following meteorological factors separately for the months of December, January, February and March (1).

(i) Maximum temperature representing the nature of solar insolation;

(ii) Gross minimum temperature, indicating the lowest minimum temperature in a locality;

(iii) Deviation of gross minimum temperature from the screen minimum temperature;

(iv) Morning relative humidity, representing the ratio of the quantity of water vapour present in the early hours of the day to the quantity required for saturation at the given temperature and pressure;

(v) Mean relative humidity connoting the ratio of the average quantity of water present to the quantity required for saturation at the given temperature and pressure;

(vi) Vapour pressure, known otherwise as saturation pressure, representing the partial pressure of the water vapour in the atmosphere; and

(vii) Wind velocity at 4 feet height.

(*c*) The important causative meteorological factors for dew formation in any locality are gross minimum temperature and morning relative humidity. These factors were examined in detail with reference to two hundred and one sets of data for different amounts of dew formation, ranging from 0 to > 3. This examination was taken up with the object of predicting dew formation at Coimbatore from a knowledge of these two weather factors.

Discussion.—(i) The data compiled separately for the different months in the dew formation periods of December to March in the years 1958–59 and 1959–60 are given in table I. The tentative inference drawn from this table is that dew formation of the order of above 3 is generally had only in the months of December and March. These two months represent respectively the initial formation and cessation periods of dew at Coimbatore. In the intervening two months of January and February the dew formation is generally of a mild order, ranging from 0 to 3.

(ii) Table II contains the details of the twenty-eight correlations worked out with dew formation and the various weather factors as indicated above. From this table the following tentative inferences are drawn :—

(*a*) Except the morning relative humidity no other meteorological factor seems to have any influence on dew formation at Coimbatore in the months of February and March. Morning relative humidity is really a highly positive influencing factor of dew formation in all the four months, namely, December, January, February and March. Only in the month of March, in which month dew formation ceases at Coimbatore, the nature of positive influence is less marked when compared with that of the previous three months.

(*b*) Only in the months of December and January, representing the commencing period of dew formation at Coimbatore, the other factors like gross minimum temperature, vapour pressure and maximum temperature have noticeable significant influence on dew formation. The ranking of these three factors are indicated hereunder in descending order :—

Gross minimum temperature;

Vapour pressure; and

Maximum temperature.

(c) Only in the month of December, i.e., in the initial stage of dew formation at Coimbatore the deviation of gross minimum temperature from the screen minimum temperature has a significant influence on the amount of dew formation.

(d) in regard to wind velocity at 4 feet height, it has mild significant influence on the amount of dew formation only in the month of December

(iii) The details of variations in gross minimum temperature and morning relative humidity with reference to dew formation ranging from 0 to > 3 are presented in Table III. A critical study of this tabular statement will reveal the following tentative inferences :—

(a) If the fall in the reading of the gross minimum thermometer is above 3°F in the months of December and January it may be taken as an indication that dew formation will be appreciable and of the order of 3 and above.

(b) Generally there seems to be an increase in the morning relative humidity ranging from 1 to 6 in the months of December and January, if the dew formation is appreciable and of the order of about 3. But the present indication is that the change in the morning relative humidity cannot be taken as a forecasting factor for dew formation under Coimbatore conditions. This may be due to the fact that in Coimbatore heavy dew formation is not a frequent and continuous occurrence.

Summary and conclusions.—(a) The tentative inferences drawn the present study are briefly indicated hereunder :—

(i) The dew formation period at Coimbatore commences early in December and lasts up to the third week in March. Both in the initial and final stages it is rather vigorous in its development.

(ii) Only the morning relative humidity exercises significant influence on dew formation right throughout the period.

(iii) The other meteorological factors like gross minimum temperature, vapour pressure and maximum temperature have significant influence on dew formation only in the months of December and January.

(iv) Deviation of gross minimum temperature from screen minimum temperature and wind velocity at 4 feet height influence dew formation only in the month of December.

(v) The data collected so far indicate that if the fall in the reading of the gross minimum thermometer is above 3°F in the months of December and January, it may roughly be taken as an indication that dew formation will be of the order of 3 and above.

(vi) Increase, ranging from 1 to 6 in the morning relative humidity in December and January broadly indicates that the dew formation will be of the order of about 3 and above. But as it is, it cannot be accepted as a reliable indication.

(b) If the data are collected for some more years, it may be possible to predict the nature of dew formation from the readings recorded with the gross minimum thermometer. In fact, in North India, where forest formation is a common yearly feature, the readings taken with this instrument are made use of for issuing frost warnings to the wheat growers. Likewise it may be possible to issue dew formation warnings to the paddy growers in and round about Coimbatore in the course of a few years.

