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The Nitrogen Nutrition of Sugarcane

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Introduction: Of the major plant food elements, sugarcane responds most to nitrogen. Phosphate and potash are only of local importance depending upon the nature of the soil and its peculiar formation. Nitrogen happens to be the chief problem in the fertiliser programme for sugarcane, and it is the most fugitive of the three elements. The yield and quality are both affected by nitrogen. Low applications result in poor yields while high doses. result in canes of poor quality. Also, the climatic conditions and the time at which the nitrogen is applied have all got an effect upon the plant's reaction. Applications made late in the season depress the sugar content and yield of juice, resulting in poor quality jaggery. It can thus be seen that the nitrogen fertilisation of sugarcane is an operation which affects the yield, the composition, and quality of sugarcane and the sugar manufacturing and open - pan industries.

Considerable attention has been paid to this problem, which is the foremost in the sugarcane countries of the world. The earliest comprehensive investigation on this aspect is by Das (11) in Hawaii who attempted a detailed physico - chemical study of nitrogen nutrition in the sugarcane plant. The main object of his study was to find out why high nitrogen doses, while giving high yields, reduce the quality of the cane and what changes in the cane plant accompanied this phenomenon. He found that high doses of nitrogen increase the vegetative growth, tillering and yield. They promoted succulence of tissues by increasing the moisture content per gram of dry matter. The sucrose content in the sap was reduced and reducing sugars increased. The characteristic effect is an increase in the total and soluble nitrogen in the tissue with increasing nitrogen doses. From these studies, he hypothesized that application of nitrogen would first increase the absorption of the ash constituents, resulting in a modification of the hydration capacity of the tissue colloids. This alteration in the hydration capacity controls the elaboration of the various carbohydrates in the tissues, presumably through its influence on the organic complex of the plant.

Along with the above workers. Ayres (3) in the same station, studied the absorption of mineral nutrients by sugarcane at successive stages of growth. A knowledge of the changing demands which the growing cane plant makes on the soil at different stages of growth was felt necessary to adopt a more rational fertiliser programme. He found that the different plant nutrients were absorbed at different rates, nitrogen being absorbed earlier than phosphate. The rate of uptake of nitrogen was most rapid upto 6 months, after which there was a marked falling off.

Studies on the nitrogen requirement of sugarcane were done by Borden (5, 6) in Hawaii. This author started with a study of the periodical uptake of nutrients and finally attempted the evolution of an index in the plant itself which could be used for assessing the fertiliser requirements of sugarcane. In a study of the early development and rate of nutrient uptake by sugarcane, Borden (4) attempted to find out the critical stages of the crop when the crop required maximum plant food. He found that the concentration of N, P, K, decreased with increase in age. The most rapid uptake of nitrogen occurred between the 4th and 9th month. The absorption of P_2O_5 was constant after the crop was well under way. Such information has been found useful for developing a rational schedule of manuring.

The usual technique of field experimentation by the use of graded quantities of fertilisers has been found to be of limited value by these workers, in solving the manurial requirements of crops. Also, it was found that the results obtained at one particular place or soil were not applicable to a place even nearby. The need for an index, either in the soil or in the plant, was found to be imperative. Soil studies failed to give any satisfactory index for the manurial needs of the plant. By means of careful tests it was found that the leaf was a reliable index of the fertiliser needs of the cane plant. This technique of "foliar diagnosis" has been adopted in Hawaii, Mauritius, Puerto Rico and Jamaica. By this technique the plant is manured only when the need is indicated by an analysis of the leaf. Whenever the leaf nitrogen value falls below an optimum value, the crop is manured. By means of this technique, it has been estimated that Hawaii was able to reduce its manurial dose considerably. Notable among the workers in this line are Borden (5) and Clements (9) in Hawaii and Craig (10) in Mauritius.

