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THE COLOUR OF GRAIN (INNER GLUMES) IN PADDY

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There is a great variety in the colour of the grain or rather in that of the inner glumes of different varieties of paddy. In many varieties the glumes are green in the early stages and ripen off to a straw-colour; i.e., they have a slightly yellowish tinge, the intensity of which varies in different varieties. In some, the grain is golden coloured. This colour, again, is of various shades variously distributed in different varieties. In some, the golden colour develops only on approaching ripeness, while as in others it is seen even in the tender grain. In some, the entire glumes have this colour, but in others only portions of them possess this colour, the rest being of straw colour, thus giving rise to the following patterns :—

(1) Full gold. (Ripening gold or deep gold.)
(2) Tipped gold.
(3) Tip and base-gold.
(4) Piebald gold.

There are also some intermediate forms in which the golden colour occurs in dots or patches.

In some pigmented varieties, the golden colour assumes a sort of dark dull appearance.

In golden coloured varieties, the internode also has invariably a golden tint. No red or brown rice is generally associated with this class of paddies, the rice being white with a light yellowish tinge, though in some varieties, the yellow colour is more intense, approaching brownness.

Brown is another colour of frequent occurrence. In this class of paddies, the glumes, when tender, are of a dirty colour, which on ripening, turns to various shades of brown, the following being the chief :—

(1) Very light brown (2) Light brown (3) Brown or reddish brown (4) Dark brown	The brown colour is generally darker in the furrows than on the ridges of the grain.

As in the case of the golden colour, piebald granular, or mottled forms also occur.

In some pigmented varieties, the purple pigment occurs in the glumes also, being prominent, in some varieties, only in the early stages of ripening and fading away almost completely by the time the grain is ripe. Such varieties pass for straw-coloured ones, though the brightness of that colour is somewhat affected. In some varieties, however, the purple colour persists even on ripening, there being differences again in the intensity of the same, so that purple glumed varieties may be grouped into three sub-classes, viz. :

(1) Fading purple
(2) Ripening light purple
(3) Ripening deep purple or purplish black.

A number of varieties develop a black colour in the glumes in the ripening stage. But, in many of these, the black colour is associated with either

the brown colour or the purple pigment referred to already, the pure black occurring only rarely, e.g., Khorea. In the varieties which show pure black colour, the unset or partially developed grains are straw-coloured, a point which enables them to be distinguished from the brownish black ones in which they are brownish. They can also be distinguished from the purplish black ones by the absence of any purple pigment in the early stages of ripening.

Varieties which the writer had opportunities to examine are arranged in the appended statement, under the different classes named above.

The significance of the different colours in the grain is however obscure. In some ancient Indian medical works, e.g., Vagbhata's Ashtangahridaya, distinction is made between the golden and brown-coloured paddies, called Raktha dhanya, and Gaura dhanya and the others, the former two being considered more healthy in general. Even at the present day, golden-coloured paddies, e.g., Ratnachudi, Bangaruthigalu (golden glumed type), Delhi Bhogalu, and Sanna Akkulu, are considered superior to others as table rices. Some of the brown types also, e.g., Molakolakulu, and Sanna Atragada are also considered superior. Astronomers in their annual almanacs (Panchangams) also generally state whether the season will be favourable to the Raktha or other paddies in any particular year.

Some varieties of paddy classified according to the colour of the grain (inner glumes).

Class.	Sub-class.	Pigmented or not.	Varieties.
I. Straw-colour.	...	Non-pigmented.	Alwarsannalu, Balaramabhogam Bangaruthigalu 3, Bayyahunda, Basangi 27, 46, 61, 79 and 90. Boddumani, Boroponko, Budamavadlu, Burma 2, Chevitisompu, Chinnamundabolalo, Chipurubayyunnda Chulakanamahipali, Co. 1, Dasaradhilu, Dusisannam, G.E.B. 24, G.E.B 1303, Gudarisannalu, Gummasari, Gunupuramsannalu, Kalahandisannalu, Kanakaratnalu, Kanakasompu 9, 14, Kevito chompa Konamani 14, 15, 16, Mahipali, Muttubayyahunda, -Naguthalisannalu, Palagummasari 7, 12, Peshanam, Prayaga, Punasakonamani, 1, 2, Radhaprayaga, Sannabayyahunda, Sannavari, Sorimundabolalo, Srikrishnabhogam, Sunkisannalu, Sunnapuvvulu, Suvarnamuthilu, Tellaradhaprayaga, Vankelu, Vavilapadusannalu.
		Pigmented ...	Basangi 33, 75, Drohanapugada 2, Garikasannavari 1, 6, Kokkeradhanyam, Kotthamallisamba, Peshanam 2, Rasangi 21, 23, 24, 26, 29, Swarnalu 9.
II. Gold ...	(*a*) Full-gold—		
	1. Ripening gold.	Non-pigmented.	Hemasannalu.
	2. Deep gold.	Do.	Bangaruthigalu 1, Panianla, Sanna Akkullu, Turpusanna akkullu 3, Yerrabakkalu.
	Do.	Pigmented ...	Araloddilu, Lodhralu, Lodhari, Moharo.
	(*b*) Tipped gold.	Non-pigmented.	Garudavahanalu, Kondakurangi Ratnachudi, 5, 7, 15.
	Do.	Pigmented ...	Ratnachudi 14.
	(*c*) Tip and base-gold.	Non-pigmented.	Ratnachudi 11.
	Do.	Pigmented ...	Ratnachudi 13.
	(*d*) Piebald gold.	Non-pigmented.	Ratnachudi 8, 9.
	Do.	Pigmented ...	Harisankar.
III. Brown.	(*a*) Very light brown.	Non-pigmented.	Bangaruthigalu 2, Bobbilibudama. Burma 1, 4, 5, Koyyisompu, Maharajabhogam, Mundlavari, Palagummasari 4.
	Do.	Pigmented ...	Punasa akkullu 10.
	(*b*) Light brown.	Non-pigmented.	Kosisompu.
	Do.	Pigmented ...	Tobarasulu, Gudakutta.

Some varieties of paddy classified according to the colour of the grain (inner glumes)—cont.

Class.	Sub-class.	Pigmented or not.	Varieties.
III. Brown —*cont.*	(*c*) Brown or reddish brown.	Non-pigmented.	Aravadamsamba 8, Sanna atragada, Pedda atragada, Pedda akkullu, Punasa akkullu 3, 5, 9, Bobbiliganti, Dhanyarasulu, Kosakaddilu, Molakolakulu, Muthusamba, Ramagarudasamba, Red sirumani.
	Do.	Pigmented ...	Aravadamsamba 6, Punasa atragada, Korangusamba, Charabudama.
	(*d*) Dark brown.	Non-pigmented.	Punasa akkullu 16, 23, Vajjanam.
	Do.	Pigmented ...	Kakirekkalu 2.
IV. Purple.	(*a*) Fading purple.	Do. ...	Batla mokudi, Basangi 55, Bodamoli, Borigi, Drohanapugada 1, 2, Kakirekkalu 4, Konna, Krishnakatukalu, Mosapurulu, Nallakonamani, Navakottisannalu 3, 5, Peddakanneralu 1, 2.
	(*b*) Ripening light purple.	Do. ...	Vasannavadlu 2.
	(*c*) Ripening dark purple.	Do. ...	Kakirekkalu 1, Kovilasannalu.
V. Black ...	(*a*) Pure black ...	Non-pigmented.	Khorea.
	(*b*) Brownish black.	Do.	Baital fakir, Nalla budama.
	Do.	Pigmented ...	Nalla arelu (Dalwa), Puntia.

A PRELIMINARY NOTE ON A FUSARIUM PARASITIC ON BENGAL-GRAM (*CICER ARIETINUM*)

BY

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Bengal-gram (*Cicer arietinum*) is a member of the family Leguminosae. It is an important crop of the black soils of the Madras Presidency and is grown immediately after the North-East Monsoon rains. The normal area under the crop is about 121,000 acres.

Butler (1) has recorded *Neocosmospora vasinfecta* on Bengal-gram but all his inoculations were negative. Wollenweber (2) also states that Cicer is subject to a Fusarium wilt but makes no mention of the isolation of the pathogenic organism.

In January this year (1928) specimens of wilted Bengal-gram plants were received from the Experimental Station, Hagari, Bellary District. Microscopic examination of these revealed the presence of Fusarium spores in the affected places. To find out the pathogenicity of this organism some of the bits of the affected parts were incubated and single spore cultures established from the spores produced on the incubated bits.

About the same time, the same disease was noted on the Bengal-gram crop in the Central Farm, Coimbatore. Detailed examination of these wilted plants showed in some cases of wilting a species of a Fusarium and in others a Rhizoctonia.

Symptoms.—The first sign of the disease in nature is a drooping of the leaves caused by loss of turgidity in the leaves and the tender portions of the stem. As the disease advances, the wilting becomes more pronounced and necrosis of tissues is seen in the collar region. When such wilted plants are pulled out they either easily break away at the collar or in cases when the tap root comes out the lateral roots are broken and left behind. Examination of these lateral roots in the soil showed that disintegration had set in by the invasion of the causal organism.

Morphology of the fungus in cultures.—As soon as the organism was brought into pure culture its behaviour in different media was studied.

The following is a brief account of the observations made on the growth of the fungus in different media :—

(i) *Potato-dextrose agar 2 per cent.*—In this medium the fungus grows luxuriantly with the production of good fluffy and cottony growth of mycelium in a week. At the end of the third week, the white cottony growth gradually changes to a very light buff with matting of the mycelium in some places of the tube. Even after six weeks the tube was found to maintain the same colour. Examination of the tube on the 13th day showed a number of spores varying from non-septate to three septate, the non-septate spores preponderating. The conidia are hyaline and slightly curved. Besides these conidia, terminal as well as intercalary chlamydospores are seen growing singly or in chains. A few cases of chlamydospore formation inside the conidia were also observed. They are relatively thick walled and are pear-shaped, elliptical or spherical. They are found to have dense granular contents varying in colour from hyaline to light brown.

Percentage and measurements of conidia in cultures 13 *days old.*

	Per cent.	Average measurements.
0 septate	72·5	19·9 × 4·2μ.
1 „	25·0	19·9 × 4·45μ.
2 „	1·1	25·5 × 5·25μ.
3 „	1·4	33·25 × 5·6μ.

(ii) *Steamed rice.*—In this medium the organism also grows well with the formation of conidia and chlamydospores as in potato-dextrose agar. The colour in this medium, however, is peculiar and quite different from any of the other media tried. On the third day, the growth is

quite fluffy with an ashy tinge. In the course of a week the colour gradually changes to pale pink and during the third week it was observed to have changed to Venetian Pink and Alizarine Pink to Salmon Buff in places and fully covered with Flesh Pink mycelium all over the tube.

Percentage and measurements of conidia in cultures 8 *days old.*

		Per cent.	Average measurements.
(*a*) 0 septate	... ...	95·9	12·95 × 3·85μ.
1 „	... ...	4·1	17·5 × 4·2μ.

Percentage and measurements of conidia in cultures 47 *days old.*

		Per cent.	Average measurements.
(*b*) 0 septate	... ...	81·0	12·3 × 3·9μ.
1 „	... ...	18·4	18·2 × 3·9μ.
2 „	... ...	0·3	25·2 × 4·5μ.
3 „	... ...	0·3	30·8 × 4·9μ.

(iii) *Brown's synthetic medium.*—In this medium the organism does not grow so well as in potato-dextrose or steamed rice. Though the growth is more subdued with light buff in places, there is a marked change in the conidia produced; septate conidia are more in evidence than in the other two. The chlamydospores are similar to those in the potato-dextrose medium.

Percentage and measurements of conidia in cultures 10 *days old.*

		Per cent.	Average measurements.
0 septate	... ...	75	12·6 × 3·5μ.
1 „	... ...	21	19·25 × 4·5μ.
2 „	... ...	2	23·8 × 4·9μ.
3 „	... ...	2	28·7 × 5·25μ

(iv) *Bengal-gram stem* (*sterilized*).—Here the fungus produced a good fluffy growth with septate conidia predominating. One peculiar feature of this medium is that a few four septate conidia are

produced. The septate conidia are more frequent than in other media tried.

Percentage and measurements of conidia in cultures 25 days old.

		PER CENT.			
0 septate	...	24	17·3	×	3·85μ
1 „	...	42	21·0	×	3·85μ
2 „	...	13·8	25·5	×	4·2μ
3 „	...	20·2	31·8	×	5·25μ
4 „	...	rare	42·0	×	4·9μ

Average percentages and measurements of conidia.

		PER CENT.			
0 septate	...	70·0	15·0	×	3·86μ
1 „	...	22·0	19·2	×	4·2μ
2 „	...	3·0	25·0	×	4·7μ
3 „	...	5·0	31·1	×	5·25μ
4 „	...	rare	42·0	×	4·9μ

In none of these cultures has it been possible to get any sclerotial formation.

