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STUDIES ON GROWTH AND CHEMICAL COMPOSITION OF TOBACCO VARIETIES. IV - COMPARATIVE EFFECTS OF VARIOUS COMBINATIONS OF FERTILIZERS ON ECONOMIC POTENTIALITIES OF TOBACCO PLANTS

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ABSTRACT

In two experiments, tobacco plants were treated with various combinations of ammonium nitrate (23% N) and compound C (3.5% N, 25% P and 16% K). At all levels used in experiment I, stem length and number of leaves were increased above the control values. An increase in the dry weight associated with a decrease in the ash content in leaves were also observed. With higher fertilizer levels used in experiment II, progressively greater reduction in stem length and number of leaves were apparent. Also the dry weight and ash content in leaves were variably reduced in relation to control values.

All combinations of both fertilizers used, in general, variably increased the total soluble−N whereas protein−N increased, remained unaltered or decreased. In consequence, the total−N and the nicotine contents were increased in relation to control values. But, with all higher rates of fertilizer, the protein − as well as the total−N were in general variably reduced with a concomitant increase in nicotine and total soluble−N.

Marked changes in the total amount and in the relative composition of the carbohydrate pool were apparent. These changes were associated with a general reduction in the chlorine content of all treated plants in the two experiments conducted.

These pattern of changes observed in growth and quality components are discussed in relation to crop production and good quality of tobacco.

INTRODUCTION

Tobacco crop production is still under experimentation in the Sudàn, with the aim to produce an export quality. Prior to 1965, commercial growing of cigarette tobacco was confined to the south, but recently the experimental scheme of tobacco cultivation in the Sudan spread over to include Darfur and Kosti, Sennar and other Blue Nile areas. As indicated in the National Tobacco Company Report (1965/66) promising results were obtained but a judicious nutritional programme is essential to obtain not only high yield but also good quality. Thus, quality in tobacco has been reported to depend upon the amounts and ratios of sugars and nitrogen constituents present in the leaf (Van Dierendonck, 1959 and Collins *et al.,* 1965).

In a previous communication (Younis and Wasfi, 1973) Na_2SO_4 and K_2SO_4 treated plants showed favourable growth responses. In these respects NaC1 and KI were less favourable. Combination of K_2SO_4 with NaCl appeared to counteract the inhibitory effects of NaCl. With these chemical fertilizers, marked changes in the total amount and in the relative composition of the nitrogen and carbohydrate pools were obtained and discussed in relation to the quality of tobacco plants produced.

Further studies showed that treatment with various N:P:K ratios led to progressive stimulation of tobacco growth with the progressive increase in nitrogen and potassium concentration (Younis and Wasfi, 1975). Also fertilization of tobacco plants with potassium sulphate and ammonium phosphate (1:2) led to marked increase in growth criteria measured. Quality components in tobacco leaves were also measured and marked changes obtained were correlated with production of tobacco leaves of high commercial quality (Younis and Wasfi, 1987).

At Sennar area, the use of compound C (3.5% N : 25% P : 16% K) and ammonium nitrate (23% N) as fertilizers for tobacco plants has been practiced. The objective of this study was thus to make a trial using compound C and ammonium nitrate to investigate the effects of various combinations of these compounds on the growth and chemical composition of Kustaga 51 and Burley 21 tobacco varieties.

MATERIALS AND METHODS

Time course experiments

In the first experiment, tobacco seeds var. Kustaga 51 were sown in a seedbed of a mixture of Nile silt and coarse sand (2:1). Thereafter uniform seventy–three–day–old seedlings were transplanted into soil ridges; 70 cm apart, 40 cm wide and 20 cm high. In each flat topped ridge, 5 seedlings were planted in holes, each being evenly spaced at 70 cm apart on the top of the ridge. Three days later various combinations of ammonium nitrate (23% N) and compound C (3.5% N : 25% P : 16% K) were applied for each seedling as indicated in the tables.

For each of these treatments 10 plants occupying 2 separate ridges were used. The fertilizer, in the amounts indicated in the tables, was placed in a hole 15 cm deep and 8 cm away from the seedling . Watering, reridging, topping and suckering were carried out as described by Younis and Wasfi (1973). The experiment was terminaed at the age of 74 days after the transplanting date.