Acknowledgment.—The authors' thanks are due to Kumari T. P. Anna for her assistance in the compilation of the concerned data. Their thanks are also due to all those, who have been responsible for the collection of the data on dew formation and also the other meteorological data made use of in this study.

References.—(i) Padmanabamoorthy, B. and Subramanyam, V.P., Jl. of Scientific and Industrial Research, Vol. 19-A, No. 2, February 1960, P-82.

(ii) Venkiteswaran, S. P. and Venkataraman, R., Indian Jl. of Meteorology and Geophysics, Vol. 9, 1958, P. 363–70.

TABLE I.

Intensity of Dew Formation at Coimbatore.

Serial number.	Amount of Dew formation	December 1958.	December 1959.	January 1959.	January 1960.	February 1959.	February 1960.	March 1959.	March 1960.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	Trace.	4	2	3	6	9	4	2	1
2	1·0	4	..	7	3	6	5	3	2
3	2·0	2	..	3	3	2	2	1	1
4	2·5	..	..	..	1	..	..	..	..
5	3·0	2	3	3	2	..	1	..	1
6	3·5	..	..	..	2	..	1	..	2
7	4·0	1	1	..	..	..	..	..	..
8	4·5	..	2	..	..	..	..	..	1
9	5·0	..	2	..	1	..	1	..	1
10	5·5	..	4	..	..	..	1	..	3
11	6·0	..	2	..	..	1	..	..	1
12	6·5	..	..	..	..	..	..	..	..
13	7·0	..	1	..	..	..	..	..	..
14	7·5	..	1	..	..	..	..	..	..
Total number of dew days (A)		13	18	16	18	18	15	6	13
Total number of dew days, amount being 3·5 and above (B) ..		1	13	..	3	1	3	..	8
Precentage of B/A.		7·7	72·2	6·3	16·7	5·6	20·0	16·7	61·5
Average Percentage.		40·0		11·5		12·8		39·1	

TABLE II.

Correlation between Dew formation and Meteorological Factors at Coimbatore.

Serial number	Correlation between dew formation and Meterological Factors.	December A	December B	January A	January B	February A	February B	March A	March B	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	Maximum temperature.	−0·44 ± 0·13	Y**	−0·25 ± 0·13	Y*	−0·08 ± 0·13	N	−0·26 ± 0·17	N	A = r ± S.E. B = Nature of significance.
2	Gross minimum temperature.	−0·68 ± 0·11	Y***	−0·57 ± 0·11	Y***	−0·12 ± 0·13	N	+0·19 ± 0·17	N	Y = Significant N = Not significant
3	Deviation of gross minimum temperature from screen minimum temperature	+0·43 ± 0·13	Y**	+0·25 ± 0·13	N	+0·17 ± 0·13	N	−0·10 ± 0·18	N	* = P = 0·05 (*) = P = 0·02 ** = P = 0·01 *** = P = 0·001
4	Morning relative humidity.	+0·48 ± 0·13	Y***	+0·40 ± 0·12	Y***	+0·40 ± 0·12	Y***	+0·37 ± 0·16	Y(*)	
5	Mean relative humidity.	+0·01 ± 0·15	N	+0·02 ± 0·13	N	+0·23 ± 0·13	N	+0·21 ± 0·17	N	
6	Vapour pressure.	−0·52 ± 0·13	Y**	−0·35 ± 0·12	Y**	+0·07 ± 0·13	N	−0·33 ± 0·17	N	
7	Wind velocity at 4 feet height.	−0·30 ± 0·14	Y*	−0·13 ± 0·13	N	+0·07 ± 0·13	N	−0·09 ± 0·18	N	

TABLE No. III.

Prior indication of dew formation.