In an article on "A search for guidance in the nitrogen fertilisation of sugarcane", Borden (5) found that soil analysis for both total and available nitrogen failed to give any specific guidance when the crop was under way. He found that foliar nitrogen was more reliable and in a growing crop he determined levels of nitrogen in the leaf indicative of deficiency, sufficiency and excess of nitrogen in the soil. In a subsequent study, Borden (7) studied the effect of nitrogen on the yield and composition of sugarcane. By applying graded doses of nitrogen he found that the concentration of nitrogen in all parts of the cane increased with increase in nitrogen added to the soil. The crop was found to show a deficiency of nitrogen at 11 months (in Hawaii sugarcane is a biennial crop) when the nitrogen in total dry weight was only 0·23%, 1·28% in leaf punches, 0·89% in leaf blades. At this stage, it has been found profitable to apply some more nitrogen to effect an increase in final yields. This system of controlled fertilisation was very helpful in economising manurial expenses in Hawaii. Borden (6), extended his studies to second ratoon crops also and found that the indices for the ratoon crops for optimum yield were higher than for the plant crops.

Craig (10) in Mauritius was able to establish a correlation between leaf nitrogen and crop response. In subsequent years, it was possible to control nitrogen fertilisation of sugarcane by means of leaf analysis. Definite levels of N, P and K in the cane leaves were found to be indicative of the manurial requirements of sugarcane. However, there were characteristic levels of nutrients for each variety and hence varietal differences must also be taken into consideration.

Asana (1) working in Bihar, studied the absorption of nitrogen by the sugarcane plant at different stages of growth. He found that the rate of uptake of nitrogen increased to a maximum in about 17 weeks and thereafter there was a steady decline. These studies are of value in indicating the periods of plant food requirements by the crop.

Lakshmikantham and Sankaram (15) sought to determine the optimum nitrogen requirement of sugarcane in the Anakapalle tract by means of a field experiment with graded doses of nitrogen from 0 to 250 lb. nitrogen. Considering the yield, they found that 100 lb. nitrogen per acre to be the optimum for sugarcane in this tract. The conclusions were based mainly on yield and economics of cultivation and do not indicate the periodical requirements and utilisation of nitrogen by the crop.

Rege (16) at Padegaon studied the nitrogen requirement of sugarcane. Biochemical studies on the crop and the soil revealed 300 lb. nitrogen. to be the optimum in that tract, beyond which it was not economical. In a more recent study, Rege and Sannabhadti (17) studied the physiological behaviour of important cane varieties, with regard to the uptake of the major plant food elements. They found that during the early stages of growth, nutrient absorption takes place at a much greater rate than the elaboration of dry matter. The maximum absorption was found to occur during October – November and later. the cessation of growth brings a reversal in the uptake. These studies have been found useful to draw up different manurial schedules for different varieties without detriment to soil fertility.

Khanna, Prasad and Sinha (14) studied the applicability of foliar diagnosis as an index for optimum fertilisation for sugarcane in Bihar. They found that both the standard leaf and the alcohol extract of the standard leaf were better than the whole plant for assessing nutrient requirements. This was particularly so in the case of phosphates. The maximum uptake of nitrogen was in May and that of phosphates in August.

Work was done in Madras to find out the optimum nitrogen requirements of the cane crop for the different soil and climatic conditions that exist in different cane tracts and tentative schedules were drawn up by field experimentation at the various research stations. This information, valuable as it is, does not give an insight into the behaviour of the cane plant, when the cane crop needs the manure most and whether the applied manure is efficiently utilised. Dutt in his report of sugarcane research in India has stressed the need for recommending the minimum additional dose of fertiliser over and above the farmyard manure the ryot invariably applies. There is also a need to reduce the manure bill for sugarcane. All these require investigations on the cane plant at different stages of growth and detailed investigations were taken up with the object of elucidating :—

(a) the fate of the fertilisers applied to the soil;

(b) the composition and uptake of nitrogen by cane plant at different stages of growth, to determine the 'critical periods' in the life of the cane plant;

(c) the effect of cane growing on soil fertility;

(d) the possibility of finding out an index in cane tissue which can indicate its manurial requirements;

(e) the effect of such fertilisation on the composition of juice and jaggery quality.

Such information is essential to evolve a sound system of manuring, for maintenance of soil fertility at high levels and producing cane of good quality, since the ultimate objective is more sugar and jaggery of good quality.

Material and Methods: With the above objects, a field experiment was laid out at this station with graded doses of nitrogen viz., 100, 150 and 200 lb. nitrogen with two varieties, Co. 527 (early) and Co. 419 (late). The layout was a split plot design with six replications. Before planting, the soil of experimental field was analysed to have an idea of the basic fertility level of the soil.

TABLE I.

Initial analysis of the soil.

