Investigations on the Effect of Foliar Application of Nitrogenous Fertilizers on Quality Constituents of Chewing Tobacco (*Nicotiana tabaccum* Linn.)*

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Tobacco, though related botanically to other important crop plants is unique in that the leaf constitutes the valuable part of the plant. Commercial properties of leaf are greatly correlated with its chemical composition which in turn can, to some extent, be controlled by regulated supply of nutrients. Many studies on the influence of soil applied fertilizers on the quality constituents of the tobacco leaf have been reported. But there seems to be no published work on the effect of foliar applied fertilizers on the quality characters of tobacco. In the present paper, results of the investigation on the influence of foliar feeding of nitrogen on the elements of quality in chewing tobacco conducted at the Agricultural College and Research Institute, Vellayani, are summarized.

Review of Literature

Nitrogen is of outstanding importance rot only in its effects on the growth of tobacco but also in its influence on the various elements of quality of cured leaf as was demonstrated by Garner (1934). Volodarsky (1948) has reported that the application of an increased quantity of ammonium sulphate increased the thickness and area of leaves. Chandanani, Thomas and Reddi Babu (1960) found that soil application of nitrogenous fertilizers increased weight per unit area and nicotine content of leaf. Anderson, Swanback and Street (1932) reported that heavily manured tobacco had a high content of potash. Lacrose (1945) found that nicotine content of tobacco leaf increased with moderate application of nitrogen. Gowarkar and Shaw (1961) reported that in beedi tobacco nitrogen significantly reduced the calcium, magnesium and chlorine contents of the leaf while it increased the nitrogen, phosphoric acid, potash and nicotine contents,

Materials and Methods

Tobacco plants (Var: Pannan) were grown in carthern pots of 45 cm diameter filled with 40 kg. of washed sand, collected from the Kovalam sea shore. Well-rotted farm yard manure at the rate of 2 kg. per 40 kg. of sand was mixed in the pots. Phosphoric acid (1 g.) and potash (6 g.) were applied in the form of superphosphate

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and potassium sulphate for every 40 kg. of sand. Vigorous seedlings of uniform size were selected for transplantation. The roots were washed with pure water. Planting of seedlings was done on 15th October, 1962, in pots arranged 90 cm in both directions. One percent solutions of pure fertilizer salts were prepared in distilled water and utilized within six hours for spraying the plants. 'Teepol' B–300 was added to the spray solutions which acted as wetting agent. Holmspray atomiser No. 600 was used for spraying the fertilizer solutions. The plants were sprayed with fertilizer solution in the evening hours. The spraying was done on the upper and lower surfaces of the leaf. The different doses of nitrogen, viz; 1 g., 2 g., 3 g. and 4g. per plant were split up into four equal parts and sprayed at fortnightly intervals, begianing from the 30th day of planting the seedlings. Control plants were sprayed with 300 ml. of pure water. As with spraying nutrients, the different doses of solid fertilizers applied to the soil were divided into four equal parts and applied at fortnightly intervals, to coincide with the dates on which foliar sprays were done. The plants were watered daily in the morning, as well as, in the evening with a hand sprinkler. The experimental lay-out was of the split–plot design in randomised block, with five replications consisting of 30 treatments each, The treatments studied were the following:-

A. Whole - plot treatments (form of fertilizer)

1. Urea M_1
2. Ammonium sulphate M_2
3. Ammonium nitrate M_3

B. Sub - plot treatments (method of application)

1. Foliar spray F_1
2. Soil application F_2

C. Sub-sub plot treatment (level of nitrogen)

1. 0 g. per plant or per 40 kg. of soil L_0
2. 1 g, „ la
3. 2 g. „ L_2
4. 3 g. „ L_3
5. 4 g. „ L_4

Thickness of leaf was expressed as weight of leaf per unit area. It was ealculated from the formula :

$$\frac{\text{Weight of green leaves per plant in grams}}{\text{Total area of leaves in sq. cm.}}$$

Samples of cured leaves from all the 150 experimental plants were taken and analysis for nicotine, nitrogen, potassium and chlorine contents was carried out. The procedure of analysis followed was as per A. O. A. C.

