26

Tropical Agricultural Research Vol. 1 1989

Some Aspects of Nitrogen Nutrition of Flue Cured Tobacco in Sri Lanka

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ABSTRACT. Tobacco is cultivated in two distinct zones of Sri Lanka, which are demarcated on the basis of monsoonal rains. The Maha regions which generally consist of eroded lands on hill slopes lie in the mid and upcountry wet and intermediate zones of the island. The Yala tracts situated in the low country intermediate and dry zones are primarily fallow paddy lands, which have insufficient water for rice production in the season. In both seasons, cropping is done intensively and the most important input for this high income crop is fertilizer. Among the primary elements of fertilizer, nitrogen is the most vital due to its direct impact on the harvestable vegetative product, the leaves.

Research in Sri Lanka does not amply demonstrate the response of this crop to nitrogen in either season. Thus a comprehensive study was undertaken to elucidate the response of flue cured tobacco to nitrogen in both seasons, at selected representative sites in the two regions. The nitrogen rates were developed to incorporate the current recommendations as well as to direct the response to higher and lower rates.

The crop in the Maha season responded significantly to the highest rate of nitrogen. This response was plant growth, leaf size and number, yield of green leaf and the cured product. This suggests the high requirement of nitrogen to maximize both yield and quality of the cured product on these eroded soils. In contrast, while green leaf yield parameters increased significantly with increasing rates of nitrogen in the Yala season, the quality of the cured product was lowered at nitrogen rates above 100 kg/ha indicating that optimal rates of nitrogen for Yala lie around 50–100 kg/N/ha. The results discuss the current fertilizer practices and possible improvement to optimize nitrogen use efficiency in Maha and Yala cultivations of flue cured tobacco in Sri Lanka.

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INTRODUCTION

Nitrogen nutrition has a profound effect on development and biochemical properties of flue cured tobacco (*Nicotiana tabacum L*) (Chaplin and Miner, 1980; Miner and Sims, 1983). This is due to the relationship of N and vegetative growth. Thus large quantities of nitrogen fertilizer is used in the cultivation of flue cured tobacco in the developed world (Mc Cants and Woltz, 1967).

Research on tobacco in Sri Lanka has been limited to a few isolated studies. Jayanethi and Sabanathan, 1968, 1969 an unreported work of the Ceylon Tobacco Company, the primary tobacco producer in Sri Lanka, recommends a range of nitrogen fertilizer for tobacco. These current recommendations of nitrogen vary from 60 – 90 kg/ha. in the *Maha* region and 40 – 60 kg/ha. for the *Yala* region, where the crop is established on uncultivated rice fields. These recommendations are revised periodically by the Ceylon Tobacco Co. (de Silva, 1985). No research has hitherto been conducted on the optimum ratio of ammonium (NH_4^+) to nitrate (NO_3^-) nitrogen in the current application of nitrogen to tobacco. However, studies (*eg.* Elliot, 1970; Raper and Mc Cants, 1967; Mc Cants and Woltz, 1963) of the western world identify the usefulness of an optimum ratio of these two forms of fertilizer nitrogen for the growth and yield of tobacco plants. This study was done to determine the response of tobacco to nitrogen fertilizer in the *Yala* region of cultivation in Sri Lanka. The effect of different proportions of NH_4^+ nitrogen to NO_3^- nitrogen on the growth, yield and quality of the cured tobacco in the *Yala* region was also evaluated.

MATERIALS AND METHODS

Locations

The experiment was conducted in Galewela and Melsiripura in the Kurunegala district in 1987 and 1988 *Yala* seasons respectively. The locations were sited in the intermediate zone of Sri Lanka. The annual rainfall of the region lies in the range of 1700 – 2300 mm.

Soils

The soils of the two sites were TROPA QUALFS (Low humic gley). Some important characteristics of the soils of the two sites are given below.

