can never take the place of the testing of the productions in the locality itself and under local conditions. To state the problem in a concise manner, the breeding of suitable improved canes for the various parts of India with its wide variation in soil and climatic conditions, is essentially a team work composed of the Breeder at Coimbatore and the officers in charge of the local testing stations. The Sugarcane Breeding Station at Coimbatore feels confident that, in the efficient testing of the new productions, it can count on the help of the audience here in a joint endeavour to place on a satisfactory footing the raw material for such a *Vital Food* industry as that of the *Indian Gur* and *Sugar Industry*.

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THE MANURING OF SUGARCANE *

By B. VISWA NATH, F.I.C.,

Government Agricultural Chemist, Coimbatore

A crop of 30 tons of sugarcane per acre removes 80 lbs. of nitrogen, 50 lbs. of phosphoric acid and 180 lbs. of potash from the soil. An examination of the results of field experiments for 25 years at all the experiment stations in the Presidency, chiefly at Samalkot, Anakapalle and Palur, reveals that the problem of nitrogen nutrition of the sugarcane is of greater importance than that of either phosphoric acid or potash. In the manurial programme of the Experiment stations, the application of oil cakes is the chief item and the soundness of the scheme is reflected in its wide adoption in the sugarcane tracts.

An analysis of the results of work at the different experiment stations in the Presidency is attempted in this paper with a view to obtain information on the requirement of the sugarcane plant in regard to the three principal manurial constituents, Nitrogen, Phosphoric acid and Potash.

The economics of the different systems of manuring are not discussed here, as that would very widely with the locality, and the ruling prices of the manures and the crop. Attention is confined to a discussion of the relative merits of different manures and the combinations in which they are beneficial to sugarcane. The subject matter is divided into three broad divisions :

(1) manuring as affecting the yield,
(2) manuring as affecting the quality of the juice and the jaggery and
(3) manuring as affecting the vegetative and reproductive quality of the resulting seed material.

(1) Manuring as affecting yield

Evaluation of results : There are two ways of evaluating yields in sugarcane experiments.

(i) as weight of cane
(ii) as weight of jaggery.

The latter is doubtless important from the ryot's point of view but to an experimenter, it is open to certain objections. The yields of jaggery on weight of cane and on weight of juice vary up to 5 per cent. These differences are due to variations in mill efficiency, and to differences in the methods of

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preparation of jaggery. These were discussed at length in a paper by Kasinath and myself in the Year Book of the Department for 1928. For these reasons the discussions are based on weight of cane. There is experimental evidence, based on carefully controlled milling and jaggery boilings, to show that the brix values may be taken to compute the yields of jaggery, where such figures are required.

Nitrogen nutrition of the plant: The use of bulky manures, like cattle manure and green manure, is commendable wherever practicable with small additions of concentrated fertilisers like oil cakes and Ammonium sulphate. Judging from our knowledge of the present position, the invariable use of cattle manure, except for light basal dressings, is generally impracticable, and the availability of green manure is restricted to certain localised areas. The choice of nitrogenous manures has necessarily to fall on oil cakes and chemical fertilisers.

Sugarcane responds to all forms of nitrogenous manuring but in varying degrees as is seen in the following statement.

Relative merits of different mineral and organic fertilisers

Averages of 3 years with duplicate plots. (Coimbatore experiments)

Mineral manures		*Oil cakes*	
Percentage increase over standard: Calcium cyanamide		Percentage increase over standard: Safflower cake	
Calcium Nitrate ...	+0·46	Castor cake ...	+11·8
Ammonium sulphate ...	+9·70	Groundnut cake ...	+2·5
Potassium Nitrate ...	+1·27	Pungam cake ...	+1·76
		Gingelly cake ...	+12·3

At Samalkot Ammonium sulphate was 10·9 per cent better than castor cake and 5·3 per cent better than groundnut cake, while at Palur Ammonium sulphate was 7·35 per cent better than groundnut cake.