S. No.	Constituents	Results of analysis
1	Moisture%	3·46%
2	Total Nitrogen	0·046%
3	Nitrate – Nitrogen (mg. per 100 grms soil)	1·12 mg.
4	Organic carbon	0·34%
5	C/N ratio	7 7
6	pH	7·4

The data reveal that the initial fertility level of the soil is high enough.

Subsequently, soil samples were drawn every month from the different treatments and analysed for nitrate nitrogen and moisture to study the release of nitrogen from the manures under different treatments. Simultaneously, plant samples were drawn to study the composition and uptake of nitrogen per acre. Since the uptake of nitrogen per acre was calculated every month, the "unit length" method of sampling was adopted where one-half of the experimental plots were divided into strips, and alternative strips were taken from each replication and then mixed and a composite sample obtained. These samples were immediately used for moisture determination and another sample oven-dried for nitrogen estimation. From the nitrogen content in the strips taken on fresh basis, the uptake of nitrogen per acre was calculated.

Results and Discussion: (a) *Composition of the cane plant:* Fig. 1 gives an idea of the effect of nitrogen application upon the composition of the cane plant. The trend of nitrogen concentration in the cane plant is to decrease with age, the youngest plant having the highest concentration. It shows that the formative stage is characterised by higher absorption than utilisation by the plant. As soon as the cane plant starts its "grand period of growth" from June - July, the utilisation proceeds at a faster rate than the absorption of nitrogen which results in what is called a "poverty adjustment" balance, but when the maturity phase sets in, no more nitrogen is required and actually there is a return of nitrogen to the underground portions and the soil by the time the cane is harvested. A clear understanding of this nitrogen metabolism is essential for a rational schedule of manuring for the cane crop. Yuen and Hance (18) in Hawaii believe that the nitrogen concentration must be kept at the higest level, preferably at luxury concentration, in the formative stage along with optimum moisture conditions to enable the plant to tiller well. Failure of this early tillering will result in lesser number of mother shoots, and finally give a lower yield of cane and sugar per acre. When the grand period sets in, there is need to maintain high amounts of availabe nitrogen in the soil to cope with the rapid utilisation by the cane plants. As soon as the maturity phase sets in, there should not be much available nitrogen in the soil, since it has been found that high amounts of nitrogen in the soil helps sugar breakdown rather than accumulation. In the present study also, high amounts of nitrogen in the body of the cane plant resulted in low sucrose content in the cane juice, as seen in Table II.

TABLE II.

Nitrogen in cane tissue and sucrose % in juice.

S. No.	Details	August	November		Harvest	
		Nitrogen %	Nitrogen %	Sucrose %	Nitrogen %	Sucrose %
1	Co. 419 : 100 N	0·75	0·42	7·63	0·29	17 04
2	,, : 150 N	0·83	0·57	7·13	0·20	16 58
3	,, : 200 N	0·95	0·56	7·26	0·36	15·85
4	Co. 527 : 100 N	0·85	0·55	11·37	0·42	15·14
5	,, : 150 N	0·94	0 55	9·62	0·42	15·14
6	,, : 200 N	0·97	0·60	8·74	0·46	14·66

