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STUDIES ON INORGANIC NITROGEN FERTILIZERS FOR TOBACCO

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SUMMARY

Responses of flue-cured tobacco were examined in relation to different sources of inorganic nitrogen fertilizer. In a preliminary pot trial seven sources of nitrogen were compared, and in two subsequent field trials varying proportions of nitrate and ammonium fertilizers were studied. The preliminary pot trial showed that nitrate, ammonium and urea fertilizers gave similar responses in terms of leaf quality index and cured leaf nitrogen and chlorine levels, with phosphorus levels tending to be higher with ammonium and urea sources of nitrogen. In the following two field studies, tobacco yield, quality index and cured leaf inorganic chemical constituents were not modified to any appreciable extent by the proportion of nitrate and ammonium nitrogen fertilizers applied.

I. INTRODUCTION

Commercial tobacco fertilizers used in the Mareeba-Dimbulah area of North Queensland have varied in the form of inorganic nitrogen included in them. Prior to the mid 1960s all fertilizer nitrogen was applied in nitrate form. Since then ammonium-N fertilizers have become more commonly used as fertilizer manufacturers have introduced to the district partly or wholly ammoniated fertilizers. In field studies comparing two fertilizer mixtures, one supplying nitrogen as nitrate nitrogen and the other supplying nitrogen as ammonium nitrogen, Caulley and Ward (1972) found that a more consistent yield and quality index response was obtained to the fertilizer mixture containing nitrogen in the nitrate form.

In comparing various sources of inorganic nitrogen for flue-cured tobacco, Tisdale (1952) found no significant differences in yield or value of tobacco from field studies. Similar results were reported by Patel (1964). However, in reviewing tobacco nutrition McCants and Woltz (1967) reported variable field responses to nitrate and ammonium sources of nitrogen, variations in response being attributable to the degree of oxidation of ammonium nitrogen to nitrate nitrogen as influenced by biological conditions existing in the soil.

With the increasing use of ammonium nitrogen as part of or as the sole source of nitrogen in fertilizer mixtures for tobacco in North Queensland, pot and field studies were undertaken during the period 1965 to 1967 inclusive to assess the effect of form of inorganic nitrogen on flue-cured tobacco under local conditions.

II. METHODS AND MATERIALS

In 1965, a preliminary pot study (experiment I) was conducted to assess the response of tobacco (cv.Q34 Hicks) to several nitrogenous fertilizers in terms of cured leaf quality and inorganic chemical constituents. Sodium potassium nitrate (15% N), sodium nitrate (16% N), calcium nitrate (20·5% N), ammonium sulphate (21% N), floranid (28% N), ammonium nitrate (25% N) and urea (46% N) were compared as preplant applications equivalent to a level of 1·8 g nitrogen per plant. Superphosphate (9·6% P) and potassium sulphate (40% K) were applied at the same time to provide a total of 3·2 g phosphorus and 7·3 g potassium per plant. Plots comprised a single plant grown in individual free-draining pots each holding approximately 70 lb (air-dry weight) of a sandy loam soil. The soil had been fumigated and well mixed prior to potting. The experiment, planted on September 11, 1965, and comprising a randomized block design (7 treatments x 4 replications), was located in the field at Parada Research Station. The pots were positioned to provide a plant spacing of 21 in. in rows 4 ft apart and a protective screening wall enclosed the entire experiment. Plants were topped uniformly to 18 leaves. Leaf was harvested as it matured and cured in small experimental curing cabinets.

In 1966 and 1967 (experiments II and III), studies were confined to a comparison of nitrate and ammonium sources of nitrogen which were applied in the following proportions:

Nitrate Nitrogen	*Ammonium Nitrogen*
100	0
66	33
50	50
33	66
0	100

Appropriate proportions of sodium potassium nitrate, ammonium nitrate and ammonium sulphate were used to make up the required mixtures. During the 1966 season, studies were conducted at the Research Station on second-year tobacco land on a free-draining sandy loam soil. In the following season a loamy sand site was chosen on a commercial farm where volunteer weeds preceded the tobacco crop. At both field experimental sites the soil was fumigated with EDB approximately 3 weeks before transplanting and seedlings were machine-transplanted at a plant spacing of 22 in. in rows 4 ft apart.