Serial number and amount of dew formation in code numbers.	December		January		February		March		Remarks.
	A	B	A	B	A	B	A	B	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0 to Tr. ..	..	..	— 2·1	+ 4	— 7.1	Nil	— 9·1	+ 2	(1) A = Gross Minimum Temperature in oF.
			— 8·5	+ 2	—11·8	Nil			
			— 1·5	+ 1	+ 2·2	+ 18			
			+ 4·3	— 3					
			— 5·3	+ 4					
2. 0 to 1 ..	— 6·2	+ 1	— 8·3	+ 4	— 9·5	+ 3	— 2·7	— 6	(2) B = Morning Relative Humidity as percent.
			— 3·8	— 1	—11·5	Nil	— 3·7	—11	
			— 9·0	+ 4	+ 3·1	+ 8			
					— 5·3	+ 2			
3. 0 to 2 ..	— 2·8	+18	— 5·4	— 1	— 2·0	— 1	..	..	(3) Tr. = Trace.
			— 7·1	— 3	— 8·2	+ 5			
4. 0 to 3 ..	—12·1	+ 2	—14 0	+ 5	..	..	..	..	
	— 8·4	+ 6	— 4·6	+ 5					
	— 3·1	+ 2	— 3·4	+ 1					
5. 0 to > 3 ..	— 4·2	Nil	..	..	— 3·2	— 7	..	..	
	— 6·3	— 1							
	— 5·7	Nil							
6. Tr. to 1 ..	— 4·9	+ 3	— 1·4	+ 2	+ 1·0	+ 4	+ 2·9	+ 2	
			— 0·1	— 4					
7. Tr. to 2 ..	..	..	— 2·9	+ 2	— 4·6	+ 4	+ 2·1	+ 4	
			— 9·3	— 3					
8. Tr. to 3 ..	..	..	..	..	..	..	..	..	
9. Tr. to > 3 ..	— 3·1	+ 2	— 3·8	+ 6	..	..	..	..	
10. 1 to 2 ..	+ 1·1	— 1	+ 3·3	+ 4	+ 0·1	+ 2	..	..	
11. 1 to 3 ..	+ 1·7	+ 1	— 0·7	+ 4	..	..	+ 0·4	+ 4	
12. 1 to > 3 ..	..	..	— 1·9	+ 5	+ 3·4	+ 4	..	..	
13. 2 to 3 ..	..	..	..	..	— 4·9	+ 1	..	..	
14. 2 to > 3 ..	..	..	..	..	..	..	+ 1.8	—13	

DEW FORMATION AT COIMBATORE.

By C. Balasubramanian and Komalam P. Nayar.

Presented by Komalam P. Nayar.

Discussion.—Dr. N. R. Bhat, Director, Central Sugarcane Research Institute, Coimbatore and President of the First Meeting of the Academy of Agricultural Sciences wanted to know the reason for considering the months separately. Further he expressed that the values of correlation coefficients of the morning relative humidity and dew formation were low. He also suggested the working out of a multiple correlation taking gross minimum temperature and morning relative humidity as two independent factors, with dew formation as the dependant factor.

Sri C. Balasubramanian, Agricultural Meteorologist replied that the months of December to March fall in different seasons, namely, North-East Monsoon period (December), Dry weather period (January and February) and Hot Weather period (March) and hence the data were analysed separately month var. In regard to the values of correlation coefficients of morning relative humidity and dew formation the levels of significance were very high, being $P=0{\cdot}001$ for the months of December, January and February and $P=0{\cdot}02$ for the month of March. The suggestion for working out multiple correlation will be carried out when some more data are collected.

Dr. A. Mariakulandai, Professor of Agronomy, suggested the study of profiles in the atmosphere. The Agricultural Meteorologist replied that this study will be taken up when suitable facilities are provided.

Sri C. P. Natarajan, Assistant Agricultural Chemist, desired to know the duration of dew formation. He was informed that the dew formation occurs late in the mid-night and continues till the early hours of the next day.

Sri Mohammed Ali, Assistant Agricultural Engineer (Research) wanted to know the relationship existing between cloud formation and dew formation and whether the magnetic forces and solar radiation have any bearing on the formation of clouds and dew and whether the dew is charged positively or negatively as in the case of clouds. The Agricultural Meteorologist said that there is no relationship between dew and cloud formation. Cloud has a defined form while dew has not. In dew there is no electric charge. Solar insolation has no effect on dew formation. In fact dew, mist, etc., form only after the sun sets and vanish after the sun rises.

Sri M. D. Prabhu, Lecturer in Agronomy asked whether it would be possible to forecast the period of dew formation from the analysis of the previous data. The Agricultural Meteorologist replied that under Coimbatore conditions dew formation commences early in December and lasts up to the third week of March. Dew formation period will vary from place to place. When sufficient data are collected, prediction of commencement of dew formation may be possible.

Sri T. Srinivasan, Post-graduate student asked as to whether there is any correlation between the quantum of dew formation and yield of dry land crops. The Agricultural Meteorologist replied that dew is an inestimable source of moisture for dry land crops. For instance, the *Cicer* crop in dry lands gets the maximum benefit from dew formation. In the arid and semi-arid regions of the world dew formation is of great importance to plants as an inestimable and valuable source of moisture.

Sri C. V. Govindaswamy, Lecturer in Mycology said that blast incidence on paddy is noted even in the month of September under Coimbatore conditions and wanted to know as to whether dew formation could be expected in this month. He was replied that only violent changes in the morning relative humidity could occur in September and they might be responsible for the incidence of blast on paddy in September. Actual dew formation commences at Coimbatore only early in December.

