THE MADRAS AGRICULTURAL JOURNAL

Vol. XL SEPTEMBER 1953 No. 9

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TO LET

The Madras Agricultural Journal

Vol. XL September 1953 No. 9

Editorial

Thoughts for the Month: Every one — whether he is a politician, medical man, lawyer, business man, or a Governmental official is now having a mixed feeling of joy and sorrow. Joy is due to the fact that the division of the Madras State will give ample scope for pushing through various plans of development. Sorrow is on account of want of full faith and confidence in the prosperity of the divided States.

As Scientists the members of the Madras Agricultural Students' Union, have no such element of sorrow at all. It is a recognised fact that scientists belong to the nation at large and their commissions and omissions are to be assessed at international level. Particularly the scientists, engaged actively in furthering the lot of the tiller of the soil, know only one thing, i. e., their findings should have a wider range of applicability. In fact, the value of the finding of an agricultural scientist lies in its suitability for universal application.

The Madras Agricultural Students' Union, has been an organisation for the past thirty-six years, functioning as a common platform for the meeting of agricultural scientists, practical agriculturists and students of the Colleges of Agriculture in the Madras State. This Union wishes the newly formed Andhra State all prosperity and plenty with a very bright future. At the same time the Union appeals to the members of the Agricultural Department of the Andhra State to protect the interest of the Union in as best a manner as they can. The Union, in turn, assures them that it will do its best to add to the prosperity and sound future of the Andhra State.

May the Almighty shower His choicest blessings on the New Andhra State.

The Late Mr. P. D. KARUNAKAR

Born : 5th September 1900
Died : 9th September 1953

Sri P. D. Karunakar was born in Salem on the 5th September 1900 of an illustrious family of Indian Christians. His father the late Mr. K. T. Paul, General Secretary of the Y. M. C. A. was a well known international worker and a Christian leader of progressive and outspoken views. Sri Karunakar had his early schooling at Salem and after a short stay as student at the Agricultural College, Sabour, Bihar, left for the United States of America where he took the B. Sc. degree in Iowa and the M. Sc. in Bacteriology in Rutgers. He was a student of the eminent bacteriologist Selman A. Waksman, with whom he was associated in some of the investigations on humus formation.

He was appointed Agricultural Bacteriologist at the Agricultural College & Research Institute, Coimbatore in 1923, became Agricultural Chemist in 1947, and later was appointed Principal of the College in 1950. At the time of his death on 9th September 1953 he was Principal of the Sister College of Agriculture at Bapatla. In May he attended at Bantoung, Java, as a representative from India, the F. A. O. meeting of Experts on Soils and Fertilisers and later he was entrusted by that body with the organisation and conduct of the International Training Centre of Soil Fertility Workers at Coimbatore, as its Honorary Director from July to October 1952.

Sri Karunakar was an indefatigable worker who sometimes neglected his health at the call of duty. He was a stern but kindly disposed disciplinarian and there have been occasions when even with those he had been intimately associated with, he took an uncompromising attitude, on what he sincerely believed, were inviolable principles. As a member of the Chemistry Section his name was associated with many investigations, but amongst his major contributions with fellow workers can be mentioned (1) his work on the possibilities of Trichinopoly phosphate utilisation by sulphur bacteria; (2) his work on the decomposition of green manure in wetland conditions; (3) his schemes to improve the fertility of marginal lands and (4) investigations on the utilisation of molasses.

Besides his official duties Sri Karunakar took an active interest along with his talented wife Mrs. Catherine Karunakar, in social activities both on the estate and in Coimbatore Town, where they were well known figures for the last quarter of a century. He was also a keen *Shikari*.

May his soul rest in peace.

Pollen and Pollen-Tube Studies in Rice*

By

M. K. VENKATASUBRAMANIAN, B. Sc. (Ag.), M. Sc.

Introduction: It is a well-known fact that hybridisation plays a very important part in the improvement of all crops. Work on rice hybridisation has been in progress at Coimbatore for a period of nearly forty years. In the course of this hybridisation work it was noted that interspecific crosses often failed to set seed and it became evident that a knowledge of the morphology and physiology of rice pollen as well as a complete picture of the growth of the pollen tube within the pistil was necessary for tackling this problem successfully. The previous work on this aspect was very scanty and incomplete.

An investigation was accordingly made in 1939 – '42 on the following aspects: The possibility of germinating rice pollen in artificial media; the conditions required for such germination; how long the pollen remains viable; the rate of growth of the pollen tube down the style; whether any difference exists between the growth of diploid and polyploid pollen tubes and whether there is any difference in the rate of growth in starchy and glutinous rices in regard to pollen tube growth.

Since the discovery by Von Mohl that pollen of many species germinated readily in water, artificial germination of pollen has been tried by several workers. Schleiden (1842) used sugar and gelatine and Jost (1907) germinated pollen grains in sugar-agar media. Sawyer (1917) in *Iris versicolor* observed that the culture solution prepared by adding the sap oozing out from the stalks to 30% sugar solution was superior to 30% sugar solution alone in that in the former culture the tubes grew longer and were not distorted. Cooper (1939) has been able to induce better germination in the pollen of *Carica papaya* by the addition of thiamin, lactoflavin, ascorbic and indole – 3 – acetic acids to the culture medium. Vassiliev (1941) in tomato found that boron in the form of borax or boric acid promoted pollen growth, the best medium being 15% sugar solution plus 0·003% boric acid. Bair and Loomis (1941) found that in the artificial germination of maize pollen, a major factor of success is the degree of embedding of the pollen grains in the still soft agar, best results being obtained when grains were two-thirds embedded. Smith (1942) studied the effect of the addition of indole – 3 – acetic acid, indole – 3 – butyric acid, naphthalene-acetic acid, Vitamin B_1, and colchicine to the culture medium on the germination of the pollen of *Antirrhinum majus* and *Bryophyllum dœgremonum*. The effect of temperatures on these cultures was also investigated by him. He found that the auxins favourably stimulated pollen germination and growth. Evidence of favourable stimulation by Vitamin B_1 was not obtained while colchicine was found to depress germination and growth.

Material and methods: (a) *Material:* The extensive varietal collection available at the Paddy Breeding Station was utilized in these investigations. Observations were made both in the winter and the spring crops of rice using the following varieties:

* Part of the Thesis submitted to the Madras University for the M. Sc. degree examination, 1943.

1. *Diploid* (2n—24) : GEB. 24, CO. 1, CO. 6, CO. 8, CO. 10, CO. 13 and MTU. 9.
2. *Auto-tetraploid* (2n—48) : From GEB. 24 by colchicine treatment.
3. *Glutinous rice:* T. 120, White Puttu and Black Puttu.
4. *Cleistogamous rice:* T. 651.
5. *Wild rices: Diploid* (2n—24) *Oryza longistaminata.* Teraploid (2n—48) *Oryza eichingheri* and *Oryza latifolia.*

(b) *Methods:* Pollen required in large quantities for chemical analyses and enzyme studies were collected on large watch glasses in the field at the time of anthesis by tapping the panicles over watch glasses. The pollen was passed through a sieve to remove anthers and other extraneous matter. For germination studies in artificial media and morphological studies where smaller quantities are quite sufficient a dozen or more earheads containing the maximum number of unopened spikelets were cut two to three inches below the ring at about 10 A. M. and taken to the laboratory wrapped in wet cloth, then placed in a bottle of water. Within an hour the spikelets open, and the pollen is freely shed.

The following methods for tracing pollen tubes in the pistil are in general use: 1. *In situ:* In the case of thick styles as in *Datura* the outer cortical tissue is dissected out exposing the axial strand of conducting tissue in which the pollen tubes are found embedded. This exposed tissue is stained. 2. *In sections:* Pistils are embedded in paraffin, cut in serial sections and stained on the slide.

In the case of rice the technique had to be modified owing to the slender nature of the pistil. The entire pistil was stained at different intervals after anthesis with cotton blue in lactophenol. Spikelets were marked as they opened on a panicle and flowers thus marked out were collected at half-hour intervals up to four hours. The pistils were dissected out and placed in cotton blue iu lactophenol for four to six hours and cleared in lactic acid. After they had cleared well two or three of these pistils were mounted on a slide in a drop of lactic acid, the base of the ovary was incised. the stigmas were spread out and the cover glass was pressed. In some instances the ovules were pressed out uninjured and the pollen tubes could be seen on the integument with their tips inside the micropyle. The slides were sealed in asphalt lac or a mixture of gum mastic and paraffin.

To trace the course of the pollen tubes inside the ovary and for observations of the nuclei the pistils were fixed in Langlet's modification of Navashin's fluid or Allan's modification of Bouin's fluid at intervals of fifteen minutes upto two and a half hours after anthesis and later at half-hour intervals till four and a half hours. The pistils were embedded in paraffin, median longitudinal sections and transverse sections 15 μ to 20 μ were cut and stained in Haidenhein's iron-alum haematoxylin and

Fleming's triple stain. Since extra-nuclear bodies got stained by both these stains, for study of nuclei, sections were stained in Fuchsin sulphurous acid and counter-stained with Fast Green.

For studying the gametes, whose anthers were fixed at the time of anthesis in Langlet's modification of Navashin's fluid and sections were cut 6 μ thick and stained by the Feulgen and Fast Green technique.

Observation: *Pollen grains: Size, Chemical composition, Germination and Longevity:* (i) *Size:* Though there is a certain amount of variability in shape and size between pollen from different rice varieties, in any particular variety there is a remarkable uniformity of size; further, polyploid grains are bigger in size than the corresponding diploids; and pollen grains are more uniform in diploids and tetraploids than in triploids. This seems to be a natural corollary, as cell size is dependent on the chromosome number (Darlington 1937). The diameter of the tetraploid grains is about 1·25 time that of the corresponding diploid grains, indicating that in volume the tetraploid is nearly twice that of diploid grains.

(ii) *Chemical composition:* It has been observed (Czapek 1913, 1920, 1921) that pollen grains, just like seeds are provided with considerable food material. The moisture content of pollen in different species and genera of plants varies from 5 to 50% Even in the same species a variation from 5·25 to 10 5% has been observed but on an average the moisture content of pollen grain may be taken as 10%. Lidforss (1899) examining a number of species of pollen found the average moisture content to be 10%. Starch has been found in many kinds of pollen; as also small amounts of sucrose and glucose. In sugarcane too, it has been found that the main reserve materials in the pollen grains are sugar and starch.

In this investigation, pollen from a medium duration variety CO. 1 was chosen for examination and the chemical analysis of pollen grains was carried out according to standard methods.

The results of the analysis are presented below:

Enzymes	*Occurrence*	*Remarks*
Diastase	+	A high diastatic activity was noted.
Invertase	+	Very high activity.
Pectinase	+	Feeble.
Cytase	—	
Lipase	—	
Pepsin	+	
Trypsin	+	A high tryptic activity was noted.

Moisture	..	6·88%
Ether extractives	..	3·42%
Proteins	..	20·69%
Crude fibre	..	3·74%
Ash	..	3·20%
Carbohydrates* (by difference)	..	62·07%
		100·00%
* Reducing sugars	..	14·11%
Sucrose	..	25·18%
Starch	..	9·66%
Other carbohydrates	..	13·12%

From the results it is clear that the reserves are mainly carbohydrates and proteins, the former in the form of reducing sugars and starch. By qualitative microchemical tests it was established that the starch grains in pollen were from 2·7 to 5·4 μ in length. The presence of cellulose is indicated both in the pollen grains and in pollen tubes; callose and pectins were also noted to be present in pollen grains.

Enzymes: Several investigators have noted previously that various enzymes exist in pollen grains and play an important part in the nutrition of the pollen tube as well as in the penetration of the stylar tissues, by the pollen tubes. Erlenmeyer (1874) found evidence of diastatic activity in pine pollen. Green (1891) studied the digestion of starch in tissues of *Lilium* and concluded that "the starch was evidently in the process of digestion by the diastase, ministering to the formation of cellulose composing the walls of the tubes." Kamman (1904) found diastase, invertase, and a proteolytic enzyme in rye pollen. Paton (1921) reports the presence of diastase, invertase, pectinase, catalase, reductase, pepsin, trypsin and erepsin in the pollen of several varieties studied. Dutt and Ayyar (1930) observed the presence of diastase and invertase in sugarcane pollen. On analysis, rice pollen shows a high percentage of sucrose, starch and proteins while the other extractives are *not* low. As such, rice pollen was tested for the presence and relative activity of the enzymes, invertase, diastase, pepsin, trypsin and lipase and also for pectinase and cytase, as these are said to aid the penetration of stylar tissues by pollen tubes.

Diastase: Rice pollen has a high diastatic activity; the hydrolysis of starch being almost complete within the first 24 hours. When examined for the nature of the amylase system present it was found that both the saccharogenic and the dextrogenic types were present. In the glutinous variety of rice it is presumed that the dextrogenic amylase system is more active.