Results

/. *Thickness of Leaf*

The thickness of leaf was expressed as weight per unit area. Mean values of the weight in g. per sq. cm, of leaf as influenced by the various treatments are presented in Table I.

The three sources of nitrogen did not differ in their influence on the thickness of leaf. The effect of foliar application of nitrogen in increasing leaf thickness was less in comparison with the soil application. Mean values of leaf thickness corresponding to different levels of nitrogen were markedly different. A progressive increase of this character of the leaf with increased levels of nitrogen was discernible.

2. *Total Nitrogen*

Average values of total nitrogen of cured leaf as influenced by the various treatments are furnished in Table II.

TABLE I

Average weight of leaves in g. per square cm.

Fertilizer	Level	F_1	F_2	Average
M_1	L_0	0.06174	0.06202	0.06183
	L_1	0.06314	0.06308	0.06311
	L_2	0.06490	0.06500	0.06495
	L_3	0.07196	0.07188	0.07192
	L_4	0.07406	0.07400	0.07403
Average		0.06716	0.06719	0.06717
M_2	L_0	0.06184	0.06173	0.06177
	L_1	0.06288	0.06314	0.06301
	L_2	0.06474	0.06506	0.06490
	L_3	0.07188	0.07222	0.07205
	L_4	0.07390	0.07430	0.07429
Average		0.06705	0.06925	0.06708
M_3	LO	0.06264	0.06204	0.06244
	L_1	0,06292	0.06314	0.06303
	L_2	0.06510	0.06452	0.06481
	L_3	0.07210	0.07202	0.07206
	L_4	0.07300	0.07400	0.07350
Average		0.06715	0,06714	0.06716
Data Mean		0.06690	0.07720	0.07200

'F' ratio (at 5%) for F mean—4.94 sig.
C. D. (at 5%) for L means—0.0002
Inference : F_2 F_1 L_4 L_3 L_2 L_1 L_0

TABLE II

Total nitrogen content of cured leaf (dry) in percentage as influenced by the treatments

Fertilizer	Level	F_1	F_2	Average
M,	L_0	2.20	2.20	2.20
	L_1	2.48	2.30	2.39
	L_2	2.53	2.42	2.47
	L_3	2.91	2.83	2.87
	L_4	3.25	2.85	3.05
Average		2.67	2.52	2.60

Fertilizer	Level	F_1	F_2	Average
M_2	L_0	2.22	2.20	2.21
	L_1	2.40	2.27	2.33
	L_2	2,46	2.34	2.40
	L_3	2.60	2.79	2,69
	L_4	2.65	2.77	2.71
Average		2.46	2.47	2.47
M_3	L_0	2.20	2.20	2.20
	L_1	2.50	2.32	2.41
	L_2	2.50	2.41	2.45
	L_3	2.86	2.81	2.83
	L_4	3.11	2.84	2.97
Average		2.63	2.52	2.57
Data Mean		2.59	2.50	2.55
C. D. at 5% for M means		—	0.0124	
do. F ,,		—	0.0101	
do. L ,,		—	0.0153	
Inference: M, M_3 M_2		F_1 F_2	L_4 L_3 L_2 L_1 L_0	

There was significant difference among the mean values of total nitrogen as affected by the three forms of fertilizers (M_1, M_2 and M_3). M_1 tended to increase the nitrogen content of leaves more than M_3 and M_2, while M_3 was superior to M_2 in its effect on nitrogen content. Regarding the influence of the method of application of fertilizers, the two methods (F_1 and F_2) differed distinctly in their effect on nitrogen content of leaf. F_1 was superior to F_2 in this respect. The mean values of nitrogen content corresponding to the different levels of fertilizers were significantly different. The nitrogen content of leaves increased progressively with the rise in dose of fertilizer. The interactional effect of method of application and dose of fertilizer on the precentage of nitrogen content of leaf was found to be significant. The treatment combination F_1 L_4 registered the highest value of precentage nitrogen content of leaf closely followed by F_2 L_4.