(xiii) PERFORMANCE OF FOREIGN VARIETIES OF SUGARCANE AT CUDDALORE (A PRELIMINARY STUDY).

BY C. EKAMBARAM, R. PERUMAL RAJA AND V. K. APPAJI
(Central Sugarcane Research Station, Cuddalore.)

Introduction.—Introduction of better varieties of Sugarcane is an important item in the programme of development of the crop. Better varieties can be bred within the country taking into account the needs of the different regions or outstanding foreign varieties can be introduced and tried. Tremendous success has already been achieved by the Coimbatore bred canes, which in the main combines in itself the blood of *Saccharum officinarum*, and *Saccharum spontaneum*. In general, introduction of foreign varieties may have limited scope owing to variation in climatic and seasonal factors and environmental conditions. However in sugarcane, successful introduction of foreign varieties is nothing foreign. Before the coming-in of the Coimbatore bred canes in cultivation like Co. 213, Co. 281 and Co. 419, etc., in the early thirties, most of the area in the South, was under the cultivation of foreign varieties like B. 208, striped Mauritius, Purple Mauritius and J. 247, and they have been holding the field for a sufficiently long time, till 1937, until, they were replaced by the Coimbatore seedling cane, Co 419. It may be stated that the present wonder cane Co. 419 which is dominating for over two decades and still occupies 82 per-cent of the area under sugarcane in the State, contains the blood of the foreign variety POJ. 2878, which itself was reputed as the wonder cane of Java. Hence search for outstanding foreign varieties of sugarcane opens up a fruitful line of improvement. Even in case, no foreign variety can be directly introduced as such for general cultivation, they can be at least utilised as breeding material for transmitting some of their outstanding qualities.

The Sugarcane Breeding Institute, Coimbatore, has been recently sending a number of foreign varieties for study. It was therefore considered useful to review their performance at Cuddalore so that it may serve to bring out their qualities.

Review of Literature.—Reviewing the performance of some of the important Canal Point varieties under Coimbatore conditions and their use as parent material for breeding, Panje and Ethirajan (1958) reported that though the initial hybridisation work was carried out with use of the foreign and Indian canes, successful breeding was done only after making use of the wild species *S. spontaneum*. However, a large number of foreign varieties like POJ. 2878, B.3412, CAC. 87, CP. 807, D. 74, etc., were imported and used as parents in the later breeding work. Some of the canes from Java and U.S.A. tried at State Research Stations proved a failure for commercial cultivation and some of them were restricted for commercial

cultivation by proprietory rights of the concerned breeding organisation. Further, the diseases, climatic and cultural conditions in this country circumscribe spread of the foreign varieties. However some varieties may prove successful.

Material and Methods.—Eleven foreign varieties, viz., Q. 49, Q. 50, Pindar, N. Co. 291, N. Co. 351, TUC. 521, CP29/320, CP33/324, CP34/79, CP36/105 and CP49/50 belonging to Queensland, Natal and U.S.A. were received from the Sugarcane Breeding Institute, Coimbatore in 1957. They were multiplied during the year and studied in small duplicate study plots during the years 1958–59 and 1959–60 along with the other varieties and the standards, for all their economic characters like germination, tillering vigour, arrowing, yield, juice quality and susceptibility to pests and diseases. Promising ones among them were also tried in the preliminary yield trial for one year during 1959–60. The above varieties were also studied at the farm of the East India Distilleries and Sugar Factories, Limited, Nellikuppam during 1958–59 and 1959–60.

Similarly, six foreign varieties were received in 1958 and studied for one year during 1959–60. They were CP36/111, CP44/101, CP44/153, CP47/193, N.Co. 339 and POJ. 3016.

Fourteen foreign varieties, viz., Q. 57, Q. 58, N. Co. 310, N. Co. 376, CP50/11, CP50/28, Ragnar, Trojan, B. 37161, B. 37172, C.B. 38-22, C., 278, M. 112/34 and R.R. 900 were received during 1959. They were multiplied and put under study for the first year during 1960–61.

Results and Discussion.—The average results of the study of all their economic characters in the varietal study plots are furnished in tables I to IV.

(i) *Germination.*—Only short crop seed material was used for planting. Germination varied from 39·9 percent to 58·9 percent, it being lowest in CP 34/79 (39 percent) and highest in CP 29/320 (58·9 percent). Germination in some of the high quality canes like CP 34/79, CP 49/50 and Pindar was lower. In general, the germination compared favourably with the standards, Co. 419, Co. 449 and Co. 527. But the varieties received during 1958 were inferior to the standards Co. 419, Co. 449 and Co. 527 in germination.