Invertase: Here too, rice pollen shows a high level of invertase activity the hydrolysis being complete within 24 hours itself. Pectinase activity on the other hand is only slight. Cytase and lipase were tested for and found to be absent in rice pollen. Among proteolytic enzymes pepsin was present at a high level of activity. Trypsin also was present in an active form.

Artificial germination of the pollen: Experiments on the artificial germination of rice pollen conducted in India, Japan and Philippines and at Coimbatore 1925 and 1934 had not been successful. As pollen viability is of great importance in rice breeding a fresh approach to this problem was felt desirable.

Experiments were tried on pollen from three varieties, an early duration type CO. 13, medium CO. 1 and late CO. 8; all trials were made

with water, before trying various other nutrient media. The following technique gave consistent and reproducible results in pollen germination (Venkatasubramanian 1943). Given proper humidity and temperature, rice pollen germinates without any culture solution. The humidity required is 100 per cent but it is important that it is not supplied by a sheet of water directly underneath the pollen, as the percentage of bursting was very high when humidity was maintained in this manner. It was found best, after a number of trials, to germinate the rice pollen inside a moist chamber. The bottom of the moist chamber was filled with water and a layer of cotton wool or filter paper soaked in water is placed inside. The pollen is dusted over a glass slide and the slide placed on the filter paper, with the pollen side upward. The moist chamber is then placed inside a chamber in which a temperature of 28—29°C is maintained. Grown in this manner, rice pollen gives from 50 to 60% germination and the length of the tubes varies from 130 μ to 140 μ, with a maximum of 238 μ.

In culture media, 10% sugar in an agar medium gave the highest germination, which, however, was only 14%. Addition of growth-promoting substances, like indole-3-acetic acid, thiamin, lactoflavin etc., in small quantities is reported by several workers to improve the germination and growth of pollen tubes but in respect to rice pollen no increase was noticeable either in pollen germination or in the length of pollen tubes by any of the substances noted in the table below:

Chemicals added to 10% sugar and 0·7% agar	Particulars	Remarks
Indole-3-acetic acid	1/10,000	No germination, protoplasm granular.
	1/100,000	do.
	1/1,000,000	Same as control *
1%, Diastase	One drop in 10 c.c. of medium.	No germination.

Germination in control (10% sugar and 0·7% agar) did not exceed 12%; maximum tube length was 47 μ.

Chemicals added to 10% sugar and 0·7% agar	Particulars	Remarks
1% Diastase.	5 drops in 10 c. c. of medium.	No germination.
	10 do.	do.
Yeast.	One drop of 0·1% yeast to 1 c.c. of medium.	2 or 3 tubes in a field as in the control.

Chemicals added to 10% sugar and 0·7% agar	Particulars	Remarks
	One drop of 1% yeast to 1 c. c. of medium.	do.
	One drop of 10% yeast to 1 c. c. of medium.	Burstings many. No germination.
Pistil extract.	50 pistils ground with pure sand in 10 c. c. of water.	
	One drop to 1 c. c. of medium.	Protoplasm granulated. No germination.
	One drop of 10 times diluted extract to 1 c. c. of medium.	do.
	One drop of 100 times diluted extract to 1 c. c. medium.	No germination.
Rice germ extract.	25 germs from sprouting seeds were ground with pure sand in 10 c. c. of water.	
	One drop to 1 c. c. of culture medium.	Protoplasm granulated.
	One drop of 10 times diluted extract to 1 c. c. of medium.	No germination.
	One drop of 100 times diluted extract to 1 c. c. of medium.	Same as control.
Honey (in place of sugar) & 0·7% agar.	Honey was added to the lukewarm agar solution.	
	2% honey.	No burstings. No germination.
	10% honey.	do.
	20% honey.	do.
Calcium nitrate.	0·01 M and 0·001 M.	Granular protoplasm. No germination.
Potassium chloride.	do.	do.

(4) *Effect of hydrogen-ion concentration on pollen germination:* Lloyd (1917) observed in *Lathyrus odoratus* that an increase in the rate of pollen-tube growth took place when acetic acid was added in concentration of N/25600 to N/1600 to 40% sugar solution. Brink (1925) concluded that pH may modify pollen-tube growth through a direct effect upon the chemical reactions attending the digestion of food reserves. Studies were made on rice pollen to test the effect of different H-ion concentrations on the germination and growth. A range of pH values from 5·28 to 8·04 was tested in media adjusted to different pH values by means of M/100 malic acid, N/100 sulphuric acid and N/100 sodium hydroxide. The culture media were spread on glass slides and dusted with pollen and then kept inside a moist chamber maintained at

28·5°C ± 0·5°C and 100% humidity. The results are presented in Table below:

Variety Co. 13

pH	Total No. of grains examined	No. of grains burst	No. of grains germinated
5·29	279	60	nil
5·59	237	30	..
5·91	292	74	..
6·24	244	80	..
6·47	258	84	..
6·64	195	4	..
6·81	277	1	..
6·97	190	14	..
7·17	260	6	..
7·38	192	nil	..
7·73	218	nil	..
8·04	271	nil	..
6·64 (Sugar agar)	241	62	32

Mixed sowing to induce pollen germination: This method was employed successfully by Branscheidt (1930). He found that pollen of *Lilium tigrinum*, which gave no germination in any culture media was induced to germinate by mixing the pollen with that of *Helianthus*. In a similar manner rice pollen was mixed with the pollen of *Vinca minor* and sown in a 10% sugar agar medium to see if the germination of rice pollen could be stimulated. Examination after one hour showed that only *Vinca* pollen had germinated and developed long tubes. Rice pollen did not germinate.

A consideration of the results on artificial germination of rice pollen shows that rice pollen is very exacting in its requirements for germination. Unlike the pollen of many graminaceous plants, which readily germinate in sugar agar media, the germination of rice pollen in artificial media has not so far been achieved with any measure of success. Addition of growth-promoting substances, various acids and chemicals to the sugur agar media has been of no help in providing a favourable substratum for the growth of the pollen tube of rice. In most cases, the pollen merely formed a few short tubes, without any further growth. When placed in media of low concentrations the contents in most of the grains burst; only a few grains showing protuberances that for all practical purposes could not be regarded as germination. In media of higher concentrations the presence of numerous unburst grains with knobs was characteristic. But the same rice pollen which refused to develop tubes in any culture medium germinated freely on a dry slide placed in a moist chamber maintained at temperatures between 28° and 29°C., and humidity 100% As to why the behaviour of rice pollen towards culture media and mere moisture should be so different, is not

easy to explain. The fact that in the moist chamber, the pollen grains not only germinated quite readily but under certain combinations of temperature and humidity also developed fairly long tubes, indicate that these provided the most favourable conditions for absorption, swelling and growth. But under conditions, where the water is added direct to the pollen, bursting usually results. It is likely that in such a case the excess water proves injurious in a purely physical manner. Such a phenomenon was considered by Brink (1924) as predominantly osmotic, although not entirely independent of the imbibitional processes of the pollen grains. It seems obvious from the low water content of rice pollen and the high percentage of protein colloids in it, that imbition is the chief though not the sole factor, in the swelling and bursting of the grains.

The cause of the pollen grains bursting in low concentrations of the medium is probably due to the rate of absorption being in excess of the swelling capacity of the grains. It is characteristic, however, that in all concentrations of the sugar agar medium no bursting of the pollen tube was observed. After the formation of some short tubes equal to or often less than the diameter of the pollen grains, further growth was completely checked. The cause of such premature cessation of growth of the pollen tube cannot be attributed to insufficient food supply and it seems probable that other factors are at work in checking growth.

The stigma of rice has been observed to contain no special secretions. It is held by Jost (1905), Martin (1913) and others that in germination of pollen grains, the function of stigmas that do not produce any secretions is to regulate the moisture supply. On the rice pistil, the pollen seems to get the requisite conditions of humidity for easy germination; the further growth of the tube inside the pistil being aided by the solvent action of the growing tip and by the enzymes produced therein. In culture media these conditions are rather difficult to get, so that the artificial germination of rice pollen is achieved only with great difficulty.

Longevity of rice pollen: In rice, varieties are found which differ very much in the time at which they come to flower. In hybridising these varieties it was noted that adjusting the time of sowing was not very effective since many of the varieties were season-bound. It was therefore felt that if pollen could be preserved for some time it would help in such hybridisations. Further, such preserved pollen could be transported to places where the female parent grows best. For hybridisation work in sugarcane long-distance shipment of pollen has been found quite successful (Sartoris 1942). Anthony and Harlen (1920) found that barley pollen remained viable for 24 hours in a cool dark room when enclosed in a loose van Tieghem cell with a piece of pea leaf as moisture-giving medium. Takashi (1927) found that in Japan 40%

humidity for barley and 50% humdity for maize gave the best results. However, he observed that the duration of pollen viability was rather short for these two cereals. Sugarcane pollen has been preserved by Dutt (1929) at temperatures between 5°C and 12°C and 85% humidity in an atmosphere of carbon dioxide for 13 days. Vijayasaradhy (1939) found that carbon dioxide atmosphere was not necessary and he successfully preserved sugarcane pollen for six weeks at temperatures between 9°C and 13°C and 90% humidity. Ayyangar and Rao (1936) were able to preserve *Sorghum* pollen for six days by keeping the pollen in paper packets at 10°C. Traub and O'Rork (1936) have been able to preserve *papaya* pollen for five months at 34°F and 13% humidity. It appears that temperature and humidity are the chief governing factors in pollen preservation.

Viability tests made on rice pollen at half-hour intervals after collection showed that the pollen loses its viability quickly under normal conditions of temperatures and humidity. Experiments were made to test preserved pollen 24 hours after collection. This period of 24 hours was fixed so as to obtain fresh stigmas for testing the viability of pollen and to avoid vitiating the results by using immature stigmas.

Pollen from C0 8, a winter crop was collected in the field on a clean glass surface at the time of anthesis and was transferred to dry and sterile tubes which were kept at 0°, 4°, 10° and 15°C. The pollen was tested 24 hours afterwards on fresh stigmas. The pollen was found to have caked and only that kept at 10°C showed a tendency for germination. Spikelets from matured, undehisced anthers were kept at 0°, 4°, 10° and 15°C and the pollen from these was tested 24 hours after storage. In this case also there was no germination and the pollen had agglutinated. To get over this difficulty spikelets were kept in a moist chamber at 10°C in which the humidity was maintained at 85%. Examination of the anthers 24 hours after storage showed that the pollen was powdery. The pollen when dusted on fresh stigmas germinated and 10 minutes after dusting pollen tubes had entered the style as in natural pollination. There was no germination 48 hours after storage. Spikelets from a spring crop of C0·8 were preserved according to Vijayasaradhy's method (1939) at 5°, 8°, 13° and 15°C. and 85%, 90%, 95% and 98% humidity. On dusting the pollen on fresh stigmas 24 hours after storage it was seen that in all combinations of temperature and humidity the germination was poor, being not more than 2 or 3 grains on a pistil. Even fresh pollen when dusted on stigmas did not germinate. This might be due to the high temperature and low humidity in the field at the time of dusting.

Pollen tube growth in Vivo: *The pistil:* The ovary is monocarpellary, unilocular and ovoid. There are two terminal styles arising from the tip of the ovary. Two vascular strands branching off from the base of the ovary run laterally and are continued inside the styles. The

styles consist of a tapering column from the upper half of which arise 60 to 80 delicate branches. Each branch is about 1/3 mm. long. These branches in turn give off papillæ each about 50μ long. These serve as resting places for the pollen grains.

Germination of the pollen on the stigma: Spikelets were emasculated between 7 and 8 A. M., covered with bags and pollinated with fresh pollen between 10 and 11 A. M. when the flowers normally open. Pistils were removed at intervals of 1, 2 and 3 minutes after pollination and examined both fresh and stained in iodine-potassium iodide. It was found that the pollen grains had developed protuberances at the germ pores in less than two minutes and within 3 minutes these grew into short tubes.

The role of the stigma in germination of pollen falls under two distinct categories. Artschwager and Starret (1933) found in the sugar beet that the epidermis of the stigmatic lobes was covered with a sweet secretion very favourable for pollen tube growth. They further found that the plastids of the stigmatic papillæ contain protein crystalloids. Ziegenspeck (1926) observed that the stigmatic cells of *Alopecurus* and *Phleum* have pores on their walls and are loaded with starch. Pollen tubes were seen to enter the stigma through these pores. Jost 1905 found on examining the stigmas of *Dactylis*, *Glyceria* and *Secale* a thin film of liquid at the point of contact where the stigmas were pressed under the cover glass.

Kearney (1923) and Ayyangar (1938) on the other hand could not detect any secretion in cotton stigmas facilitating germination of pollen. Ayyangar observed that the stigmatic cell walls are mucilaginous and that they absorb water and regulate the water supply to the pollen grain. Similarly Martin (1913) in *Trifolium pratense* conducted microchemical tests on the stigmas. His tests showed no sugars or starch in the piapillæ and he concluded that the function of the stigma in pollen germination is to regulate water supply.