Germination of conidia.—The conidia germinated readily in distilled water in two hours. They either give rise directly to a network of mycelium or chlamydospores. The germinating conidia produce chlamydospores in two ways. In one case the germ tube is produced for some distance when the tip swells and forms itself into a chlamydospore. In the other, the germ tube forms itself into a chlamydospore so close to the conidia that there is no trace of any connecting link between the conidia and the chlamydospore.

Pathogenicity.—In order to prove the pathogenicity of the Fusarium isolated from wilted bengalgram plants, two series of inoculations were carried out.

First series.—As usual the soil and the pots were sterilised and seeds were sown. When the seedlings were about two weeks old and were

sufficiently grown, inoculations were tried at the collar region. An equal number of controls were also maintained. When the seedlings were inoculated at the soil level, the leaves showed signs of drooping on the third day and on the fourth day the apical shoot loses its turgidity and bends over. By the fifth or sixth day the plants collapsed at the collar region and fell over. (*See* plate.)

The following table gives the details of inoculation experiment :—

Number of pots.	Number of seedlings inoculated.	Manner of inoculation.	Results.
One	Two	Collar, at the soil level (*unwounded*).	Positive.
Two	Three in each ...	Do.	Do.
One	Three	Do.	Do
One (big) ...	Six	Do.	Do.
One („) ...	Three	Do.	Do.
One („) ...	Nine	Do.	Do.

Second series.—In this series also the soil and the pots were sterilised. The soil in four pots was mixed with Fusarium culture and seven seeds were sown in each pot. Four other pots were sown similarly but without the addition of the fungus and were kept as controls. The seeds germinated and the seedlings showed normal growth but on the fifteenth day after sowing, the seedlings in the inoculated soil showed drooping and on the seventeenth day all of them toppled over.

The organism has been reisolated in pure culture from these wilted plants.

In both the series the inoculations have proved positive. This fact shows that infection in nature can take place either by hibernating mycelium or spores in the soil or by air borne spores deposited at the collar region.

Inoculations on Bengal-gram seedlings.
1. Pot showing effects of inoculation. 2. Control pot

Cross inoculation experiments.—Cross inoculations were repeated twice on the following plants with *negative* results.

Gossypium hirsutum, G.indicum, G.herbaceum, Cajanus indicus, Crotalaria juncea, Sesamum indicum, Hibiscus cannabinus and Vigna catiang.

Work on other phases of the life-history of the disease and its control is in progress.

I wish to express my indebtedness to M.R.Ry. S. Sundararaman Avargal, Government Mycologist, for the guidance and encouragement given to me during the course of this work.

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LIFE-HISTORY NOTES ON *MICROBRACON SERINOPÆ, RAMKR.* *(*M.S.*).—A PARASITE ON *NEPHANTIS SERINOPA*

BY

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Introductory.—Of all the parasites utilized by the Madras Agricultural Department to fight the Coconut caterpillar—*Nephantis serinopa*—on the West Coast, *Microbracon serinopae, Ramkr.* is the latest recruit. During a tour undertaken by the writer in August 1927, in Cochin and the adjoining British Territory, he collected and brought with him a few of these parasites with a view to making a study of their life-history and seeing if they could be bred under confinement for the purposes of distribution in infested areas on the West Coast. As it was found possible to rear them out in large numbers at the Insectary at Coimbatore, they were subsequently distributed to the parasite breeding stations at Calicut, Mangalore and Ponnani. Large numbers of these parasites have, during the past twelve months, been bred at some of these stations and liberated in affected gardens on the West Coast.

Life-history.—The following are a few notes on observations made on the life-history and habits of this parasite at the Insectary at Coimbatore.

The adult parasite.—The female wasp (fig. 5) is $2\frac{1}{2}$ mm. long and deep brown in colour. The legs are brown except for the tarsi which are black. The abdomen has dark brown dorsal bands on some of its segments and ends in a long ovipositor.

* This is the manuscript name given to this species by Dr. T. V. Ramakrishna Ayyar, who proposes to publish a description of this insect soon.

The male (fig. 6) is slightly smaller in size, but has a larger number of antennal segments than in the female. The abdomen is darker and is somewhat pointed at the tip.

Eggs—(*Figs. 1 and 1-A*)—The female lays eggs a day or two after emergence. Copulation generally takes place on the day of emergence. After stinging the caterpillar, the female lays about 8–12 eggs generally on its ventral surface, though sometimes the eggs are seen laid on the sides also. The maximum number of eggs laid by a female kept under confinement in a test tube was 440 in 55 days (*vide* Table I).

Eggs are pale yellow in colour and slightly curved. They are 0·5 mm. long and 0·2 mm. broad. The egg period is a little more than a day. In one case it was found to cover 27½ hours.

Grubs—(*Figs. 2 and 2-A*).—The newly hatched grubs are pale white and about 0·6 mm. long and 0·25 mm. broad. After 8–10 hours they assume a pale yellow colour. On the second day these turn pinkish and are then 2 mm. long and 0·75 mm. broad. On the third day they become deep pink with scattered white dots all over the body, and measure about 3 mm. long and 1 mm. broad. When full-fed they are 3–3½ mm. long and 1 mm. broad. These then spin white cocoons of silk (fig. 4) by the side of the dead caterpillar and in a day or two pupate inside. The larval period is 3–4 days.

Pupae—(*Fig. 3*).—The pupa is 2½ mm. long and 1 mm. broad and pale white in colour, when fresh. Later on the abdomen becomes yellow, the antennae and legs black and the thorax brown. The pupal period is 2–4 days.

Duration of life-cycle.—From Table II, it is clear that the whole life-cycle does not take more than 9 days and in a few cases seven days have been found sufficient for it to complete the life-cycle. The length of its life-cycle is therefore shorter than in *Elasmus nephantidis*, Rohw. and *Parasierola* sp. —two other caterpillar parasites on Nephantis— where the life-cycle covers 10—16 and 11—16 days respectively.

Parthenogenesis.—Normally males and females are present and are known to copulate on the day of emergence. Parthenogenetic reproduction has, however, been noted in this species as in some other species of Hymenoptera.

Food of adults.—The adult parasites seem to prefer the body juices of the caterpillars and when these fail they feed on jaggery water. In the case of adults kept for noting their longevity jaggery water alone was given to them.

Other hosts.—These wasps have not been found parasitising any other caterpillar in nature. Under confinement they preferred Nephantis caterpillars to lay their eggs on, but in their absence they laid eggs on other caterpillars as well. Of the following caterpillars given to them, *Argyria fuscivenalis* Hmps., *Utethesia pulchella* Linn., a noctuid on cotton, *Prodenia litura* Fb., *Marasmia trapezalis* Gn., *Earias* sp. and *Parnara mathias*, Fb. the parasites laid eggs on all ; but only in the case of the first three, adults were reared out successfully, while in the last four, the grubs hatching out of the eggs were found to turn sickly and perish.

Longevity of adult wasps.—For longevity experiments glass tubes 6″ × 1″ were used. Wasps were introduced into them and fed with jaggery

water daily. Table III gives the longevity records of 110 parasites kept under observation. The maximum record of longevity in the case of a female was 66 days.

Adults which were not supplied with any food lived only 2–4 days.

Hyperparasites.—So far, the writer has not come across any hyperparasites on this species. Rao Sahib Y. Ramachandra Rao, Government Entomologist, however, informs me that he reared a species of *Pleurotropis* from specimens of cocoons of this Microbracon collected in Cochin in November 1925.

Other species of Microbracon noted in South India.—Dr. T. V. Ramakrishna Ayyar to whom specimens were submitted for examination believes this to be a new species of Microbracon. Already seven species of this genus have been noted, viz., *M. lefroyi* D. & G., *M. tachardiae* Cam., *M. gelechiadiphagus* Ramkr., *M. incarnatus* Ramkr., *M. melleus* Ramkr., *M. chilocida* Ramkr., and *M. pictus* Ramkr.

Comparison of the life-history records of the three larval parasites of Nephantis.—Table IV gives a comparison of life-history notes of *Elasmus nephantidis*, *Parasierola sp.* and *Microbracon serinopae* Ramkr., all parasitic on Nephantis caterpillar. Form this table it will be seen that in *Microbracon serinopae* the total life-cycle is shorter, the longevity of adults greater and the egg-laying capacity higher than in the other two.

In conclusion I wish to express my thanks to Rao Sahib Y. Ramachandra Rao, Government Entomologist, for his valuable advice in the course of the work.

TABLE I.

Egglaying records of a female emerged on 3rd September 1927.

Date.	Number of eggs laid.	Remarks.
Sep. 3	15	Nephantis serinopa caterpillar introduced.
„ 4	18	Do.
„ 5	5	Do.
„ 6	13	Do.
„ 7	12	Do.
„ 8	20	Do.
„ 9 and 10	4	Do.
„ 11	6	Do.
„ 13	8	Do.
„ 14	7	Do.
„ 15	3	Do.
„ 16	4	Do.
„ 17	No egg	Do.
„ 18	„	Do.
„ 19	5	Do.
„ 20	15	Do.
„ 21	14	Do.
„ 22	9	Do.
„ 23	2	Do.
„ 24	3	Do.
„ 25	16	Do.
„ 26	11	Do.
„ 27	16	On Utetheisa pulchella caterpillar.
„ 28	13	Do.
„ 29	15	Do.
„ 30	15	Do.
Oct. 1	9	Do.
„ 2 and 3	No egg	On Nephantis serinopa caterpillar.
„ 4	9	Do.
„ 5	No egg	Do.
„ 6	9	Do.
„ 7	No egg	Do.
„ 8	17	Do.

Egglaying records of a female emerged on 3rd September 1927—cont.

Date.	Number of eggs laid.	Remarks.
Oct. 9 and 10	17	On Nephantis serinopa caterpillar.
„ 11	12	Do.
„ 12	8	Do.
„ 13	7	Do.
„ 14	9	Do.
„ 15	13	Do.
„ 16 and 17	8	Do.
„ 18	4	Do.
„ 19	2	Do.
„ 20	4	Do.
„ 21	19	Two Nephantis caterpillars given.
„ 22 and 23	16	Do.
„ 24	17	Do.
„ 25	4	Do.
„ 26	No eggs	Do.
„ 27	15	Do.
„ 28	Died	

TABLE II.

Table of life-history records.

Serial number.	Eggs found laid.	Larva found hatched.	Duration of egg period in days.	Date of cocooning.	Duration of active larval life in days.	Found pupated.	Duration of larval period in days.	Adults emerged.	Duration of pupal period in days.	Total life cycle.
	1927.	1927.		1927.		1927.		1927.		
1	3rd Sep. ...	4th Sep. ...	1	6th Sep. ...	2	8th Sep. ...	4	11th Sep. ...	3	8
2	3rd ,, ...	4th ,, ...	1	6th ,, ...	2	8th ,, ...	4	12th ,, ...	4	9
3	4th ,, ...	5th ,, ...	1	7th ,, ...	2	8th ,, ...	3	11th ,, ...	3	7
4	4th ,, ...	5th ,, ...	1	7th ,, ...	2	8th ,, ...	3	12th ,, ...	4	8
5	5th ,, ...	6th ,, ...	1	8th ,, ...	2	...	...	13th ,, ...	...	8
6	6th ,, ...	7th ,, ...	1	9th ,, ...	2	...	...	13th ,, ...	...	7
7	6th ,, ...	7th ,, ...	1	10th ,, ...	3	...	...	15th ,, ...	...	9
8	6th ,, ..	7th ,, ...	1	8th ,, ...	...	...	...	14th ,, ...	...	8
9	7th ,, ...	8th ,, ...	1	10th ,, ...	2	...	...	16th ,, ...	...	9
10	7th ,, ...	8th ,, ...	1	11th ,, ...	3	...	...	16th ,, ...	...	8
11	7th ,, ...	8th ,, ...	1	10th ,, ...	2	12th Sep. ...	4	14th ,, ...	...	7
12	8th ,, ...	9th ,, ...	1	11th ,, ...	2	...	..	15th ,, ...	...	7
13	12th ,, ...	13th ,, ...	1	16th ,, ...	3	17th Sep. ...	4	20th ,, ...	...	8
14	12th ,, ...	13th ,, ...	1	16th ,, ...	3	...	...	21st ,, ...	...	9
15	13th ,, ...	14th ,, ...	1	16th ,, ...	2	...	...	20th ,, ...	...	7
16	13th ,, ...	14th ,, ...	1	...	...	...	...	21st ,, ...	...	8
17	14th ,, ...	15th ,, ...	1	...	...	...	...	23rd ,, ...	...	9
18	15th ,, ...	16th ,, ...	1	20th Sep. ...	4	...	...	23rd ,, ...	...	8
19	16th ,, ...	17th ,, ...	1	20th ,, ...	3	...	...	24th ,, ...	...	8
20	20th ,, ...	21st ,, ...	1	...	...	...	...	29th ,, ...	...	9
21	21st ,, ...	22nd ,, ...	1	...	...	...	...	30th ,, ...	...	9

22	22nd	„	...	23rd	„	...	1	25th	Sep.	...	2	27th	Sep.	...	4	1st	Oct.	...	4	9
23	24th	„	...	25th	„	...	1	27th	„	...	2		...		...	3rd	„	...	...	9
24	27th	„	...	28th	„	...	1	1st	Oct.	...	3	3rd	Oct.	...	5	8th	„	...	5	11
25	2nd	Oct.	...	3rd	Oct.	...	1		...		...		...		...	11th	„	...	...	9
26	4th	„	...	5th	„	...	1		...		...		...		...	12th	„	...	...	8
27	4th	„	...	5th	„	...	1		...		...		...		...	13th	„	...	...	9
28	5th	„	...	6th	„	...	1		...		...		...		...	14th	„	...	...	9
29	6th	„	...	7th	„	...	1		...		...		...		...	15th	„	...	...	9
30	11th	„	...	12th	„	...	1		...		...		...		...	19th	„	...	...	8
31	12th	„	..	13th	„	...	1		...		..		...		...	20th	„	...	...	8
32	15th	„	...	16th	„	...	1	18th	Oct.	...	2	20th	Oct.	...	4	23rd	„	...	3	8
33	16th	„	...	17th	„	...	1		...		...		..		...	24th	„	...	...	8

TABLE III.