In the second experiment, tobacco seeds var. Burley 21 were used. The plan of the experiment was essentially similar to that of experiment I except that transplantation of the seedlings was made at the age of 75 days and the experiment was terminated at the age of 81 days from the transplanting date. Also, bearing in mind the results of experiment I, higher concentrations of ammonium nitrate and compound C were tried in this second experiment.

In both experiments, spraying with thimul 35 (40 cc per 1 gallon of water) was made after the emergence of the seedlings. Spraying was further carried out at regular intervals of fortnights till the termination of each experiment to control diseases.

During the period of each experiment, growth measurements were taken and at the end; lower yellow 'mature' leaves were separately pooled from plants receiving the same treatment for chemical analyses. 'Mature' leaves do not indicate an exact age (grade) accurately reflecting the real nature of the physiological changes in the leaves used, but it was mainly concerned with the response of leaves to fertilizers (Younis and Wasfi, 1973). The petioles, the midribs and the veins were removed and discarded from each sample of leaves which was then dried, in an oven at 70°C with forced ventilation, to constant weight. The desiccated dried leaves were then ground to a fine powder which was used as the starting material for carbohydrate and nitrogen analyses. By so doing, it was possible to represent every part of the 'mature' leaves of each replicate plant in the sample to be analysed.

The ash content was determined by introducing known weights of thoroughly ground leaves into a muffle furnace at 600°C for 6 hours. The weighed ash was then used as the starting material for determination of chlorine.

The methods used for carbohydrate, nitrogen, nicotine and chlorine estimations were as described by Younis and Wasfi (1973). The results obtained from the analyses of triplicate samples were remarkably close and so only the mean values are presented in the tables. For growth measurements, fortnightly record of stem length and number of leaves per plant was made for 8 weeks after treatment and data presented in tables are means of 10 replicates.

EXPERIMENTAL RESULTS

Experiment I (Kustaga 51 plants)

Growth responses

Stem length (Table 1). Though for 14 days there was no response to the fertilizer treatments, thereafter these treatments resulted in increased stem length. With both treatments and at all levels, stems were higher than in the control. However, it could be noticed that the increase in ammonium nitrate concentration resulted in a progressive decrease in stem length; while an increase in compound C concentration resulted in a progressive increase in stem length.

Table 1

The effects of various combinations of ammonium nitrate and compound 'C' on the mean length of stem (cm) in main axis of Kustage 51 tobacco plants grown under field conditions.

Treatment per plant	Weeks after treatment			
	2	4	6	8
Control	9.9 ±0.198	25.8 ±0.52	45.0 ±1.35	89.0 ±2.67
Ammonium nitrate ; 1.25g + Compound 'C' ; 5.0g	9.3 ±0.186	44.4 ±0.89	88.4 ±2.65	110.2 ±3.31
Ammonium nitrate ; 2.5g + Compound 'C' ; 5.0g	9.5 ±0.190	42.8 ±0.86	82.2 ±2.46	108.2 ±3.25
Ammonium nitrate ; 5.0g + Compound 'C' ; 5.0 g	9.7 ±0.194	39.8 ±0.80	75.2 ±2.26	98.8 ±2.96
Ammonium nitrate ; 7.5g + Compound 'C' ; 5.0 g	9.6 ±0.192	38.4 ±0.77	73.8 ±2.21	96.4 ±2.89
Ammonium nitrate ; 5.0g + Compound 'C' ; 7.5 g	9.8 ±0.196	44.2 ±0.88	80.4 ±2.41	106.6 ±3.20
Ammonium nitrate ; 5.0g + Compound 'C' ; 10.0g	9.6 ±0.192	45.0 ±0.90	88.2 ±2.69	112.3 ±3.37

Number of leaves (Table 2). In general there has been an increase in the number of leaves in all treatments as in the case of stem height. Again the progressive increase in concentration of compound C favoured the production of more leaves while the increase in ammonium nitrate concentration exerted the reverse effect.

Dry weight and ash content of 'mature' leaves (Table 2). The various combinations of ammonium nitrate and compound C caused an increase in the dry weight whereas the ash content of the leaves was decreased.

Table 2

The effects of various combinations of ammonium nitrate and compound 'C' on: (1) mean number of leaves and (2) dry weight (given on fresh weight basis) and ash content (given on a moisture - free basis) of 'mature' leaves of Kustage 51 tobacco plants grown under field conditions.