To determine whether there was any sugary stigmatic secretion in rice the styles from about 300 pistils were carefully dissected out and shaken for two minutes in 3 c. c. of distilled water. The water was drained off into another test tube and to 2 c. c. of this water were added 5 drops of a 20% alcoholic solution of alphanaphthol and 5 c. c. of concentrated sulphuric acid were run into the bottom of the tube from a pipette. The absence of a violet ring indicated the absence of sugars. With crushed styles the test showed that sugars were present in the styles. Further examination of fresh pistils under the microscope with and without cover slips failed to disclose even a trace of free moisture on the stigma. In all the species of diploid and polyploid rices only one pollen tube was seen to emerge from a pollen grain.

The course of the pollen tube inside the style: In general, pollen tubes could be seen just entering the style may encounter any of the following conditions depending on the particular type of stylar tissue. 1. The style contains an outer cortex and an inner conducting tissue along which the pollen tubes travel as in *Datura* etc. 2. The style is hollow and the stylar canal is sometimes lined with glandular cells as in *Iris* etc. 3. The style is slender without any specialised conducting tissue. The pollen tubes pass down the stylar tissue. The rice style belongs to the last class.

Within five minutes after pollination a few of the pollen tubes could be seen just entering the style. Within ten minutes most of the pollen tubes had entered the stylar tissue and some were halfway down the style. The contents of the pollen grains were seen to align themselves and migrate into the tube Many tubes were found to bulge at their tips and stop growing further while in a few cases, despite a small bulge growth was continued. Inside the growing tubes starch grains could be seen throughout the length of the tubes. The contents of the tubes move towards the tips forming swellings which increase in size in the later stages of growth.

Observations made in the pollen grains and pollen tubes showed the appearance and continued presence of starch. This is not uncommon though by no means universal. Ishikawa (1918) observed that the plasm of the pollen tubes of *Oenothera* contains starch granules which are fusiform, spherical or ellipsoidal but never uniform as in pollen grains and concluded that the starch grains undergo some chemical change owing probably to their being used up in the nutrition of the tube. Renner (1919) found that in *Oenothera* the ripe living pollen grains were always packed with starch which in the germinating pollen grain is transformed into fat. He observed that in germination the starch grains pass mostly into the pollen tube where they were seen 'eroded' into very small bodies as they gradually disappeared. Brink (1924) following the digestion of reserve material by microchemical tests in the pollen tubes of *Vinca minor* observed that when the longer tubes had reached their maximum length the reserve either greatly diminished or disappeared completely. Most previous workers in the field would appear, however, to associate starch with the role of a reserve food substance rather than as an intermediate regulating the metabolic activity of the growing pollen tube.

Observations made in pollen tubes of rice point to a different type of role for the starch. Initial examination of the tissues of the pistil showed only a limited occurrence of starch. The pistils were cleared in 10% chloral hydrate for 6 to 12 hours, stained with iodine and examined under the microscope. The test proved negative in the stigmas and the style; the pericarp alone giving a positive indication for starch. The pollen grain, however, as already said contained considerable amounts, but detailed observations made during its germination and growth showed that the initial amount of starch present in the grain could form but a small fraction of the amount finally found in the tube. During the early

stages of growth of the pollen tube it was observed that the grains get emptied of their starch granules.

Microchemical tests: Since the formation of starch in living plant tissue is in response to changing conditions of sugar concentrations, the pistillate tissues in which the pollen tube grows were analysed for sugars by microchemical methods. The analysis showed that the growing pollen tube traverses a region of the pistil which contains considerable amounts of sugar and a free interchange of these substances between the pollen tube and the pistillate tissues should be taking place as a result of osmotic differences. It was noted that pollen tubes traverse all regions in the stylar tissue except the vascular portions. There was no evidence of disorganisation of the cells adjacent to the tube but the cells were seen to have got compressed by the invading pollen tube, indicating the intercellular nature of its growth. The presence of pectinase in the pollen grains has been demonstrated previously and it is probable that with the aid of the pectinase, the growing pollen tube digests the middle lamellae and forces its way between the cells by the hydrostatic pressure exerted by its contents.

The course of the pollen tube inside the ovary: Pollen tubes were seen to enter the ovary in about 30 minutes after pollination and in another 30 minutes in many cases they were seen near the micropyle and in some cases inside the embryo sac. In a few pistils fixed 45 minutes after anthesis pollen tubes were seen near the micropyle. Inside the ovary the tubes were seen to travel over the integuments. In a few cases it was observed that the tubes invade the integument and pierce the nucellar tissue. The pollen tubes when near the micropyle were found to contain two male gametes at their tip. The tube passes through the micropyle, works its way between the cells of the nucellus and then enters the embryo sac, passing through one of the synergids and finally reaches the base of the egg. A number of darkly-stained granules also were seen deposited near the egg. In most of the ovules examined 2 to 2½ hours after pollination such deeply stained granules were evident. These have been called X-bodies and have been considered by various workers as characteristic of fertilization. (Wheat, Watkins 1925; sugar beet, Artschwager and Starret 1933; *Eleusine coracana*, Krishnaswami et al, 1937). In other plants pollen tubes have been known to traverse other parts of the gynaecium before entering the ovules. Knight (1917) in plums observed pollen tubes going beyond the ovules and entering other parts of the flower. In rice no such abnormal behaviour has been noted. Though as many as seven pollen tubes have been noted entering the micropyle never more than one pollen tube and two male gametes have been seen inside an embryo sac.

Rate of growth of pollen tubes: The rate of growth of pollen tubes in rice from the time of germination to their entry into the embryo sac

appears to be uniform. Five minutes after pollination the tubes were seen to enter the style covering a distance of 300 μ in the stigma; in 15 minutes many of these had covered another 675 μ in the style and in half an hour after pollination the tubes had reached the ovary covering 1500 μ. In the next 15 minutes the pollen tubes had travelled about 600 μ inside the ovary indicating that the rate of growth is fairly uniform.

Nuclear behaviour: Golinsky (1893) found that pollen of many grasses including *Triticum* was 3-nucleate at the time of shedding. This 3-nucleate stage would appear to be a characteristic of *Gramineae* as this condition has been observed by Cannon (1900) in *Avena fatua* by Miller (1918) and Weatherwax (1923) in maize and Dutt et al (1932) in sugarcane. Acetocarmine smears of anthers boiled in chloral hydrate showed pollen grains to contain three nuclei, the vegetative nucleus taking the stain very very faintly. Acetocarmine smears of anthers from spikelets that are likely to open the following day showed two male nuclei in the pollen grain indicating thereby that the male nucleus divides at least 24 hours before anthesis. Sections of anthers stained by the Feulgen technique showed the gametes as spindle-shaped bodies embedded in the dense protoplasm of the pollen grain. They contained a number of chromatin granules and a few showed a sheath of cytoplasm. There was no evidence of even a single vegetative nucleus. That the vegetative nucleus does not get stained even with Feulgen may be due to (1) the chromatin of the vegetative nucleus is too finely dispersed to be easily visible, (2) the chromatin is of a different composition from that of the other nuclei (Gardiner 1935) and (3) the tube nucleus is disintegrating. Since the vegetative nucleus stains rather imperfectly even 24 hours before anthesis and since it does not get stained with Feulgen at the time of anthesis I believe that the vegetative nucleus disintegrates as in *Crinum* (Suita 1937), *Tradescantia*, (Sax 1933) and *Portulaca* (Cooper 1935) and therefore plays no part in the growth of the pollen tube.

Migration of nuclei: In barley, Pope (1937) observed the male nuclei inside the pollen tube 10 minutes after pollination. In *Scilla* Brink (1924) found that the migration of the generative nucleus took place one hour after pollination. Ishikawa (1918) suggests that the male nuclei are dragged by the plasm of the tube causing the movement of the male cells towards the embryo sac. Welsford (1914) observed that the cytoplasm of the germinating pollen grain has a streaked appearance suggesting that the nuclei are carried out by the streaming of the cytoplasm. She further observed that the protoplasm of the tube after the male cells are formed no longer had the appearence of active streaming but appeared as if it had been disturbed by a moving body.

In rice pistils fixed 10 minutes after pollination the germinating pollen grains showed streaked cytoplasm inside suggesting its flow into the tube. The following stages of migration of male nuclei were observed.

(i) In the pollen grain itself. Male nuclei that had not migrated were seen side by side inside the pollen grain. (ii) In the pollen grain

migrating one behind the other (plate 1 fig. 5 & Text fig. 11), (iii) In the pollen tube inside the stigma, (iv) In the pollen tube inside the stylar region. A careful examination of the preparations suggests that the nuclei are carried down the pollen tube by the streaming of the cytoplasm. There was no evidence of active migration.

(h) *Pollen tube growth in polyploids:* To study the relative growth of pollen tubes in tetraploids, pistils of *Oryza eichingheri* (2n = 48) and autotetraploid GEB. 24 were fixed at various intervals after self-pollination and examined after staining both the entire pistil as well as sections of pistils. It was observed that in the former the behaviour of the pollen tubes was quite similar to that of diploids. The time taken for reaching the embryo sac was about one hour after pollination. Pollen tube growth in the autotetraploid GEB. 24 was found to be different from that of GEB. 24 diploid in that even 4 hours after pollination the pollen tubes had hardly penetrated the stigmatic papillae and about 50% of the pollen tubes had burst. For determining the relative size of the pollen tubes emerging from diploid and polyploid pollen grains the diameter of 50 tubes was measured as close to the grain as possible since the diameter of any pollen tube was not uniform throughout its length Measurement had to be limited to varieties with white stigma as in those with purple stigma the course of the pollen tube was not clearly visible. Measurements are given below in Table XVIII.

TABLE XVIII

Species	Diameter in μ	No. of tubes	Total No. of tubes	Average diameter in μ
GEB. 24 (2n) (*Oryza sativa*)	5·4	5	50	7·02
	7·2	45		
do. (4n) (*Oryza sativa*)	7·2	46	50	7·48
	10·8	4		
Oryza latifolia (4n)	3·9	17	50	5·68
	5·9	21		
	7·8	12		
Oryza longistaminata (2n)	3·9	12	50	5·61
	5·9	33		
	7·8	5		

Though the average diameter of the pollen grains in tetraploid (GEB. 24) was higher than that of the diploid the average diameter of the pollen tubes of both diploid and tetraploid GEB. 24 is about the same. In the case of wild rices *Oryza latifolia* and *O. longistaminata* the tubes are somewhat smaller in diameter than those of cultivated rices.

With a view to studying the behaviour of the pollen from a diploid plant on the stigma of a tetraploid plant and *vice versa* the following crosses were made between diploids and tetraploids.

GEB. 24 (2n) × GEB. 24 (4n)
GEB. 24 (4n) × GEB. 24 (2n)
GEB. 24 (2n) × *Oryza eichingheri* (4n)
GEB. 24 (4n) × *Oryza ecihingheri* (4n)
GEB. 24 (2n) × *Oryza latifolia* (4n)
GEB. 24 (4n) × *Oryza latifolia* (4n)

The wild species, *O. eichingheri* and *O. latifolia* could not be used as the female parent owing to the caducous nature of the spikelets. The crossed spikelets were collected at the end of 15 minutes, 30 minutes, one hour and two hours after pollination and stained in cotton blue in lactophenol. It was noted that with the exception of the pollen of *O. eichingheri* which germinated freely when dusted either on a 2n-stigma or 4n-stigma, pollen from tetraploid when dusted on 2n-stigma did not germinate; all bursting on the stigma itself. When a diploid pollen was dusted on a tetraploid stigma, pollen germinated, many of the pollen tubes burst within the stigmatic region and some of them entered the ovary. There was no seed setting. *O. latifolia* pollen when dusted on tetraploid and diploid stigma behaved alike. There were only short tubes which burst on the stigma itself.

Blakeslee at al (1923) and Buchholz and Blakeslee (1929) working on *Datura* mention three possible causes of failure of seed-setting mentioned by them viz., (1) Failure of the proper union of the germ with both the egg and the polar nuclei, (2) Failure of the zygotes to develop after fertilization and (3) Nutritional difficulties resulting in the death of the embryo are likely to be operative in the case of rice also.

Pollen-tube growth in glutinous rices: In glutinous rices part of the carbohydrate reserve in the endosperm as well as in the pollen grain is a dextrine staining red with iodine unlike that in the ordinary variety where the reserve is partially starchy. This glutinous character has been found to be a monogenic recessive to the normal starchy character. On crossing a glutinous with a non-glutinous variety of rice, the anthers of F_1 plant contain a mixture of starch and glutinous pollen grains in equal numbers (Parnel 1921). The F_1 on selfing bears non-glutinous and glutinous seeds. According to expectation the non-glutinous and glutinous grains should be in the ratio of 3:1. Actually there is a significant excess of non-glutinous grains.