In experiment II the five mixtures were compared either as single preplant applications or as two equal split applications (preplant and a side-dressing 36 days after transplanting). Fertilizer levels applied were equivalent to 20 lb N/ac, 77 lb P/ac and 80 lb K/ac. Preplant phosphorus, potassium and the appropriate nitrogen fertilizer were applied in a single band, with nitrogen side-dressings being applied beside the plant line and covered during hilling-up operations. Transplanting was carried out on September 19, 1966, and plot size was 0·006 ac. The experimental design comprised a factorial 5 x 2 with 3 replications. The crop was grown under spray irrigation and conventional cultural practices were followed.

Experiment III was located on a commercial farm and the same five nitrate nitrogen and ammonium nitrogen mixtures were compared. The treatments were applied at two levels (equivalent to 20 and 40 lb N/ac) and at three times of application (viz. all preplant; half preplant + half at hilling; one-third preplant + one-third at hilling + one-third at budding). Superphosphate (9·6% P) and sulphate of potash (40% K) were applied preplanting at levels of 53 lb P/ac and 100 lb K/ac respectively. All preplanting fertilizers were applied into a single furrow with nitrogen side-dressings being added beside each plant. The design consisted of a factorial 5 x 2 x 3 with 2 replications. Plots (0·006 ac) comprised two rows each 33 ft long. Tobacco seedlings were transplanted on September 2, 1967. Conventional cultural practices under spray irrigation were followed.

Data recorded for each experiment varied depending on the scope of the experiment. In experiment 1, because plot size was limited to one plant, all cured leaf was bulked per plant for quality appraisal and chemical analysis. In experiments II and III, cured leaf yield, quality index and chemical analysis data were recorded. Leaf samples for chemical analysis from experiments II and III consisted of a weighted average of leaf from basal (lug) and middle plant positions. Before analysis, midribs were removed and the lamina was ground to pass a 1 mm sieve. Analyses includes nitrogen, phosphorus and chlorine (expt. I), nitrogen, phosphorus, potassium, calcium, magnesium and chlorine (expt. II), and nitrogen and chlorine (expt. III). Total nitrogen and phosphorus analyses were made by automated colorimetric methods using a "Technicon" autoanalyser and potassium was determined by flame photometry. Chlorine levels were determined by the electrometric titration method of Best (Piper 1950), while calcium and magnesium were determined by atomic absorption spectroscopy.

III. RESULTS

(a) Experiment I

Plant size generally in the pots was small compared with field-grown tobacco, especially with the floranid treatment. Leaf area measurements at 55 days after transplanting, using the accepted formula $^2/_3$ (length x maximum breadth) showed that with floranid the leaf area was significantly smaller ($P = 0 \cdot 01$) than that from any other treatment (Table 1). Cured leaf quality index (Table 2) showed no significant differences between treatments. Cured leaf nitrogen levels (Table 2) varied significantly ($P = 0 \cdot 05$) between treatments, being the highest with sodium potassium nitrate (1·12% N) and lowest with urea (0·93% N). Phosphorus levels in cured leaf varied significantly ($P = 0 \cdot 05$) and tended to be lower with nitrate-nitrogen fertilizers. No significant differences in the chlorine levels resulted from the different nitrogen treatments.

TABLE 1

LEAF AREA 55 DAYS AFTER TRANSPLANTING (EXPT. I, 1965)

Source of Nitrogen		Leaf Area (sq cm)
Sodium potassium nitrate	..	4,955
Sodium nitrate	..	5,059
Calcium ammonium nitrate	..	5,210
Ammonium nitrate	..	5,012
Ammonium sulphate	..	5,097
Floranid	..	3,871
Urea (soil)	..	5,067
Necessary differences for significance	5%	541
	1%	741
	S.E.	182

TABLE 2

CURED LEAF QUALITY AND INORGANIC CHEMICAL CONSTITUENTS* (EXPT. I, 1965)