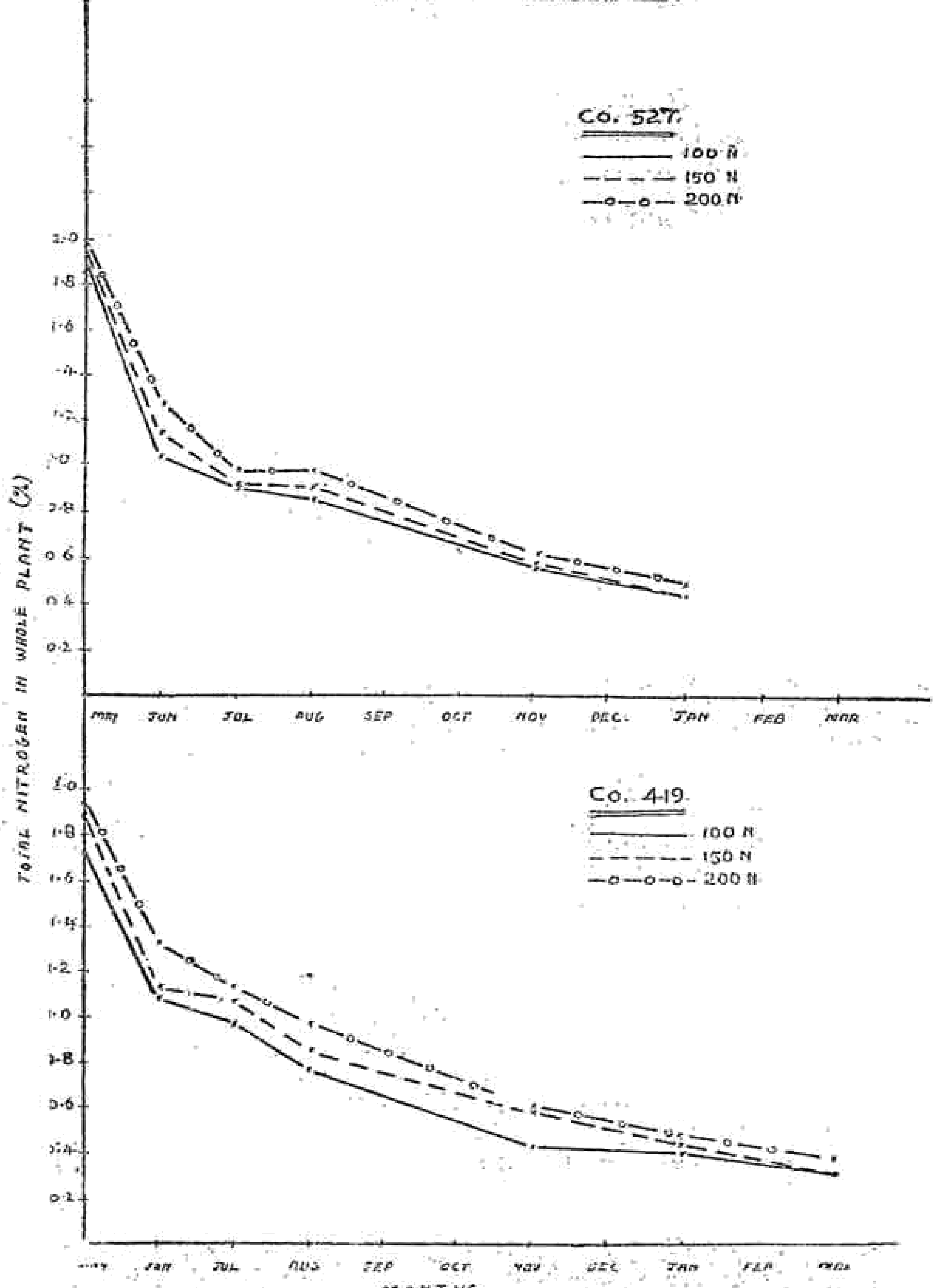
The effect of increasing doses of nitrogen on the composition of the whole plant is given below:

TABLE III.

Total Nitrogen in the whole plant *(% Oven-dry basis).*

S. No.	Details	May	June	August	November	Harvest
1	Co. 419 : 100 N	1 71	1·05	0·76	0·42	0 29
2	,, : 150 N	1·83	1·09	0·83	0·57	0·29
3	,, : 200 N	1·85	1·30	0·95	0·56	0·36
4	Co. 527 : 100 N	1·85	1·09	0·85	0·55	0·42
5	,, : 150 N	1·88	1·12	0·94	0·55	0·42
6	,, : 200 N	1 89	1·25	0 97	0·60	0·46

FIG. 1. TOTAL NITROGEN IN WHOLE PLANT.
(PER CENT OVEN-DRY SAMPLE.)