	Galewela	Melsiripura
pH	6.5 ± 0.42	6.75 ± 0.34
%C	0.62 ± 0.03	0.38 ± 0.01
% Total N	0.05 ± 0.002	0.09 ± 0.003
Texture	Sandy loam	Sandy clay loam – Sandy loam
Bulk Density	1.57 ± 0.16	1.62 ± 0.09

Cultivar

The selected cultivar was 'Sathan' for both trials. This was chosen as it covers over 90% of the extent under flue cured tobacco in this region.

Treatments

Yala 1987

The N levels selected for *Yala* 1987 were 40, 50, 60 and 70 kg/ha. Each N fertilizer level contained three combinations of NO_3^- and NH_4^+. The combinations were developed by mixing different proportions of Sulphate of Ammonia – SoA (20.6% NH_4^+ –N) and Ammonium Nitrate – (18.2% NH_4^+ – N and 7.8% NO_3^- –N).

The levels of P_2O_5, K_2O and MgO were kept constant. The levels were 95 kg. P_2O_5, 105 kg. K_2O and 16 kg. MgO per ha. These were blended manually prior to application.

Yala 1988

As the response of tobacco to the above treatments was marginal, the N levels were revised for the 1988 *Yala* season. The revised N levels were 10, 50, 100 and 150 kg.N/ha. The three combinations of NO_3^- –N, NH_4^+–N used in 1987 *Yala* were not changed. The rates of other nutrients were also similar to those of the *Yala* 1987 season.

Cultural Practices

Land preparation

The land was prepared manually. Seedlings (40 days old; mean height 15 cm 2.1 cm) procured from a commercial nursery were planted in the prepared beds at a spacing of 60 x 75 cm, at the onset of the *Yala* season in mid May 1987 and end April 1988.

Management

The fertilizers were applied as two split applications on the 7th and 21st day after transplanting. The blended fertilizers were applied into a semi circular furrow around each plant.

At the time of fertilizer application, the two lower leaves of each plant were removed. Weeding and intercultivation was carried out after each fertilizer application. Detopping of inflorescence was done on all plants soon after flowering.

Recommended spraying for pest and disease control were carried out at periodic intervals. There were no major problems of pests and diseases in both seasons.

Measurements

Plant Establishment and Survival was assessed by counting the number of plants of each plot two weeks after transplanting.

Plant growth measurements

Number of leaves per plant was recorded by counting the number of fully opened leaves in randomly selected plants just prior to the emergence of the inflorescence.

The height of selected plants were measured soon after detopping.

Leaf area per plant was determined on randomly selected plants by measuring the length and width of leaves. This data was used in the equation : Leaf Area = (length x width) x 0.6345 (Tso, 1972)

Yield Measurements

The data obtained from 36 plants per plot was used to compute the yield parameters per hectare on the basis of a plant density of 21780 plants/ha.

Green leaf production per hectare : By determining the fresh weight of leaves.

Cured leaf production per hectare : By determining the weight of the flue cured leaf per plot.

Economic return per hectare : On the basis of prices paid by the Ceylon Tobacco Company Ltd. to different cured leaf grades in the respective seasons.

RESULTS AND DISCUSSION

Climate

Table 1 presents the rainfall received during the two *Yala* seasons along with the mean monthly rainfall data and temperature. A comparison of the *Yala* 1987 rainfall with the 10 year mean indicates that this season received a significantly lower quantity of rainfall. In contrast the rainfall received in the *Yala* 1988 season was comparable to mean monthly values. Hence, the *Yala* 1987 was considered an unusually dry season for tobacco cultivation.

Crop Establishment

Evaluation of the percentage of survival of established plants illustrated no significant differences between the adopted fertilizer treatments in both seasons. Thus the nitrogen fertilizer does not have any adverse effect on survival of transplanted tobacco seedlings. However, plant survival in the *Yala* 1987 was significantly lower (*i.e.* 90% $\pm$ 2.4%) than in the *Yala* 1988 season (99% $\pm$ 0.25%). This can be attributed to the very low rainfall received in the month after establishment (*i.e.* June 1987) in contrast to that of *Yala* 1988. This data confirm the reported (Akehurst, 1981) requirement of wet weather soon after establishment, for survival of transplanted tobacco seedlings.