(ii) *Tillering.*—Tillering was recorded in the third month after planting by counting the total number of shoots and expressing in terms of germinated bud.

Tillering varied from 2·8 to 3·7. It was best in TUC. 521, a thin cane and least in Q. 49, a thick cane.

TUC. 521, C.P. 34/79, C.P. 49/50, N. Co. 351 and N. Co. 339 recorded better tillering than the standards Co. 419 and 449 (Vide Tables I and IV).

(iii) *Arrowing.*—Arrowing took place by November. There were stray cases of arrowing only in four varieties, C.P. 29/320, C.P. 36/105, N Co. 291 and CP 47/193 except in CP 44/153 which arrowed to an extent of 25·6 per cent.

Even among the standards, only Co. 527 arrowed to an extent of 4 per cent.

(iv) *Weight of individual cane.*—Only two varieties, viz., Pindar (3·30 lb.) and Q. 49 (3·25 lb.) recorded higher weight per individual cane than the standards Co. 419 (3.10 lb.), Co. 449 (2.70 lb), and Co. 527. (2·60 lb.).

In the rest of the varieties it ranged from 1;25 lb. in N. Co. 351 to 2·0 lb. in Q. 50.

(v) *Pests and Diseases.*—Incidence of early shoot borer (*Chilotraea infuscatella, S*) was high in the varieties Pindar, CP 34/79 and N. 291.

Severe attack of top borer (*Scirpophaga nivella*) was noticed in the varieties N. Co. 291, Q. 50, Q. 49.

Only three varieties CP 33/324 and CP 29/320 were found susceptible for " Smut " Disease.

Though incidence of ' Mosaic ' was noticed in all the varieties it was high in the varieties Pindar, N. Co. 351, CP 33/324 and CP 44/53.

(vi) *Juice quality.*—Juice analysis was done every month from December to April and C.C.S. percent is given in Table I. All the foreign varieties except TUC 5211 recorded higher C.C.S. per cent than the standards. in December. CP 49/50 was particularly rich with 11·26 per cent C.C.S. as early as December followed by Pindar 10·73 per cent C.C.S. CP 34/79 and CP 36/105 also recorded over 10 per cent C.S S. by December.

During the peak maturity period February–March the varieties CP 34/79 (13·29 per cent), Q. 49 (13·26 per cent), Pindar (13.8 per cent) and CP 49/50 (12·59 per cent) recorded higher C.C.S. per cent than Co. 449 (12·32 per cent) which was the best among the standards.

During late season in April CP 34/79 was again the best with 13·97 C.C.S. followed by Pindar (13·87 percent), Q. 49 (12·97 percent) and CP 49/50 (12·76 per cent).

All the other foreign varieties recorded much lower juice quality than the standards in April.

The juice quality of TUC 521 was particularly poor throughout. CP. 34/79 distinguished itself as an outstanding quality cane, suitable for crushing in all seasons and maintaining high juice quality particularly in the late season. The quality of CP. 49/50, Pindar and Q. 49 was also quite good.

(vii) *Yield and C.C.S. in tons per acre.*—None of the foreign varieties yielded more tonnage of cane than the standard variety Co. 419. However, the yields of CP. 34/79 and Q. 49 were high with over 48 tons of cane per acre followed by CP. 49/50 (43·6 tons). From the point of C.C.S. in tons per acre CP. 34/79 was the best (6·43) followed by Q. 49 (6·39) and CP 49/50 (6·10). The standard varieties Co. 527, Co. 449 and Co. 419 recorded 5·8 to 6·0 tons of C.C.S. per acre.

Preliminary yield trial of early varieties—1959–60.—Five varieties CP. 33/324, C.P. 34/79, CP. 36/105, CP. 49/50 and Pindar were compared with the standards Co. 449 and Co. 527 in a replicated and randomised trial. The results are given in Table II.

None of the foreign varieties yielded more than the standard. However, all of them were better in quality of juice. CP. 34/79 was particularly good followed by Pindar, CP. 49/50 and CP. 33/324.

Performance of the varieties at the factory farms—Nellikuppam.—All the above varieties were studied at the farm of the East India Distilleries and Sugar Factories Limited, Nellikuppam and the results are given in Table III. The results also confirm the superior qualities of the varieties CP. 34/79, CP 49/50, Q. 49 and Pindar.

Foreign varieties received during 1958–59.—The results of one year performance of the foreign varieties recorded during 1958 are given in Table IV. Out of the six varieties received two varieties CP. 36/111 and CP. 44/101 were rejected due to their susceptibility to rust disease. Another variety POJ. 3016 was also rejected as it proved already inferior to the standards. None of the remaining three varieties, viz., N. Co. 339, CP. 44/153, CP. 47/193, were superior to the standards in all respects.