Similar behaviour was observed by Brink and Mac Gillivray (1924) in the waxy and non-waxy pollen of maize and the chief reason adduced for the significantly less number of grains with waxy endosperm was the different rates of growth of pollen tubes in the two groups. Brink and Burnham (1927) also in maize, came to the conclusion that the difference in rate of growth of the two kinds of pollen tubes was during the period they were dependent on the pollen reserves and when the pollen tubes became dependent on the pistillate tissue for their growth the rate of growth was the same. To find out if there was any difference

in the rate of growth of the pollen from glutinous and non-glutinous rices the following combinations were studied.

i. (a) Self-pollinated glutinous pistil.
   (b) Self-pollinated non-glutinous pistil.
ii. (a) Glutinous pistil pollinated with non-glutinous pollen.
   (b) Non-glutinous pistil pollinated with glutinous pollen.
iii. (a) Glutinous pistil pollinated with a mixture of glutinous and non-glutinous pollen taken from an F_1 plant of glutinous × non-glutinous.
   (b) Non-glutinous pistil pollinated with pollen from the same sourse as (iii) (a).

In self-pollinated glutinous and non-glutinous pistils stained in iodine-potassium iodide 5 minutes after pollination pollen tubes were seen entering the style. In pistils of both, fixed one hour after self-pollination, pollen tubes had reached the micropyle indicating the same rate of growth of pollen tubes. In (ii—a) and (ii—b) pollen tubes of both groups had reached the micropyle an hour after pollination indicating that the rate of growth was not affected by the nature of the pistil. (iii) Pollen tubes of both groups were seen to enter the style five minutes after pollination and enter the ovary 30 minutes after pollination. Since there was no difference in growth even when the pollen tubes were dependent on their reserves it has to be concluded that there is no difference in the rate of growth also.

Pollen tube growth in cleistogamous rices: In the cleistogamous flowers of *Viola odorata* Madge (1929) observed the pollen germinating inside the anther, pushing through the anther wall and growing towards the stigma. Corczynski (1932) observed that in cleistogamous flowers pollen tubes penetrate the wall of the anther. The growth of pollen tubes was studied in a cleistogamous variety of rice where the spikelets are unable to open due to the earhead being enclosed within the sheath. In all cases anthers were seen to shed pollen freely on the stigma, the pollen germinated and the tubes were seen to go down the style. There was no instance of pollen germination inside the anther.

Conclusions: A study of the morphology of the pollen of several varieties and species of rice did not reveal any marked difference in shape though some difference was noted in their size. The volume of the tetraploid pollen grains was twice that of the corresponding diploid pollen and was found to contain a high percentage of carbohydrates and proteids. The enzymes, invertase, diastase and pectinase, pepsin and trypsin were present in the pollen. The pollen is delicate and after the dehiscence of the anthers lives only for a short time under natural conditions but by controlling the temperature and humidity the pollen could be kept viable for 24 hours.

Germination of rice pollen in nutrient media was unsuccessful but under optimum conditions of temperature and humidity the pollen germinates freely without any media. Gametogenesis occurs in the pollen grain at least 24 hours before shedding. The sperms are two in number. The vegetative nucleus appears to disintergrate before pollen germination.

Pollen grains germinate freely on the stigma and the pollen tubes could be traced up to their entry inside the embryo sac. No stigmatic secretion could be detected. Pollen grains falling on the stigmatic papillae germinate quickly and penetrate the stigmatic papillae within three minutes after pollination. On germination the contents of the pollen grain stream into the tube and the sperms are carried along with the current into the tube. There are evidences to show that new starch is formed during the growth of the tube. This is probably necessary to restore the osmotic equilibrium disturbed by the inflow of sugars from the pistillate tissue.

The rate of growth of pollen tube is uniform in most of the varieties examined. In autotetraploid GEB. 24 the growth of the pollen tubes was slow. Inside the style the growth of the pollen tube is intercellular, there is no disorganisation of stylar tissue. Under Coimbatore conditions fertilisation occurs two hours after pollination. There was no evidence of polyspermy though as many as seven pollen tubes were seen at the micropyle.

The diameter of the tetraploid pollen tube was found to be the same as that of the diploid one. The diameter of the pollen tubes of the tetrapoloid and diploid wild rices was less than that of the cultivated ones. When the diploid pollen was dusted on the tetraploid stigma the germination was good whereas in the reciprocal crosses there was no germination. Pollen of *O. eichingheri* (4n) was found to germinate equally well on stigmas of both diploid and tetraploid plants.

Studies on the rate of pollen tube growth in glutinous and starchy rices did not reveal any 'certation'. The pollen of cleistogamous rice germinates only on the pistil while in the cleistogamous flowers of other plants the pollen often germinates inside the anther.

SUMMARY.

1. A detailed study of pollen and pollen tubes in rice has been made.

2. Stored up food material in the pollen consists of sucrose, reducing sugars, starch and proteids. In addition the enzymes, invertase, diastase, pectinase, pepsin and trypsin were found to be present.

3. The pollen was found to germinate freely on a clean, dry glass slide kept inside a moist chamber maintained at a temperature of 28°–29°C and humidity 100%.

4. Rice pollen which does not live even for a few hours under natural conditions was successfully preserved for 24 hours at a temperature of 12°C and humidity 85%.

5. Examination of fresh pistils did not reveal any stigmatic secretion.

6. The pollen tubes appear to draw their initial nourishment from their own reserves. Evidences show that the sugars in the pistillate tissue are also utilized by the growing tube.

7. There was no evidence of polyspermy, though in some cases as many as seven tubes were seen entering a micropyle.

8. The rate of growth of the pollen tube from the time of pollen germination to its entry into the embryo sac appears to be uniform being about 2·5 m.m. in one hour.

9. Polyploid tubes are slower in growth than the diploid ones but the pollen tubes of polyploid species of wild rices were found to have the same rate of growth as those of the diploids.

10. Pollen from a diploid plant was found to germinate well on a tetraploid stigma and grow down the style while in the reciprocal crosses there was no germination, all the pollen having burst.

11. The starchy and the glutinous pollen tubes were found to have the same rate of growth on either type of pistil.

12. Pollen of cleistogamous rices behave as in normal ones; the filaments elongate, anthers dehisce and the pollen is shed on the stigma where it germinates normally. The pollen was not found to germinate inside the anther.

Acknowledgements: I wish to acknowledge my deep indebtedness to Sri C. R. Srinivasa Iyengar, Paddy Specialist and later Headquarters Deputy Director of Agriculture (Retired), Madras and express my grateful thanks for his keen interest and guidance throughout the progress of this investigation. I am also indebted to Mr. N. L. Dutt, Sugarcane Expert, Coimbatore and to Dr. M. Vijayasaradhy, Plant Physiologist, Sugarcane Breeding Station, Coimbatore for help and advice; and to Dr. S. Kasinath, Professor of Chemistry, Benaras Hindu University for suggestions and criticisms on the chemical aspect of the work.

BBLIOIGRAPHY

ARTSCHWAGER, E. & STARRET, R. C. 1933. The time factor in fertilization and embryo development in sugar beet. J. Agric. Res. 47: 823—843.

AYYANGAR, G. N. R. & RAO, V. P. 1936. Studies in *Sorghum*. Ind. J. agric. Sci., 6: 1299—1922.

AYYANGAR, N. K. 1938. Pollen tube studies in *Gossypium*. J. Genet., 37: 69—106.

BAIR, R. A. & LOOMIS, W. E. 1941. The germination of maize pollen. Science, 94: 168—169.

BRANSCHEIDT, P. 1930. Quoted by Chandler et al (1937) Cytologia p. 77)

BLAKESLEE, A. P. et al. 1923. Inheritance in tetraploid *Daturas*. Bot. Gaz. 76: 329—373.

BRINK, R. A. 1924. (a) The physiology of pollen. Amer. J. Bot. 11: Pp. 218—228, 283—294, 351—374, 417—436.

BRINK, R. A. 1924. (b) Preliminary study of role of salts in pollen tube growth. Bot. Gaz. 78: 361—377.

BRINK, R. A. 1925. The influence of H-ion concentration on the development of the pollen tubes of the sweet pea (*Lathyrus odoratus*). Ame. *Jr.* Bot. 12: 149.

BUCHOLZ, J. T. & BLAKESLEE, A. F. 1929. Pollen tube growth in crosses between balanced chromosomal types of *Datura stromanium*. Genetics, 14: 538.

BUCHOLZ, J. T. & BLAKESLEE, A. F. 1930. Pollen tube growth and control of gametophytic selection in cocklebur-a 25-chromosome *Datura*. Bot. Gaz. 90: 366—383.

CANNON, S. W. 1900. Proc Calif. Acad. Sci. 1: 329—364.

COOPER, W. C. 1939. Vitamins and germination of pollen grains and fungus spores. Bot. Gaz. 100: 844—853.

GOOPER, D. C. 1935. Microsporogenesis and development of male gametes in *Portulaca oleracea*. Amer. J. Bot. 22: 453.

CZAPEK, F. 1913, 1920, 1921. Biochemie der pflanzen. 2nd Ed. 3 vols. pp. 852.

DARLINGTON, C. D. 1937. Recent advances in cytology. 2nd Ed. London. P. 220.

DUTT, N. L. 1929. Studies in sugarcane pollen with special reference to longevity. Agric. J. India. 24: 235—244.

DUTT, N. L. & AYYAR, K. V. G. 1930. A preliminary note on the chemical composition and the enzymes of sugarcane pollen. Agric. J. India. 25: 31—33.

DUTT, N. L. & KRISHNASWAMI, M. K. 1932. Observations on male nuclei in the sugarcane. Indian J. agric. Sci. 2: 47—50.

EAST, E. M. & PARK, J. B. 1919. Studies on self-sterility, II. Pollen tube growth. Genetics. 3: 353—366.

ERLENMEYER, E. 1874. Uber de Fermente in den Bienen im Bienenbrot und in pollen. Sitzuhgsb. Akad. Wiss. Munchen, Math-phys. Cl. 4: 204—207 (Quoted from Paton, J. B. 1921).

GARDINER, M. S. 1935. The origin and the nature of the nucleus. Quar. J. Micro. Sci. 77: 523.

GOLINSKI, 1893. Bot. Central Bl. 55: 1-17 (Quoted from DUTT et al. 1932).

GREEN, J. R. 1891. On the occurrence of diastase in pollen. Ann. Bot. 5: 511—512.

GORCZYNSKI, T. 1932. Biol. Abstr. 1932. (2127).

HERBERT NILSSON, N. 1920. Quoted from Biblio. Genetica. IV: 401-492. (1928)

ISHIKAUA, R. M 1918. Studies on the embryo sac and fertilization in *Oenothera*. Ann. Bot. 32: 279—317.

JOST, L. 1905. Zur Phisiologie des pollen. Ber Deutch. Bot. Ges. 23: 534—515. (Quoted from Brink, 1924).

JOST, J. 1907. Uber die selbsterilitat einiger Bluten. Bot. Zts. 65: (Quoted from Maheswari and Wulff, Stain Tech. 12: 61—70, 1937).

KAMMAN, O. 1904. Quoted from Paton, J. B.; Amer. J. Bot. 8: 471—501.

KNIGHT, L. J. 1917. Physiological aspects of self sterility, in apples. Proc. Amer. Hort. Soc. 14 : 101—105.

KRISHNASWAMI, N. et al. 1937. Cytological studies in *Eleusine coracana*. Beihefte zum Bot. central. Blt. Bd LVII : 297—318.

LIDFORSS, B. 1899. Quoted from Paton, J. B. Amer. J. Bot. 8 : 471—501.

LLOYD, B. 1917. The colloidal properties of protoplasm. Imbition in relation to growth. Trans. Roy. Soc. Canada 4. P. 133.

MADGE, M. 1929. Spermatogenesis and fertilization in the coleistogamlous flowers of *Viola odorata*.

MARTIN, J. N. 1913. The physiology of pollen of *Trifolium pratense*. Bot. Gaz. 56 : 113—126.

MILLER, E. C. 1918. Development of the pistillate spikelet and fertilization in *Zea mays*. J. Agric. Res. 18 : 255.

PARNEL, F. R. 1921. Note on the determination of segregation by examination of the pollen of rice. J. Genet. 11 : 209—212.

PATON, J. B. 1921. Pollen and pollen enzymes. Amer. J. Bot. 8 : 471—501.

RENNER, O. 1919. Quoted by Gates, R. R. ; Bibiliographia Genetica. (1928) IV : 401—492.

SARTORIS, G. B. 1942. Longevity of sugarcane and corn pollen – a method for long distance shipment of sugarcane pollen by airplane. Amer. J. Bot. 29 : 395.

SAX, K. & EDMONDS, H. W. 1933 Development of the male gametophyte in *Tradescantia*. Bot. Gaz. 95 : 156—164.

SMITH, P. F. 1942. Studies of the growth of pollen with respect to temperature, auxins, colchicine and vitamin B_1. Amer. J. Bot. 29 : 56—66.

SUITA, N. 1937. Studies in the male gametophytes of angiosperms, II. Cytologia. Jub. Part II 920—937.

TAKASHI 1927. From Biol. abstr. 1930. 19474.

TRAUB, H. P. & O'Rork, C. T. 1936. Papaya pollen germination and storage. Proc. Amer. Soc. Hort. Sci. 34 : 18.