Table 1. Climatic data of the experimental sites during the experiments.

	J	F	M	A	M	J	J	A	S	O	N	D
Mean monthly RF (mm)	26.38	12.30	36.03	253.40	163.30	109.30	82.0	83.15	206.50	458.5	147.1	151.2
RF in Galewela 1987 (mm)	147.50	0.50	38.75	285.75	127.50	14.75	Nil	12.25	169.75	472.25	224	70.5
RF in Melsiripura 1988 (mm)	6.25	43.75	27.00	475.50	152.00	78.00	123	171.00	254.50	205.25	186.0	64.0
Mean monthly $T^{0}C$	26.00	25.80	27.80	28.30	28.50	27.90	28.4	27.60	28.40	27.40	25.8	26.2

Source: Ceylon Tobacco Company Ltd. 1988 (unpublished data)

Plant Growth

The plant growth characters of transplanted tobacco seedlings in *Yala* season of 1987 and 1988 are presented in Tables 2 and 3 respectively. Leaf number per plant at flower initiation did not vary significantly in both seasons. Plants in all treatments maintained approximately 22 $\pm$ 2.8 leaves in both seasons. Thus leaf number can be considered a species characteristic, which is not affected by the adopted nitrogen treatments.

Leaf area per plant increased with increasing nitrogen contents in both seasons. Thus as reported by Akehurst – 1981, leaf area has a direct response to applied nitrogen. Within each N level, increasing levels of NO_3^- fertilizer also increased leaf area per plant, irrespective of the rate of nitrogen. This indicates that application of nitrogen in the form of nitrates increases leaf area of tobacco. This could be considered a resultant feature of the preferential uptake of NO_3^- ions by the arable highland crops (Mengel and Kirkby, 1987). In addition specific studies on tobacco (eg: Mc Cants and Woltz, 1967) also report reduction of yields when the crop is fertilized with NH_4^+ nitrogen in contrast to application of NO_3^- nitrogen. However, optimum levels of NO_3^- contents in tobacco fertilizer cannot be identified on the basis of the results of this study.

Evaluation of the leaf area per plant in *Yala* 1987 and 1988 show increased figures in the latter season at comparable rates of nitrogen. For example, the leaf area of plants receiving 50 kg. N in *Yala* 1988 was 400% greater than of 1987. This could be attributed to the level of response of crops to nitrogen under dry conditions (Eck, 1984) as seen in the *Yala* 1987 season.

Yields

Green leaf production per plant closely follow that of leaf area due to the close relationship between leaf area, leaf number and leaf yields in tobacco (Tso, 1972). Thus increased nitrogen as well as increased rates of NO_3^- enhances leaf yields per plant (Table 2 & 3). Again, due to the ready response of the crop to nitrogen and to its application in the readily available NO_3^- form; data of both seasons do not show optimal rates of nitrogen for increased green leaf production in tobacco.

Table 2. The effect of the quantity of N and different proportions of NO_3^- and NH_4^+ fertilizer on some agronomic and quality characteristics of flue-cured tobacco in 1987 *Yala* at Galewela.

N Level kg/ha	NO3 Level %	No.of IVS/ plant	L Area/ plant m^2	G/L prod. mt/ha	C/L prod. mt/ha	Bright grade	Return/ha Rs.x1000 %
40	0	23.13	0.3139	2.8890	0.4482	64.66	21.9810
	20	24.25	0.2940	4.3906	0.5096	63.26	24.3110
	30	23.27	0.3027	2.7740	0.4923	70.90	23.8490
50	0	20.52	0.2611	4.4616	0.6328	63.06	29.0930
	20	21.72	0.3380	4.6213	0.6054	77.60	28.5100
	30	22.97	0.3225	2.8946	0.4708	72.03	22.7970
60	0	21.21	0.3172	3.8723	0.5442	77.63	25.7980
	20	20.60	0.3174	3.2776	0.4493	71.80	21.8210
	30	21.21	0.3030	5.5433	0.7245	69.00	32.6110
70	0	23.55	0.3428	4.0450	0.5965	75.70	27.8710
	20	22.50	0.2796	6.1106	0.7200	74.60	32.4200
	30	21.11	0.2584	4.9103	0.6413	79.46	29.2820
LSD (0.05)		ns	ns	0.737	0.0714	5.82	3.2760
CV %		11.1	12.2	9.35	6.79	4.39	6.65