Source of Nitrogen		Quality Index	Chemical Analysis (%)†		
			N	P	Cl
Sodium potassium nitrate	..	30·0	1·12	0·44	0·49
Sodium nitrate	..	35·9	1·08	0·47	0·43
Calcium ammonium nitrate	..	31·4	1·03	0·48	0·54
Ammonium nitrate	..	36·4	1·07	0·57	0·45
Ammonium sulphate	..	35·5	1·09	0·55	0·52
Floranid	..	34·1	1·02	0·68	0·48
Urea (soil)	..	34·7	0·93	0·56	0·43
Necessary differences for significance	5% ..	N.S.	0·13	0·06	N.S.
	1% ..	..	0·18	0·08	..
	S.E. ..	2·6	0·04	0·02	0·02

* Data expressed on basis of all leaves per plant combined.

† Expressed on oven-dry weight and web-free basis.

(b) Experiment II

In this experiment comparing five nitrate nitrogen and ammonium nitrogen mixtures, no plant growth differences were evident. Cured leaf yield and quality index (Table 3) showed no significant differences as the result of split fertilizer application. Neither graded yields nor percentage nondescript leaf were altered to any significant extent by varying the proportions of nitrate nitrogen and ammonium nitrogen. However, there was a tendency towards a reduction in leaf quality index with increasing proportion of ammonium nitrogen in the fertilizer—this was evident in the overall quality index (all leaf) and quality index of leaf grades (Table 3). Cured leaf chemical constituents (Table 4) were not significantly altered by time of fertilizer application (either all preplanting or half preplant plus half 36 days later). In relation to form of nitrogen there was a trend towards increasing phosphorus levels in the lugs with increasing proportions of ammonium nitrogen in the fertilizer. Potassium, calcium, magnesium and chlorine levels in cured leaf did not follow any particular trends. There were no significant interactions between form of nitrogen and time of nitrogen application.

TABLE 3

CURED LEAF YIELD AND QUALITY DATA (EXPT. II, 1966)

Treatment	Graded Yield (lb/ac)	Percentage Nondescript Leaf	Quality Index			
			Lugs	Leaf	Top Leaf	All Leaf
(a) Form of nitrogen—						
100% nitrate	1,749	3·7	44·7	46·9	31·4	44·3
66% nitrate	1,597	6·3	43·7	42·7	28·5	41·0
50% nitrate	1,655	5·1	49·9	38·1	31·0	38·4
33% nitrate	1,543	4·9	44·3	43·9	29·9	41·1
0% nitrate	1,644	4·8	45·1	40·3	27·7	39·8
Necessary differences for significance 5% ..	220*	3·5*	13·2*	6·2	6·9*	4·9
Necessary differences for significance 1% ..	..	..	..	8·5	..	6·8
S.E. ..	73·4	1·2	4·4	2·1	2·3	1·6
Time of nitrogen application—						
All preplant	1,672	4·8	45·7	43·3	29·0	41·7
½ preplant + ½ hilling	1,603	5·1	45·3	41·5	30·4	40·1
Necessary differences for significance (5%)	139*	2·2*	8·3*	3·9*	4·3*	3·1*
S.E. ..	46·4	0·7	2·8	1·3	1·4	1·0

* Denotes no significant differences.

TABLE 4

CURED LEAF CHEMICAL CONSTITUENTS (EXPT. II, 1966)
Results expressed on web-free and oven-dry weight basis

