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EFFECTS OF FERTILIZER PLACEMENT AND RIDGING ON YIELD AND QUALITY OF FLUE-CURED TOBACCO

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SUMMARY

A 3-year study was made to determine if changes in present cultural practices of banding fertilizers and subsequent ridging of tobacco influenced tobacco production on a light-textured soil. Flat cultivation was compared with ridging, and banded and broadcast fertilizer placement methods were also examined.

No differences in yield, quality or N, P, K and Cl contents of cured leaf were recorded between ridged and flat-cultivated tobacco. Broadcasting of an N:P:K fertilizer mixture was comparable with banding in respect of both yield and quality. Banding of fertilizers and ridging both appeared to enhance early field growth but did not improve final yield or quality when compared with broadcasting or flat cultivation.

I. INTRODUCTION

Present cultural practices in the Mareeba-Dimbulah area of North Queensland include band application of fertilizers and subsequent ridging or hilling-up of soil along the plant line. On the majority of soils transplanting is made on a comparatively flat soil surface and ridging is carried out 4-7 weeks later. The ridge so formed can vary from a few inches to more than a foot in height.

Under these conditions chloride accumulation, as a white crust, has been observed in tobacco fields and normally becomes apparent during the harvesting period. Concentrations of over 200 p.p.m. chloride have been measured on the soil surface along the plant line where the soil has been hilled-up.

With furrow irrigation, Crack and Chippendale (1961) found that chloride accumulation was greater in the tobacco hill than in the adjacent furrow. This was attributed to the use of irrigation water containing 30–40 p.p.m. Cl and the subsequent movement of chlorides into the hill where conditions for leaching were absent for most of the season. Compared to the high chloride content of Burdekin water (30–40 p.p.m. Cl^-), water used in the Mareeba–Dimbulah area has a low chloride content ($<$ 10 p.p.m. Cl^-). Although water of low chloride content is used and spray irrigation is practised in the Mareeba–Dimbulah area, chloride accumulation on the tobacco hill still occurs.

Cultural practices of concentrating fertilizers in a narrow zone and ridging of soil along the plant line appeared to be the factors which could accentuate conditions for chloride accumulation. Although this accumulation at the soil surface does not cause problems at present, studies were undertaken to determine if flat cultivation and broadcasting of fertilizers adversely affect tobacco production or modify this present accumulation of chlorides.

II. METHODS

Studies with flue-cured tobacco (cv. Hicks) were conducted during the three seasons 1964, 1965 and 1966 at Parada Research Station in the Mareeba–Dimbulah area. The soil type used, Dimbulah sandy loam, consisted of a light coarse sandy loam A horizon (0–15 in.) overlying a red gritty clay loam (Keefer and Ward 1961).

Treatments.—The study comprised a split plot design with four replications. Main effects compared ridging of tobacco with flat cultivation and furrow planting. With ridging, a hill approximately 6–8 in. high was formed some 6–7 weeks after transplanting. With flat cultivation, the hilling-up operation was omitted. In a third treatment plants were planted approximately 4–5 in. below ground level, and the furrow had filled in by the time of ridging. This third treatment was not intended as a commercial practice but was included to provide the additional plant support which normally occurs with ridging. Apart from the differential hilling treatments, normal cultivation practices were followed.

Superimposed on these three main treatments were fertilizer sub-plots of 1/160 ac, in which banded and broadcast fertilizer applications were compared. Preplanting fertilizer, applied by hand, was either banded in a single furrow approximately 3 in. wide or broadcast over the width of the plot (2 rows or 96 in.) and mixed with the surface soil. With subsequent normal cultivations the broadcast fertilizer would probably have been incorporated within the surface 4 in. of soil. Both banded and broadcast fertilizers were applied at the same rates per acre.

Details of previous land history, fertilizer applications and general cropping data are given in Table 1. Differences in cropping history and levels of fertilizer applied were varied to examine treatment effects under a wider range of conditions.