3. Nicotine

Table III presents the average values of the nicotine content of leaves as influenced by the treatments.

TABLE III

Nicotine content as percentage of dry cured leaf

Fertilizer	Level	F_1	F_2	Average
M_1	L_0	1,928	1.960	1.944
	L_1	1.924	2.210	2.067
	L_2	1.928	2.250	2.089
	L_3	1.946	2.484	2.215
	L_4	1.946	2.720	2.333
Average		1.934	2.325	2.130

Fertilizer	Level	F_1	F_2	Average
	LO	1.906	1.905	1.905
	L_1	1.914	2.280	2.097
M_2	LS	1.906	2.610	2.280
	L_3	1.900	2,680	2.325
	L_4	1.970	2.680	2.325
Average		1.944	2.431	2.188
	LO	1.902	1.920	1.911
	L_1	1.902	1.924	1.913
M_3	L_2	1.950	1.956	1.953
	L_3	1.968	1.970	1.969
	L_4	1.974	1.974	1.974
Average		1.940	1.948	1.944
Data mean		1.939	2.235	2.087

C. D. at 5% for M means — 0.0348

,, F ,, — 0.0284

,, L ,, — 0.0160

Inference M_2 M_1 M_3 F_2 F_1 L_4 L_3 L_2 L_1 L_0

The mean values of nicotine in the leaf corresponding to the sources of nitrogen (M_1, M_2 and M_3) vary significantly. The highest nicotine percentage was obtained for M_2, followed in decreasing order by M_1 and M_3. It was found that soil application (F_2) procured more nicotine content of leaf than foliar spraying (F_1). The influence of the different levels of nitrogen on the percentage content of nicotine of leaf was highly significant. The higher values of nicotine invariably corresponded with the increasing levels of nitrogen.

4. Potash

Data regarding the effect of various treatments on the potash content of cured leaf is presented in table IV.

TABLE IV

Potash content as percentage of dry cured leaf

Fertilizer	Level	F_1	F_2	Average
	LO	3.508	3.482	3.495
	L_1	3.598	3.604	3.601
M_1	L_2	3.634	3.616	3.625
	L_3	3.714	3.720	3.717
	L_4	3.722	3.842	3.782
Average		3.635	3,652	3.644

Fertilizer	Level	F_1	F_2	Average
M_2	L_0	3.516	3.470	3.493
	L_1	3.504	3.618	3.561
	L_2	3.512	3.652	3.582
	L_3	3.550	3.760	3.655
	L_4	3.602	3.768	3.685
Average		3.536	3.653	3.594
M_3	L_0	3.432	3.454	3.443
	L_1	3.558	3.548	3.569
		3.632	3.636	3.634
	L*	3.670	3.778	3.724
	L_4	3.690	3.836	3,763
Average		3.596	3.656	3.626
Data Mean		3.589	3.653	3.621

C. D, (5%) for M means — 0.017
,, for L ,, — 0.018
Inference M_1 M_3 M_2 F_2 F_1

The three sources of nitrogen differ markedly in their influence on the potash content of leaves. The increment in the average potash content of leaves was lowest in the case of M_2. M_1 and M_3 did not differ significantly in their effect on potash content. With the rise in dose of nitrogen the potash content of leaf increased. Higher percentage content of potash was consistently obtained in the case of increased levels of nitrogen (L_4 and L_3).

5. *Chlorine*

Mean values of chlorine content of leaf as influenced by the various treatments are given io Table V.