Treatment per plant	Mean number of leaves per plant				Dry wt	Ash
	Weeks after treatment					
	2	4	6	8	%	%
Control	7.3 ±0.15	11.8 ±0.36	17.1 ±0.42	25.3 ±0.60	17.52 ±0.35	16.58 ±0.34
Ammonium nitrate ; 1.25g + Compound 'C' ; 5.0g	7.4 ±0.16	13.1 ±0.62	21.6 ±0.32	28.3 ±0.56	20.14 ±0.40	15.34 ±0.36
Ammonium nitrate ; 2.5g + Compound 'C' ; 5.0g	7.8 ±0.14	12.9 ±0.58	21.5 ±0.34	28.2 ±0.62	23.36 ±0.48	15.08 ±0.31
Ammonium nitrate ; 5.0g + Compound 'C' ; 5.0g	7.6 ±0.15	12.3 ±0.52	20.4 ±0.48	27.0 ±0.59	19.45 ±0.41	14.30 ±0.28
Ammonium nitrate ; 7.5g + Compound 'C' ; 5.0g	7.3 ±0.17	12.1 ±0.44	19.8 ±0.98	26.4 ±0.64	18.64 ±0.38	13.08 ±0.26
Ammonium nitrate ; 5.0g + Compound 'C' ; 7.5g	7.2 ±0.14	12.6 ±0.56	21.2 ±0.24	28.0 ±0.70	24.44 ±0.52	16.29 ±0.38
Ammonium nitrate ; 5.0g + Compound 'C' ; 10.0g	7.4 ±0.13	13.0 ±0.64	21.6 ±0.52	28.4 ±0.66	19.62 ±0.42	14.56 ±0.30

Analysis of leaves

Nitrogen content of 'mature' leaves (Table 3). Except for treatment with ammonium nitrate (1.25 g) + compound C (5 g) which was without effect, all the other combinations of ammonium nitrate + compound C variably increased the total soluble−N content of the leaves. Also, with an increase in concentration of compound C, a progressive increase in total soluble−N was observed.

Table 3

The effects of various combinations of ammonium nitrate and compound 'C' on the nitrogen content of 'mature' leaves of Kustage 51 tobacco plants grown under field conditions. All data are given on a moisture−free basis.

Treatment per plant	T.S.N. %	P.N. %	T.N. %	Nic. %	T.N./Nic.
Control	1.31 ±0.04	0.70 ±0.03	2.01	1.09 ±0.02	1.84
Ammonium nitrate ; 1.25g + Compound 'C' ; 5.0 g	1.28 ±0.03	1.14 ±0.03	2.42	1.13 ±0.03	2.14
Ammonium nitrate ; 2.5g + Compound 'C' ; 5.0 g	1.70 ±0.05	0.68 ±0.03	2.38	1.25 ±0.04	1.90
Ammonium nitrate ; 5.0g + Compound 'C' ; 5.0 g	1.7 ±0.05	0.54 ±0.02	2.24	1.66 ±0.05	1.35
Ammonium nitrate ; 7.5g + Compound 'C' ; 5.0 g	1.90 ±0.06	0.30 ±0.01	2.20	1.82 ±0.05	1.21
Ammonium nitrate ; 5.0g + Compound 'C' ; 7.5 g	2.03 ±0.07	0.40 ±0.02	2.43	1.95 ±0.06	1.25
Ammonium nitrate ; 5.0g + Compound 'C' ; 10.0 g	2.20 ±0.07	0.43 ±0.01	2.63	2.02 ±0.06	1.30

Protein−N in leaves increased markedly due to treatment with ammonium nitrate (1.25 g) + compound C (5 g). Increasing the rate of ammonium nitrate to 2.5 g + compound C (5 g) did not affect the content of protein−N. On the other hand, all the other combinations of ammonium nitrate + compound C markedly decreased the protein−N; with increasing ammonium nitrate concentration, a progressively greater decrease in protein−N was observed.

All treatments included in this experiment increased the total−N above the control level; the magnitude of increase being highest in case of treatment with ammonium nitrate (5 g) + compound C (10 g).

The nicotine content increased in all treated plants above that of controls. With an increase in concentration of nitrogen, a progressively greater increase in nicotine content was observed.

The total−N to nicotine ratio increased above that of controls by 16.3% and 3.3% in case of treatment with ammonium nitrate; 1.25 g + compound C; 5.0 g and ammonium nitrate; 2.5 g + compound C ; 5.0 g respectively. The other treatments in this experiment, however, comparatively decreased the total−N to nicotine ratios below that of control values.