Longevity records of adults.

Tube number.	Number of adults introduced.	Number of days alive.	
		Males.	Females.
1	1	38	...
2	2	11	55
3	1	8	...
4	1	10	...
5	2	4	66
6	2	...	17, 22
7	1	...	20
8	4	18, 18, 18, 18	...
9	3	20, 26	16
10	3	18, 21, 22	...
11	3	10, 11, 17	...
12	1	10	...
13	3	24, 27, 29	...
14	2	9	18
15	5	9, 17, 23, 28	18
16	2	28	28
17	7	10, 15, 26, 27, 47	41, 45
18	9	14	35, 37, 46, 47, 48, 56, 52, 50
19	8	6, 13, 19, 20, 22, 24, 25	9
20	6	13, 15, 19, 20, 25	13
21	15	8, 11, 12, 17, 17, 21, 22, 22, 22, 25, 26, 29, 31	11, 21
22	5	9, 20, 20	20, 21
23	8	18, 19, 22, 23, 23, 26	26, 29
24	12	4, 17, 19, 27, 28, 29, 30, 34, 38	20, 45, 49
25	2	25	26
26	2	...	15, 23

* *A comparison of three larval parasites on Nephantis caterpillar.*

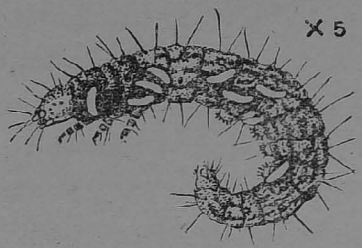
Particulars.	Elasmus nephantidis.	Parasierola Sp.	Microbracon serinopæ.
Egg stage	24–36 hours ...	24–48 hours ...	24–28 hours.
Larval stage	3–4 days ...	3– 4 days ...	3–4 days.
Pupal stage	6–7 days ...	7– 8 days ...	2–4 days.
Total lifecycle	10–12 days ...	10–16 days ...	7–9 days
Maximum record No. of eggs, laid by one female.	57	142	440.
Maximum record of longevity of adults.	20 days ...	44 days ...	66 days.
Stage of host parasitized.	Larva (quiescent condition preparatory to pupation).	Larva (full grown).	Larva (medium size).
Natural enemies ...	Chalcid Wasp.	1. Proctotrupid. 2. Eurytoma Sp. 3. Pleurotropis. 4. Pediculoides ventricosus.	Pleurotropis Sp.

* There is also another larval parasite, a Braconid, *Apanteles taragamae* parasitic on this caterpillar. It is very efficient in the sense that only one egg is laid on each caterpillar and this is enough to destroy it. As detailed life history work has not been done on this, it is not included in the table.

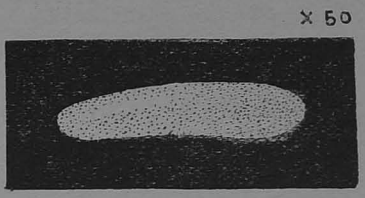
DESCRIPTION OF PLATE.

Microbracon serinopae.

1. Egg magnified × 50
1A. Paralysed caterpillar with eggs × 5.
2. Full grown larva × 15.
2A. Paralysed caterpillar with grubs × 5.
3. Pupa, enlarged × 15.
4. Cocoons of Microbracon sp. under shrivelled body of caterpillar × 5.
5. Adult wasp—Female × 10.
6. Adult wasp—Male × 10.



1 A



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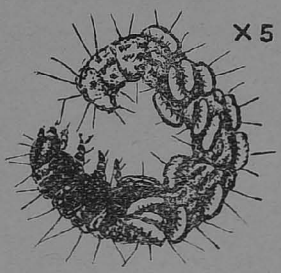
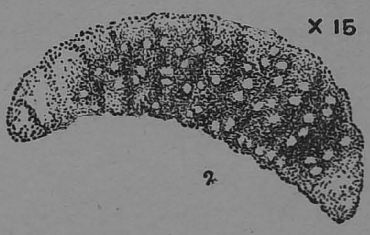


2 A



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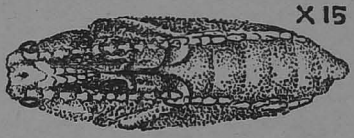

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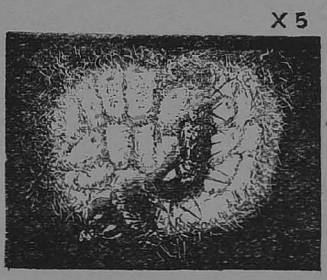

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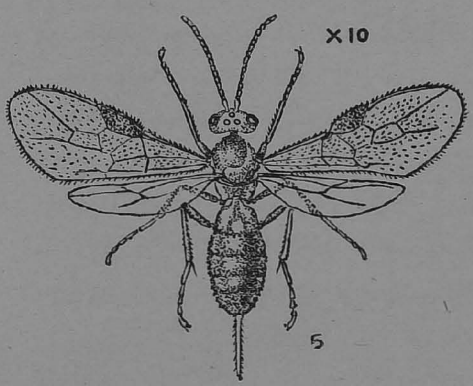

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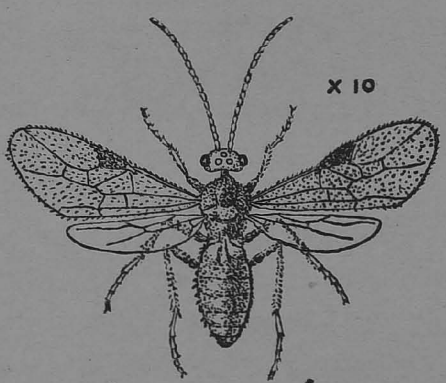


6

Microbracon serinopæ, Ramkr. (M.S.).
Life-history.

CONTROL OF RAT DAMAGE IN PADDY FIELDS

BY

K. VENKATARAMAN, M.A. (HONS.),
Assistant Paddy Specialist, Aduturai.

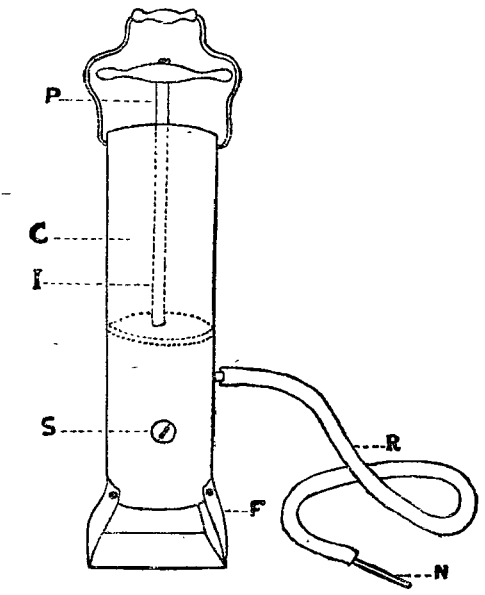
General.—Rats, which generally harbour in bunds of paddy fields, form a serious menace to the crop. The devastating inroads which they make on the paddy crop in the maturing stages, are dreaded by the ryot ; and popular belief has it that a single rat accounts for the loss of half a kalam or 32 lb. of paddy grain. The damage usually starts at flowering time of the crop, although instances of rat cuts before the flowering stage are not unknown. The damage may extend up to four weeks from the time the crop runs into ears.

The nocturnal field-rodent commences its destructive activities in the dark, and cuts ear-heads by nibbling at their stalks. The cut ear-heads are carried by the rat and stored well inside its burrow. The writer once chanced to notice a rat-burrow crammed full of ripe earheads of paddy meant, no doubt, as a stock of provisions for the subterranean occupants. The rat-burrows are neither straight nor do they keep to a constant depth below ground-level. They are tortuous and ramify in their course, often having false runs intended to mislead the natural enemies of the wily rat. Sometimes there are two exits for a single rat-hole facilitating the escape of the rat when pursued.

Control measures—(a) The native rat-catcher.—The usual expedient adopted by ryots for controlling the pest consists in engaging professional rat-catchers to dig out the burrows and kill the rats. The rat-catcher reconnoitres the field-bunds intent on locating rat-runs. There seem to be certain signs which enable him to distinguish the inhabited rat-burrows from the deserted ones. The piling up of fresh earth by the side of bunds, and a peculiar smell thereof, are considered by the rat-catcher to be indications of an inhabited rat-burrow. After fixing upon a likely rat-hole, the rat-catcher proceeds to work at it from the top downwards, ruthlessly digging bunds and keeping a wary eye all the time to meet the fugitive. Any rat emerging out of the burrow, promptly falls a prey to his stick. (If, however, no rat should be forthcoming, the rat-catcher abandons that rat-hole and proceeds with the next burrow located by him.) This measure tends to alleviate the rat-nuisance and minimize damage to the crop. However, the remedy while curing one evil gives rise to another. If the depradations of the rat have thus been checked, the ravages wrought by the rat-catcher on the bunds have still to be made good. The dug-out bunds, therefore, form the primary disadvantage incidental to the rat-catcher's method.

As regards the cost involved, it may be stated that the rat-catcher is generally paid by the results of his catch, at one anna for every adult rat killed. The sub-joined table contains details regarding payments to the rat-catcher and the cost of subsequent repairs to bunds.

Cyanogas Foot-pump



C—Cylinder of pump.
S—Screw lid of charging chamber.
F—Foot-rest.
P—Piston with handle
R—Rubber tube.
N—Nozzle.
I—Position of piston and washer inside.

Month.	Date on which rat catcher was engaged.	Number of rats caught.	Wages paid to rat-catcher.	Cost of repairing bunds.
			Rs. A. P.	Rs. A. P.
August 1927	7th ...	10	0 10 0	0 7 0
December 1927	3rd ...	18	1 2 0	0 14 0
,, ...	6th ...	18	1 2 0	0 10 6
,, ...	9th ...	34	2 2 0	1 0 6
,, ...	15th ...	18	1 2 0	0 14 0
,, ...	17th ...	16	1 0 0	0 14 0
,, ...	22nd ...	14	0 14 0	0 14 0
		128	8 0 0	5 10 0

Total cost of killing 128 rats by engaging the rat-catcher and renewing bunds later Rs. 13-10-0.

(*b*) *Trials with Cyanogas foot-pump*—(i) *Description of the foot-pump.*—The Cyanogas foot-pump is an instrument designed for use in the control of rat-damage. The appliance consists in the main of an arrangement for pumping out through a metallic nozzle calcium cyanide dust thrown into it. The charging chamber in the barrel of the pump is first filled with calcium cyanide dust, and the strokes of the piston thereafter cause a forcible ejection of the cyanide dust through the nozzle. The fatal effect of calcium cyanide dust is due to the fact that when it is exposed to the air, it is acted upon by atmospheric moisture forming hydrocyanic acid gas which is extremely poisonous. That grade of the commercial stuff known as Cyanogas "A" dust, is recommended for use with the foot-pump in exterminating rats in field-bunds. The old pattern of the pump fitted with rubber washer for the piston was not quite satisfactory, as the rubber washer wore out very quickly, and replacement was difficult owing to the cumbrous nature of the attachment. Another pattern of the pump with

the piston having a simple leather washer was found to work more satisfactorily.

(ii) *Results of trials.*—The Cyanogas foot-pump was first tried at this station in August 1927. A definite quantity of calcium cyanide "A" dust, was put into the receptacle of the pump and preliminary trials were made with six holes in field-bunds. The "cyanide" dust was pumped into each burrow, and the hole was immediately closed with earth to prevent the escape of the poisonous gas into the atmosphere. After the lapse of about six hours, every one of the treated holes was dug out with a view to discover the poisoned rats inside. Out of the six holes treated, only three showed dead rats inside; and the remaining three were probably deserted burrows. In another case, the cyanogas-pump was used for "gassing" a rat-hole into which a rat had previously been noticed to enter. In this instance, a positive result was obtained on excavating the rat-hole. It therefore seemed certain that in the case of inhabited rat-burrows "cyanogas-pump" was sure to be effective. Moreover, the ease with which the foot-pump may be carried, and the deadly nature of the gas evolved, readily commended its use.