TABLE V
Chlorine content as percentage of dry cured leaf

Fertilizer	Level	F_1	F_2	Average
M_1	Lo	2.544	2.492	2.518
	L_1	2.540	2.562	2.551
	L_2	2.550	2.564	2.557
	L_3	2.870	2.424	2.647
	L_4	2.974	2.040	2.507
Average		2.695	2.416	2.556
M_2	Lo	2.528	2.484	2.506
	L_1	2.622	2.566	2.594
	L_2	2.636	2.514	2.575
	L_3	2.682	2.396	2.539
	L_4	2.780	2.404	2.592
Average		2.649	2.472	2.561

Fertlizer	Level	F_1	F_1	Average
M_3	L_0	2.518	2.466	2.492
	L_1	2.612	2.556	2,584
	L_2	2.620	2.414	2.517
	L_3	2.780	2.214	2.497
	L_4	2,818	2.108	2.463
Average		2.669	2.351	2.510
Data Mean		2.671	1.413	2.542
C, D. for M means	—	0.038		
,, F ,,	—	0.259		
,, L ,,	—	0.191		
Inference		$\overline{M_2\ M_1\ M_3}$	$\overline{F_1\ F_2}$	$L_1\ \overline{L_3\ L_2}\ L_4\ L_0$

There was marked difference among the sources of nitrogen in their influence on chlorine content of leaf. The increase in the chlorine content on account of M_2 was significantly greater than M_3, but was on par with M_1. Foliar application of fertilizers (F_1) tended to produce significantly higher precentage of chlorine than soil application (F_2). The chlorine content of leaves tended to increase with the higher levels of nitrogen when applied through foliage, while the opposite was the trend noticed in the case of soil application of nitrogen. The interactional effect of method of application and level of nitrogen on the percentage content of chlorine in leaf was found to be significant. The treatment combination, $F_1\ L_4$ corresponded to the highest value for chlorine and was statistically superior to all other treatment combinations.

Discussion

Foliar spray of nitrogen fertilizers has marked influence on the quality constituents of the tobacco leaf, like weight per unit area, total nitrogen, potash, chlorine and nicotine.

The thickness of leaf expressed as weight per sq. cm. progressively increased with the higher doses of foliar applied nitrogen. An increase of 16 per cent over control was recorded for the highest level of nitrogen, viz; 4 g. per plant. The same trend was noticeable in the case of application of fertilizers to the soil.

Foliar application of nitrogenous fertilizers tended to increase the precentage of total nitrogen content of dry cured leaves. The increase of nitrogen content was greater when the fertilizers were applied as foliar sprays as compared to soil application. Urea sprays tended to increase the nitrogen content of leaves more than ammonium nitrate and ammonium sulphate (Fig. 1). The tendency of the nitrogen content to increase in leaves consequent on foliar spraying of nitrogenous fertilizers has been reported in other crops by various workers (Oland, 1950, Sako, 1960). The increase in nitrogen content of leaves consequent on nutrient sprays occurs not only because of direct absorption of the applied solution through leaves, but also indirectly, by enhancing the uptake through roots, as has been demonstrated by Thome (1957),