VASSILIEV, I. V. 1941. Effect of boron on germination of pollen and growth of pollen tubes in tomato. Compt. Rend (Dok) Acad. Sci. U. R. S. S. Ser. 30 : No. 6. pp. 532—534.

VIJAYASARADHY, M. 1939. Thermo or vacuum flasks for preserving sugarcane pollen. Curr. Sci. 8 : 555.

WATKINS, A. E. 1925. Genetical and cytological studies in wheat. J. Genet. 15 : 323—336.

WEATHERWAX, P. 1923. The story of the Maize Plant.

WELSFORD, E. J. 1914. The genexis of the male nucleus in *Lilium*. Ann. Bot. 28 : 265—270.

VENKATASURAMANIA, M. K. 1943. Artificial germination of rice pollen. Current Science. 12 : 208—209.

ZIEGENSPECK, H. 1926. Uber Amyloidfenster in den Narbenpapillen des *Alopecurus* und *Phleum*. Ber. Dtsch. Bot. Ges. 44 : 561.

Breaking the Rest Period of Potato Seed

A Review of Trials at the Agricultural Research Station, Nanjanad

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Introduction: Potato is grown on the Nilgiris over three well-defined seasons. An early crop is taken on a small scale, wherever irrigational facilities exist, between February and May over an extent of about 1,500 acres. The main crop (*Kar bogum*) occupies the largest area of nearly 11,500 acres, is planted in March – April and harvested in August – September. The second crop (*Adi-bogum*) is planted in about 7,000 acres in August. Both the main and the second crops are purely rain-fed. Freshly harvested tubers are not useful for immediate planting, as they remain dormant for a period of two to three months. For obtaining good yields, the tubers have to be stored for about two months to give them time to sprout and then planted. Lavallee (13) found that the four years, results 1893—96 proved in favour of the sprouted seed, with considerable and consistent differences in yield over the unsprouted seed. The average results of 1,465 experiments on the effect of sprouting on yield, carried out in Ireland during the thirteen years 1903—15, were as follows: (Data from *J. Dep. Agric. Ire.*, 18, p. 163).

Yield per acre from sprouted seed: 12 tons 5 cwt.
do. unsprouted seed: 10 tons 6 cwt.

Greig (4) reported increased yield from germinated over ungerminated seed of from 34 to 39·5 bushels per acre. Much larger increases have been recorded in Ireland in which gains of from 61·6 to 74·7 bushels were obtained. In England the value of the sprouted seeds has been recognised to such an extent that they fetch a price amounting to 30 shillings per ton in excess of the price allowed for the same variety of unsprouted seed potatoes.

On the Nilgiris, to ensure that the seed material for the three different crops is available in a sprouted state, the harvest from the second crop is used for planting the main crop, while the one from the main crop is used for planting the irrigated crop. There is sufficiency in seed for both the main and the irrigated crops. An acute shortage of seed material is experienced with regard to planting the second crop which occupies 7,000 acres, since the seed for the purpose has to be obtained from the harvest of the irrigated crop which is raised over about 1,500 acres. In view of this limited area, availability of seed material is always found insufficient for meeting the requirements of the second crop. Hence, cultivators are compelled to make this good by utilising the seed

from the main crop harvested in July–August for planting the second crop in August–September. But, since the respective harvests and plantings overlap, such seed has no time for natural sprouting. Therefore, recourse has to be taken to break the dormancy by force-sprouting the main crop seed, to render it fit for immediate planting without sacrifice of ultimate yields.

The general practice among the Nilgiri potato growers is to fill the freshly lifted main crop tubers into hessian bags and to stack them in lofts over the hearths in their homes. Within a period of about four weeks, the sprouts emerge as a result of this heat treatment. Trials were conducted at the Agricultural Research Station, Nanjanad, to find out if a cheap, handy and elegant means could be developed to force-sprout fresh-lifted potato tubers. Three main objectives were kept in view, viz., (1) the method should be capable of large-scale adoption by ryots and within their means; (2) the treatment should not effect the viability of the seed in any way, leading to a consequent loss in stand and (3) the yields secured through the use of treated seeds should be optimum and up to the level of the ones from the naturally sprouted seed. The results of the investigations, detailed in this paper, revealed that among the three methods described, the treatment of the seed with vapour of carbon-disulphide was the best and the most practical one for large-scale sprouting.

Review of Literature: Various mechanical, thermal and chemical methods have been recommended by workers for inducing sprouting. Appleman (1) encouraged sprouting by peeling the seed-skin and by treatment of the tubers with a solution of hydrogen peroxide. Butler (2) found that tubers exposed to free air circulation sprouted earlier than those stored in still air while, Loomis (7) concluded that storage for six weeks at 20°C, followed by four weeks at 32°C tended to effect even sprouting. Peeling of the skin of seed tubers (care being taken not to injure the eyes) and storing them in moist sawdust for a week was, according to Pal and Nath (9), very effective for breaking dormancy. Exposure of the whole seed or cut pieces for 24 hours to ethylene chlorhydrin vapour was concluded by Denny (3) to be most successful. Some other effective alternatives, according to the same authority, were soaking cut tubers for one hour in solutions of 2–3% sodium and potassium thiocyanate, 1–3% ammonium thiocyanate, 1% thiourea and exposures to vapours of ethyl bromide, ethylene dichloride, carbon-bisulphide (1–2 ml. in 35 litres), dichlorethylene and trichlorethylene. In all the above vapour treatments, the lower limits of concentration were given for cut tubers and the higher limit for whole tubers. Again in general, higher concentrations were required for freshly harvested tubers than for those approaching the end of the dormancy period. The effects of yeast extract in breaking the rest period were reported by Guthrie (5), while Julen (6)

found treatment of tubers with ascorbic acid useful. Stimulation of sprouting by the introduction of 0·1% by volume of ethylene into the storage atmosphere, four times during a period of six days, was induced by Vacha and Harvey (12) who concluded that, in every case, plants from treated tubers grew more rapidly than those from the untreated ones. Other chemical treatments to abbreviate the dormant period in potato tubers include the soaking of cut pieces for one hour in 0·5 M sodium nitrate solution as per Rosa (10); the successful use of many sulphur compounds in this direction by Miller (8) and Thorntons (11) method of obtaining bud-growth within seven to nine days by continuous treatment of the relatively dry tubers with 2% oxygen.

Materials and Methods of Investigation: The studies under report were conducted at the Agricultural Research Station, Nanjanad, for a continuous period of five years, starting with the second crop season of 1944. The following four variants were adopted for the seed materials used and the trials were laid out in randomised replicated blocks.

Treatments:

A ..	Seed from the preceding irrigated crop sprouted naturally under storage.	
B ..	Seed from the main crop,	force-sprouted by peeling the skin.
C ..	do.	force-sprouted by treatment with carbon-bi-sulphide.
D ..	do.	force-sprouted by stacking in lofts over the fire-place.

Freshly-lifted tubers were used for the three treatments B, C and D. For treatment B, the skins of the seed tubers were carefully peeled leaving the eyes intact and the tubers afterwards kept in moist saw-dust for a period of 15 days before planting. In regard to treatment C, the tubers were subjected to fumigation with vapours of carbon-di-sulphide at the rate of one ounce of the chemical per 32 cubic feet of tubers, roughly amounting to about 800 lb. kept in air-tight containers, or dealwood boxes made air-tight by plastering with mud and cow dung. This induced sprouting in ten days and, with another week of resting inside straw after treatment, the tubers were found to have good sprouts and to be ready for planting. The required quantity of carbon-disulphide was kept in an open bottle inside the air-tight container for use in the treatment. The material for the last treatment D was packed in gunny bags and kept on lofts over the hearths for a period of three weeks before planting, as is the general practice among the ryots.

Great care was exercised in selecting tubers of uniform weight and size for all the treatments and seed rate and manuring were maintained at identical levels. The popular commercial variety, *Great Scot*, was used for the entire course of the trials.

Summary of Results: The results of the trials for the five year period 1944–'48 are furnished hereunder:

Year	Acre yield in lb. for treatments				General Mean	Standard Error	Z. Test	Cri. Diff. (P=0·05)	Remarks
	A	B	C	D					
1944	10,007	6,900	12,263	*	9,723	600	Satisfied	1,280	
1945	9,200	8,167	6,803	*	8,056	564	,,	1,080	
1946	7,828	5,940	8,044	9,024	7,709	840	,,	1,800	
1947	3,828	4,156	6,344	5,944	5,068	639	,,	1,392 †	
1948	14,600	9,320	8,620	10,680	10,805	764	,,	1,665	

* Not included in the trials for the two years.

† Partially cut by ground frost.

Conclusions: 1944: C, A, B; 1945: A, B, C; 1946: D, C, A, B; 1947: C, D, B, A; 1948: A, D, B, C.

Discussion: The main objective of the trials was to investigate the possibilities of force-sprouting freshly-lifted dormant tubers for planting without appreciable loss of yield, a necessity which was compelled by the dearth of naturally sprouted seed for the second crop. Without resorting to such artificial means, the area under the second crop would tend to dwindle considerably which would, in turn, result in shortage of seed for the main crop. Thus, the need to keep the coverage of the second crop from shrinking is necessary and urgent.

Peeling of the skins, as per treatment B, is not a practice that can be commended, since there is always the risk of infection by diseases into the material from the raw exposed surface. For large-scale treatment this method is not practicable. Except in the year 1945, it has not proved itself good for increased yields.

The carbon-disulphide treatment (C) has many points in its favour. The chemical is cheap, easily handled and safe. The sprouting induced is uniform since the highly volatile vapours permeate through the entire material under treatment. The results have also proved promising for, in three out of the five years, 1944, 1946 and 1947, it has recorded optimum yields.

The ryots' method of keeping the tubers over warm hearth (D) has also recorded good yields for the three years 1946, 1947 and 1948 over which it was tried. While this practice may be useful for handling small lots, it will not admit bulk quantities. If the bags are stacked one over the other, the top bags might not get the full benefit of the heat with the result that sprouting will not be either uniform or complete.

Considering the relative efficacies of the three treatments, it is concluded that the use of carbon-disulphide offers the best way to break dormancy.

Summary: For breaking the rest period of potato seed tubers, carbon-disulphide, at the rate prescribed, has been found very useful. Sprouting is uniform and complete and the method, which is safe and simple, has proved very cheap too, the cost of treatment of seed required to plant an acre working out to Rupees two only. This practice developed at this Station, is now being adopted by many ryots on the Nilgiris as they have found that, very often, such force-sprouted material gives as good a yield as naturally sprouted seed.

Acknowledgment: The experimental data included in this paper form the results of work on the subject for the years 1944 – '48 and were collected from the related records and reports. During the above period, Sri P. A. Nathan and P. N. Nayar were in charge of the Station as the Deputy Director of Agriculture, Nilgiris, and as Superintendent, respectively. The authors gratefully acknowledge their valuable guidance and help in the conduct of the trials.

BIBILIOGRAPHY

1. APPLEMAN, C. O. (1916): Biochemical and physiological study of the rest period of tubers of *Solanum tuberosum*. *Bot. Gaz.*, 61, 265—94.
2. BUTLER, O. (1919): Storage of potatoes. *Circ: N. H. Agri. Exp. Stn.*, 20.
3. DENNY, F. E. (1926): Hastening the sprouting of dormant potato tubers. *Amer. J. Botany.* 13.
4. GREIG, R. B. (1906): Field experiments. *J. Dep. Agric. and Tech. Inst. Ireland.* 8, 296—297.
5. GUTHRIE, J. D. (1941): A preparation from yeast that is active in breaking the rest period of buds. *Cont. Boyce Thompson Inst.*, 12.
6. JULEN, G. (1944): Vitman C metabolism in potatoes. *Biol. Abstr.*, 20.
7. LOOMIS, W. E. (1927): Temperature and other factors affecting the rest period of potato tubers. *Pl. Physiol.* 2.
8. MILLER, L. P. (1931): The influence of sulphur compounds in breaking the dormancy of potato tubers. *Contr. Boyce Thompson Inst.*, 3.
9. PAL, B. P. AND NATH, P. (1938): Shortening the rest period of the potato (*Solanum tuberosum, L.*) *Indian J. agric. Sci.* 8, 777—786.
10. ROSA, J. T. (1923): Abbreviation of the dormant period in potato tubers. *Proc. Amer. Soc. hort. Sci.* 1923.
11. THORNTON, N. C. (1933): Carbon-dioxide storage for breaking the dormancy of potato tuber. *Contr. Boyce Thompson Inst.*, 5.
12. VACHA, G. A. AND HARNEY, R. B. (1927): The use of ethylene, propylene, and similar compounds in breaking the rest period of tubers, bulbs, cuttings and seeds, *Pl. Physiol.*, 2.
13. LAVALLEE As mentioned by Salaman in "Potato Varieties".