TABLE 1

SEASONAL CROPPING DATA

——	1964 Season	1965 Season	1966 Season
Previous land history	2 years grass	2 years grass	2nd year tobacco
Plant fertilizer	800 lb/ac of a 1% N: 7·7% P: 8·3% K mixture	800 lb/ac of a 2% N: 6·2% P: 8·3% K mixture	1,000 lb/ac of a 2% N: 6·2% P: 8·3% K mixture
Fertilizer side-dressings	200 lb/ac of a 4% N: 3·9% P: 16·6% K mixture (43 days)*	Superphosphate (9·6% P) at 2 cwt/ac (39 days)*	Sodium potassium nitrate at 140 lb/ac (65 days)*
Total fertilizer	N–16, P–69, K–99 (lb/ac)	N–16, P–78, K–66 (lb/ac)	N–41, P–71, K–99 (lb/ac)
Ridging*	43 days	49 days	47 days
Harvest period	58 days	69 days	76 days
Total field growth period*	128 days	138 days	143 days

* Days after transplanting.

Growing conditions.—Apart from the treatments imposed, normal cultural practices were followed. Cover crops, either Rhodes grass (*Chloris gayana* Kunth) in 1964 and 1965 or tobacco (1966), were ploughed under in February or March during the normal "wet" season. Transplanting was done on September 7, 17 and 19 in 1964, 1965 and 1966 respectively. The crops were grown under spray

irrigation, receiving weekly applications of 1·0–1·2 in. after plants had become established. In comparing seasons there was a progressive decrease in rainfall from 1964 to 1966 during the growing and most of the harvesting period.

Leaf evaluation.—Harvesting of leaf commenced some 10 weeks after transplanting and continued at approximately weekly intervals for a further 8–10 weeks (Table 1). The cured leaf was graded by harvest date, leaf grades being based on the schedule described by McDonald (1961). Quality ratings (or relative grade values) were based on values set by the District Adviser (E. J. McDonald) and represent the summation of (weight of each leaf grade multiplied by its respective commercial relative value) divided by the total graded weight per plot.

Data recorded.—During 1964 and 1965 seasons plant height was measured at the budding and flowering stages respectively. Levels of soil chlorides in the plant line were examined during the harvesting stage of the 1964 season. Cured leaf yields were recorded and the leaf assessed. Cured leaf samples (lamina only) were analysed for nitrogen, phosphorus, potassium and chloride content and results expressed on a moisture-free basis. Soil and leaf chlorides were determined by electrometric titration (Piper 1950), P and total N by automated colorimetric methods using a "Technicon" autoanalyser, and K by flame photometry. Cured leaf samples for these analyses were taken from basal and middle plant positions. Weighted averages of all saleable leaf from two consecutive harvests from both basal and middle plant positions were sampled.

III. RESULTS

(a) 1964 Season

Growth of the crop was satisfactory and no field differences between treatments were apparent. However, plant heights at budding (Table 2) showed a tendency for taller plants with ridging, while plants receiving banded fertilizer were also slightly taller. Soil chloride results (Table 3) showed no differences between ridged and flat-cultivation treatments. Soil samples for chloride analysis were collected when a white crust was visible on the soil surface. This crust was observed adjacent to or in the plant line and its occurrence near the plants was not modified by treatment.

TABLE 2

MEAN PLANT HEIGHT (IN.)

Treatment	1964 (early bud stage)	1965 (full flower stage)
(1) Ridged tobacco	25	35
(2) Flat cultivation	20	28
(3) Furrow-planted	19	29
(a) Banded fertilizer ..	23	32
(b) Broadcast fertilizer ..	22	30

TABLE 3

SOIL CHLORIDE LEVELS WITHIN THE PLANT ROW (P.P.M. Cl)—1964 SEASON

Treatment	Mid-harvest	Completion of Harvest		
	Soil Depth (in.)	Soil Depth (in.)		
	0–2	0–4	4–8	8–12
(1) Ridged tobacco	9	6	5	5
(2) Flat cultivation	8	8	5	5
(3) Furrow-planted	8	8	6	5
(a) Banded fertilizer	8	7	6	5
(b) Broadcast fertilizer	7	8	5	5