Cabohydrate content of 'mature' leaves (Table 4). As compared with control plants , all treatments variably reduced the content of reducing sugars, except for treatment with ammonium nitrate (5 g) + compound C (5 g) which induced an increase of 7.1% over the control value.

Except for ammonium nitrate (1.25 g) + compound C (5 g) which slightly decreased the sucrose content, the other treatments included in this experiment variably increased the sucrose content.

The starch content of the treated plants variably decreased below the control value. Total sugars showed a similar behaviour to that of starch which is the predominant fraction in the carbohydrate pool. A progressive decrease in the contents of starch and total sugars might have been apparent with the increase in ammonium nitrate concentration in the fertilizer mixture applied. But when compound C was used at rates (g/plant) higher than those of ammonium nitrate, a lower drop in starch and total sugars were apparent.

Chlorine content of 'mature' leaves (Table 4). The level of chlorine in all treated plants, except for those treated with ammonium nitrate (5 g) + compound C (10 g) decreased below the control value . In the latter treatment, 15.7% increase in the chlorine content above the control value was obtained.

Table 4

The effects of various combinations of ammonium nitrate and compound 'C' on (1) the carbohydrate content (all data are given on a moisture–free basis and are expressed as glucose equivalents) and (2) the chlorine content of the 'mature' leaves of Kustaga 51 tobacco plants grown under field conditions.

Treatment per plant	Red. sugars %	Sucrose %	Starch %	Total sugars %	Chlorine %
Control	1.14 ±0.04	0.91 ±0.03	7.25 ±0.22	9.30	0.83 ±0.03
Ammonium nitrate ; 1.25g + Compound 'C' ; 5.0 g	1.00 ±0.03	0.84 ±0.02	6.45 ±0.19	8.29	0.62 ±0.02
Ammonium nitrate ; 2.5g + Compound 'C' ; 5.0 g	1.00 ±0.04	1.20 ±0.04	5.94 ±0.18	8.14	0.57 ±0.02
Ammonium nitrate ; 5.0g + Compound 'C' ; 5.0 g	1.24 ±0.03	1.09 ±0.03	5.69 ±0.17	8.02	0.54 ±0.03
Ammonium nitrate ; 7.5g + Compound 'C' ; 5.0 g	0.84 ±0.04	1.21 ±0.04	5.54 ±0.16	7.59	0.54 ±0.02
Ammonium nitrate ; 5.0g + Compound 'C' ; 7.5 g	0.61 ±0.02	1.29 ±0.04	6.21 ±0.18	8.11	0.62 ±0.03
Ammonium nitrate ; 5.0g + Compound 'C' ; 10.0 g	0.72 ±0.02	1.32 ±0.05	6.45 ±0.20	8.49	0.96 ±0.04

Experiment II (Burley 21 plants)

Growth responses

Stem length (Table 5). As in experiment I, the response to the fertilizers was apparent 4 weeks after treatment. As compared with untreated plants, application of ammonium nitrate and compound C, at the rate of 5 g for each per plant, induced no change in stem length. Ammonium nitrate at higher rates in combination with 5 g of compound C variably reduced the shoot height of the treated plants below those of control; the highest percentage of reduction being of the order of 20%.

Table 5
The effects of various combinations of ammonium nitrate and compound 'C' on mean length of stem (cm) in main axis of Burley 21 tobacco plants grown under field conditions.

Treatment per plant	Weeks after treatment			
	2	4	6	8
Control	7.0 ±0.14	26.1 ±0.52	47.4 ±0.95	96.4 ±1.93
Group a				
Ammonium nitrate ; 5g + Compound 'C' ; 5g	7.8 ±0.16	26.1 ±0.56	48.3 ±0.96	98.4 ±1.98
Ammonium nitrate ; 10g + Compound 'C' ; 5g	7.1 ±0.15	20.1 ±0.42	40.1 ±0.82	84.9 ±1.80
Ammonium nitrate ; 20g + Compound 'C' ; 5g	7.7 ±0.16	18.8 ±0.38	38.2 ±0.78	81.6 ±1.68
Ammonium nitrate ; 30g + Compound 'C' ; 5g	7.5 ±0.17	16.9 ±0.34	36.0 ±0.76	77.2 ±1.58
Group b				
Ammonium nitrate ; 10g + Compound 'C' ; 10 g	7.6 ±0.16	26.0 ±0.56	45.8 ±0.94	94.2 ±1.88
Ammonium nitrate ; 10g + Compound 'C' ; 20 g	7.0 ±0.15	26.0 ±0.52	45.1 ±0.92	93.4 ±1.84
Ammonium nitrate ; 10g + Compound 'C' ; 30 g	7.1 ±0.16	23.5 ±0.48	43.2 ±0.88	90.0 ±1.80
Ammonium nitrate ; 10g + Compound 'C' ; 40 g	7.8 ±0.17	21.0 ±0.46	41.3 ±0.86	87.3 ±1.82