Table 3. The effect of the quantity of N and different proportions of NO_3^- and NH_4^+ fertilizer on some agronomic and quality characteristics of flue-cured tobacco in 1988 at Melsiripura.

N level kg/ha	NO3 level %	No.of IVS/ plant	L area/ plant m^2	G/L prod. mt/ha	C/L prod. mt/ha	Bright grade %	Return/ha Rs.x1000
10	0	20.6	1.091	9.9154	1.6502	87.1	75.7163
	20	20.9	1.113	11.9796	1.9858	91.3	98.6724
	30	22.3	1.276	11.2120	2.0908	85.8	92.6068
50	0	23.2	1.635	15.3349	2.3736	87.0	107.1369
	20	23.5	1.569	14.3909	2.2960	90.2	106.0023
	30	23.8	1.667	14.6764	2.3779	89.0	108.4006
100	0	24.0	1.809	16.3016	2.5949	86.9	103.9928
	20	24.5	1.913	16.8759	2.6620	83.1	112.5918
	30	24.5	1.829	16.4042	2.9552	83.8	95.2825
150	0	23.3	1.644	15.6890	2.9970	85.9	98.7295
	20	23.9	1.709	18.0227	2.6768	86.5	104.5700
	30	24.8	1.969	19.3375	2.9409	71.2	84.1784
LSD (0.05)		2.10	0.345	2.1655	0.5107	3.0	7.0106
CV %		4.89	11.66	7.81	11.2	1.9	3.84

However, the data clearly illustrate the lack of significant response of tobacco to applied nitrogen in the seasons with low rainfall.

Cured leaf production in tobacco is dependent upon green leaf production (Akehurst, 1981), as the process involved does not alter the ratio between the two parameters. This is highlighted in this study, as the data on cured leaf produced, follow that of green leaf yields. Thus, cured leaf production is increased with increased rates of nitrogen fertilizer irrespective of the season. In addition, application of a great part of nitrogen in the form of NO_3^-' has a greater beneficial effect than when applied as NH_4 nitrogen. However, due to dry conditions in *Yala* 1987, the yields of cured leaf in this season were lesser than those of *Yala* 1988.

Bright Grades and Returns

The economic return of tobacco production of Sri Lanka is dependent upon the production of bright grades of cured leaf, rather than on green leaf or cured leaf yields. This is due to the higher prices paid for bright grades due to their value in the manufacturing process. The effect of the adopted nitrogen fertilizer treatments on the percentage bright grades and monetary return in *Yala* 1987 are presented in Tables 4 and 5.

The data suggests that both percentage bright grades and the return per hectare are increased by application of greater quantities of nitrogen fertilizer. The increase of the NO_3^- nitrogen content also increases the percentage bright grades and the monetary return as well.

In contrast the data on these two parameters in *Yala* 1988 shows a different trend. The percentage bright grades and the returns are reduced significantly when the nitrogen fertilizer rate exceeds 50 – 100 kg.N/ha. Similarly, NO_3^- nitrogen decreases the percentage bright grades and return per hectare when applied in ratios exceeding 20% of the total nitrogen content. This could be due to the presence of large quantities of succulent leaves at high total nitrogen and NO_3^- – N rates in an easily utilizable form, under conditions of adequate moisture. Thus under adequate moisture contents the economically important characters of tobacco (*i.e.* percentage bright grades) is limited by very high quantities of fertilizer nitrogen. In contrast, this trend is not

Table 4. The effect of the quantity of N and different proportions of No_3^- & NH_4^+ fertilizer on bright grades and monetary returns in 1987 Yala at Galewela.