Form in which nitrogen may be applied: Although Ammonium sulphate has been found superior to cakes, this superiority is not so great as to rule out the use of cakes. Besides, the possible adverse effects on the soil from continuous application of Ammonium sulphate and the losses of Nitrogen likely to occur in the absence of sufficient supplies of organic matter, have to be considered. This leads us to the study of the effect of combinations of cake and Ammonium sulphate nitrogen. The results of such experiments at Palur and Samalkot throw light on this subject.

At Palur, castor cake plus Ammonium sulphate (75 lbs. cake N and 25 lbs. ammonium sulphate N) was distinctly better than castor cake alone while the results of experiments at Samalkot show that Ammonium sulphate by itself is as good as when combined with either groundnut cake or castor cake.

	SAMALKOT	PALUR
	Average of 3 years. (103 lbs. nitrogen.) Per cent increase over standard.	Average of 6 years. (100 lbs. nitrogen.) Per cent increase over standard.
Groundnut cake alone ...	Standard	
Groundnut cake plus Ammonium sulphate ...	+5·4	
Ammonium sulphate alone ...	+5·3	
Castor cake	Standard	Standard
Castor cake plus Ammonium sulphate ...	+11·6	+3·42
Ammonium sulphate alone ...	+10·9	...

A further analysis of the figures at Palur discloses better, the effect of manurial treatment, when the plots are divided into rich and poor ones. While the order of merit of the different treatments in the poor as well as rich plots remains the same as that we have already seen, the response is better in the poorer plots ; cake plus Ammonium sulphate gave 11·8 per cent over the standard as against 6·4 per cent in the richer plots.

Another point to be noted is that as between castor cake and groundnut cake as manure for sugarcane, the experimental results reveal no appreciable differences and may it therefore be taken that groundnut cake and castor cake are of the same efficiency, on the basis of equivalent doses of nitrogen.

Optimum dose and combination of cake and mineral nitrogen : Progressively increasing applications of nitrogen result in progressive increases in yields but as would be expected the response per unit of increase is not proportional.

Palur experiments

TREATMENT	Per cent increase in yield over standard.	Per cent increase for every additional 50 bs. N. over the previous one
Groundnut cake 50 lbs. nitrogen ...	Standard.	.....
Groundnut cake 100 lbs. nitrogen ...	+ 30·9	+ 30·5
Groundnut cake 150 lbs. nitrogen ...	+ 57·0	+ 19·9
Groundnut cake 200 lbs. nitrogen ...	+ 85·6	+ 18·3
Cake N. 40 lbs. plus mineral N. 10 lbs.	+ 16·0	.....
Cake N. 80 lbs. plus mineral N. 20 lbs.	+ 41·6	+ 22·1
Cake N. 120 lbs. plus mineral N. 30 lbs.	+ 50·3	+ 6·1
Cake N. 160 lbs. plus mineral N. 40 lbs.	+ 73·8	+ 15·6

N.B.—Cake N represents nitrogen given in the form of groundnut cake Mineral N represents nitrogen given in the form of Ammonium sulphate.

It is seen that, taking the yields for fifty pounds of cake nitrogen as the standard, increased yields are obtained as the quantities of nitrogen are increased either as cake nitrogen alone or as a mixture of cake plus Ammonium sulphate nitrogen ; but the increases are similar in both the systems of manuring only up to a point, i.e., up to 100 lbs. nitrogen either as cake alone or combined with Ammonium sulphate. Further, 100 lbs. of mixed nitrogen as 80 lbs. of cake and 20 lbs. of Ammonium sulphate are seen to be superior to 100 lbs. of cake here also as with 75 lbs. of cake and 25 lbs. of nitrogen, which we have already seen earlier in this paper to be better than when all the nitrogen was in the form of cake.

Above 100 lbs., mixtures of organic and mineral nitrogen are inferior to organic nitrogen and this is seen in the increments due to a unit of increase in nitrogen. For instance, taking the yield from 50 lbs. of cake nitrogen as the standard, the enhancement in yield due to increase of nitrogen from 50 to 100 is 30·5 per cent for organic nitrogen and 22·1 for mixed nitrogen ; with increase from 100 to 150 lbs., the response over 100 is 19·9 per cent for organic nitrogen and 6·1 per cent for mixed nitrogen. Similar differences are noticed with 200 lbs. nitrogen. An examination of the effect of replacing cake nitrogen with ammonium sulphate nitrogen lends further support to these observations.