In group b, treatment of plants with a constant rate of ammonium nitrate in combination with various rates of compound C resulted in a progressive slight reduction in stem elongation with an increase in concentration of compound C; the percentage of reduction below control, however, did not exceed 10%. Thus, it seems that the supplemental addition of compound C to a high concentration of ammonium nitrate partially nullified its inhibitory effect on stem elongation.

Number of leaves (Table 6). The changes in the number of leaves in response to the various fertilizer treatments are, in general, similar to those reported for stem length.

Table 6

The effects of various combinations of ammonium nitrate and compound 'C' on: (1) mean number of leaves and (2) dry weight (given on fresh weight basis) and ash content (given on a moisture–free basis) of 'mature' leaves of Burley 21 tobacco plants grown under field conditions.

Treatment per plant	Mean number of leaves per plant				Dry wt %	Ash %
	Weeks after treatment					
	2	4	6	8		
Control	9.3 ±0.20	13.0 ±0.26	21.6 ±0.46	28.4 ±0.58	10.76 ±0.22	20.62 ±0.50
Group a						
Ammonium nitrate ; 5g + Compound 'C' ; 5g	9.5 ±0.22	13.4 ±0.28	21.8 ±0.44	28.8 ±0.56	10.80 ±0.20	20.68 ±0.52
Ammonium nitrate ; 10g + Compound 'C' ; 5g	9.4 ±0.20	11.8 ±0.24	20.1 ±0.42	27.0 ±0.54	10.85 ±0.24	19.89 ±0.48
Ammonium nitrate ; 20g + Compound 'C' ; 5g	9.5 ±0.24	11.8 ±0.25	20.0 ±0.40	26.8 ±0.56	11.10 ±0.26	19.96 ±0.46
Ammonium nitrate ; 30g + Compound 'C' ; 5g	9.6 ±0.26	11.5 ±0.26	19.7 ±0.40	26.5 ±0.56	11.18 ±0.28	17.95 ±0.40
Group b						
Ammonium nitrate ; 10g + Compound 'C' ; 10g	9.2 ±0.22	12.9 ±0.28	21.3 ±0.46	28.2 ±0.58	10.82 ±0.24	18.88 ±0.42
Ammonium nitrate ; 10g + Compound 'C' ; 20g	9.3 ±0.21	12.7 ±0.26	21.1 ±0.44	28.0 ±0.60	11.07 ±0.28	18.38 ±0.46
Ammonium nitrate ; 10g + Compound 'C' ; 30g	9.3 ±0.24	12.1 ±0.26	20.4 ±0.42	27.4 ±0.56	11.30 ±0.29	18.31 ±0.42
Ammonium nitrate ; 10g + Compound 'C' ; 40g	9.7 ±0.28	12.0 ±0.28	20.4 ±0.44	27.3 ±0.58	11.26 ±0.28	18.10 ±0.44

Dry weight and ash content of 'mature' leaves (Table 6). Compared with controls, the different treatments included in groups a and b slightly increased the dry weight of the collected leaves. On the other hand, the ash content was, in general , slightly reduced below that of controls.

Analysis of leaves

Nitrogen content of 'mature' leaves (Table 7). All treatments of group a reduced the total−N of the treated plants below the control level. The reduction was found to increase with an increase in concentration of ammonium nitrate.

Application of ammonium nitrate at a constant rate with various concentrations of compound C (group b) also led to a reduction in total−N content of treated plants. Progressively greater reduction in the total−N was again obtained with an increase in concentration of compound C. However, the magnitude of reduction was lower than that obtained in group a.

Treatment with ammonium nitrate (5 g) + compound C (5 g) induced slight if any change in the protein−N content of the leaves. Higher rates of ammonium nitrate in combination with 5 g of compound C considerably decreased the protein−N content below that of controls.