(A) Percentage bright grades

NO_3 Levels / N Levels kg/ha	0%	20%	30%	Mean
40	67.66	63.26	70.9	67.27
50	63.06	77.60	72.03	70.88
60	77.63	71.80	69.00	72.81
70	75.70	74.66	79.46	76.60
Mean	71.0	71.80	72.85	-

(B) Return per hectare (Rs. x 1000)

NO_3 Levels / N Levels kg/ha	0%	20%	30%	Mean
40	21.981	24.311	23.849	23.3806
50	29.093	28.510	22.797	26.8002
60	25.798	21.821	32.611	26.7440
70	27.871	32.420	29.282	29.858
Mean	26.1862	26.7658	27.1350	-

Table 5. The effect of the quantity of N and different proportions of NO_3^- & NH_4^+ fertilizer on bright grades and monetary returns in 1988 Yala at Melsiripura.

(A) Percentage bright grades

NO_3 Levels / N Levels kg/ha	0%	20%	30%	Mean
10	87.1	91.3	85.8	88.06
50	87.0	90.2	89.0	88.73
100	86.9	83.1	83.8	84.60
150	85.9	86.5	71.2	81.20
Mean	86.7	87.7	82.4	-

(B) Return per hectare (Rs. x 1000)

NO_3 Levels / N Levels kg/ha	0%	20%	30%	Mean
10	75.7163	98.6724	92.6068	88.9985
50	107.1369	106.0023	108.4006	106.8910
100	103.9928	112.5918	95.2828	103.9558
150	98.7295	104.5703	84.1784	95.8263
Mean	96.3938	105.4593	94.9080	-

observed during dry seasons, when nitrogen fertilizer use by tobacco plants is restricted due to the lack of sufficient soil moisture. The data also indicates the potential of income generation of tobacco in a good season with adequate soil moisture irrespective of the rate of nitrogen fertilizer. However, when optimum level of nitrogen is applied (*i.e.* 50 kg. N in the ratio of 20% - 80% NO_3^- -N and NH_4^+ -N) in a good season (*e.g. Yala* 1988), the return per hectare is 250% greater than when similar quantity of nitrogen is applied in a dry season (*e.g. Yala* 1987).

CONCLUSION

Tobacco is a crop requiring significant quantities of nitrogen due to the harvesting of the leaves. However, the quantity of applied nitrogen determines the quantity of the cured leaf, and thus the economic returns of the cured leaf, and thus the economic returns to the farmer. The results of this study reveals that the establishment and survival of transplanted seedlings of tobacco is not affected by nitrogen fertilizer. Similarly, leaf number per plant which is considered as varietal characteristic is also not affected by nitrogen fertilizer. In contrast vegetative growth of the leaves and thus the harvest, both green and cured leaf is linearly responsive to added nitrogen and to increased quantities of NO_3^- -N in the applied fertilizer irrespective of the type of the weather.

The importance of applying an optimal quantity of nitrogen fertilizer with a correct quantity of NO_3^- -N is illustrated in the wet *Yala* 1988 season. Application of excess nitrogen with high quantities of NO_3^- -N reduces the percentage bright grades. However, this phenomenon was not observed in the dry *Yala* 1987 season.

The study also signifies the importance of rainfall in determining the response of tobacco to nitrogen fertilizer. The lack of moisture in *Yala* 1987 precluded the development of response observed at comparable nitrogen rates in *Yala* 1988 abundant rainfall. Thus in the *Yala* season of Sri Lanka , due consideration should be given to the availability of rainfall or the maintenance of adequate soil moisture by means of irrigation (in dry seasons) in determining the nitrogen requirements for flue cured tobacco.

ACKNOWLEDGEMENTS

Gratitude is expressed to Messrs. A.V.N. Silva, the Leaf Manager and S.B. Rajakaruna, Agro Development Manager of the Leaf Division of Ceylon Tobacco Company Limited, for the provision of facilities for this study.

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