Superior quality of foreign varieties.—Out of 11 foreign varieties tried four varieties CP. 34/179, CP. 49/50, Q. 49 and Pindar recorded high juice quality and only three Coimbatore varieties, viz., Co. 1178, Co 1200, Co. 1221, out of the 60 varieties studied along with foreign varieties, were on par with the above foreign varieties in juice quality. But in respect of yield, 21 varieties out of the 60 Coimbatore varieties yielded better than the high yielding ones among the foreign varieties (viz., CP. 34/79, Q. 49 and CP. 49/50).

This clearly brings out the superior juice quality of the foreign varieties over Coimbatore canes.

Among the 14 foreign varieties received during 1959, Q. 58 is having very good vigour and stand and appears promising. Further study is in progress.

Comments on individual varieties.—The following are the remarks on the performance of the foreign varieties received during 1957 :—

Q. 49—	A thick, rich purplish cane resembling Co. 419, vigorous with erect habit medium tillering soft rind and solid core. It is a self trashing variety—An all season cane maintaining its quality even late in the season. Fairly good yielder.
Q. 50—	A medium thick purplish violet cane with medium vigour, erect habit and hard rind. Mid season cane with moderate yield—Fairly good tillerer. Highly susceptible to Top borer attack.
Pindar.	A thick violet rich all season cane with medium vigour spreading habit, thick ashy coating soft rind and solid core. It is a brittle cane with characteristic, splitting of the internodes particularly in late tillers. A self trashing variety. Highly susceptible for borers and Mosaic. Tillering not up to the mark—Moderate yielder.
N. Co. 291.	Medium thin yellowish purple cane with medium vigour—Mid season cane—Medium tillerer—Fairly good germinator. Highly susceptible for Top borer attack—Moderate yielder.
N. Co. 351.	Medium thin yellowish cane with early vigour, good tillering and stand—Quality not good—Poor yielder—Highly susceptible to Mosaic.
T. U. C. 521.	Thin purplish cane with medium vigour—erect habit—Good tillering and stand—Poor in juice quality and yield.

C.P. 29/320 (Co. 281 × CP 27/34) Flowering variety.	Medium thin violet cane—Early mid cane with good vigour, erect habit and very good stand—Susceptible to Smut disease—Very good germinator—Moderate yielder.
C.P. 33/324 (C.P. 27/139 × C.P. 31/432).	Medium thick cane, Yellowish early-Mid cane with medium vigour and spreading habit—Stand of the crop is not good. Susceptible to smut and Mosaic.
C.P. 34/79 (P. J. 2878 × Badila) × C.P. 116).	A medium cane violet in colour with early vigour and good tillering—erect habit—fairly good in stand narrow erect leaves resembling Co. 281. A rich all season cane particularly maintaining high sucrose in the late season. Fairly good yielder and the best among the foreign varieties.
C.P. 36/105 (Co. 281 × C.P. 1165).	Medium thin purplish cane with good early vigour, erect habit and very good in stand—Fairly good tillerer—all season cane with fairly good yield. Highly susceptible to top borer attack.
C.P. 49/50—	Medium cane purplish with early vigour, erect habit with good tillering and stand—All season cane with very high sucrose content—Fairly good yielder.

Summary and conclusion.—Though much success has been achieved in the breeding of better varieties of cane at Coimbatore, trial and introduction of foreign varieties may also lead to fruitful results. The eleven foreign varieties released from the Sugarcane Breeding Institute, Coimbatore during 1957 were multiplied and studied during 1957–59 and 1959–60. Six foreign varieties released during 1958–59 were also studied for one year during 1959–60. The results of their performance are embodied in this paper.

Except TUC. 521, N. Co. 339 and CP. 44/153 all the varieties were better in juice quality than the standards in the early season (December). Four varieties out of eleven (viz), C.P. 34/79, Q. 49, Pindar and CP. 49/50 were outstanding quality canes maintaining high juice quality even during the late season in April, whereas only three Coimbatore varieties out of 60 Co. varieties studied, were outstanding quality canes maintaining high juice quality as the above foreign varieties proving the superiority of the foreign canes in juice quality. Most of the Co. canes were high yielders.

From the point of yield of cane the foreign varieties were less than the standard Co. 419. However the varieties CP. 34/79 and Q. 49 were similar to the standards Co. 449 and Co. 527.

Owing to high juice quality CP. 34/79, Q. 49 and CP. 49/50 have recorded higher C.C.S. in tons per acre than the standards. These promising varieties deserve further trial. They can also possibly be used as breeding material for infusing better quality in our canes.