(1) Effect of Ammonium sulphate replacement

Particulars	Per cent increase or decrease over nitrogen given as cake alone.
(Cake N. 40 lbs. plus mineral N. 10 lbs.) over (Cake N. 50 lbs) ...	+ 16·0
(Cake N. 80 lbs. plus mineral N. 20 lbs.) over (Cake N. 100 lbs.) ...	+ 8·2
(Cake N. 120 lbs. plus mineral N. 30 lbs.) over (Cake N. 150 lbs.) ...	— 4·3
(Cake N. 160 lbs. plus mineral N. 40 lbs.) over (Cake N. 200 lbs.) ...	— 6·4

It is seen that even when the ratio between organic and mineral nitrogen is kept constant, the effectiveness of Ammonium sulphate is gradually diminished as its quantity is increased, and above a certain quantity is even detrimental. This view finds support in another set of experiments to determine the optimum proportions of organic and mineral nitrogen.

Proportions of cake and Ammonium sulphate

Treatment	Percent increase in yield over standard.
Cake N. 50 lbs. ...	Standard
Cake N. 100 lbs. only ...	+ 30·9
Cake N. 80 lbs. plus mineral N. 20 lbs. ...	+ 41·6
Cake N. 60 lbs. plus mineral N. 40 lbs. ...	+ 56·5
Cake N. 40 lbs. plus mineral N. 60 lbs. ...	+ 38·2
Cake N. 20 lbs. plus mineral N. 80 lbs. ...	+ 49·6
Mineral N. 100 lbs. only ...	+ 40·5

Effect of Phosphates on yield. Of the three phosphates tried, the addition of super phosphate has shown an increase of 8.1 % over the nitrogen plots. Curiously enough fish guano and bonemeal have depressed yields, the former more so than the latter. Whether this is due to the richness of experimental plots in all the stations or to the doubtful nature of the quality of fish guano and bonemeal it is difficult to say. Almost immediately after the beginning of these experiments fish guano has become a rare commodity and instances are not wanting when fish guano and bonemeal are not what they are supposed to be. These results must therefore be taken with caution. Nevertheless, phosphates are a necessary factor in any scheme of sugarcane manuring, irrespective of their effect on yields.

Effect of potash on yield. There seems to be no need for applications of Potash. There is on record one experiment of only 3 seasons' duration in which the yields were depressed to the extent of 40. 2%, which is surely a sufficiently powerful deterrent to pursue further.

(2) Effect of Manuring on the Quality of Juice

Using 100 lbs. of nitrogen with and without phosphates, no differences are visible in the analyses of juices from the differently manured plots in so far as the sugars and non-sugars are concerned.

Average figures for 2 years 1928–29 and 1929–30 for Palur

	Groundnut cake.	Cake plus Ammonium sulphate.	Ammonium sulphate.
Brix ...	21·59	21·75	22·05
Sucrose ...	20·01	20·22	20·28
Co-efficient of purity ...	92·64	92·81	91·90
Glucose ...	0·53	0·63	0·62
Non-sugars ...	1·05	0·90	1·16

Average figures for 3 years 1925-26 to 1927-28.

	Fish	Castor	Castor Cake	Castor Cake
...	Guano	Cake	+ Amm. Sulphate	+ Amm. Sulphate
...	...	...	+ Super.	+ bonemeal
...	...	...	(50 lbs. P_2O_5)	(50 lbs. P_2O_5)
...	...	...	...	...
Brix	21·02	21·18	20·86	21·18
Glucose	0·73	0·66	0·76	0·75

There is however a large volume of opinion that heavy application of nitrogenous manures especially of Ammonium sulphate tend to produce jaggery which will not easily set and which runs in wet weather. There is no experimental evidence with us on this point but Mr. Sanyal at Pusa observes that jaggery obtained from cane manured with Ammonium sulphate is of inferior quality. Phosphates are believed to counteract the bad effects of Ammonium sulphate in the production of jaggery and how far this holds good under our soil conditions has yet to be tested.