Great difficulty, however, was experienced in discriminating inhabited rat-holes from deserted rat-burrows, and it was not feasible to check up results by digging out every rat-hole that was treated. Even if such a course had been adopted, the task would have been a thankless one entailing laborious repairs to bunds. The safest course under the circumstances was to treat alike all rat-burrows whether inhabited or not, and a

campaign of "gassing" systematically rat-holes in all field-bunds at the station was started. The success of the campaign was to be judged inferentially by the absence of rat-damage to the crop. This systematic campaign was pursued in all *kuruvai* fields during the months of September and October in the years 1927 and 1928, and the result was remarkable. No rat-damage was noticed on the *kuruvai* crops.

The table given below contains details of the cost of working the "cyanogas-pump" in fumigating rat-holes. Since it was definitely found that "gassing" with the pump proved fatal to the inhabitant of the rat-hole, if at all the rat-hole was inhabited, the treated holes were not dug out. A half-pound charge of calcium cyanide "A" dust in the chamber of the foot-pump, was found sufficient to treat 58 rat-holes making twelve complete strokes of the piston for each rat-hole treated.

Cyanogas foot-pump.

Date.	Number of rat-holes "gassed."	Number of hours for which a cooly was at work.	Cost of labour used.
1927.			RS. A. P.
13th August	12	2	0 1 9
17th do.	17	2	0 1 9
18th do.	27	2	0 1 9
2nd September	20	2	0 1 9
6th do.	7	2	0 1 9
10th do.	28	2	0 1 9
12th do.	11	2	0 1 9
17th do.	9	2	0 1 9
Total ...	131	16	0 14 0

Total number of rat-holes gassed from 13th August to 17th September 1927.	Quantity of calcium cyanide "A" dust used.	Cost of "A" dust used.	Cost of labour for handling pump.	Total cost.
	LB. OZ.	RS. A. P.	RS. A. P.	RS. A. P.
131	1 2	1 15 6	0 14 0	2 13 6

	RS. A. P.
Total cost for treating 131 rat-holes with Cyanogas foot-pump using 1 lb. and 2 oz. of calcium cyanide "A" dust.	2 13 6

Now, presuming that out of the 131 rat-holes "gassed" fifty per cent were inhabited ones—(a presumption which is safe to make when dealing with over a hundred rat-runs)—65 rats have been killed at a cost of Rs. 2–13–6, whereas the corresponding cost for destroying 65 rats by indenting on the services of the professional rat-catcher works out to Rs. 6–14–8. The cyanogas-pump is therefore 58·5 per cent cheaper than the "rat-catcher" and as efficient, with the additional advantage of avoiding dug-out bunds.

(*c*) *Rats caught in crab-traps.*—In an article in the year book for 1927 on "Crabs in paddy fields" mention has been made by the writer that field-rats have often been trapped in the pots meant for crabs. The crabtrap, in brief, may be described as a "mud chattie" buried in the field just flush with groundlevel and baited with rice-bran. It must be stated that rats were found trapped only in those chatties which were partly filled with water. The numbers of such rats trapped in crab-pots during the current paddy-season are given below.

Month.	Number of field rats trapped gratuitously in crab-pots.
July 1928	24
August 1928	27
September 1928	14
October 1928	10

It should be borne in mind that this aggregate catch of 75 rats during July to October 1928 was only a side-issue to the carrying on of a systematic campaign directed mainly against crab-damage.

PARTHENOGENESIS IN COCONUT

BY

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Assistant Paddy Specialist, Aduturai.

"Parthenogenesis" or the development of a reproductive cell (egg-cell) into an embryo without fertilisation, is a phenomenon of uncommon occurrence in higher plants. Ordinarily, in "Phanerogams" or flowering plants, reproduction by the fusion of two sexually differentiated cells, to wit, the ovum and sperm-cell, is the rule. The fusion of the ovum-nucleus with that of the generative nucleus of the pollen-cell, forms the essence of fertilisation, and this leads to the development of an embryo. The second generative nucleus of the pollen-cell also fuses with the secondary nucleus of the embryo-sac to form the endosperm nucleus which ultimately gives rise to the endosperm. The act of fertilisation has therefore a double aspect, primarily giving rise to the embryo, and secondarily stimulating the formation of the endosperm. It is therefore evident that in the case of parthenogenetic development, the formation of a true

endosperm cannot be expected although an embyro might be formed from the unfertilised egg-cell.

Among higher plants, instances of parthenogenesis have been noted in some Compositeæ, and also in Alchemilla, Thalictrum purpurascens, Wickstrœmia indica, Ficus hirta, and Marsilia Drummondii. A case of parthenogenesis observed by the writer in coconut (Cocos nucifera) is briefly described in this note.

In a village nine miles away from Nannilam, a coconut tree was found to bear leafy seedlings sprouting up directly from the floral portion "in situ". From a direct enquiry on the spot, it was learnt that the tree had not borne a single mature coconut with endosperm, but that it produced only "buttons" (unfertilised small nuts) some of which strangely grew out into green seedlings, while still attached to the parent tree. A floral branch was severed from the tree and photographed (see plate I). The tree at the time of inspection bore several green seedlings that had sprouted out of "buttons" on the branches of the inflorescence. Several of the "buttons" were cut across and examined, and they all proved to be unfertilised ovules without any sign of endosperm whatever. The seedlings that had grown "in situ" from the "buttons" were of various stages of growth, the tallest of them measuring 26·5 inches in height, and bearing five green leaves.

It was considered that an examination of an unopened spathe might give some interesting insight into the origin and development of these seedlings from unfertilised ovules. Accordingly an unopened spathe was cut from the tree. The spathe was ripped open with a strong knife, and a

PLATE I.

scrutiny of the inflorescence revealed that some of the ovules had started to develop and had produced growth primordia. Since normal pollination in the coconut can take place only after the natural splitting open of the spathe, and the dehiscence of the anthers, the fact that some ovules in the immature unopened spathe showed signs of development and growth, unmistakably points to parthenogenetic development.

Survival of such seedlings after transplantation.—An attempt was made to see if these parthenogentically produced seedlings would survive when severed from the floral branch, and planted in suitably-prepared soil. Accordingly, two of the biggest seedlings were carefully separated from the floral branch and planted in pits, which had been filled up with well-prepared soil.

The height of these seedlings when planted was noted as shown below :—

Date of planting.	Number of pit.	Height of seedling.	Number of green leaves on it.
		INCHES.	
30th November 1927	1	24·5	4
Do.	2	22·5	5

The seedlings were carefully watered and looked after. The leaves, however, dried up one after the other and finally both the plants died after five weeks. This only afforded a confirmation of what the writer was told at the site of the tree in the village, that such seedlings had failed to establish themselves when planted in the soil. It is probable that the parthenogenetically produced seedlings lacked the necessary vigour for effecting establishment on the soil.

EFFECT OF SPACING ON SOME ECONOMIC CHARACTERS IN COTTON

BY

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Introduction.—Spacing is one of the environmental factors that operate upon the plants of any crop, and may, therefore, induce fluctuating variations within the members of even a pure line. It is possible that a pure strain of cotton grown consecutively for a few years under a particular spacing, may become considerably modified in its quantitative characters such as lint length, lint weight and seed weight, when transferred to a narrower one.

Under ordinary field conditions in improved methods of agriculture, cotton is sown with the drill the tynes of which are a foot and a half apart, and the crop later on thinned to a distance of 9 inches between plant and plant in the row. But, this spacing ($1\frac{1}{2}' \times \frac{3}{4}'$) has been found in practice to be inadequate for the pedigree plots, as the breeder has to be frequently moving between the plants for studying their characters.

With a view to investigate whether the narrower spacing obtaining under field conditions would appreciably alter the values of the economic characters in cotton, the present enquiry was taken up at the Cotton Breeding Station, Koilpatti, in the season of 1927–28.

Material and methods.—Seeds of a pure strain (539) of Karunganni (*Gossypium Indicum*) were sown in a fairly uniform portion of field No. 26B. on the 31st October 1927, in two adjacent plots. In the one, the seeds were dibbled at a distance of

3 feet between rows and 2 feet along the row as in the pedigree plots, while in the other, they were drilled in the ordinary way.

In both plots, two plants were left out as outskirts, on all the four sides, in order to eliminate the marginal effects. When the plants had grown up to a maturity and begun to put forth their floral buds, 59 normal vigorous plants were marked out from each plot and serially numbered. Care was taken to see that the selected plants had neighbours on all sides.

A flowering and bolling record was maintained daily for each of these 59 plants. Dated tags were tied to flowers on the day of their opening and the bolls developed from them picked with their respective dates of flowering. The maturation period was thus ascertained. The produce both of season and summer from the whole plot excluding outskirts was collected at regular intervals of three days from the 24th March up to 3rd July 1928.

(1) *The node at which the first sympodial branch arises.*—In the early part of January, by which time the floral buds appeared, the position of the node at which the first sympodial branch appeared was determined for each plant in the two plots, and frequency tables were worked out.

Node.	3′×2′.	Drilled.
8	...	1
9	1	3
10	4	11
11	28	55
12	49	72
13	32	101
14	22	89
15	6	39

Node.				3′×2′.	Drilled.
16	...	...	...	2	13
17	...	...	...	1	5
18	...		...	...	1
19	...	...	...	...	1

It will be found that in the case of the sown plants, the modal value is at the 12th node, while in the drilled plot it occurs at the 13th.

(2) *Flowering.*—A record was maintained of the number of flowers that opened in each plant daily. From this, the average number of flowers produced per plant per day was calculated and represented in Plate I.

The greater area enclosed by the curve for widesown plants clearly depicts the much greater amount of flower production in them. Secondly, it is also apparent that the wider-sown plants are later in flowering than the drilled ones. The maximum height in the case of the drilled plant is attained on the 8th of March after which there is only a gradual decline. But in the other, flower production begins to increase steadily only after this date and a high flush is maintained between the 11th March and of the 7th of April. A similar lateness prevails over the summer picking as well.

Balls and Holton (2) have also come to the conclusion that " the flowering curve comes to an end later and later with wider spacings."

It may also be mentioned that the wide-sown plants have, on a total, produced about 200 flowers while the field-sown ones, only 40. That is, the former has put forth five times as much as the latter. Balls(1), working with Egyptian cotton,

PLATE I.