Acknowledgment.—Thanks are due to the Indian Central Sugarcane Committee which is partly financing the Scheme of Sugarcane Research in this State. Thanks are also due to Messrs. East India Distilleries and Sugar Factories, Limited, Nellikuppam, for kindly furnishing the results of the performance of the varieties on their farm.

Literature.—Panje R.R. and Ethirajan, A.S. 1958—"Notes on Foreign cane varieties"—Ind. Jour. Sug. Res. and Dev. Vol. II. Part 2, January-March 1958.

Table I.

Consolidated data of two years study—Central Sugarcane Research Station, Cuddalore. Foreign varieties received during 1957–58.

Serial number and variety.	Germination percent.	Tillering capacity per germinated bud.	Arrowing percent.	Number of canes harvested per acre.	Yield in tons per acre.	Average weight per millable cane in lb.	Juice analysis data—C.C.S. percent.					C.C.S. in tons per acre.
							December.	January.	February.	March.	April.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1 Q. 49	46·7	2·8	Nil.	34,200	48·4	3·25	7 74	10·92	12·61	13·26	12·97	6·39
2 Q. 50	44·7	3·2	Nil.	25,750	34·9	2·00	6·85	8·39	12·05	12·00	11·52	4·05
3 Pindar	46·2	3·0	Nil.	29,500	39.6	3·30	10·73	10·51	12·37	13·08	13·87	5·24
4 N. Co. 291	55·9	2·9	1·2	63,000	43·1	1·65	7·32	7·96	11·05	10·00	8·99	4·76
5 N. Co. 351	53.7	3·4	Nil.	55,750	30·8	1·25	8·44	9·12	10·12	8·99	9·21	3·22
6 TUC 521	45·2	3 7	Nil	46,000	26·9	1·40	2·79	6 15	10·00	9·67	6·89	2·60
7 CP 29/320	58 9	3·1	4·0	60,750	35·1	1·35	9 06	11·23	11·94	11·67	8·51	4·12
8 CP 33/324	50.4	3·1	Nil.	30,750	31·5	1·90	9·50	10·02	11·86	12·00	9·13	3·95
9 CP 34/79	39·9	3·5	Nil.	39,000	48·9	1·55	10·24	12·57	12·73	13·29	13·97	6·43
10 CP 36/105	50·1	3·2	1·25	71,500	45·3	1·55	10·03	10·36	12·07	11·19	11·00	5·10
11 CP49/50	41·8	3·5	Nil.	57,750	43·6	1·80	11·26	11·50	12·54	12·59	12·76	6·10
12 Co. 419	45·4	3·2	Nil.	44,000	53·3	3·10	7·51	5·22	10·41	10·30	10·77	6·05
13 Co. 449	47·5	3·3	Nil.	44,100	47·0	2·70	7·48	5·77	12·32	11·52	11·94	5·92
14 Co. 517	36·5	3·8	3·20	50,850	48·4	2·60	6·94	6·10	11·59	11·04	11·29	5·79

Table II.

Performance of foreign varieties in preliminarg yield trial (early) during 1959–60.

Serial number and variety.	Yield per acre.		Number of canes harvested per acre.	Juice analysis prior to harvest.			C.C.S. in tons per acre.	Remarks.
	In tons.	In maunds.		Sucrose per cent.	Purity. per cent.	C.C.S. per cent.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1 C.P. 33/324	35·4	964	28,700	17·24	89·36	12·13	4·3	
2 C.P. 34/79	35·0	953	37,200	19·08	90·76	13·53	4·7	
3 C.P. 36/105	44·6	1,214	50,700	15·32	83·66	10·49	4·7	
4 C.P. 49/50	39·1	1,064	38,900	17·18	87·33	11·93	4·7	
5 Pindar	23·5	640	18,400	18·24	89·45	12·90	3·0	
6 Co. 449	55·0	1,497	43,800	15·12	87·28	10·29	5·7	
7 Co. 527	52·1	1,421	50,800	14·59	84·89	10·02	5·2	

Table III.

Performance of foreign varieties at East India Distilleries and Sugar Factories Farms at Nellikuppam—Consolidated data of two years 1958–59 *and* 1959–60.