(3) Manuring as affecting the Vegetative and the Reproductive Quality of the Resulting Seed

The investigations on the influence of manuring on the vitality of the resulting seed, which have been in progress in our laboratory were extended to Sugarcane also. I am indebted to Rao Bahadur T. S. Venkataraman, and Mr. Nandalal Dutt for affording facilities for the conduct of experiments at their respective stations. As in the case of the other crops experimented with, significant differences exist in the cropping capacities of the setts obtained from differently manured plots. The setts from mineral manured plot were 15·0 per cent superior to those from unmanured plot, while the setts from the organic manured plot were 35·9 per cent superior to those from the unmanured plot.

These results suggest the possibilities of increasing yields by producing vigorous seed material from a well manured nursery plot. Apart from this, the point of interest now is that by heavy manuring in the nursery plot the quantity of manure supplied to the bulk planting area may be reduced. Indirect confirmation of this on the field scale is available from the results of the interesting work at Anakapalle by Messrs. A. C. Edmonds and S. Sitarama Patrudu on what is called *the short crop seed method*. I am indebted to them for the information obtained from them and from their published annual reports and papers.

The short crop seed material is raised in a fairly heavily manured nursery and therefore is more vigorous than the normal material from the planting area. While distinct differences are seen in the yields from high and low manurial treatments when planted with ordinary seed material, no appreciable differences are seen when the short crop material is used. With normal seed material plots receiving 134 lbs. nitrogen have given an increased yield of 7·1 per cent over these receiving 106 lbs. nitrogen, while with the setts from

more heavily manured nursery, the difference in favour of plots receiving 134 lbs. nitrogen as against these receiving 106 lbs. nitrogen was only 0·77 per cent.

Summarising, it may be stated that

(1) Sugarcane responds best to nitrogenous manuring.
(2) a mixture of cake and Ammonium sulphate in the proportions of 4 : 1 or 3: 2 is the most profitable.
(3) 100–150 lbs. nitrogen is the optimum dose per acre.
(4) phosphates do not directly contribute to increase in yields, but are necessary for the proper ripening of cane and the production of good jaggery.
(5) potash depresses yields.
(6) using 100 lbs. nitrogen with or without phosphates, the quality of juice, as judged by analysis, is not appreciably affected.
(7) large applications of nitrogenous manures specially Ammonium sulphate tend to produce soft jaggery with poor keeping qualities.
(8) the use of setts from a crop raised on a well manured plot gives a better crop and permits reduction of the quantity of manure for the planting area.

SUGAR-CANE INSECTS IN SOUTH INDIA *

By RAO SAHIB Y. RAMACHANDRA RAO, M.A., F.E.S.
Government Entomologist, Coimbatore

Our Sugarcane Pests

Sugarcane is no more free from the attentions of insect-pests than the other major crops cultivated in South India. The setts that are planted are attacked by white ants; very often the joints are eaten up until they are reduced to mere shells, and the germination of buds is affected. The shoots are liable to attack by, at least, three kinds of caterpillar borers, which kill them outright. These borers may also attack the joints of canes during their growth and cause a decrease in the yield of sugar. The leaves may be infested with various kinds of sucking insects: mealy-wings (Aleurodes), mealy-bugs, plant-lice and leaf-hoppers. In some tracts, the Paddy grass-hopper—Hieroglyphus—may invade the crop and reduce the leaves to mid-ribs. Cockchafer grubs may in some places damage the planted crop. Rats, squirrels and jackals are also known to carry their depredations into the cane crop.

Sugarcane Pests in other Lands

Although South India has a goodly share of ills due to insect-agency, still she has upto now been free from various insect foes known to infest other countries of the world. In Hawaii, one finds the serious leaf-hopper pest—*Perkinsiella saccharicida*—which has been, after long-continued efforts, brought under control by biological agency i.e., by the introduction of parasites. Secondly, there is the weevil-borer, *Rhabdocnemis obscura*, found also in some of the islands of the Lesser Antilles, and thirdly, Hawaii has the stemborer—*Diatraea saccharalis*—different from the Indian species. In Fiji, the major pests are the wireworms and certain beetle borers. In Queensland, the chief

* Paper read at the M.A.S.U. Conference, July 1930.