An Inter-specific Musa Hybrid Produced at the Central Banana Research Station, Aduthurai

By

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Introduction: Success in banana hybridization depends on the right type of male parent and a review of banana breeding work done at the Imperial College of Tropical Agriculture, Trinidad reveals that the present work, after about thirty years of research on the subject, centres round the synthesis or discovery of a suitable male parent for the Gros Michel variety with a view to evolve a disease-resistant Gros Michel banana. During the above studies they have found that species crossing and crossing of diploids with tetraploids offer good possibilities for the production of new triploids. The objective of the breeding work undertaken here is to produce a dwarf type of the well-known vegetable variety, Monthan by making use of *Musa coccinea*, the shortest-statured *Musa* species as male parent. Dwarf types of bananas are desirable as they resist wind much better than tall ones without decrease in the total contribution to yields due to the inclusion of more plants per acre.

Material and Methods: The technique of banana pollination followed at the station is based on the method adopted at Trinidad. The inflorescence which has the female flowers of the particular variety selected for pollinotion, is located one day before the lifting of the bract which exposes the female flowers and bagged. Next a suitable male bud of the particular variety selected as the male parent is selected with a view to get fresh, healthy pollen from the opened male flowers for a number of days. From this the old bracts and opened male flowers are removed and after cleaning the male bud, it is bagged with a much smaller-sized bag than the bunch bag, called the pollen bag. This is to prevent insects from contaminating the pollen. Only fresh pollen is used for all pollination work. Pollination is done very successfully in the mornings between 7 and 8-30 A. M. with pollen from freshly-opened male flowers, collected in a suitable sized petri dish. A piece of blotting paper to remove water drops, if any, at or near the stigmas of the female flowers at the time of pollination and when working with more than one male perent, a small quantity of absolute alcohol in a specimen tube to rub over the hands and fingers of the operator when they become contaminated with foreign pollen are also needed. A tall field ladder on four legs 12 to 15 feet high which could be easily folded and carried by one man is also necessary. The female flower bunch is labelled just prior to pollination. When the pollen is available in plenty in the dehisced anthers, as in the case of the male flowers of *M. coccinea*, the male flowers themselves are handled to dust the pollen on the exposed

stigma. The stigma is generally receptive for about a day after the lifting of the bract. If there is very little pollen in the anthers as is the case with certain varieties, the pollen is scraped and applied. On the morning of pollination, the bunch bag is carefully removed, the opened bract is well rolled back and the compound tepals of the exposed female flowers are pushed back gently to fully expose the stigmas. The stigmatic heads should be fresh, glistening and white at the time of pollination. When two bracts open in a day, it is not unusual to find the stigmas in the first hand dull coloured. In such cases it is desirable to pollinate the hands twice in one day both in the morning and evening. With certain varieties like *Rasthali,* the stigma becomes dull coloured even at the time of lifting of the bract, and it is necessary in such cases to lift the bract, open the flowers and pollinate. Generally one hand of female flowers is pollinated in one day and the total number of days required for pollination of a particular inflorescence depends on the number of hands of female flowers. It is important that the male bud selected is healthy and big enough to supply every day fresh male flowers for the entire period of pollination of the particular inflorescence. The inflorescence is bagged immediately after the pollination is over. The bag covers the bunch till the styles have dropped from the pollinated flowers.

Observation: The pollination of the female flowers of a selected inflorescence of *Monthan* with pollen from *Musa coccinea* was done for a period of seven days from 3—6—1951 to 9—6—1951 as detailed below :

Female parent	Male parent	Date of pollination	No. of hands	No. of female flowers crossed
Monthan	*Musa coccinea*	3—6—1951	1	12
		4—6—1951	2	14
		5—6—1951	3	14
		6—6—1951	4	16
		7—6—1951	5	14
		8—6—1951	6	14
		9—6—1951	7	14

The bunch was harvested on 2-9-1951. Twelve good seeds were extracted on 7-9-1951. The seeds were sown in seed trays on the same date. Two seeds germinated 42 days after sowing and a third one after 48 days. The third seedling being weak did not survive. The two healthy seedlings were potted when they were about five inches tall on 15-11-1951. Both were transplanted on 20-12-1951. The first plant has produced eleven suckers by 7-7-1952 and the parent plant is not expected to survive due to rotting at base. The second hybrid has produced three suckers by 7-7-1952 and has flowered on the same date. A brief description of the female and male parents and the and the hybrid which has flowered are given below.

Discussion: The hybrid described above has mostly intermediate characters between the male and female parents and has clearly shown

accentuation of some of the desirable characters, detailed below, which are lacking in the female parent.

(i) Position and nature of the bunch – held nearly horizontally as compared with the erect position of the bunch in *M. coccinea.*

(ii) Two rows of female flowers as compared to one row in the male parent.

(iii) More number of fruiting hands and increase in finger length.

(iv) Increase in plant size over the male parent.

(v) Satisfactory production of suckers near the parent with marked decrease in the stoloniferous nature of the corm when compared to *M. coccinea.*

The above observations indicate that the first step of building up the desired male parent with the object of breeding a dwarf type on *Monthan* has been achieved.

M. coccinea belongs to the '*Callimusa*' section with chromosome number (2 – n = 20) and so far has successfully crossed only with the *Australi musa* section, with the same chromosome number. This is the first record of success of banana variety in the '*Eumusa*' section (chromosome No. 2 – n = 22) crossing with a typical species of the '*Callimusa*' section. The species hybrid collections (S. H. Series) at Trinidad do not contain this. Too much caution need not be given to the difference in chromosome status of the male parent, as it has been definitely established by Cheesman and his co-workers that the character of parthenocarpy is independent of polyploidy.

Summary: A useful hybrid between *Monthan* (Female) and *M. coccinea* (Male) has been produced at the Central Banana Research Station, Aduthurai which holds out promise in the synthesis of a useful male parent for further work on the variety, *Monthan* with the object of producing a dwarf type which could resist winds better without reducing the total yields as a result of the possibility of addition of more plants per acre. The hybrid, male and female parents are described.

Acknowledgment: The author is working in the Banana Research Scheme partly financed by the Indian Council of Agricultural Research.

BIBLIOGRAPHY

CHEESMAN, E. E. 1951. Banana breeding at the Imperial College of Tropical Agriculture. Emp. Marketing Bull. No. 47 December 1951.

do. do. 1934. Principles of Banana breeding – Trop. Agri. Vol. XI.

DODDS, K. S. 1943. The genetic system of Banana varieties in relation to Banana breeding. Emp. J. Expt. Agri. Vol. XI.

	Monthan (Female Parent)	Monthan x *Musa coccinea*	*Musa coccinea* (Male Parent)
Pseudostem:	274 cm. in height and 65 cm. in girth at base, coloured yellowish green with waxy bloom moderately present near petioles and tender outer surfaces of leaf sheath.	95 cm. in height and 29 cm. in girth at base, coloured pale green (distinctly less green than *Musa coccinea*) Waxy bloom present sparsely.	44 cm. in height and 19 cm. in girth at base, coloured light green with very light waxy bloom on petiole base.
Leaf:	Petiole 52 cm. in length and 12 cm. in girth, leaves well spread and leaf sheath clasping pseudostem tightly. Petiole colour yellowish green with waxy bloom present moderately and margins bordered dark brown and petiole edges nearly meeting.	Petiole 24 cm. in length and 7 cm. in girth slightly bent with some leaves drooping and leaf sheath covering the pseudostem tightly. Petiole colour pale green with brown margins and edges a little apart.	Petiole 11 cm. in length and 3 cm. in girth, position nearly erect and leaf sheath clasping the pseudostem loosely. Petiole colour light green with pinkish margins and edges clearly apart.
	Lamina 175 cm. in length and 65 cm. in breadth, colour of upper surface deep green and lower surface pale green with waxy bloom and with severe shredding by wind. Texture of lamina some what thick midrib fairly deep and narrow with un-equal lamina base and nearly truncate apex.	Lamina 64 cm. in length and 26 cm. in breadth, colour of upper surface deep green and lower surface green with no waxy bloom and insignificant shredding by wind. Texture smooth and thicker than *Musa coccinea*, midrib deep with winged lamina base and obtuse apex, sometimes with a cleft.	Lamina 33 cm. in length and 15 cm. in width, colour of upper surface deep green and lower surface light green with no waxy bloom and no shredding by wind. Texture smooth and thin, midrib shallow with winged lamina base and obtuse apex.
Inflorescence:	Pendulous and glabrous with yellowish green colour of the peduncle. The basal flowers are female with two sterile bracts, the first one showing foliage character. The outer colour of bracts with fruiting flowers is deep purple with a tinge of violet and with plenty of waxy bloom. The colour of the inner surface is a shade lighter with grooves.	Held nearly horizontally with yellowish green colour of the peduncle. The basal flowers are female with two sterile bracts, the first one with a distinct small leaf blade. The outer colour of bract with fruiting flowers is chocolate with deepening towards the margins and with no waxy bloom. The inner surface is flesh-coloured and smooth.	Quite erect, with light green peduncle. The basal flowers are female with a tendency for hermaphrodite nature in the last hand adjoining the male flowers. There are two sterile bracts and the foliage character is distinct in the first one. The bracts are conspicuously coloured the outer colour being scarlet with no waxy bloom. The inner surface is not grooved and tinged less.

	Monthan (Female Parent)	Monthan x *Musa coccinea*	*Musa Coccinea* (Male Parent)
Female Flower:	In two rows, colour of united tepal light purple with streaks, length 4·8 cm. and breadth 1·8 cm. lobes five, three outer and two smaller ones inner, coloured yellow; free tepal translucent, shallow and boat shaped and apex acute and pointed.	In two rows, colour of united tepal creamy, length 3 cm. and breadth 1 cm lobes three distinctly visible in the outer whorl and two minute ones in the inner, all coloured orange; free tepal curved, boat shaped and conspicuous when compared with *Musa coccinea* and pointed.	In one row, colour of united tepal deep orange, length 2·3 cm. and breadth 2 cm. being more like a tube surrounding the style, lobes only three discernable, which are big sized free tepal not at all conspicuous being inside the tube formed by the compound tepal, very small in size shallow and light yellow in colour, boat shaped and apex mucronate.
	Staminodes five, filament coloured white with stigma exerting.	Staminodes five, filaments coloured white with stigma almost touching the top of the staminodes.	Staminodes two to five; (one hand next above the male phase develops flowers nearly harmaphrodite with two stamens and the rest staminodes. This is only a tendency occasionally noted, the fruits do not develop).
	Pistil with three angled ovary, coloured light green with purplish tip.	Pistil, with three to five angled ovary, green and much smaller in size than the ovary of Monthan.	
	Style 4·1 cm. in length, stout and yellowish with a big-sized capitate stigma.	Style 3 cm. in length, whitish with a light orange coloured small sized and capitate stigma.	Pistil, small sized, three angled and light green in colour. Style 2·5 cm. in length, white with the small orange coloured capitate stigma.
	Number of hands seven, with 12, 14, 14, 16, 14 and 14 fingers in successive hands.	Number of hands four with 5, 8, 7 and 8 fingers in successive hands.	Number of hands three with 3, 3 and 2 fingers in successive hands.

	Monthan (Female Parent)	Monthan x *Musa coccinea*	*Musa Coccinea* (Male Parent)
Male Flowers:	In two rows with number per bract varying from 12 to 14. United tepal five lobed and coloured rose red, length 5·3 cm. and breadth 1·1 cm; free tepal coloured light rose with mucronate apex.	In two rows, with number per bract varying from nine to ten. United tepal coloured light yellow and five lobed; length 3·1 cm. and breadth 1·2 cm. lobes coloured deep yellow free tepal translucent, linear and boat shaped with a pointed apex.	In one row, with not more than four flowers per bract; united tepal light orange in colour, five lobed, length, 3·2 cm. and breadth 2 cm. free tepal very small sized, transparent shallow with a winged and pointed apex.
	Stamens 5 with no pollen; filament 3 cm. in length and anther lobes 2·2 cm. There is a pistillode with a style 4·9 cm. long and small capitate stigma.	Stamens 5 with anthers containing scanty pollen; filament white, 1·5 cm. in length; anthers light yellow in colour 1·7 cm. in length with longitudinal dehiscence. Style white 3·1 cm. in length with a small orange coloured stigma.	Stamens 5 with anthers containing plenty of pollen; filament light yellow 1·5 cm. in length; anthers light yellow in colour 1·5 cm. in length with longitudinal dehiscence Style 2·7 cm. in length with a small orange tipped stigma.
General Ramarks:	A hardy and cosmopolitan variety Corms big sized and not stoloniferous, giving rise to suckers freely.	Stoloniferous habit of *Musa coccinea* is noted to some extent in the increased length and shape of the corm suckers freely in the case of one hybrid and moderately in the case of the second.	Clearly stoloniferous in habit, suckers being produced at a distance of a yard from the parent plant. Suckers freely only under favourable environments with regard to water supply, manuring etc.