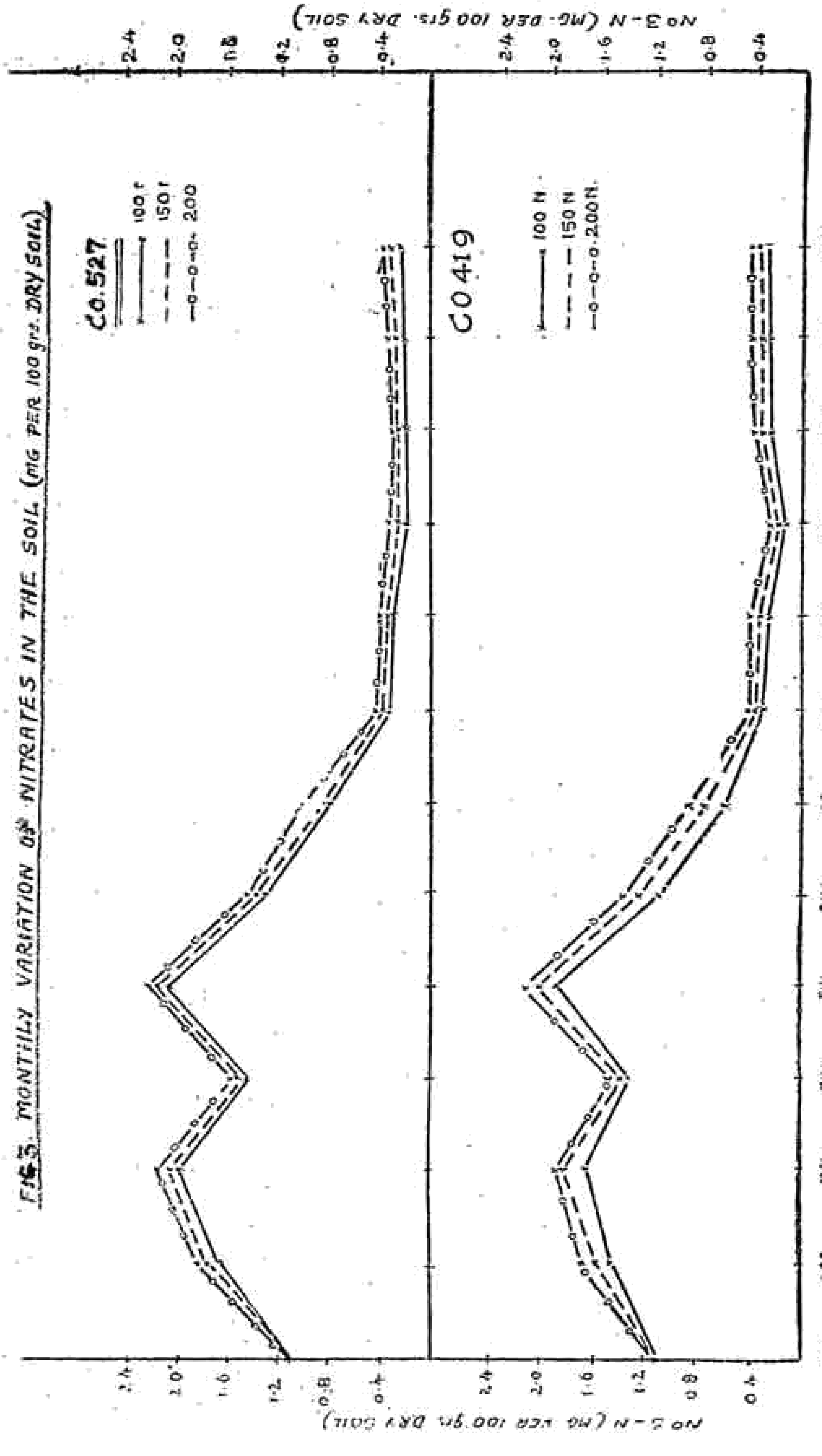


FIG. 5. MONTHLY VARIATION OF NITRATES IN THE SOIL (MG PER 100 grs. DRY SOIL)

It can be seen that there is a slight increase in nitrogen in the cane tissue with an increase in the dose of nitrogen. It is more marked in the early stages of growth and is maintained upto harvest. In the two varieties, taking the lowest dose of 100 lb. N into consideration, it can be seen that Co. 527 throughout records a higher nitrogen content in its tissue than Co. 419, the late varity. The greater detrimental effect of 200 lb. N on juice quality of Co. 527 as shown in table II, may be due to this.

(b) *Uptake of nitrogen per acre:* The periodical uptake of nitrogen by the cane plant as computed by the unit length method of sampling is given in Table IV.

TABLE IV.