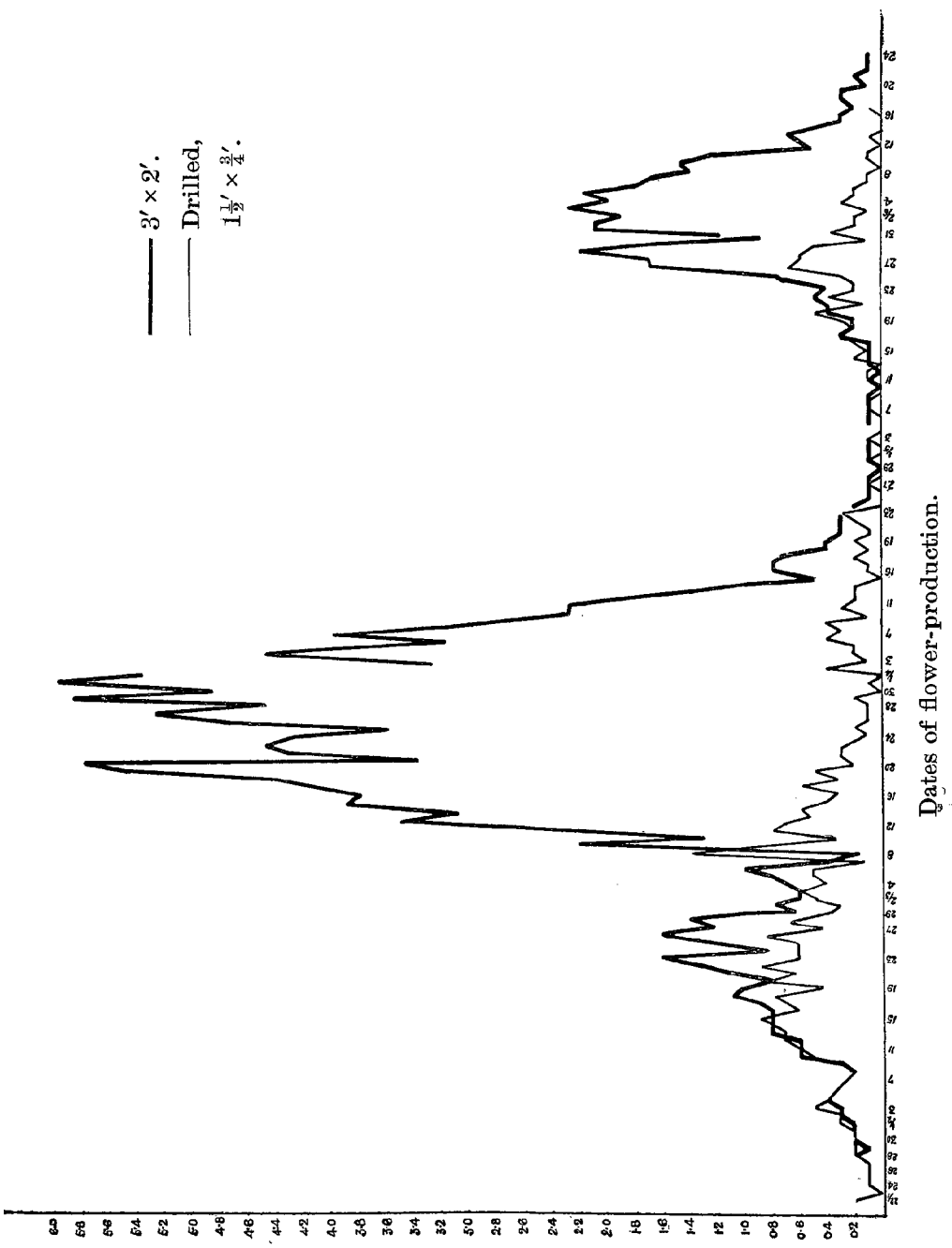
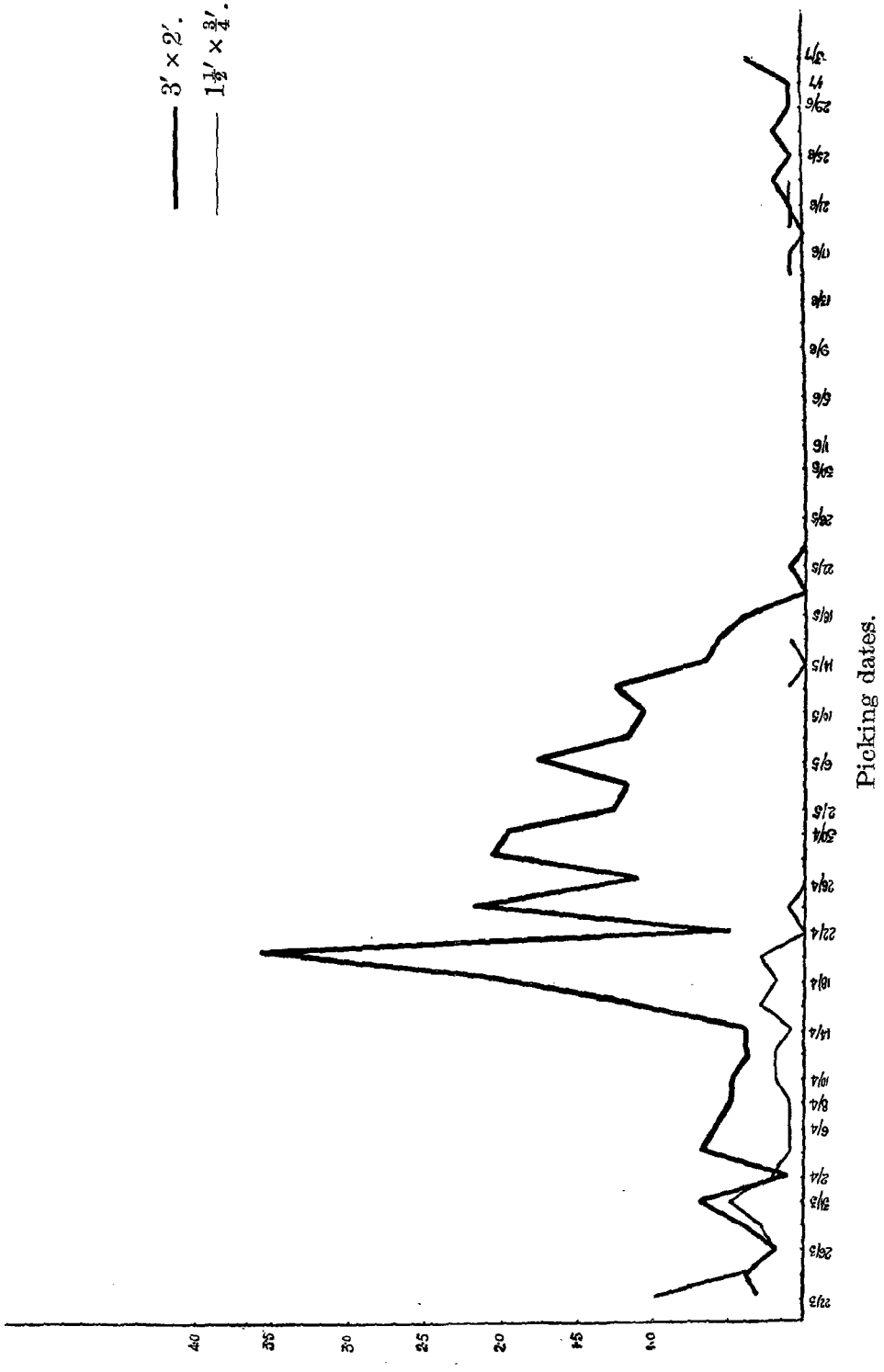

3′ × 2′.
Drilled,
1½′ × ¾′.
Number of flowers per plant per day.
Dates of flower-production.

PLATE II.



found that the wide-sown plants produced four times as many flowers as the other.

(3) *Bolling.*—Every alternate day, a record was made of the number of bolls that dehisced in each plant together with the locular composition of the boll. The number of bolls per plant per day was worked out to form the bolling curve shown in Plate II.

It is seen from the curve that the maximum number of bolls per plant per day in the wide-sown plants, is attained only on the 20th of April, whereas in the drilled ones, it is as early as the 22nd March. With narrower spacing, fruiting is brought about a month earlier. Balls and Holton have also found that the closer the spacing the sooner the maximum bolling is reached.

Macnamara(4), Tisdale(5), and Stansel(6), have independently of one another observed that close spacing reduced the size of the bolls. As no boll measurement was taken up in the present inquiry, this point could not be dealt with.

(4) *Maturation period.*—The interval between the flowering and picking dates was calculated and shown below :—

Dates of flowering.	3 locked.		4 locked.	
	3′ × 2′.	Drilled.	3′ × 2′.	Drilled.
1928				
20th February	39	41	39	40
27th February	39	39	37	39
5th March	39	38	38	37
12th March	37	37	36	37
26th March	37	37	34	32
Average ...	38·2	38·4	36 8	37·0

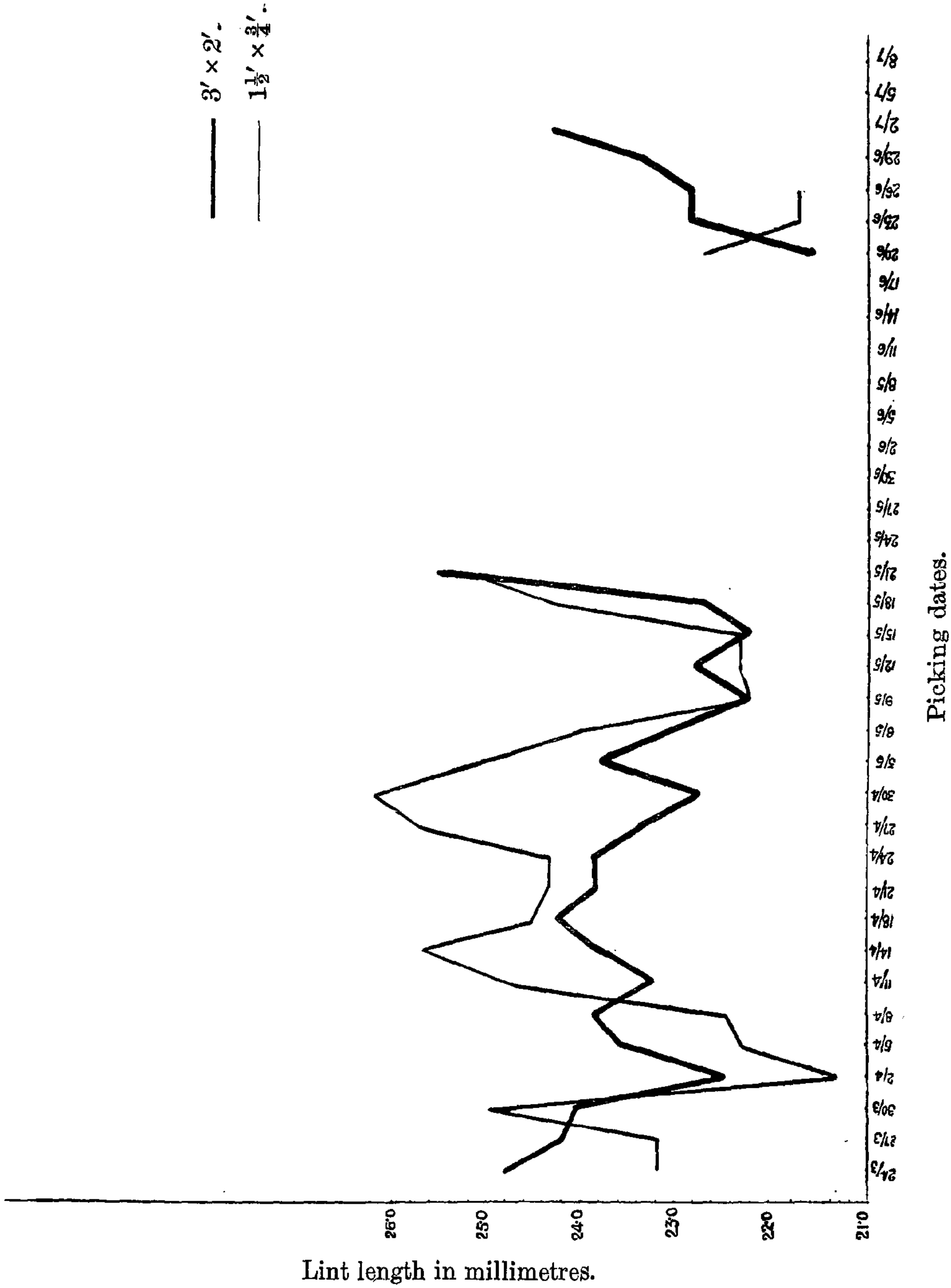
From the averages of the maturation period between the two plots, it is obvious that there is no appreciable difference. The difference was further examined statistically by the application of student's method of working out the standard deviation of the difference. There was found to be no significant difference.

(5) *Lint length.*—The third seed from each of six locks selected from the produce of each picking date was combed out on the right side. The maximum length of lint on the seed to the edge of the halo along a radius was measured and the average of the six readings taken. The lint length in millimeters is represented in Plate III. The range of variation is much greater in the narrow-spaced-plants than in the wide-sown ones. But the difference between the two was found to be not statistically significant.

(6) *Seed and lint weights.*—For the determination of seed and lint weights, samples each of 100 good seeds were chosen as nearly as possible from 100 different locks, as this has been found by Hilson(3), to be a sufficiently large number on which to determine average seed weight and average weight of lint per seed. In order to eliminate the error introduced by fluctuation in atmospheric humidity, the necessary corrections were made to the final weights of lint and seed.

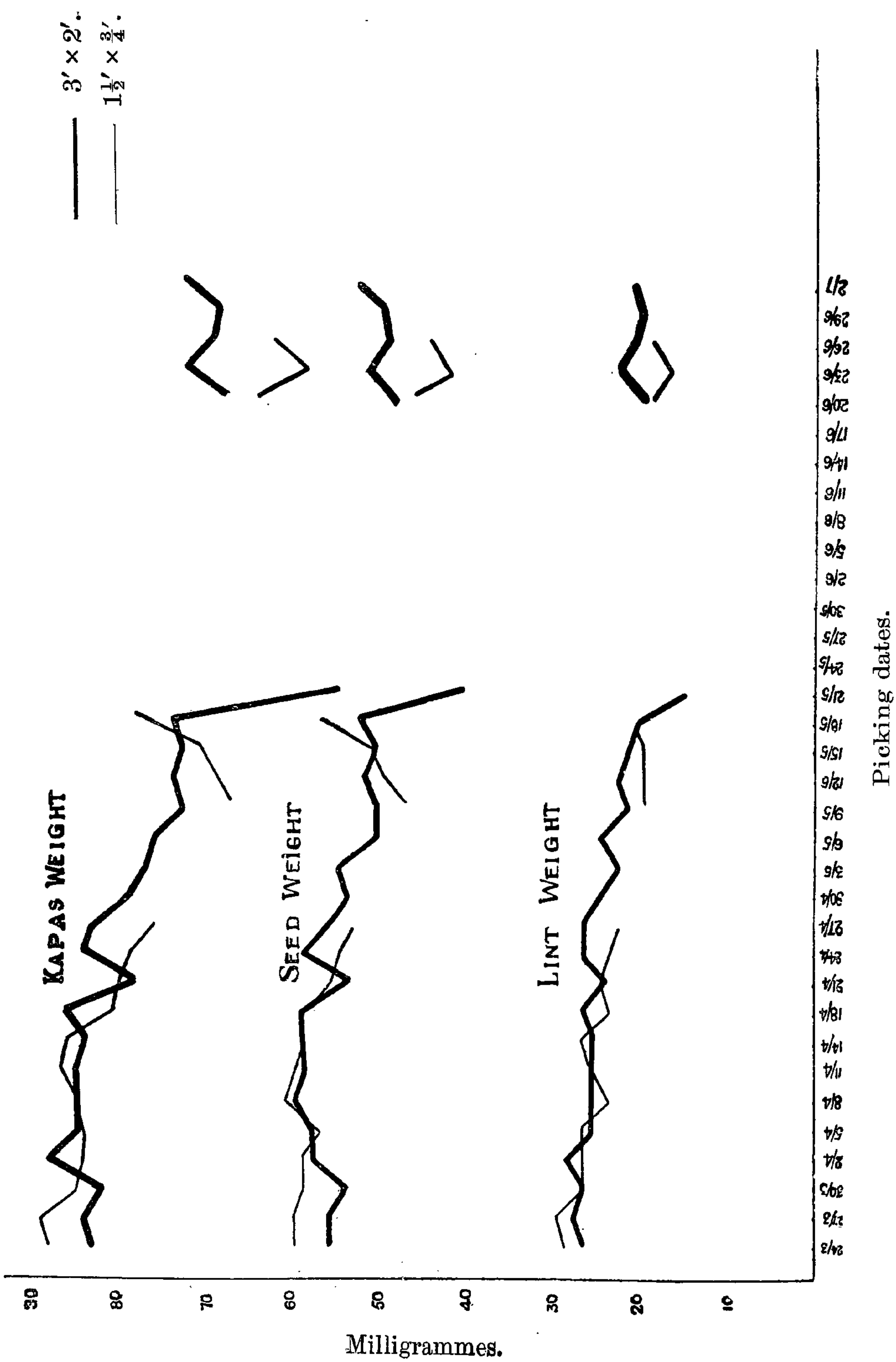
Seed weight.—The sample of 100 seeds selected from the produce of each picking date, was ginned and after removing the broken and damaged ones, the remaining ones weighed and counted. The weight of the sample divided by the number of seeds in it, gives the weight per seed in milligrammes as shown below.