Treatment	Lugs						Leaf					
	N	P	K	Ca	Mg	Cl	N	P	K	Ca	Mg	Cl
(a) Form of nitrogen —												
100% nitrate ..	1·63	0·40	3·2	3·4	0·65	1·14	1·55	0·31	2·1	2·7	0·42	0·98
66% nitrate ..	1·71	0·43	3·3	3·8	0·71	1·22	1·57	0·33	2·2	2·9	0·40	1·09
50% nitrate ..	1·46	0·50	3·0	2·9	0·44	0·83	1·54	0·33	2·1	3·1	0·46	0·97
33% nitrate ..	1·58	0·50	3·3	3·3	0·58	1·12	1·57	0·36	2·4	3·2	0·45	1·03
0% nitrate ..	1·67	0·49	3·2	3·5	0·75	1·04	1·55	0·31	2·2	2·9	0·48	1·09
Necessary differences for significance 5%	0·24	0·09	0·6*	0·9	0·18	0·37	0·12*	0·08*	0·25	0·48*	0·09*	0·23*
Necessary differences for significance 1%	0·33	0·13	..	1·2	0·25	0·50	..	..	0·34	..	..	..
S.E.	0·08	0·03	0·2	0·30	0·06	0·12	0·04	0·03	0·08	0·16	0·03	0·08
(b) Time of nitrogen application—												
All preplant ..	1·61	0·46	3·2	3·3	0·63	0·99	1·54	0·32	2·2	3·0	0·44	1·00
½ preplant + ½ hilling	1·61	0·47	3·2	3·5	0·062	1·15	1·58	0·34	2·2	2·9	0·44	1·06
Necessary differences for significance (5%)	0·15*	0·06*	0·4*	0·6*	0·12*	0·23*	0·07*	0·05*	0·2*	0·3*	0·05*	0·15*
S.E.	0·05	0·02	0·14	0·19	0·04	0·08	0·02	0·02	0·05	0·10	0·02	0·05

* Denotes no significant differences.

(c) Experiment III

In addition to evaluating varying proportions of nitrate nitrogen and ammonium nitrogen, two levels of nitrogen (20 and 40 lb/ac) and various times of application (one, two and three equal applications) were compared. Graded yield and quality index results are presented in Table 5, and cured leaf nitrogen and chlorine levels are given in Table 6.

TABLE 5

Cured Leaf Yield and Quality Data (Expt. III, 1967)

Treatment	Graded Yield (lb/ac)	Percentage Nondescript Leaf	Quality Index			
			Lugs	Leaf	Top Leaf	All Leaf
(a) Form of nitrogen—						
100% nitrate	1,303	9·9	37·7	38·4	21·8	37·5
66% nitrate	1,422	9·7	36·9	39·3	19·8	36·8
50% nitrate	1,393	8·9	37·5	38·3	24·5	36·1
33% nitrate	1,397	10·1	34·7	36·7	18·1	34·5
0% nitrate	1,404	8·0	36·4	39·6	23·9	37·1
Necessary differences for significance (5%)	155*	3·0*	8·4*	4·5*	7·4*	3·9*
S.E.	53·6	1·0	2·9	1·6	2·6	1·4
(b) Level of nitrogen—						
20 lb/ac	1,446	7·6	39·7	40·1	22·6	38·4
40 lb/ac	1,322	11·0	33·6	36·8	20·7	34·4
Necessary differences for significance 5%	98	1·9	5·3	2·9	4·7*	2·5
Necessary differences for significance 1%	132	2·6	7·2	3·9	..	3·3
S.E.	33·9	0·7	1·8	1·0	1·6	0·9
(c) Time of nitrogen application—						
All preplant	1,329	10·1	35·1	38·3	22·7	35·9
½ preplant + ½ hilling	1,375	9·2	37·9	39·0	20·7	37·3
⅓ preplant + ⅓ hilling + ⅓ budding	1,448	8·7	37·0	38·0	21·5	36·0
Necessary differences for significance (5%)	120*	2·3*	6·5*	3·5*	5·8*	3·0*
S.E.	41·5	0·8	2·3	1·2	2·0	1·0

* Denotes no significant differences.

TABLE 6

Cured Leaf Chemical Constituents (Expt. III, 1967)

Results expressed on web-free and oven-dry weight basis

Treatment	N (%)		Cl (%)	
	Lugs	Leaf	Lugs	Leaf
(a) Form of nitrogen—				
100% nitrate	1·79	1·49	1·50	0·50
66% nitrate	1·71	1·58	1·29	0·53
50% nitrate	1·72	1·53	1·67	0·54
33% nitrate	1·71	1·57	1·49	0·54
0% nitrate	1·73	1·52	1·52	0·62
Necessary differences for significance (5%)	0·18*	0·16*	0·35	0·14*
S.E.	0·06	0·06	0·12	0·05
(b) Level of nitrogen—				
20 lb/ac	1·67	1·47	1·48	0·57
40 lb/ac	1·80	1·61	1·50	0·52
Necessary differences for significance 5%	0·12	0·10	0·22*	0·09*
Necessary differences for significance 1%	0·16	0·14	..	..
S.E.	0·04	0·04	0·08	0·03
(c) Time of nitrogen application—				
All preplant	1·68	1·54	1·43	0·54
½ preplant + ½ hilling	1·80	1·53	1·55	0·58
⅓ preplant + ⅓ hilling + ⅓ budding	1·72	1·54	1·49	0·52
Necessary differences for significance (5%)	0·14*	0·13*	0·27*	0·10*
S.E.	0·05	0·43	0·09	0·04

* Denotes no significant differences.