Water Grass (*Brachiaria mutica*) — a Suitable Fodder for Araku Valley

By

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Araku Valley

Introduction: The problem of fodder is becoming acute day by day in the Agency tracts. A sound system of crop husbandry with special emphasis on the growing of fodders, is considered as an effective step in solving the fodder problems of these areas. In Araku Valley of Visakhapatnam district, where the summer heat reaches 100°F or 105°F and winter registers 36°F, it is difficult for any fodder grass to grow well during those parts of the year. Consequently, acute scarcity for fodder grasses exists in these hills during those periods. The need for a drought-resistant fodder grass which will be capable of yielding some fodder during the drought months was keenly felt. In 1950, at the instance of the Director of Agriculture, *Brachiaria mutica*, popularly called Buffalo Grass or Water Grass was introduced into Araku Valley from the Central Farm, Coimbatore to study its performance and assess its suitability as a fodder for this tract. The crop raised in 1951 was under observation for about one and a half years. This note gives a summary of the observations recorded at the Government Fodder Farm, where the average annual rainfall is fifty-four inches, (N. W. Monsoon 32·39"; N. E. Monsoon 10·59"; Hot weather 9·89").

Performance of the Crop: Slips were planted in June 1951 in a plot of forty cents brought to a fine tilth by ploughing and harrowing twice. Well-rotten cattle manure was applied at the rate of ten tons per acre. About ten thousand slips were planted giving a spacing of two feet between rows and one and a half feet in the row. A few gaps found due to failure of slips to strike root were filled up in September with fresh slips, to ensure a uniform stand of the crop. Towards the end of September all the slips were observed to have established well. Growth was not vigorous during the cold weather months and the first cutting was therefore taken in February. During rainy months, it was possible to take a cutting once a month, but during the hot and cold weather periods, only one or two cuttings could be taken. Growth was vigorous during April-May when the summer showers were greatly beneficial for its rapid growth. A slight lull during the south-west monsoon period facilitated one intercultivation during this year when the crop was manured with farm-yard manure at the rate of ten tons per acre. The yield of green fodder obtained for the period during which the crop was under observation is indicated in the following table:

TABLE.

Yields of Water grass at Araku Valley.

Year	Number of cutting	Month of cutting	Yield per plot (40 cents) (green fodder) pounds	Yield per acre (green fodder) pounds
1952	1	February	600	1,500
	2	June	2,920	7,300
	3	July	10,260	25,650
	4	August	6,200	15,500
	5	October	2,200	5,500
	6	November	4,560	11,400
Total ..	6	6	26,740	66,850

The data indicate satisfactory yield of green fodder. It is presumed that in the succeeding years, the yield of the crop would improve as the crop lends itself to intercultivation and manuring. Even after repeated cuttings, the grass remained tender and did not become fibrous. The palatability of the water grass was observed to be good as the cattle relished it well when fed.

Conclusion: The observations indicate the suitability of water grass for Araku Valley and neighbouring Agency tracts, due to its drought-resistant nature and general suitability for raising under rainfed conditions and in situations where adequate irrigation facilities do not exist. There seems to be a great scope for popularising this grass in dry cultivable waste lands and adopting it as a measure of soil conservation by growing it for plugging gullies to break the force of water and aid the deposition of silt. It will thus go a long way in solving the scarcity of fodder grassess of these regions during the hot and cold weather and periods.

EXTRACTS AND GLEANINGS

Sandalwood oil is extractable in the following species, other than the Indian sandalwood. (i) Osyris tenuifolia (Santalaceae), Africa, Tanganyika, Oil 87%; (ii) Ecarya spicata (Santalaceae), Australia.

A piece of the planking of a boat in the harbour of Karachi, West Pakistan was found severely attacked by borers. The wood was Teak *(Tectona grandis)*. The borers were a species of Sphaeroma, probably *Sphaeroma terebrana* (Isopods) which jn the space of one and half year had entirely riddled the teak-planking of this new boat. (Royal Tropical Institute, Amsterdam, Information and Research in 1952 of the Tropical Products' Department).

Weather Review — For the month of August 1953.

RAINFALL DATA

Division	Station	Total rainfall for the month in inches.	Departure from normal in inches	Total since 1st January in inches	Division	Station	Total rainfall for the month in inches.	Departure from normal in inches	Total since 1st January in inches
Orissa & Circars	Gopalpur	15·6	+7·9	36·1	Central Contd.	Vellore	3·0	— 2·7	10·3
	Calingapatnam	10·2	+3·4	31·0		Gudiyatham*	2·5	— 2·4	12·9
	Visakhapatnam	4·8	—0·4	18·4		Salem	2·8	— 3·8	26·1
	Arakuvalley*	9·9	+0·5@	31·8		Coimbatore (A. M. O.)*	1·1	— 0·1	20·3
	Anakapalle*	6·6	+1·2	17·9		Coimbatore	0·9	— 0·3	19·2
	Samalkot*	7·5	+2·1	23·0		Tiruchirappalli	1·6	— 2·5	15·4
	Kakinada	3·9	—1·7	18·5					
	Maruteru*	9·0	+2·8	25·1	South	Nagapattinam	1·9	— 1·2	10·9
	Masulipatnam	10·3	+4·0	22·5		Aduturai*	2·0	— 2·5	9·1
	Guntur*	6·0	+0·5	16·7		Pattukottai*	0·6	— 2·9	11·6
	Agrl. College, Bapatla*	7·1	+1·9	13·1		Madurai	3·1	— 1·0	20·6
						Pamban	0·1	— 0·5	5·7
	Agrl. College, Farm, Bapatla*	6·6	X	15·5		Koilpatti*	1·7	— 0·5	10·3
						Palayamcottai	0·1	— 0·6	9·1
	Rentachintala	5·7	+2·2	16·5		Ambasamudram*	0·2	— 0·1	14·3
Ceded Districts	Kurnool	3·7	—0·8	13·0	West Coast	Trivandrum	3·0	— 1·7	42·7
	Nandyal*	3·8	—0·4	13·7		Fort Cochin	8·9	— 5·0	79·7
	Hagari*	0·1	—2·3	7·6		Kozhikode	10·1	— 7·0	81·5
	Siruguppa*	0·9	—2·4	11·9		Pattambi*	8·4	— 0·1	62·1
	Bellary	0·4	—2·0	12·1		Taliparamba*	14·7	— 9·5	90·6
	Cuddapah	1·1	—4·1	8·3		Wynaad*	13·9	— 0·9	70·1
	Kodur*	6·8	+2·7	12·9		Nileshwar*	14·6	— 8·0	104·3
	Anantapur	1·5	—1·8	10·6		Pilicode*	15·3	— 5·5	97·4
						Mangalore	14·1	—11·4	98·6
Carnatic	Nellore	3·8	+0·8	7·6		Kankanady*	15·0	— 8·0	103·1
	Buchireddipalem*	1·4	—0·8	6·4	Mysore & Coorg	Chitaldrug	0·7	— 2·7	8·6
	Madras (Meenambakkam)	2·4	—2·2	6·8		Bangalore	1·7	— 3·3	19·6
						Mysore	0·7	— 2·6	16·9
						Mercara	28·3	+ 1·5	111·4
	Tirurkuppam*	3·2	—2·6	8·6	Hills	Kodaikanal	4·8	— 2·2	£34·1
	Palur*	5·0	—0·7	13·2		Coonoor*	2·6	— 1·6	37·5
	Tindivanam*	5·2	+0·7	14·2		Ootacamund*	4·9	— 0·1	37·5
	Cuddalore	5·5	+0·7	13·5		Nanjanad*	9·9	+ 2·8	50·0
Central	Arogyavaram (Chittoor dt.)	0·8	—2·4	9·6					

Note:—

1. * Meteorological Stations of the Madras Agricultural Department.
2. @ Average of eight years data for Arakuvalley is given as normal.
3. Average of ten years' data is taken as normal.
4. X The Farm was started only in 1951.
5. £ *Errata:* The rainfall during July at Kodaikanal was only 10·6″ and and total since 1st January was 29·3.

Weather Review for August 1953

The unsettled conditions which prevailed over the West Central Bay of Bengal during the last 3 days of July 1953, intensified into a cyclonic storm of small core in the northwest angle of the Bay on 2 - 8 - 1953, 100 miles south of Calcutta, and crossed the coast near Balasore on the same night and weakened. This progressively weakened while moving west-north westwards till it became unimportant over Kutch and the adjoining lower Sind on 7 - 8 - 1953. Under its influence rainfall was widespread along the West Coast and coastal Andhradesa during the first 4 days of the month. Unsettled conditions were again observed in the north Bay of Bengal, which concentrated into a deep depression centred at 08-30 hours. I. S. T. on 11 - 8 - 1953, 150 miles south-south-east of Calcutta. This deep depression slowly moved westwards, weakened on 14 - 8 - 1953, crossed the Orissa coast the same night near Chandbali and further weakened to a trough of low extending over Orissa, Chota Nagpur and East Madhya Pradesh. This became unimportant over north Madhya Bharat on 18 - 8 - 1953. Under its influence rainfall was widespread in coastal Andhradesa from 8th to 14th August, 1953. There was unprecedented flood in the Godavari from the night of 15 - 8 - 1953, which caused devastation in the central delta with loss estimated at about 50 crores of rupees. The Cauvery was in spate on the 18th August 1953, which submerged low-lying areas round about Tiruchirapalli but this subsided quickly.

A surface low lay over south-east Uttar Pradesh and another one over East Pakistan on 19 - 8 - 1953. The former became less marked in three days and the latter on the very next day. Unsettled conditions were observed in the north Bay of Bengal on the evening of 22 - 8 - 1953, which moved inland and concentrated into a depression over Chota Nagpur on the following day. But this weakned further and merged with the seasonal trough on 24 - 8 - 1953. A low pressure wave moved into north Bay of Bengal from Upper Burma on 26 - 8 - 1953 and caused unsettled conditions, which persisted there upto 28 - 8 - 1953 and moved inland on 29 - 8 - 1953. A low pressure area lay over Chota Nagpur and the adjoining areas on 29 - 8 - 1953 and this became less marked on the succeeding day. The monsoon generally weakened over the Peninsula on 30 - 8 - 1953.

The noteworthy rainfalls and the Zonal rainfall for the month are furnished hereunder.

Note-worthy Rainfalls for the Month

S. No.	Date	Place	Rainfall in inches for past 24 hours
1	1—8—1953	Mercara	4 2
2	2—8—1953	Mangalore	3·1
3	9—8—1953	Gannavaram	2·3
4	27—8—1953	Cuddalore	4·3
5	31—8—1953	Rentachintala	3·1
6	31—8—1953	Madurai	2·3

Zonal Rainfall

S. No.	Name of zone	Rainfall for the month	Departure from normal	Remarks
1	Orissa and Circars	8·05	+ 1·93	Above normal
2	Ceded districts	2·29	— 1 39	Below normal
3	Carnatic	3·79	— 0·59	Just below normal
4	Central districts	1·81	— 2·03	Far below normal
5	South	1·21	— 1·16	Below normal
6	West Coast	11·80	— 5·71	Far below normal
7	Mysore and Coorg	7·85	— 1·78	Below normal
8	Hills	5·55	— 0·28	Just below normal

Agricultural Meteorology Section,
Lawley Road P. O.,
Coimbatore, Dated 11—9—1953.

A. S., C. B. M. & M. V. J.

TRADE NOTES

The increase in area under cotton, sugarcane and red gram is respectively 10·7, 11·5 and 6·6 per cent over the previous five-year averages under these crops while the area under Bengalgram records a decrease by 11·1 percent. The area under potato is estimated to have increased by 3·8 per cent over that of last year, the average figures for the past quinquennium not being available.

In spite of adverse seasonal conditions commercial crops-like cotton and sugarcane have shown a tendency to increase in area. The trend for a rise in acerage under potato is also visible in spite of unfavourable season for this crop in all the three districts where it is raised. It is also apparent that farmers have become self-conscious of their role in promoting higher crop production in the country. When the planning schemes should be able to meet their full needs for improved seed and fertilisers it can be confidently hoped that they will help the State towards the self sufficiency with some approximate justice, understanding as they do, the signs of the time. (From the State Marketing Officer.)

ERRATA

Vol. XL February 1953 No. 2. Page 58. Line 5. For Makkeeram read makkam.

Vol. XL. July 1953 No. 7. Page 328.

Para	Line	[For	[Read
1.	8.	economics	economic.
2.	3.	Raynalds	Reynolds
	7.	and fine banana	and gave banana.
	8.	all through systematice—	a thorough systematic.
	10.	nom, now, (Musasapientum L, et Musa)	nom, nov, (Musa sapientum L. et Musa Paradisiaca.)
	11.	Bose	Bor
	13.	that this not	that this is not
	16.	Bose	Bor
3.	1.	As a book	As a born
	3.	5 exotic types instable	5 eco-types unstable.
4.	1.	cenguratulated	congratulated.
	3.	Or	On.