Periodical uptake of Nitrogen *(lb. per acre).*

	Details						
	Variety		Dose of Nitrogen (in lb. per acre)	Formative stage	Early grand period	Maximum uptake (during grand period)	Harvest time
1	Co. 419	:	100 N	23·5	111·7	129·0	94·0
2	Co. 419	:	150 N	36·7	152·9	178·5	96·4
3	Co. 419	:	200 N	47·3	169·8	191·7	104·6
4	Co. 527	:	100 N	27·7	132·5	169·6	127·7
5	Co. 527	:	150 N	34·9	145·1	246·4	134·0
6	Co. 527	:	200 N	44·1	158·4	234·0	163·6

It can be seen that, in spite of the high nitrogen concentration in the early stages (Table III), the uptake per acre is lowest during the formative stage, showing that under normal conditions, the nitrogen requirement is negligible in the early stage. It can also be seen thst the uptake is more with increased nitrogen doses, but this is not reflected in increased yields of cane. The rate of uptake rapidly increases with the onset of the grand period and during this period as much as three-fourths of the total nitrogen is taken up. By harvest time there is a fall in the nitrogen per acre. Thus the early grand period stage can be taken as the "critical period" in the life of the plant, during which it requires the maximum amount of available nitrogen. The dose and time of manuring should be so adjusted that adequate nitrogen is made available to the plant during this stage. In the case of higher doses of nitrogen, beyond 100 lb. N, the higher accumulation in the plant body without a corresponding increase in yield results in poor juice quality.

(c) *Release of Nitrogen from manures:* The periodical availability of nitrogen from different treatments was studied throughout crop growth. The data are presented in Table V.

TABLE V.

Nitrate-nitrogen in soil during crop growth *(Original* $NO_3 = \frac{1.12 \text{ mg.}}{100 \text{ gm}}$*)*

S. No.	Details	April	May	June	July	August	Sept.
1.	Co. 419 : 100 N	1·54	1·69	1·33	1·92	1·10	0·56
2.	" 150 N	1·61	1·76	1·33	2·03	1·28	0·74
3.	" 200 N	1·64	1·78	1·38	2·08	1·37	0·82
4.	Co. 527 : 100 N	1·70	2·02	1·44	1·10	1·30	0·80
5.	" 150 N	1·74	1·97	1·42	2·14	1·35	0·70
6.	" 200 N	1·72	2·06	1·47	2·15	1·40	0·95
S. No.	**Details**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**
7.	Co. 419 : 100 N	0·29	0·24	0·11	0·22	0·22	0·21
8.	" 150 N	0·36	0·30	0·15	0·22	0·20	0·27
9.	" 200 N	0·36	0·30	0·20	0·22	0·19	0·27
10.	Co. 527 : 100 N	0·36	0·30	0·18	0·22	0·19	0·23
11.	" 150 N	0·36	0·30	0·27	0·22	0·22	0·23
12.	" 200 N	0·36	0·30	0·27	0·26	0·21	0·27

The analysis of the soil for nitrate-nitrogen shows that higher nitrogen doses did not result in higher availability of that element in proportion to the dose applied, presumably due to some limiting factor operating. By the stage of maturity, however, no difference in the nitrate-nitrogen is noticeable among the different treatments (Fig. II).

The first half of the manure applied at planting time is found to reach peak availability (Fig. II) in about 1½ to 2 months in the case of all treatments. But it was already noted that the nitrogen requirement during this stage is very little and hence the utilisation of the dose is not complete and is likely to be wasted. The second half of the manure given at earthing-up time is found to maintain a higher level of available nitrogen during the grand period. The rapid fall in available nitrogen after July appears to be due to high uptake by the plant.

Thus a comparative study of the uptake of nitrogen by the cane plant and the release of nitrogen from the applied manures has yielded useful data regarding the manurial requirement of the cane crop. The "Early grand period" stage is the most critical perid for nitrogen in the crop. The release of nitrogen from the soil in the different manurial treatments shows that the rate of availability is not conducive to efficient utilisation since the first peak is not fully utilised by the plant when it is in a formative stage of development. These studies warrant the conclusion that for an efficient utilisation of manure, it must be applied 1 to 1½ months after planting. Further studies in this line are in progress.

(d) *Composition and quality of the juice :—* The effect of high nitrogen on the chemical composition of the cane juices was studied through an analysis of the juice, both for sugar and non-sugar constituents. The data are given in Table VI.

TABLE VI.