Neither form of nitrogen nor time of nitrogen application gave any significant differences in terms of cured leaf yield or quality index (Table 5). Although split applications of nitrogen gave a slight increase in graded yields and a decrease in the percentage of nondescript leaf, differences did not reach significance. Yield and leaf quality index responses were more pronounced when the two levels of nitrogen (20 and 40 lb N/ac) were compared. There was a significant decrease ($P = 0{\cdot}05$) in graded yield and a significant increase ($P = 0{\cdot}01$) in the percentage nondescript leaf when the level of nitrogen nutrition was raised from the equivalent of 20 lb N/ac to 40 lb N/ac. Leaf quality index was also significantly affected by the level of nitrogen fertilizer applied, both on an overall plant basis and in relation to basal (lug) and middle (leaf) plant positions.

Analysis of cured leaf for nitrogen and chlorine showed no significant trends in relation to form of nitrogen applied (Table 6). The percentage chlorine in leaf grades, however, showed an increasing trend with increasing proportions of ammonium nitrogen in the fertilizer. Nitrogen levels in cured leaf were significantly higher as the result of the higher nitrogen application. Interactions between forms of nitrogen, levels of nitrogen and time of nitrogen application did not show any consistent significant trends.

An estimate of the rate of harvesting was made to determine if form of nitrogen in experiments II and III affected the rate of maturity. For this assessment the term "leaf ripening index" has been used to describe the percentage of leaf harvested at specific harvest dates in each season. The results (Table 7) did not indicate any consistent trends in experiment II; in experiment III there was a tendency for an increased rate of ripening with an increasing proportion of ammonium nitrogen in the fertilizer.

TABLE 7

LEAF RIPENING INDEX (%)

Expressed as a percentage of total cured leaf harvested at indicated dates for the two field experiments

Form of Nitrogen	Expt. II, 1966 12.i.67 (Harvest No. 8)	Expt. III, 1967 19.xii.67 (Harvest No. 5)
100% nitrate	47·2	41·2
66% nitrate	47·7	40·5
50% nitrate	45·4	44·1
33% nitrate	46·6	43·9
0% nitrate	51·5	47·1

IV. DISCUSSION

Yield and quality index data from the two field experiments did not show any significant trends in terms of form of nitrogen. These findings differ from those of McCants and Woltz (1963), who found that yield and quality were enhanced by increasing the percentage of nitrate nitrogen. Elliot (1970), on the other hand, reported highly significant increases in yield and grade index when fertilizer nitrogen increased from 0 to 100% ammonium nitrogen.

The increased uptake of phosphorus with ammonium and urea-type nitrogen sources, as occurred in experiment I, is in agreement with findings of other workers as reported by Grunes (1959). This trend was also apparent in experiment II for leaf from the lower or lug plant position. As differences in percentage phosphorus were not consistent for lug and leaf plant positions in experiment II, phosphorus levels were not determined in experiment III.

The soils used in these studies (Dimbulah sandy loam and Algoma loamy sand) have been described previously (Keefer and Ward 1961). They could be considered average tobacco soils for the district and as such have good drainage and a sandy textured surface soil and are well aerated for most or all of the tobacco season. Under these conditions nitrification would be expected to proceed readily. In addition, soil temperatures are generally moderate to high, ranging between 70°F and 80°F at the 4 in. soil depth for the main growing season, September to December. Thus on the basis of studies by Parker and Larson (1962), nitrification would not be inhibited under conditions normally experienced during the tobacco season in North Queensland. This would undoubtedly account for the general similarity in responses obtained to both nitrate and ammonium fertilizers when compared in terms of cured leaf yield, quality index and inorganic chemical constitutents.

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