Departmental Notifications

GAZETTED SERVICE

Postings and Transfers

Name	From	To
Annamalai, C.	D. A. O. on leave	Cane Dev. Officer, Andhra State
Annaswami Iyer, A. K.	D. S. O. Cuddapah	D. A. O. Bellary
Abraham, Dr. P.	Plant Physiologist, Bapatla	Cardamom Specialist, Singampatty
Anantaraman, S. E.	Asst. Agrl. Eng. Tractor workshop, Bellary	Asst. Agrl. Eng. H. Q. D. A's Office, Andhra State
Balasubramaniam, C. S.	Lec. in Ent. Bapatla	Asst. Entomologist, Civil supply, Coimbatore
Bhushanam, K.	D. A. O. Vijayavada	Asst. Marketing Officer, Andhra State
Francis, T. S.	D. A. O. Srikakulam	Addl. D. A. O. Pattukottai
Jaganatha Rao, C.	Cotton Exten. Officer, Coimbatore	To Proceed on leave
Govindaswami, C. V.	Lec. in Mycol. Bapatla	Reverted
Krishnamurthy, C. S.	Asst. Mycol. Anakapalle	Crop and Plant Protection Officer, Coimbatore
Krishna Rao, D. V.	Asst. Agrl. Chemist, Coimbatore	To proceed on leave
Krishna Reddy, T.	Asst. Marketing Officer, Cuddapah	D. A. O. Cuddapah
Kylasam, M. S.	Asst. Ent. Civil supply, Trichy	Asst. Ent. Civil supply, Madras
Mukundan, M.	D. A. O. Ootacamund	Supdt. A. R. S. Wynad
Mohamad Ali, A.	Dy. D. A. Visakapatnam	Spl. Dy. D. A. (Crop sampling), Madras
Mohd Abbas, U. B.	Sugarcane Inspector, Visakapatnam	Addl. D. A. O. Madhurai
Narayana, G. V.	On leave	Principal, Agrl. College, Bapatla
Nagaraja Rao, P. R.	Asst. Ent. Board of Revenue, Madras	Reverted
Nambiar, P. K.	Addl. D. A. O. Pattukotai	Reverted
Parthasarathy, S. V.	Sugarcane Specialist, Anakapalle	To proceed on leave
Palanivelu, T. S.	Asst. Agrl. Eng., Bellary	To proceed on leave
Rama Rao, V.	Spl. Dy. D. A. Crop Sampling, Madras	Dy. D. A. Visakapatnam
Ramesh N. Adyanthiah.	P. P. O. Myco., Coimbatore	Reverted
Ramabhadran, G.	S. D. O. Millets, Bellary	To proceed on leave
Radhakanth, P. K.	Asst. Agrl. Eng. Madras	Asst. Agrl. Eng. Cuddapah
Sulaiman.	Asst. Marketing Officer, Kakinada	D. A. O. Ootacamund
Subbarao, K.	D. A. O. Bellary	D. A. O. Nellore
Santhanakrishnan, B.	D. A. O. Nellore	D. A. O. Guindy
Sambamurthy, K.	Asst. Fruit Specialist, Coimbatore	Reverted
Subbarao, A.	do.	do.

Name	From	To
Sankaranarayana, Reddy, N.	Asst. Agrl. Eng. Bellary	Asst. Agrl. Eng. Agrl. College, Coimbatore
Shanmugham, C. R.	Asst. Agrl. Eng. Chittoor	Reverted
Srinivasan, V.	Chillies Specialist, Guntur	Asst. in pulses, Coimbatore
Srinivasan, Dr. N.	Lec. in Agrl. Economics, Bapatla	Lec. in Agrl. Economics, Coimbatore
Sambasiva Rao, I.	Teaching Asst. Agrl. College, Bapatla	D. A. O. Srikakulam
Seshadri, A. R.	Gazetted Asst. Lec. in Ento., Bapatla	Crop and P. P. O. Coimbatore
Sanyasi Raju, M.	Govt. Agrl. Chemist, Coimbatore	To proceed on leave
Seshadri Iyangar, G.	Asst. Cotton Specialist, Narasaraopet	To proceed on leave
Subramania Chetty, M.	Asst. Cotton Exten. Officer, Bellary	To proceed on leave
Sridharan.	Asst. Agrl. Eng. Mech.	Asst. Agrl. Eng. H. Q. Madras
Narayanan, N. G.	Asst. Cotton Specialist, Siruguppa	Asst. Cotton Specialist, Koilpatty
Mayandi Pillai, S.	Asst. Cotton Specialist, Koilpatty	Cotton Certification Officer, Rajapalayam
Krishnaswami, P. N.	Cotton Certification Officer, Rajapalayam	Gazetted Asst. to the Cotton Certification Officer, Rajapalayam
Kannian, K.	Gazetted Asst. to the Cotton Certification Officer, Rajapalayam	Reverted
Thomas, K. C.	Addl. D. A. O. Madhurai	Reverted
Tirumal Rao, V.	Government Entomologist, Coimbatore	To proceed on leave
Viswanatha Reddy, D.	Compost Dev. Officer, Madras	P. A. to D. A. Andhra
Venkatakrishnan, G.	D. A. O. Guntur	Reverted
Venkatanarasinga Rao, M. B.	Paddy Specialist, Coimbatore	Paddy Specialist, Samalkota

UPPER SUBORDINATE SERVICE

Postings and transfers

Name	From	To
Apparao, P.	Certification Inspector Rajapalayam	Cotton Asst. Siruguppa
Ali Hyder, R.	A. D. Rayadrug	P. A. to D. A. O. Bellary
Bucheswara Rao, A.	Storage Asst. Guntur	A. D. Guntakal
Subramaniam, S.	F. M. Central Farm, Coimbatore	A. D. Tiruchi
Balasubramaniam, V.	Coconut Nursery Asst. Pattambi	O. S. Asst. Nileshwar
Basappa, K. S.	A. D. Pattikonda	A. A. D. Kudithini
Chalamiah Sastry, K. V.	Spl. A. D. Manures Kothapeta	A. D. Kothapeta
Gajapathy, V.	Spl. A. D. Pattukotai	F. M. A. R. S. Satyamangalam

Name	From	To
Gopalakrishnan, G.	A. A. D. Erode	Spl. A. D. Cotton, Coimbatore
Gobinatha Rao, P. V.	A. D. Palamanner	A. D. Hadagalli
Jaganatha Rao, E.	Supdt. Sugarcane Liason Farm, Kulitalai	Spl. A. D. Sugarcane Chittor
Kuttimudali, K. S.	A. D. Trichi	F. M. Central Farm, Coimbatore
Krishnaswami, A. R.	Fruit Asst. Coonoor	Asst. in Paddy Coimbatore
Kuppuswami, B. S.	Horticultural Instructor, Coimbatore	Fruit Asst. Coimbatore
Koraga Bhandari, K.		Spl. A. D. Sugarcane, Coondapur
Kamalanathan, S.	Cotton Asst. Coimbatore	Certification Inspector Rajapalayam
Krishnamurthy, K. A.	S. D. A. Pattukottai	A. D. Tiruvellore
Loganathan, N. S.	O. S. Asst. Pollachi	O. S. Asst. Tindivanam
Meenakshisundaram, D.	Asst. in Paddy Coimbatore	Asst. in Botany, Coimbatore
Mathuram, G. H.	Asst. in Botany, Coimbatore	Res. Asst. Indian Agrl. Research Institute, New Delhi
Mohd Azimuddin, S.	A. D. Kothapeta	Spl. A. D. Manures, Kothapeta
Muthukumarappa, S.	Sugarcane Pest Scheme Karur	Spl. A D. Sugarcane Act, Nellikuppam
Muthuswami, R.	Spl. A. D. Namakal	A. D. Cheyyur
Nagarajan, V.	A. D. Shiyali	Spl. A. D. Lady Willingdon Leprosy Sanitorium, Tirumani
Nageswara Rao, N.	Spl. A. D. Vijayawada	S. D. A. Amalapuram
Narasimhalu, K.	A. D. Tiruvellore	A. D. Ponneri
Narayana Iyer, N.	Marketing Asst., Madras	S. D. A. Cuddalore
Narasimham, B.	Hort. Asst. Bapatla	F. M. Arakuvalley
Narasimhamurthy, K.	Asst. in Millets, Coimbatore	Asst. in Pulses, Narasapatnam
Nageswara Rao, P.	Certification Inspector Rajapalayam	Cotton Asst. Cocanada Improvement Scheme Narasaraopet
Narasimhadas, T.	O. S. Asst. Nileshwar	Coconut Nursery Asst. Samalkota
Nagabhushanam, K.	S. D. A. Masulipatam	Spl. A. D. Pithapuram
Narayana Rao, K.	Journal Asst. Kannada	P. A. to D. A. O. Kurnool
Nallagounder, C. S.	Soil Conservation Asst. Dharapuram	F. M. Central Farm, Coimbatore
Perraju, A.	P. P. A. Ent. Cuddapah	Sugarcane Asst. Anakapalle
Paramanandam, P.	Sugarcane Pest Scheme Karur	A. D. Palani
Prabhuswami, G. R.	S. D. A. Mangalore	Journal Asst. Kannada, D. A's. Office, Madras
Purnapragnachar,	O. S. Asst. Adoni	F. M. Siruguppa
Ramana Rao, D. V.	S. D. A. Amalapuram	Spl. A. D. Vijayavada
Ramalingam, M.	F. M. Panagal Farm Kalahasti	S. D. A. Chittoor
Ramanujulu Naidu, T.	A. D. Narasapur	A. A. D. Unda
Rajappan, P. V.	Fruit Asst. Kodur	Fruit Asst. Coonoor

Name	From	To
Ramasomayajulu, M. V.	F. M. Arakuvalley	Hort. Asst. Bapatla
Radhakrishna Rao,	Spl. A. D. Coondapur	Hort. Instructor, Coimbatore
Ramakrishnan, S.	Fruit Asst. Coimbatore	A. A. D. Natham
Rajagopala Reddy, V.	Paddy Asst. Buchireddi-palayam	Paddy Asst. Tirurkuppam
Ramalingeswara Rao, M.	Coconut Nursery Asst. Samalkot	O. S. Asst. Vayalpad
Radhakrishna Menon, K.	Paddy Cum Millet Asst. Pattambi	Coconut Nursery Asst. Pattambi
Ramanarayana Menon, K.	O. S. Asst.	O. S. Asst. Nileshwar
Ramalingam, M.	F. M. Panagal Farm Kalahasti	Spl. A. D. Nellore
Rangaswamy Iyangar, K.	Spl. A. D. Nellore	F. M. Panagal Farm Kalahasti
Rangaswami, G.		Asst. in Myco. Coimbatore
Rangamannar, D.	Soil conservation Asst. Bellary	Ento. Asst. Siruguppa
Srinivasamurthy, V. S.	P. P. A. Ento. Anantapur	F. M. Sugarcane Liason Farm Hospet
Samu Iyer, P. V.	Spl. A. D. Karur	Spl. A. D. Nilakottai
Sundaresan, K. R.	F. M. Nellikuppam	Spl. A. D. Sugarcene, Namakkal
Subramaniam, S.	A. D. Nilakottai	A. D. Peravurni
Satyanarayana, G.	S. D. A. Chittoor	F. M. Panagal Farm Kalahasti
Suryarao, N. V.	A. A. D. Undi	A. D. Narasapeta
Sasibhusan,	Asst. in Cotton Nandyal	Asst. in Fruits, Kodur
Srinivasamurthy, V. S.	F. M Hospet	Asst. in Cotton Nandyal
Srinivasalu, S.	A. A. D. Tanjore	A. A. D. Mayavaram
Sethuraman, V.	Certification Inspector, Coimbatore	Certification Inspector, Rajapalayam
Suryanarayanamurthy, Ch. V.	O. S. Asst. Tindivanam,	O. S. Asst., Adoni
Satyanarayana, B. S.	Spl. A. D. Chittoor	A. D. Rajampet
Subramaniam, C. L.		Asst. in Myco. Coimbatore
Subramanian, N.	Soil Concervation Asst. Dharapuram	A. D. Trichy.
Thandavarayan, K.	O. S. Asst. Zonal Nucles Scheme, Tindivanam	O. S. Asst., Tindivanam
Velayudam, M.	A. A. D. Natham	A. D., Nilakottai
Venkata Rao, M.	F. M. Central Farm, Coimbatore	F. M., Bapatla
Venugopal, K.	S. D. A. Mayavaram	A. A. D., A. D. T.
Vengu, C.	A. A. D. Kuttalam	S. D. A., Mayavaram
Venkata Naidu, C.	Chemistry Asst., Bapatla	Chemistry Asst., Coimbatore
Venkateswara Rao, M.	Paddy Asst., Tirurkuppam	Paddy Asst., Buchireddipalayam
Venkata Reddy, J.	Certification Inspector, Rajapalayam	Cotton Asst., Adoni
Venkatachari, B.	do. do.	Cotton Asst., Nandyal
Vedachalam, C. D.	Soil Conservation Asst., Dharapuram	A. D., Ponneri, (Chingleput)
Vengoba Rao.	A. D., Guntakal	P. P. A. (Myco), Bellary