In group b of treatments, 10 and 20 g of compound C in combination with 10 g ammonium nitrate increased the protein−N. On the other hand, 30 and 40 g of compound C, again with 10 g of ammonium nitrate, markedly decreased the protein−N below the control level.

All treatments of groups a and b appreciably increased the total soluble−N above the control level.

In groups a and b, all treatments considerably increased the nicotine content of the treated plants above the control value. The magnitude of increase in the former was, nevertheless, higher than in the latter group of treatments. Progressively greater increase in the nicotine content was also obtained with an increase in concentration of ammonium nitrate and compound C in groups a and b respectively.

The resulting changes in the ratio of the total−N to nicotine decreased in all treated plants below the control value. The reduction in this ratio was found to increase with increasing the concentration of either ammonium nitrate or compound C.

Table 7

The effects of various combinations of ammonium nitrate and compound 'C' on the nitrogen content of 'mature' leaves of Burley 21 tobacco plants grown under field conditions. All data are given on a moisture–free basis.

Treatment per plant	T.S.N. %	P.N. %	T.N. %	Nic. %	T.N./Nic.
Control	2.27 ±0.05	0.91 ±0.02	4.18	1.40 ±0.03	2.99
Group a					
Ammonium nitrate ; 5g + Compound 'C' ; 5g	2.85 ±0.06	0.86 ±0.03	3.71	2.35 ±0.05	1.58
Ammonium nitrate ; 10g + Compound 'C' ; 5g	2.73 ±0.04	0.50 ±0.02	3.23	2.48 ±0.06	1.30
Ammonium nitrate ; 20g + Compound 'C' ; 5g	2.77 ±0.05	0.16 ±0.01	2.93	2.64 ±0.07	1.11
Ammonium nitrate ; 30g + Compound 'C' ; 5g	2.75 ±0.06	0.15 ±0.01	2.90	2.74 ±0.08	1.06
Group b					
Ammonium nitrate ; 10g + Compound 'C' ; 10g	2.83 ±0.08	0.15 ±0.01	3.98	2.02 ±0.04	1.97
Ammonium nitrate ; 10g + Compound 'C' ; 20g	2.81 ±0.06	0.97 ±0.03	3.78	2.12 ±0.04	1.78
Ammonium nitrate ; 10g + Compound 'C' ; 30g	2.77 ±0.04	0.66 ±0.02	3.43	2.38 ±0.05	1.44
Ammonium nitrate ; 10g + Compound 'C' ; 40g	2.77 ±0.06	0.61 ±0.02	3.38	2.59 ±0.07	1.31

Carbohydrate content of 'mature' leaves (Table 8). All the fertilizer treatments, in general, induced varied reductions in the reducing sugars, sucrose, starch and consequently in total sugars contents below the control levels.

Table 8

The effects of various combinations of ammonium nitrate and compound 'C' on: (1) the carbohydrate content (all data are given on a moisture–free basis and are expressed as glucose equivalents) and (2) the chlorine content of the 'mature' leaves of Burley 21 tobacco plants grown under field conditions.

Treatment per plant	Red. sugars %	Sucrose %	Starch %	Total sugars %	Chlorine %
Control	0.59 ±0.02	0.35 ±0.01	0.96 ±0.03	1.90	1.83 ±0.04
Group a					
Ammonium nitrate ; 5g + Compound 'C' ; 5g	0.45 ±0.01	0.30 ±0.02	0.80 ±0.03	1.55	1.47 ±0.03
Ammonium nitrate ; 10 g + Compound 'C' ; 5g	0.30 ±0.01	0.22 ±0.02	0.75 ±0.04	1.27	1.43 ±0.02
Ammonium nitrate ; 20g + Compound 'C' ; 5 g	0.27 ±0.02	0.14 ±0.01	0.65 ±0.04	1.06	1.41 ±0.03
Ammonium nitrate ; 30g + Compound 'C' ; 5 g	0.20 ±0.02	0.20 ±0.03	0.64 ±0.03	1.04	1.28 ±0.04
Group b					
Ammonium nitrate ; 10g + Compound 'C' ; 10g	0.24 ±0.03	0.32 ±0.03	0.68 ±0.04	1.24	1.59 ±0.05
Ammonium nitrate ; 10g + Compound 'C' ; 20g	0.31 ±0.03	0.34 ±0.02	0.71 ±0.05	1.36	1.31 ±0.04
Ammonium nitrate ; 10g + Compound 'C' ; 30g	0.35 ±0.02	0.17 ±0.01	0.87 ±0.05	1.39	0.96 ±0.05
Ammonium nitrate ; 10g + Compound 'C' ; 40g	0.40 ±0.03	0.15 ±0.01	0.68 ±0.04	1.23	0.89 ±0.04

Chlorine content of 'mature' leaves (Table 8). All fertilizer treatments appreciably reduced the chlorine content of the treated plants below the control levels. For groups a and b, it is also apparent that the magnitude of the reduction was, in general, increased with increasing the rate of the fertilizer.