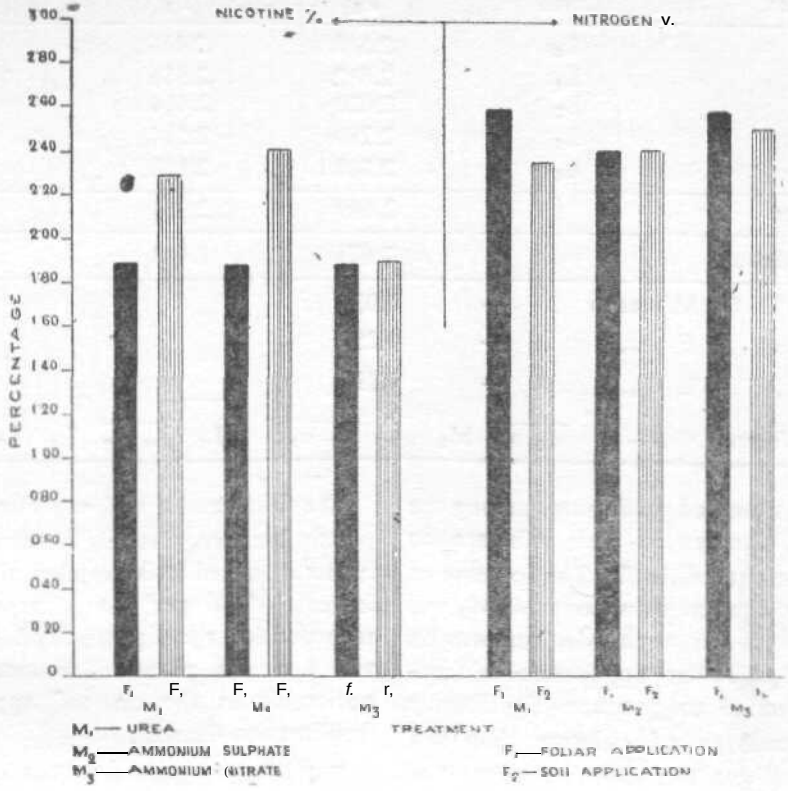


Fig. 1. Effect of Methods of Application of Fertilzers on Nicotine and Nitrogen Content of Cured Leaf (Percentages)

The percentage content of nicotine in leaves was also significantly increased by the foliar spray of nitrogenous fertilizer, but this increase was less as compared with the effect of soil application of the fertilizer (Fig. 1). A comparison of the differential influence of the three sources of nitrogen, disregarding the effect of method of application showed that the efficiency in influencing the percentage content of nicotine was in the order $M_2 > M_1 > M_3$. But taking into consideration the influence of method of application it could be seen that in the case of foliar spray, ammonium sulphate gave higher percentage content of nicotine than ammonium nitrate and urea. Urea sprays produced the least nicotine content. With soil application ammonium sulphate was again found superior to urea; but urea gave better results than ammonium nitrate.

Foliar sprays, as well as soil application, of nitrogenous fertilizers increased the percentage content of potash in cured leaves, there being no significant difference between them (Fig. 2, 3 and 4). The potash content was observed to increase progressively with the corresponding rise in the doses of nitrogenous fertilizers up to 4 g. of nitrogen per plant. Urea sprays tended to increase the potash content of leaves more than ammonium nitrate and ammonium sulphate.

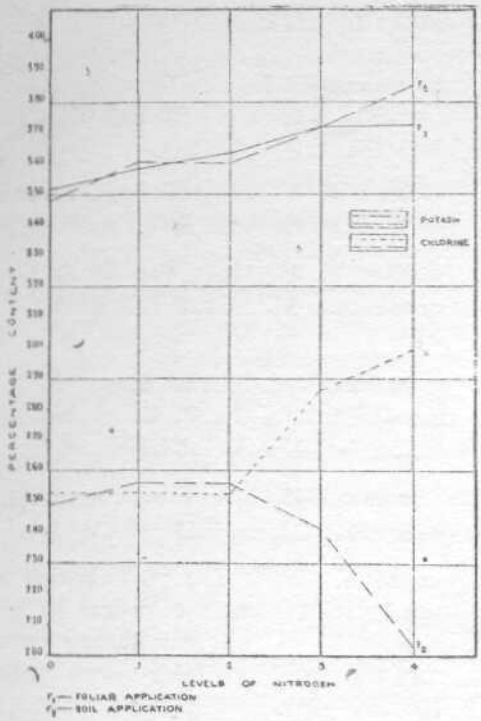
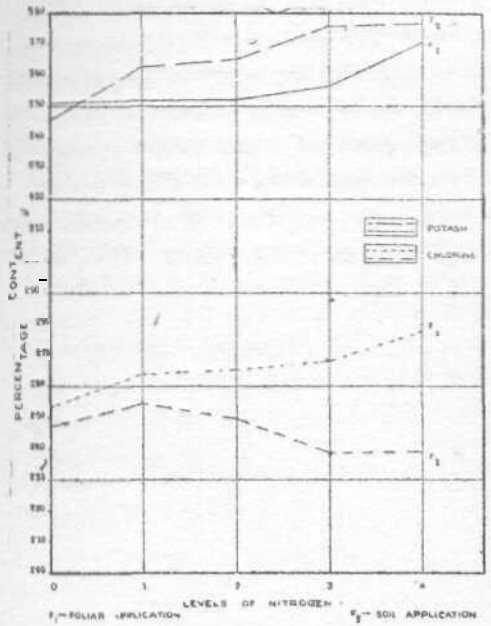