Effect of nitrogen on juice composition (1949-50)

S. No.	Details of analysis.	C. 419		Co. 527	
		100 N	200 N	100 N	200 N
1	Total solids (by drying)	20·35	20·16	16·98	16·80
2	Sucrose % (True)	19·20	18·80	15·38	15·16
3	Purity %	94·25	93·25	90·55	90·24
4	Glucose %	0 65	0·78	0·85	0·79
5	Glucose ratio	3 37	4·17	5·50	5·20
6	Ash: per 100 c. c. juice	0·36	0 32	0·35	0·37
	,, % juice.	0 33	0·30	0·33	0·35
7	Total non-sugars.	0 50	0·55	0·75	0·85
8	Organic non-sugars %	0 17	0·25	0·43	0·51
9	Ash/sucrose %	1·71	1·57	2·13	2·30
10	Organic non-sugars/sucrose %	0·91	1·34	2·77	3·32
11	Ash constituents per 100 c. c. juice				
	(a) Lime.	0·028	0·032	0·045	0·048
	(b) Magnesia	...	...	0·013	0·019
	(c) Phosphoric acid	0·027	0·018	0·017	0·014
12	Chlorine per 100 c. c. juice	0·085	0·082	0·089	0·115
13	Total Nitrogen-mgms per 100 c. c. juice	19 88	22·68	18 80	24·40
14	Non-protein N do.	9·80	10·92	6·72	13·44
15	Non-protein—N as % of total Nitrogen	49·28	48·15	35·76	55·08
16	Colloids-per 100 c. c. juice	...	...	0 34	0·36
17	Pectins	...	...	0·029	0·037

The data furnish interesting information regarding the quality of the juices. Apart from a lowering of the sucrose content in juice, the main effect of high nitrogen appears to be an increase in the organic non-sugars, specially the harmful nitrogen, colloids and pectins. This is accompanied by a reduction in the phosphate content of the juice showing an antagonism between the nitrogen and phosphate in the ion-intake by the cane plant. It is well-known that an increase in the harmful non-protein nitrogen and colloids result in juices which are difficult to clarify in the factory, increase viscosity of the syrup and prevent uniform crystallisation in the pans. It is also known that a minimum of 30 mgms of P_2O_5 per 100 c. c. juice is necessary for efficient clarification and whenever it goes less than this, it should be supplemented artificially. This detrimental effect on juice quality by an increase in the harmlful constituents is felt during the manufacture of jaggery also and the end product is generally of poor quality. The data of analysis of jaggery is given in Table VII.

TABLE VII.

Analysis of Jaggerry samples (1949—50).

S. No.	Details of Analysis	Co. 419		Co. 527	
		100 N	200 N	100 N	200 N
1	Moisture %	10·77	7·91	10·42	7·93
2	Sucrose %	76·37	76·47	78·88	78·44
3	Glucose %	11·64	10·71	10·20	9·71
4	Glucose ratio	15·24	14·00	12·70	13·38
5	Ash %	1·66	1·34	2·06	2·15
6	Total Non-sugars %	11·97	12·82	11·10	11·85
7	Organic Non-sugars %	10·31	11·48	9·04	9·70
8	Chlorine %	0 30	0·34	0·48	0·42
9	*Ash constituents:—*				
	(a) Lime %	0·20	0·24	0·25	0·17
	(b) Phosphoric acid %	0·13	0·09	0·10	0·08
10	Total Nitrogen (mgm. per 100 gms. jaggery)	31·4	38·0	68·8	118·6

Irrespective of the other constituents, the most characteristic effect is the increase in nitrogen content and a depression in the phosphate content of the juice. It can be seen that the effect of high nitrogen doses is a continuous process from an increase in the nitrogen of the plant tissue, then the juice and then the end product, the jaggery.

(e) *Soil Analysis:* To see if there is any depletion in the soil nitrogen in any of the doses of nitrogen by a season's crop growth, the soils from the different treatments were again analysed, after harvest of the experimental canes.

TABLE VIII.

Initial and final soil analysis.