DISCUSSION

The results herein reported for experiment I indicate that the different rates of ammonium nitrate and compound C induced an increase in stem length and number of leaves (Tables 1 and 2). Although the dry weight was increased in response to all treatments, yet the ash content was decreased. These results seem to be correlated with the N:P:K ratios of ammonium nitrate and compound C mixtures used. It is apparent that the best combination to be used with Kustaga 51 tobacco, so as to produce best growth response, is ammonium nitrate at 5 g and compound C at 7.5 g. Of interest in this connection, we may mention that Woltz *et al.* (1949), Elliot and Back (1963), Spratt and Gasser (1970), Younis and Wasfi (1975), Orabi *et al.* (1985), Norwal and Malik (1985), Steer and Harrigan (1986) and Ismail and Ali (1986), experimenting with a variety of field crops including tobacco, have observed increased vigour of growth with an increase of nitrogen, phosphorus and/or potassium in the substrate.

On the other hand, the heavy applications of fertilizers used in experiment II were accompanied by a general decrease in stem length, number of leaves and ash content. In support of this, Hayward and Long (1941), Ayers *et al.* (1952) and Wasfi (1970) have shown that plants grown in soil solutions containing high concentrations of soluble salts commonly exhibit markedly unfavourable growth responses. The injurious effects observed may be caused by the toxic effect of high concentration of a single ion, the interaction of two or more ions presented in high concentrations or the combined effect of high total salt concentration (Hayward and Long, 1941).

Quality in tobacco has been shown to depend on the balance of the nutrients in the leaf. Thus , Van Dierendonck (1959) stated that good quality appears to be associated with the amounts and ratios of sugars and nitrogen constituents present. Nicotine is generally recognized as the chemical compound in tobacco which provides physiological stimulation to the consumer and therefore, is an important quality constituent. Collins *et al.* (1965) defined tobacco varieties with high total−N: nicotine ratio to be light bodied and less desirable chemically and those varieties with low ratios to be heavy bodied.

As evident from Table 3, the different combinations of ammonium nitrate and compound C induced an increase in total soluble−N and nicotine whereas protein–N was decreased. These results are in accord with those of Younis and Wasfi (1987) and further substantiate the role of ammonium nitrogen in altering the total amount and the relative composition of the nitrogen pool. Furthermore, the total–N: nicotine ratios were decreased in the case of using concentrations higher than 2.5 g ammonium nitrate and 5 g compound C.

In experiment II the total–N decreased progressively with increasing the nitrogen component of the fertilizer whereas nicotine was progressively increased. In conformity with this observation, Dawson (1938) and Younis and Wasfi (1987) observed a linear increase in the nicotine content with increasing the ammonium nitrogen.

It is also to be noted that the total soluble–N content of tobacco is considerably higher than protein–N. This is possibly due to the presence of ammonium nitrogen which is generally known to hamper complex protein synthesis in plants (Webster, 1959). Furthermore, Clark (1936) and Younis *et al.* (1970) observed a greater concentration of soluble organic nitrogen in ammonium treated plants and lower inorganic or unassimilated nitrogen. This could be due to the rapid formation of amino acids and thus utilization of carbohydrates and possibly of other substances essential for protien synthesis. As evident from the present work, the low amounts of protein–N and higher total soluble–N were accompanied by low quantities of carbohydrates.

The combined effect of high total salt concentration, used in experiment II, most probably have caused the total–N (Table 7) as well as the growth measured criteria (Tables 5 and 6) to decrease. Thus harmful effects in growth and chemical constituents were observed due to excessive nitrogen application (Van Dierendonck, 1959; Patel, 1960; Wasfi, 1970). Also the decrease in total–N associated with an increase in nicotine content of treated plants resulted in low ratios of total–N to nicotine as compared with that of control plants.