PLATE III.



3' × 2'.
1½' × ¾'.
Picking dates.
24/3
27/3
30/3
2/4
5/4
8/4
11/4
14/4
18/4
21/4
24/4
27/4
30/4
3/5
6/5
9/5
12/5
15/5
18/5
21/5
24/5
27/5
30/5
2/6
5/6
8/6
11/6
14/6
17/6
20/6
23/6
26/6
29/6
2/7
5/7
8/7
26.0
25.0
24.0
23.0
22.0
21.0
Lint length in millimetres.

PLATE IV.



3′ × 2′.
1½′ × ¾′.
Kapas Weight
Seed Weight
Lint Weight
90
80
70
60
50
40
30
20
10
Milligrammes.
24/3
27/3
30/3
2/4
5/4
8/4
11/4
14/4
18/4
21/4
24/4
27/4
30/4
3/5
6/5
9/5
12/5
15/5
18/5
21/5
24/5
27/5
30/5
2/6
5/6
8/6
11/6
14/6
17/6
20/6
23/6
26/6
29/6
2/7
Picking dates.

Picking date.	3′ × 2′.	Drilled.
1928.		
24th Mar.	56·3	59·5
27th Mar.	55·8	60·4
30th Mar.	54·1	59·2
2nd Apr.	57·9	58·7
5th Apr.	58·4	57·2
8th Apr.	59·5	60·5
11th Apr.	58·9	60·4
14th Apr.	58·5	58·7
18th Apr.	58·5	58·2
21st Apr.	53·6	55·4
24th Apr.	58·0	55·0
9th May	51·3	46·9
12th May	52·1	50·4
15th May	51·0	51·2

When the average seed weights between the two plots were compared, the difference was not significant.

Lint weight.—The lint obtained from 100 seeds of each day's sample was weighed and the weight of lint per seed calculated by dividing the weight of the sample by 100. The lint weight per seed is given below in tabular form as well as graphically.

Picking date.	3′ × 2′.	Drilled.
1928.		
24th Mar.	27·4	29·4
27th Mar.	28·0	29·6
30th Mar.	27·2	26·7
2nd Apr.	28·9	26·6
5th Apr.	26·4	27·0
8th Apr.	26·3	24·0
11th Apr.	26·2	26·1
14th Apr	26·1	27·4
18th Apr.	27·3	24·2
21st Apr.	23·9	25·3
24th Apr.	26·7	24·4
9th May	22·3	20·2
12th May	22·9	19·8
15th May	21·8	20·3

The difference between wide-sown and drilled plants in their lint weights is not significant.

It may here be mentioned that Balls and Holton also agree with our inference, viz., "that lint weight showed no features due to spacing." But, it is interesting to find that they pronounce the lint produced on wide-sown plants as being distinctly inferior in appearance to and less regular than normal field sown lint.

(7) *Ginning outturn.*—The ginning percentage was calculated for the 14 samples from each plot and shown below :—

Picking date.	3′ × 2′.	Drilled.
1928.		
24th Mar.	32·7	33·0
27th Mar.	33·4	32·8
30th Mar.	33·4	31·0
2nd Apr.	33·2	31·1
5th Apr.	31·1	32·0
8th Apr.	30 6	28·4
11th Apr.	30·7	30·1
14th Apr.	30·8	31·8
18th Apr.	31·8	29·3
21st Apr.	30·8	31·3
24th Apr.	31·5	30·7
9th May	30·3	30·1
12th May	30 5	28·2
15th May	29·9	28·4

The wide-sown plants give a significantly higher ginning percentage than the field sown ones, the average for the former being 31·5 and that of the latter 30·6. It is hard to reconcile this fact with the conclusion drawn by Balls who holds that just the opposite is the case.

SUMMARY AND CONCLUSION.

(1) The total output of flowers in wide-sown plants is 5 times as many as that in the other.

(2) Narrow spacing hastens flowering.

(3) Maturation period remains the same in both spacings.

(4) Lint length does not seem to be affected by difference in spacing.

(5) There is a wider range of variation in length among field sown plants, but it is not significant.

(6) There is no significant difference between the two, as regards seed and lint weights.

(7) Wide-sown plants give a significantly higher ginning percentage than those sown in a field crop.

These results are summarised in the following table:—

SUMMARY OF RESULTS.

Comparison between 3′ × 2′ *and drilled* ($1\frac{1}{2}' \times \frac{3}{4}'$).

Character.	Number of determinations.	4 locked bolls		Difference.	Standard deviation of difference.	Difference		P.	Odds.
		Average of 3′ × 2′.	Average of drilled.			Standard deviation of difference. Z			
Maturation period.	5	36·8	37·0	− 0·2	1·5	0·14		·6028	1:2
Lint length ...	23	23·34	23·71	− 0·4	1·3	0·31		·9182	1:11
Seed weight ...	14	55·99	56·55	− 0·6	2·6	0·23		·7859	1:4
Lint weight ...	14	25·82	25·07	+ 0·7	1·9	0·37		·8946	1:8
Ginning outturn.	14	31·5	30·6	+ 0·9	1·5	0·60		·9752	1:39

As there is no significant difference between the two spacings under consideration as regards the more important economic characters, viz., lint length, lint weight, and seed weight, the breeder can safely assume that the behaviour of his cultures will not be widely different under field

conditions, from that manifested in his pedigree plots.

The writer takes this opportunity to gratefully acknowledge the valuable suggestions and enlightening criticism he has received from M.R.Ry. V. Ramanatha Ayyar Avargal and to offer his respectful thanks to him for the same. Thanks are also due to M.R.Ry. C. Jagannatha Rao for help rendered in weighments.

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RECENT AGRICULTURAL DEVELOPMENT IN MADRAS

A paper read at the Agricultural Section of the Indian Science Congress at Madras, dated 5th Jan. 1929, *by Rudolph D. Anstead, C.I.E., M.A. (Cantab), Director of Agriculture.*

I have been requested by your President to tell you about some of the recent advances made by the Madras Agricultural Department. Before attempting to do so, I want those of you who are strangers to this part of India to realize that in this Presidency we have a very wide range of conditions and we are able to grow in consequence more or less every crop which is grown in India with the single exception perhaps of Bengal jute.

On the East Coast we have three large deltas with big irrigation systems and a net-work of canals which carry paddy ; on the West Coast we have an intricate maze of rivers and backwaters ; in the central regions we have land which is cultivated under wells and tanks, or merely rainfed, and in the north the rainfall is so precarious that we are seldom free from famine conditions of greater or less intensity. Down the western side of the Presidency runs a range of hills which rise to 9,000 feet in places and provide dense jungles and open rolling grass downs. Here are situated our Hill stations where fruit and flowers can be grown which will rival those grown in England. Large areas have been brought under tea, coffee, and rubber.

Our soils range from heavy black cotton soils, through clay loams, laterites and gravels to almost pure sands, the latter carrying coconuts and casuarina.

We depend upon both monsoons and our rainfall varies from 300 inches to 20 or less. Our main crops are paddy and cotton, and we have large areas under groundnuts, millets, and coconuts. Sugarcane is a minor crop and is grown in small patches all over the Presidency and we look in a five acre block of cane as rather a big thing.

It will be understood therefore that our agricultural problems spread over a very wide range.

As in other provinces we have paid a great deal of attention to crop improvement by selection and breeding, especially with our two main crops—paddy and cotton. Development in recent years has been in the opening of new breeding stations to serve particular areas and in the study of other crops. Thus we now have four paddy breeding stations, one at Coimbatore, the headquarter station, one at Āduturai to serve the Tanjore delta, one at Maruteru to serve Gōdāvari delta, and one at Pattambi to serve the West Coast. So also with cotton we have several subsidiary stations as well as the headquarter station at Coimbatore. In 1923, a millet-breeding station was started at Coimbatore and we are now taking steps to open a a subsidiary station for millets and cotton work, these two crops being grown in rotation in the Bellary district at Adōni. Considerable progress has been made with the improvement of cholam and ragi by the usual methods of selection and it is hoped to issue the first of the improved strains to the ryots in the coming year. A beginning has also been made in a small way with the improvement of groundnuts in the same way and we contemplate the appointment of an Oil-seeds Specialist before long to take up the intensive study of this crop as well as coconuts. The latter is a big

and important crop with us, along our sea coasts. Under our conditions the coconut is never self-fertilized naturally so that selection of nuts for sowing purposes is of limited value. We have evolved a method which has proved quite successful of selfing selected trees and a number of plants have been raised as a result of both self-fertilization and cross-fertilization of trees chosen for special characters. It will naturally take a long time to produce any results of a tangible nature but a start has been made.

In recent years another advance has been made with this crop. It has always been thought that coconuts can only be grown in places where they can be watered, at least in the young stages, during the hot weather. We have been able to demonstrate on a very wide scale that coconuts can be grown quite successfully from the nursery stage without any water except the natural rainfall if dry farming methods are employed and the plants are set out 30 to 35 feet apart and the soil between them thoroughly intercultivated during the hot weather. This has enabled large areas of land hitherto carrying no crop at all to be placed under coconuts. Grown under these conditions, the palms come into full bearing at 8 to 10 years old which is a gain of several years over the local method of cultivation.

A considerable number of improved strains of both paddy and cotton have been evolved on the breeding stations and issued to the ryots. These have become popular and are in great demand but it is difficult, often impossible, to supply seed. To overcome this difficulty we have organized a system of seed farms conducted under a simple agreement

with selected ryots. There is nothing novel about this system but we are now endeavouring to persuade the seed farm ryots to form co-operative societies for the multiplication and supply of seed and in the case of cotton to combine this work with co-operative ginning and the sale of pure unmixed lint of standard types.

Full advantage of the improved strains of cotton has not been obtained by the ryots owing to the unpopularity of legislation introduced in the first place to control the ravages of insect pests and in the second to control the mixing of lint types. The Pest Act and the Cotton Transport Act have raised a storm of controversy and unfortunately brought agriculture into the realm of politics with the result that both Acts have been so modified that they are largely abortive and certainly do not now produce the result for which they were originally designed.

Cultural improvements such as the economic planting of paddy from thinly sown nurseries, the drill sowing and subsequent intercultivation of cotton and millets with bullock drawn implements have been adopted over wide areas as a result of demonstration and propaganda work.

Now that a strain of Cambodia cotton has been isolated which is vigorous and produces lint of fair quality and we are in a fair way to do the same for rainfed cottons we have begun to turn our attention to the cultivation and manuring of this crop. The question of the best time at which to sow is now under investigation. The local practice is to wait for the monsoon rains, but the results of our experiments have shown that the interval between the date of sowing and the date

of picking has a profound effect upon the final yield, and yearly sown cotton has in our hands given nearly four times the yield of late sown cotton. If future experiments confirm this result the introduction by the ryots of early sowing should have far-reaching effects.