Serial number and variety.	Population per acre. at harvest	Weight per millable cane.	Juice analysis data.											
			December		January		February		March		April		May	
			POL per cent.	Purity per cent.	POL per cent.	Purity per cent.	POL per cent.	Purity per cent.	POL per cent.	Purity per cent.	POL per cent.	Purity per cent.	POL per cent.	Purity per cent.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13	(14)	(15)
1 Q 49	33,600	3·5	18·82	94·06	16·54	87·80	18·15	87·34	..	..	..	..	..	..
2 Q 50	54,400	3·1	17·21	91·03	17·87	89 60	18·51	87·82	..	..	..	..	..	..
3 Pindar	32,000	3·1	16 52	90·26	17·67	88·59	19·03	86·60	..	..	..	..	..	..
4 N· Co. 291 ..	62,200	1·2	12·34	83·30	13·46	89·40	14.08	81·81	16·32	86.90	15·49	84·35	10·79	68·13
5 N· Co· 351 ..	55,800	1·5	12·71	81·20	10·05	80·13	15.77	88·61	16.73	88·80	15·89	83·62	14·12	79·58
6 T.U.C· 521 ..	43,900	1·2	7·47	60·97	10·89	72·90	10.09	69·83	9·83	66·95	11·22	66·55	10·52	61·75
7 C.P 29/320 ..	55,400	1·9	16.16	88·44	18.81	90·24	16.62	86·11	18.30	90·72	18·24	88·23	16·50	83·07
8 C.P. 33/324 ..	38,700	·2·7	13·68	84·45	17·68	89.10	16.76	88·39	18·29	92.46	15·68	85·27	16·62	85·50
9 C.P. 34/79 ..	45,130	1·9	17·65	90·32	19·80	90.76	18·15	88·53	19·82	91.88	19·23	88·98	17.47	84·79
10 C.P· 36/105 ..	54,800	1·9	14·32	82·91	17·42	88·41	16·65	85·67	15·99	85·61	15·16	77·52	13.70	75·11
11 C.P. 49/50 ..	53,150	1.9	16·67	88·12	16·82	88.86	15·13	80·53	20.12	91·39	17·62	87·52	13·98	77.59

TABLE IV.

Performance of foreign varieties—1959–60 received during 1958–59 S.R.S., Cuddalore.

Serial number and variety.	Germination per cent.	Tillering per cent.	Arrowing per cent.	Number of canes harvested per acre.	Yield in tons per acre.	Average weight per millable cane in lb.	Juice analysis data—C.C.S per cent.					C.C.S, in tons per acre peak maturity period.	Remarks.
							December.	January.	February.	March.	April.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1 N. Co. 339 ..	56·45	3·0	..	55,000	40·58	1·5	8·13	7·98	8·94	9·38	7·24	3·81	Susceptible to smut. Early shoot borer incidence 13·4 per cent. Top-borer incidence 20·1 per cent.
2 C.P. 44/153 ..	49·16	2·6	25·6	40,000	41·24	1·6	8·28	9·77	7·14	9·00	8·53	3·72	Very high incidence of Mosaic. Early shoot borer incidence 10·6 per cent. Top-borer incidence 22·6 per cent.
3 C.P. 47/93 ..	47·70	2·4	9·5	50,000	35·80	1·6	10·40	10·39	10·66	11·33	9·04	4·06	Early shoot borer incidence 9·5 per cent. Top-borer incidence 10·9 per cent.
4 Co. 419 ..	67·21	1·9	..	40,500	50·20	3·9	6·29	7·70	10·59	11·11	10·61	5·58	
5 Co. 449 ..	59·39	2·7	..	43,100	47·70	[illegible]	8·91	9·35	11·46	12·25	11·19	5·84	
6 Co. 527 ..	49·40	3·6	4·4	50,100	49·16		[illegible]13	7·88	11·21	11·53	11·41	5·32	

Varieties C.P 36/111 and C.P 44/101 were rejected from studies already inferior to the existing standard varieties. [illegible]ity to Rust disease and POJ. 3016 was rejected as it had proved

PERFORMANCE OF FOREIGN VARIETIES OF SUGARCANE AT CUDDALORE—A PRELIMINARY STUDY.

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No remarks.

VOTE OF THANKS BY THE SECRETARY, RESEARCH COUNCIL.

It is my pleasant duty to be here to give you a vote of thanks as the Secretary of the Research Council. On behalf of the Research Council and on behalf of the Academy of Agricultural Sciences and on my own behalf and on behalf of the Scientists of the Institute and breeding stations, I offer our sincere thanks to our Honourable Minister for inaugurating this Academy of Agricultural Sciences, Coimbatore, in spite of his multifarious activities. He has taken much trouble to go over and join us for this inauguration. I failing in my duty if I do not offer our thanks to our Director of Agricul- who has readily agreed to send the proposals to Government. I will ailing in my duty if I do not offer my thanks to our Secretary to Govern- ho has sanctioned the proposal and who is in touch with the Academy. ou all, Ladies and Gentlemen, for gracing this occasion and making n a success.