As regards the effects of carbohydrate content on the quality of tobacco leaves, it has been stated that high percent starch, particularly in presence of low soluble–N impairs the palatability of tobacco smoke produced upon combustion (Collins *et al.*, 1965). Soluble carbohydrates, on the other hand, are generally considered to have a positive effect on tobacco quality. But, an excess of sugar is undesirable because it results in an impaired taste quality (Harlan and Moseley, 1955). However, if the nitrogen–sugar balance can be maintained, tobaccos with higher sugar concentration are more desirable (Collins *et al.*, 1965).

In experiment I, a reduction in total sugars and starch was observed in all treated plants (Table 4) while in experiment II, all the carbohydrate fractions analysed diminished below the control values (Table 8). This reduction is possibly due to the availability and high nitrogen concentration at the maturity stage. Thus, a progressive increase in the various carbohydrate fractions in plants receiving 20−40 lb N per feddan and 80−120 lb K per feddan was observed in urea and potassium nitrate treated plants. Increasing the nitrogen and potassiun to 50 and 150 lb per feddan respectively was accompanied by a lower level of carbohydrate content in the leaves (Younis and Wasfi, 1975).

Chlorine, one of the elements generally present in soil and fertilizers, is easily absorbed by tobacco. In small quantities it will increase yield. In large quantities, however, it lowers quality. According to Patel (1960), excessive chlorine is one of the major causes of the usually large amounts of off−grade tobacco that has appeared in the market.

In experiment I (Table 4), with increasing the ammonium nitrate concentration, a progressive decrease in the chlorine content was apparent. But when compound C was used at levels higher than those of ammonium nitrate, a lower drop in chlorine content was observed. Consequently in experiment II, an increase in the nitrogen fertilization led to a progressive decrease in chlorine content. In accord with these results, Gauch and Eaton (1942), Reisenauer and Colwell (1950) and Younis and Wasfi (1975, 1987) observed increases in chlorine content in the leaves due to an increase of nitrogen, phosphorus and potassium levels in the substrate.

In final conclusion, to achieve the desired tobacco crop, a moderate supply of these fertilizers not exceeding 10 g per plant should be used, so as to avoid the harmful effects of excessive fertilizer application and also to induce crop production with low chlorine content, appropriate low carbohydrate content and with low total−N: nicotine ratios.

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دراسات على النمو والتركيب الكيميائي لنبات الدخان
٢ - التأثيرات المقارنة لخلطات مختلفة من المخصبات الكيماوية على الامكانيات الاقتصادية لنبات الدخان

محمود الباز يونس و ميرغني عبد الرحمن وصفي

أدت معاملة نبات الدخان بتوليفات مختلفة من نترات الأمونيوم (٢٣٪ نيتروجين) ومركب C (٣,٥٪ نيتروجين ، ٢٥٪ فوسفور ، ١٦٪ بوتاسيوم) إلى زيادات ملحوظة في نمو الساق وعدد الأوراق ، كما إقترنت الزيادة في الوزن الجاف بنقص ملحوظ في محتوى الرماد في الأوراق . وفي تجربة ثانية - عند إستعمال تركيزات أكبر من هذه المخصبات - لوحظ نقص مضطرد في نمو الساق وعدد الأوراق ، بالاضافة إلى نقص في الوزن الجاف للأوراق ومحتواها من الرماد.

أدت كل المعاملات السابقة - على وجه العموم - إلى زيادة ملحوظة في المحتوى النيتروجيني الذائب بينما كانت هناك تغيرات مختلفة في المحتوى البروتيني في الأوراق . وهذه التغيرات كانت مقرونة بزيادة في النيتروجين الكلي والنيكوتين . وعلى الرغم من ذلك فقد أدت المعاملات بتركيزات مرتفعة من المخصبات إلى نقص في محتوى البروتين والنيتروجين الكلي وكان ذلك مقرونا بزيادة في النيتروجين الذائب والنيكوتين.

ولقد أظهر التحليل الكيميائي تغيرات ملحوظة في المحتوى الكلي والجزئي للكربوايدراتات ، وكان ذلك مقرونا بنقص ملحوظ في محتوى الكلور في أوراق النباتات المعاملة.

ولقد فسرت النتائج كما نوقش أثرها في نوعية أوراق نباتات الدخان المستعملة وإمكانياتها الاقتصادية.