Fig. 2. Effect of Method of Application of Ferti)i7er (Urea) on Potash and Chlorine content of Cured Leaf



Fig, 3, Effect of Method of Application of Fertilizer (Ammonium Sulphate) on Potash and Chlorine content of Cured Leaf

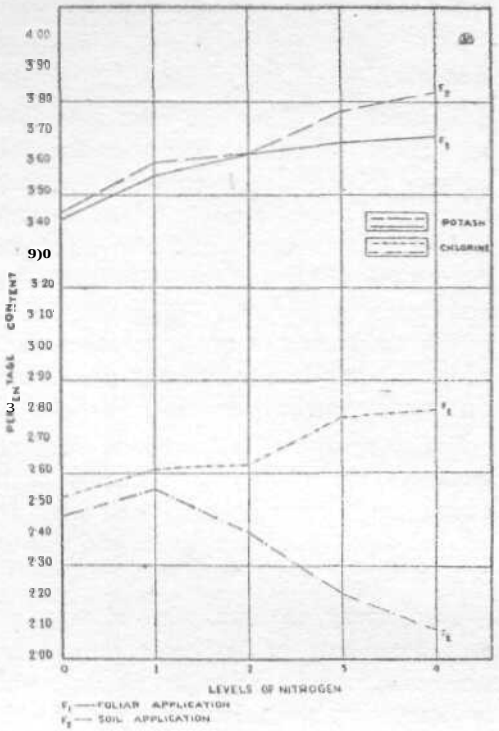


Fig. 4. Effect of Method of Application of Fertilizer (Ammonium Nitrate) on Potash and Chlorine content of Cured Leaf

Chlorine content of leaves was also seen to increase progressively with the rise in nitrogen doses of the sprays upto 4g. per plant (Fig. 2, 3 and 4). This cannot be easily explained. Probably, chlorides accumulated at the lower soil layers and more of these was absorbed by the longer roots of the plants receiving higher doses of foliar applied nitrogen. It may, however, be noted that the increase in percentage chlorine content obtained in the present investigation was well within the tolerance limit of tobacco plants, the maximum increase observed being only 2.97 per cent. Garner (1954) has stated that chlorine assimilation increases turgor, leaf area and hygroscopicity in tobacco. Considering the fact that leaf size and hygroscopicity are desirable qualities in chewing tobacco, the phenomenon of increased chlorine content of leaves observed in the present investigation appears to be beneficial.

Summary

In order to study the effects of foliar application of nitrogenous fertilizers on chewing tobacco and to compare them with those of soil application of solid forms of fertilizers, an experiment was conducted during 1962-63 at the Agricultural College and Research Institute. Vellayani. Results of the studies on the quality characteristics of the tobacco leaf which are presented in this paper may be summarised as follows:–

Foliar spray of nitrogenous fertilizers increases the quality constituents of tobacco leaf like weight per unit area, and total nitrogen, potash, chlorine and nicotine contents.

Urea spray enhances the nitrogen and potash contents of leaf more than ammonium nitrate and ammonium sulphate while in increasing the nicotine and chlorine contents ammonium sulphate is superior to the other two forms.

Foliar application of nitrogen increases the nitrogen and chlorine contents whereas soil application enhances the nicotine content of the tobacco leaf.

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