The use of light iron ploughs is also spreading but more slowly, probably on account of their price and also because of the smallness of the cattle in some places. About 2,000 ploughs a year are purchased and there must be some 10,000 now at work in the Presidency. The increased use of implements like ploughs and three-roller cane crushing mills is linked up with the problem of cattle breeding and fodder production in a very intimate way and these problems have to be dealt with as a whole and they will take time and patience to solve. We have recently started an organized campaign with the demonstration of pit silage making, but it is not always easy to find the material to silage when the cultivator does not grow enough fodder to feed his animals even in the rainy season and when he is tempted to place land under a money crop rather than under a fodder crop. There are opportunities however on the West Coast of converting the hill grasses into valuable silage and this idea is being exploited.

By economic planting, by green manuring, and by using selected strains the department has demonstrated to the ryots that it is possible to increase the yield of paddy very considerably and these methods have been applied to other crops and widely adopted. But there is a limit to this, the limiting factor being the quantity of available manurial constituents, especially phosphorus and

nitrogen in the soil. To maintain these increased yields and to obtain still better yields, more intensive manuring is necessary and unless this is attended to there is a danger that the introduction of improved strains which are inherently heavy yielders may do more harm than good by exhausting an already impoverished soil. This is a point of view which has been brought to the notice of this Congress in former years.

There is not enough cattle manure to go round and the use of artificials is indicated. Ten years ago Dr. Harrison had shown that the nitrogen in green manure is largely dissipated in the form of gas and experiments conducted on our station at Manganallur based on his work had shown that, paddy responds well to a concentrated nitrogenous manure such as sulphate of ammonia in addition to green manure and that this is particularly the case when phosphate is also added.

The difficulty at that time which stood in the way of demonstrating this to the ryots was the very high price of all imported artificials like sulphate of ammonia and superphosphate while the price of bonemeal was also tending to rise owing to the export demand and the supply of fish manure from the West Coast was variable depending upon the seasons.

Of late years the whole situation has changed and now not only sulphate of ammonia and superphosphate are easily obtainable at reasonable prices but firms are vieing with one another to sell all kinds of artificials and one of the outstanding features of recent years is the way in which the ryots have waked up to the value of manures and are quite ready to buy them. Over 3,000 tons

of sulphate of ammonia alone was purchased last year. This is due to the fact that the department had demonstrated the value of green manure and cattle and fish manure and planted the idea in their minds.

But they are now being besieged by propagandists and firms to buy sulphate of ammonia, nitrate of soda, calcium cyanamide, ammophos, leunaphos, nitro-chalk and a number of other new fertilizers about which no one knows anything at all. They naturally turn to the Agricultural department for advice, but unfortunately we also know little or nothing about these new fertilizers and as yet have had no time to experiment with them. Realizing, however, that it is our duty to test them out, we are just starting an experiment station on a new plan. This station will be subsidized by manure firms. The cost of each trial has been worked out and firms will pay a subsidy as a proportionate share, of the total cost based on the number of trials which they wish to have made. The Agricultural department will carry out the work and the trials will be conducted on scientific lines based on the latest methods adopted at Rothamsted over a period of five years when the results will be published.

In this way it is hoped to give a thorough trial to all new fertilizers placed on the market. In the first instance the trials will be confined to paddy, but if the scheme proves popular and successful it will be extended to trials with other crops and on dry as well as on wet lands.

There is a danger at present that these cheap artificial manures will be used to replace organic manures and not merely to supplement them and

this leads me to speak of another problem on which we have done a good deal of work recently. It was found by a study of our permanent manure plots that seed produced in different plots behaved in different ways, depending upon how the crop from which it was obtained had been manured. When sown on soil of average fertility seed produced on plots which had been manured with cattle manure gave a much better crop than seed which had been produced on plots manured with artificials only. This somewhat surprising result was followed up and in collaboration with Lt.-Col. McGarrison it has been found that the food value and vitamine content of the grain is probably dependent upon, and can be controlled by, the system of manuring, and that in order to produce grain of high food value the crop must be manured with organic manure. What the minimum quantity of organic manure necessary to ensure a full vitamine content in the resulting grain may be we do not yet know, but if it is all replaced by minerals the food value and vitamine content of the grain falls beneath that of an unmanured crop.

This has opened up a new field of study and we are now beginning to pay attention to the study of the food value of paddy and other crops from all points of view. It emphasizes the necessity for increasing the supply of organic manure and the system of producing artificial farm-yard manure advocated by Rothamsted has been carefully studied and we have now been able to prepare good material from waste products like prickly-pear, cane trash, weeds, stubbles, cotton stalks and even groundnut husk by a method which is

demonstratable to the ryots. We are also about to instal an experimental activated sludge plant at Coimbatore to convert our estate sewage into fertilizer for the farm.

We have also taken up the study of animal nutrition and have our own buildings and staff at Coimbatore so that we can work out local problems. We carry on this work in collaboration with and under the friendly guidance of Mr. Warth, the Imperial Physiological Chemist at Bangalore.

Turning now to other sections, we have recently attempted the biological control of a caterpillar pest of coconuts on the West Coast. This pest was introduced a few years ago to the West from the East Coast on coconut leaves carried on the railway, and it was introduced without the parasites which control it naturally on the East Coast. The consequence was that it spread with alarming rapidity and did a great deal of damage. We have now introduced a number of its natural parasites and have established laboratories where these are bred and released in large numbers. This method has met with considerable success and the pest is being kept under reasonable control. Quite recently the Icerya scale has made its appearance in the Nilgiris where it is attacking wattle and a number of local weeds. We propose to deal with this biologically also and are only awaiting a consignment of the necessary lady bird beetle from South Africa and Australia.

Satisfactory progress has been made in recent years with the control of fungoid diseases of crops. A fungus which attacks the fruit bunches of the areca palm during the monsoon has proved

controllable by spraying just before the rains with Bordeaux mixture and this method is now adopted on a large scale and involves millions of trees. The bud-rot disease of palmyra palms on the East Coast is also being controlled successfully by systematic destruction of dead trees and removal of attacked leaves at the outset of infection. The Pest Act has been introduced to deal with this disease and it has worked quite smoothly and the work is carried out systematically by the Revenue Department under our guidance, a special staff being employed for the purpose.

The most recent development in mycological research of recent years has been the search for strains resistant to certain diseases, a more logical way of attacking the disease problem in general than a frontal attack on the disease itself which can never give a permanent amelioration. This work now involves several crops and fungi, among which may be mentioned the mosaic of sugarcane, piricularia of paddy, and the wilt of groundnuts.

On the propaganda and district work side we have found that the most satisfactory way of getting information to the ryots and persuading them to adopt new methods is to demonstrate the improvement whatever it may be on their own land so that they may be convinced that it is an improvement in the first place and that it can be carried out under the conditions of life and farming in the second place. We now have hundreds of such demonstrations and confine ourselves to small plots rather than to trying to conduct big demonstration areas or model farms. The latter we have persuaded co-operative societies to undertake and we now have a few better farming

co-operative societies which conduct small model farms on which the improved methods of cultivation and manuring advocated by the department are adopted and demonstrated, one or two plots being farmed in accordance with local methods to act as a control and contrast. Departmental officers supply advice and draw up cropping schemes but the society runs the farm and keeps a profit and loss account so that it is able to demonstrate to the members the monetary gain to be obtained by the adoption of these improved methods. I may say that in the case of paddy it amounts on the average to an increased profit of about Rs. 25 per acre. Improved strains of seed are grown on these farms and the seed is sold to the members of the society. Some of these societies are now beginning to conduct the sale of implements and manures.

We take advantage of all local fairs and festivals to hold small agricultural exhibitions and to deliver lantern lectures, and we endeavour to make these as practical as possible, that is to say, we give actual demonstrations of iron ploughs at work for example and allow and encourage the visitors to handle them themselves ; during the cane crushing season we erect a sindewahe furnace and actually make jaggery over it in a thin pan, and so on.

We have just built and equipped a travelling motor van to carry an exhibition from village to village thinking that in this part of the world where we have not many railways and where they do not always pass through the most densely populated rural areas such vans would serve our purpose better than exhibition trains. One of these

van units is in show in the grounds here for you to see. We hope before long to add a cinema outfit to it, at present it carries a magic lantern outfit.

I have now touched quite briefly on some of the more important and outstanding recent developments of the Madras Agricultural Department but the time is too short to really do them justice and to cover the whole ground. I have not for example touched on the thorny problem of agricultural education partly for lack of time and also because the subject will come up elsewhere during this Congress. I have also had no time to speak of the cattle-breeding work which is being done on a large scale on three cattle farms the largest of which is at Hosur, near Bangalore.

The headquarters of our research work is situated at Coimbatore which is 12 hours by train from Madras and if any of you can spare the time to pay us a visit we shall be more than delighted to show you what we are doing and attempting to do.

RUDOLPH D. ANSTEAD,
Director of Agriculture, Madras.

RECENT AGRICULTURAL DEVELOPMENT IN MADRAS.

ABSTRACT.

The Madras Presidency provides a very wide range of climatic and physical conditions, a very large number of different crops are grown and there is a consequent wide range of agricultural problems. Paddy, millets, groundnuts and coconuts are the main crops.

A great deal of attention has been paid to crop improvement by selection and hybridization methods and a number of subsidiary breeding stations have been established for the study along these lines of paddy and cotton. More recently similar work has been undertaken with millets and a start has been made with groundnuts and coconuts.

A method of growing coconuts under dry farming conditions has made their cultivation possible over large areas hitherto waste.

Many improved strains of paddy and cotton have been evolved and issued and seed farms established to meet the growing demand for seed. Attempts are now being made to persuade co-operative societies to take up the work of seed multiplication and distribution.

Legislation to control disease of cotton and mixing of pure types has proved unpopular and not altogether successful.

The study of cultural improvements of cotton are now being taken up especially the time of sowing. The use of iron ploughs is closely linked up with cattle improvement and the fodder question and the possibilities of silage are being studied and demonstrated.

The introduction of improved high yielding strains emphasizes the necessity for intensive manuring and the use of artificials is under investigation, and a special experiment station is being started subsidized by supplying firms to test out the new fertilizers now rapidly coming in the market.

The subject of the effect of different manures on the food value and vitamine content of the

resulting grain has received special attention in collaboration with Lt.-Col. McCarrison and the application of a certain amount of organic manure appears to be essential. The bearing of this on all manurial systems is under investigation and attempts are being made to increase the available quality of this by the making of "Synthetic Farm Yard Manure" a method of doing which is demonstrated to the ryots. An activated sludge plant is being installed at Coimbatore.

Animal nutrition work is also being undertaken to study local problems.

The biological control of a caterpillar which attacks coconuts on the West Coast by means of its natural parasites introduced from the East Coast has been successfully undertaken.

The control of fungoid disease which attacks the fruit of areca palms has been controlled by spraying on a very large scale. The bud-rot of palmyra palms is also controlled under the Pest Act by a special staff.

Attention is being paid to the possibility of evolving disease resistant strains of a number of crops.

Propaganda and demonstration is concentrated on a large number of small plots on the ryots' own lands. Co-operative societies have been formed to demonstrate better farming methods on small model farms. Agricultural exhibitions are given at local fairs and festivals and a motor exhibition van has recently been purchased to travel round the villages.

YIELD FACTORS IN CANE CULTIVATION AND THEIR RELATION TO EXPERIMENTAL TRIALS

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In all crop experiments the usefulness or otherwise of a manurial treatment or of a new variety is generally judged by the ultimate yields of the marketable product. In cases involving a more detailed study of the effect of a manure or of the growth of a variety, an estimate of the various factors that contribute to the growth of a crop is usually made. As an instance in point the exhaustive inquiry by Engledow on the yields of barley may be mentioned. In all other cases, it is usual to depend on the yields of the marketable products and where treatments or varieties are under comparison the difference in the yields between two treatments or varieties is ascertained and the reliability of this difference is estimated by statistical methods.

The direct method of evaluation of experimental results is admirably suited to all crops except in the case of sugarcane, where the final test of superiority of a manurial treatment or of a variety, is the jaggery yield which obviously depends on a number of factors—the tonnage, extraction, quality of the juice and methods of preparing jaggery.

The yield of jaggery being the deciding factor, we need not concern ourselves here with tonnage, which is itself a component of a number of sub-factors. The other factors that contribute to variations in jaggery yield are—

(*a*) extraction,

(*b*) errors arising from boiling such as differing moisture contents of jaggeries, unequal removal of the scum, etc.

(*c*) if (*b*) is sufficiently high, the number of boilings done for each treatment, and

(*d*) the composition of the juice.

Errors due to extraction.—Even in experimental crushings, a 2 to 3 per cent difference in extraction is a common experience but beyond merely noting down these differences, little more is done when evaluating treatments or varieties. The percentage yields of jaggery on weight of cane and on weight of juice are no doubt examined separately but never in the true perspective of their mutual relationship. The result is that conclusions based on one are often at variance with those based on the other.

Yield of jaggery as per cent on weight of cane and juice.

	Per cent increase over control on	
	Weight of cane.	Weight of jaggery.
Samalkot	2·2	1·3
Do.	1·2	0·83
Do.	1·2	2·0
Do.	1·1	4·7
Do.	70·5	75·1
Do.	78·1	77·1
Palur	3·4	1·8
Do.	3·1	6·4

The differences noticed between computations based on weight of cane and weight of jaggery are often stated or believed to be due to differences in extraction. It is important therefore to analyse the extent to which extraction affects the fina result.