S. No.	Details	Nitrate-N Mgm./100 gms.	Total N %	Carbon %	C/N	pH
1	Co. 419 : 100 N	0·21	0·059	0·62	10·6	7·5
2	,, : 150 N	0·27	0·062	0·62	10·1	7·5
3	,, : 200 N	0·27	0·064	0·62	9·3	7·5
4	Co. 527 : 100 N	0·20	0·063	0·90	14·3	7·5
5	,, : 150 N	0·22	0·064	9·90	14·0	7·5
6	,, : 200 N	0·21	0·064	0·90	14·0	7·4
	Initial soil analysis	1·12	0·046	0·35	7·7	7·4

The total nitrogen figures for the soil after harvest of the crop reveal that at any level of nitrogen dose applied, the nitrogen in the soil is not depleted below the original level after one season of crop growth. There is practically no change in the pH values, irrespective of the variety or nitrogen dose applied. It is interesting to note that the carbon content has actually increased after one year's crop growth and this is more under Co. 527 than Co. 419. This is probably due to greater contribution of roots in the soil by Co. 527.

(f) *Yield of cane and commercial cane sugar:* The yield of cane from the different treatments, the C. C. S. % and the C. C. S. per acre are given below :

TABLE IX.

Yield and Commercial Cane Sugar.

S. No.	Details	Yield of cane tons/acre	C. C. S. %	C. C. S. per acre tons
1	Co. 419 : 100 N	42·90	11·72	5·03
2	,, : 150 N	43·49	11·60	5·05
3	,, : 200 N	42·32	10·89	4·61
4	Co. 527 ; 100 N	40·09	10·78	4·32
5	,, : 150 N	41·54	10·88	4·52
6	,, : 200 N	41·88	10·39	4·35

It can be seen that while there is not much difference in yield between the different treatments, the C. C. S. per acre have been depressed in 200 lb. nitrogen.

The above data reveal 100 lb. N to be optimum under the conditions of the trial. But it was already seen that there was likelihood of a part of the manure applied at planting time being wasted since, the cane plant was in need of only small amounts of nitrogen during the formative stage. It was also seen that a higher dose during formative stage as in 200 N did not favourably influence the yield at the end. Accumulation of high amounts of nitrogen in cane tissue due to continued availability late in the season in higher doses, result in poor quality juices. All these point to the possibility of reducing the manure dose without affecting cane yield and soil fertility. The periodical uptake of nitrogen shows that after the grand period stage there is no need for any available nitrogen. The manurial regimen must be timed to suit these conditions. This will not only reduce the manurial bill but also favour sucrose accumulation. That the time and dose of nitrogen must be based upon the knowledge of the "critical period" of a crop plant is in line with the work reported by Hester (13) and Cochran and Olson (9). In these studies it has been proved that the critical period is between 2½ to 5 months. Asana (1) has reported that the rate of uptake and the important period is from 3—6 months. Further experiments have been planned to see if the manurial dose can be reduced and juice quality enhanced by a modification of the schedule, based upon the above investigations.

Summary and Conclusions: 1. Studies on the biochemical aspects of the nitrogen of the cane plant have been presented in this paper. The object was to evolve a manurial schedule economical to the cultivator, which is at the same efficiently utilised and not detrimental to soil fertility.

2. Increasing doses of nitrogen increase the concentration of this element in the cane tissue but the effect is not much over 100 lb. N. The concentration shows a downward trend with age.

3. A study of the periodical uptake of nitrogen per acre has shown that the most critical period during which the cane plant requires the maximum amount of nitrogen is from 2½ to 5 months, before which high available nitrogen in the soil is not well utilised and after which high nitrogen depresses the juice quality, jaggery and C. C. S.

4. The analysis of nitrogen showed that the applied manure reaches peak availability in 1½ to 2 months. It is hence necessary that the time of application must be so adjusted so as to synchronise the peak availability with the "critical period" for nitrogen requirement in the cane crop.

5. Nitrogen in higher doses is carried over into extracted juice, with an increase in the colloids and other organic non-sugars, resulting in juices of poor workability. Also, the jaggery from such juices show high nitrogen and poor quality. It is found that the initially high accumulation of nitrogen is carried forward from the most tender plants up to harvest, then to the juice and the jaggery. This is thus a continuous process. High nitrogen is accompanied by low phosphate, which is not favourable for clarification.

Conclusion: A general correlation exists between vegetation maps and climatic maps, although the degree of agreement might vary in different regions and for different vegetation types (3). Any attempt to improve vegetation should therefore take into consideration the climatic factors also. Application of manures to soils is done with the aim of improving vegetation to the advantage of men and cattle. Soil management and maintenance of soil fertility can be successfully tackled only when the climatic features of the locality are clearly understood.

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