It is obvious that other conditions being the same, a lower extraction would lead to a lower jaggery yield calculated as per cent on weight of cane. This might be considered the quantity factor of the jaggery yield. There is still the quality factor to be considered and the influence of extraction on it. It would appear fair to assume as a first approximation, that a higher extraction generally goes along with a lower quality juice and *vice versa:* for the former results from an expression of juice from poorer portions of the cane. If this were true, the two factors act in opposition and their effects would follow no regular law. If, on the other hand, the quality of the juice is independent of extraction, the factor of extraction could easily be eliminated. An examination of the data obtained from certain mill trials done at Anakapalle throws some light on this question. Eight hundred pound samples of cane drawn from the same lots, were crushed in two different mills giving an average of 65 per cent and 60 per cent extraction respectively. The jaggery yields of each of the lots are separately noted and are examined statistically.

Jaggery yields (per cent on juice).

Mill No. 1.	Mill No. 2.
17·63	17·40
17·83	17·92
18·08	17·74

Mill No. 1.		Mill No. 2.
17·97		17·64
17·61		18·06
18·11		17·74
18·16		18·07
17·91	Mean	17·79

$$\sigma_1^2 = 0{\cdot}0443$$

$$\sigma_2^2 = 0{\cdot}0495$$

$$(\text{error of the mean difference})^2 = \frac{0{\cdot}0443 + 0{\cdot}0495}{7} = E^2$$

$$E = \pm 0{\cdot}115.$$

The yields are 17·91 and 17·79 per cent of juice—which are averages of seven sets of trials. Difference in per cent jaggery yield can be due to the quality of the juice and the methods of preparing jaggery. From the statistical point of view, the two yield figures are identical with an error of $\pm$ 0·115 for the mean difference. As will be found later on (*ad seq*) even small differences in degree brix, produce corresponding differences in jaggery yield. The identical jaggery yield obtained in the two cases indicate therefore that the juices had not differed in composition, i.e., whether extraction is 65 per cent or 60 per cent, the resulting juice is of the same composition from the point of view of jaggery yield. In interpreting cane experiments, on the basis of jaggery yields (per cent on weight of cane), differences in extraction are not generally indications of poverty of juice in the one cane, but are the results of an extraneous factor—the unequal efficiencies of the mills or of an indifferent manipulation of the crushing machinery and have therefore got to be allowed for. This could be done by adopting a common extraction basis for all the various treatments and varieties.

Errors arising in the course of preparation of jaggery.—These are incidental to the manufacture of jaggery from juice. The local practices of jaggery-making differ very much and involve among other minor operations the removal of scum. Further, small lapses on the part of the jaggery-maker, regarding the correct time of stopping the boiling may not materially affect in the broad sense of the term, the quality and the colour of the resulting jaggery; but it is highly probable that the moisture contents of the jaggery sample so obtained would differ materially. These causes largely depend on the person who conducts the manufacture and emphasises the obvious need for regularizing the personnel that conduct the boiling operations. Provided these precautions are taken, it is proper to assume that the errors arising from this source, obey the laws of chance. The results of a number of boilings, done now also, at Anakapalle are examined to estimate the error in question.

Error due to boiling (*brix content* = 18·5 ± 0·2).

	Yield of jaggery.	Deviation from mean (*d*).	d^2.
	20·30	1·03	1·06
	18·88	0·39	0·1521
	19·02	0·25	0·0625
	18·38	0·89	0·7921
	19·05	0·25	0·0625
	19·66	0·39	0·1521
	19·62	0·35	0·1225
Mean	19·27		0·3434

$\sigma = \pm 0{\cdot}59$

Such boilings were chosen whose juices differed in brix content by 0·2 which is about the limit by

which two consecutive brix readings are likely to differ. The jaggery yields of such boilings were calculated as percentages on juice and the error of the yields was calculated.

It will be found from the table that each individual boiling is subject to a deviation of ± 0·59 and this works up to nearly 3 per cent error in yield of jaggery. Our ideas about the negligible differences in jaggery yield are not at present well defined no doubt due to lack of exact analysis of results and under such conditions it is difficult to say if a 3 per cent deviation is huge or not. But assuming 10,000 lb. to be the normal yield of jaggery per acre, it means an increase of 300 lb. of jaggery per acre. This is certainly not negligible and it should therefore be our endeavour to minimise the error due to this source so as to place ourselves in a position to be sure about differences that are even so small as 3 per cent. The need for so doing is all the greater in experimental trials, where a treatment or variety should give an increase or decrease of 6·0 per cent for adoption or rejection.

Supposing in an experiment, the composition of the juices of any one variety or treatment were constant, the jaggery yield is generally arrived at by summing up the yields of a number of individual boilings. The deviation of this sum is not the deviation of the individual boiling but is proportional to the square root of the number of boilings done, i.e., $\sigma_s = \sigma_a \times \sqrt{n}$. It is therefore necessary that the number of boilings must be as few as possible and when comparing varieties or treatments the actual number of boilings must either be the same for each variety or treatment or should be allowed for in calculating the deviation of the differences

as follows :—$E = \pm \sqrt{(n_1 + n_2)\ \sigma_2}$
where E is the error of the difference.

Composition of the juice.—For a priori reasons, it is obvious that the yields of jaggery should be directly proportional to the brix content of the parent juices. In the third paper on the studies in the Chemistry of Sugarcane this has been graphically shown. But, apart from the general impression, little systematic study is recorded to determine the minimum range within which the above generalization holds, i.e., quantitative relationship between the two sets of data has not been worked out. We are therefore at present not in a position to say what variations in quality of juice are permissible in cane experiments.

In the Annual Report of the Anakapalle Cane Testing Station, for the year 1925–26, a number of boilings are reported the corresponding juices of which have been analysed. Boilings the corresponding brix contents of which fell within the range of 19·6 to 20·1 were graded together.

Variety—*J*-247.

Degree brix.	Jaggery yield.	Degree brix.	Jaggery yield.
19·58	18·7	19·95	20 2
19·78	18·5	19·74	19·1
19·88	19·3	19·45	18·9
20·08	19·8	19·38	18·5
19·84	19·5	19·58	19·3
19·71	19·2	19·79	18·9
19·87	19·4	19·69	18·5
19·68	18·9	19·97	19·6
20·09	19·5		
19·77±0·19	Mean.		19·2±0·50

$r = +0{\cdot}666$

Regression co-efficient of jaggery yield on brix. $= \dfrac{0{\cdot}666 \times 0{\cdot}5}{0{\cdot}19} =$ 1·7 nearly.

The jaggery yields of these boilings were also calculated as per cent on juice and their mutual correlation was worked. It was thought that if the composition of the juice were a determining factor even within this short range of 0·6 degree brix then there should be definite correlation between the brix contents and jaggery yields. As a matter of fact, a correlation co-efficient of 0·666 is obtained The regression of jaggery yield on brix is $0{\cdot}666 \frac{0{\cdot}5}{0{\cdot}19}$, i.e., 1·7. For a difference of 1 degree brix a corresponding difference could be expected in jaggery yield. Taking the average yield of a treatment or variety as 18 per cent a difference of 0·5 in the composition of the juice is likely to produce a variation of 0·85 per cent in jaggery figure, i.e., of nearly 5 per cent variation. This is certainly large. It should however be said that such small variations as 0·50 brix are difficult to be found out before it is too late, i.e., before the cane is cut—much more so to be avoided. More data should be collected and examined to enable us, as the next best step to allow for the variations in the composition of the juice. At the present time, we have necessarily to content ourselves with merely indicating the importance of efficient chemical control and it is proposed to carry on an extensive investigation into the relations of the quality of the juice and jaggery yield. It would then be possible to appreciate the significance of the brix values of juices of different experiments and varieties.

This definite correlation emphasises the importance of chemical control that is hardly appreciated in the present-day methods of cane harvest. What regulate the period of harvest, are only these—the definite possibility of the boiled juice setting into

moulds and the vagaries of the market. The effect is that only such varieties or treatments, as are immensely superior, are capable of being popularized. It is not possible, always in all places and at all times, that overwhelming superiority is obtainable. The result is that, sure though small, gains are not appreciated to the extent that they deserve and definite recommendations are therefore very difficult.

By a strict and efficient chemical control of the harvest operations, it should be possible to materially increase the efficiency of our jaggery manufacture. In the cane areas of the Northern districts the harvest of cane is spread over a period of two or more months. The harvest is generally begun at one end of the field and continued inwards irrespective of the fact whether we are getting the maximum out of the existing crop or not. This is no doubt unavoidable if the whole area of about 3 to 4 acres were put to one variety as the ryot cannot wait for the canes to attain their maximum sucrose content losing time and the opportunities of the market. The position becomes worse if it is the practice as in the upper delta of the Gōdāvari, to broadcast sets of two or more varieties which differ widely from one another, such as for example, Purple Mauritius and B-3412.

A more judicious way of planting will be to put the whole area to 3 or 4 varieties differing in their periods of ripening. The harvest should then be adjusted so as to cut always the variety that has become ripe. This would satisfy the demands of the market and at the same time assure for the ryot a better outturn. If the whole area were under one variety, what the ryot gets is

not the possible maximum but only a possible average. The necessity however of a properly laid out plan of planting is obvious. It would serve no purpose at all if the earliest maturing variety is not the most accessible of approach from outside. With a haphazard system of planting the chances of getting the best outturn are evidently $1/n$ where n is the number of varieties grown.

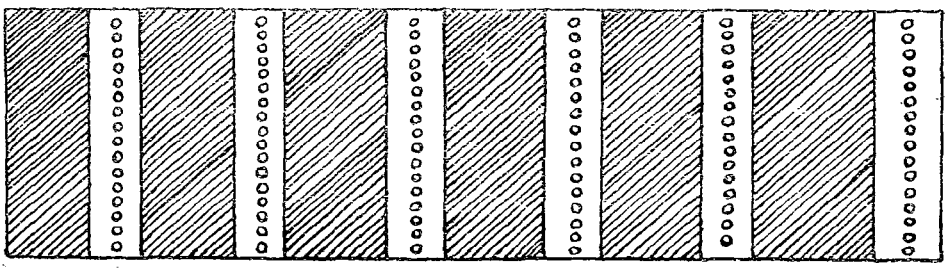
A suggestion which would suit any kind of planting and harvest may be ventured. It may not breath quite the agricultural atmosphere that any suggestion of the kind must do ; but it appears to me to possess all the necessary circumstances for a successful trial. In the second paper on the "Studies in the Chemistry of Sugarcane"* it was pointed out how within the ripening period of any variety the sucrose content of a cane was a function of the age of the individual and increased with increasing age. For ready reference the table is reproduced in an abridged form below :—

Sucrose content of canes of different age.

Name of variety.	Date of analysis.	Degree brix, 1st shoot.	Degree brix, 2nd shoot.	Degree brix, 5th shoot.
Ketari	21-8-23	17·57	17·07	15·16
	10-9-23	18·92	18·28	17·51
	24-9-23	19·05	18·70	18·19
	12-10-23	19·40	19·35	18·14
	3-11-23	19·32	18·32	...
Manjav	22-8-23	18·45	15·74	14·12
	11-9-23	18·44	16·84	15·54
	24-10-23	18·67	..	...
B. Cheriban ...	22-8-23	17·34	17·04	16·84
	11-9-23	17·87	17·81	17·97

* Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VII, No. 6.

It would be found that the canes develop more sucrose with advancing age and that at any time, an older shoot contains more sugar than its youngers. This characteristic may be taken advantage of to segregate the older and therefore maturer shoots and conduct harvest on these lines. It is realized that segregation would be very difficult and expensive in most places but it is hoped that a good amount of this objection loses its ground in the northern deltas where this suggestion does not involve additional expense or labour. In the Gōdāvari and Vizagapatam districts, canes have to be protected against winds by a system of propping and wrapping. This is done not in one operation but in two or three operations done at various stages in the life of the cane crop. This coupled with the system of line planting that is being widely adopted in the delta gives what appears to be an excellent opportunity of segregating the earlier shoots of each clump from the later ones. A diagrammatic representation of doing it is given below:—



Diagrammatic representation of segregating canes of different ages.

The shaded spaces represent the cane beds. The empty space between any two is the irrigation channel. The dots represent the bamboos which support the cane. The odd rows may be made to support the canes of the first propping. The even

rows of bamboos may be made to support the canes of the later proppings. The only point for consideration is whether the difficulties that are obviously attendant in this harvest based on this gradation system are counterbalanced by a sufficient increase in yields on the field scale.

SUMMARY AND CONCLUSION.

The importance of an analysis of yield factors is emphasised and an attempt has been made to apply it to the cane crop. In the evolution of cane experiments on the basis of jaggery yields, it is suggested—

(*a*) a uniform extraction basis be adopted,

(*b*) the number of boilings for any one variety or treatment be the same and as few as possible

(*c*) an efficient chemical control of the harvest operations is desirable.