Cured leaf data (Table 4) showed no marked differences in graded yields or quality ratings between ridged, flat-cultivated and furrow-planted tobacco, while levels of N, P, K and Cl in cured leaf were also comparable among cultivation treatments. Fertilizer applications equivalent to 16 lb N and 99 lb K/ac gave similar cured leaf nutrient levels under both banded and broadcast fertilizer placement methods. Phosphorus uptake was enhanced, but not significantly so, by broadcasting as shown by percentage P of cured leaf. In the 1964 season 61 lb P/ac was applied at planting and an extra 8 lb/ac was added 6 weeks later.

TABLE 4

CURED LEAF DATA—1964 SEASON

—	Yield (lb/ac)	Quality Rating	% N		% P		% K		% Cl	
			(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Ridged tobacco ..	1,984	37·2	1·45	1·38	·24	·25	3·61	2·88	1·74	·86
Flat cultivation ..	1,900	32·6	1·60	1·49	·26	·29	3·71	3·38	1·75	·93
Furrow-planted ..	1,906	36·1	1·43	1·42	·24	·23	3·64	3·14	1·60	·70
Banded fertilizer ..	1,927	35·5	1·48	1·44	·23	·23	3·60	3·09	1·70	·84
Broadcast fertilizer ..	1,934	35·1	1·51	1·42	·27	·28	3·71	3·17	1·70	·83

(a) Lugs. (b) Middle of plant. No significant differences were recorded.

(b) 1965 Season

In both 1964 and 1965 tobacco was grown on separate areas of land which had been under Rhodes grass for the preceding 2 years. Plant heights during 1965 followed similar trends to those noted in the previous season (Table 2). Although early field growth was comparable with that of 1964, the crop generally

became lighter in colour and body as harvesting approached. Cured leaf levels of nitrogen and potassium in leaf from the middle of the plant (Table 5) were noticeably lower than those in the preceding season.

TABLE 5

CURED LEAF DATA—1965 SEASON

	Yield (lb/ac)	Quality Rating	% N		% P		% K		% Cl	
			(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Ridged tobacco ..	1,922	32·7	1·34	1·04	·28	·27	3·16	1·73	1·57	1·09
Flat cultivation ..	2,046	30·7	1·45	1·01	·22	·25	2·80	1·81	1·82	1·08
Furrow-planted ..	1,919	31·9	1·47	·95	·27	·22	3·23	1·78	1·87	1·00
Necessary differences for significance 5%	n.s.	n.s.	n.s.	n.s.	n.s.	·04	n.s.	n.s.	·28	n.s.
Necessary differences for significance 1%						·06			·43	
Banded fertilizer ..	1,806	32·0	1·44	1·02	·26	·22	3·17	1·77	1·58	1·05
Broadcast fertilizer ..	2,118	31·6	1·41	·98	·25	·27	2·96	1·78	1·92	1·06
Necessary differences for significance 5%	n.s.	n.s.	n.s.	n.s.	n.s.	·03	n.s.	n.s.	n.s.	n.s.
Necessary differences for significance 1%						·06				

(a) Lugs. (b) Middle of plant.

Under the treatments imposed there were no significant differences in cured leaf yield, quality rating or N, K and Cl levels other than a lower chloride content in lugs from the ridged treatment (Table 5). The response to fertilizer placement of phosphorus was nullified to some extent at least by a side-dressing of 2 cwt/ac of superphosphate (21 lb/ac P) being inadvertently banded in all plots 5½ weeks after transplanting. However, it is interesting to note that 57 lb/ac P broadcast at planting plus 21 lb/ac P banded as a side-dressing gave a significantly higher ($P<0·05$) P content in leaf from the middle of the plant than did the treatment with all phosphorus banded.

(c) 1966 Season

Following the comparatively low levels of nitrogen and potassium in cured leaf from the 1965 season, the amount of fertilizer applied was increased in the following year. Commercial practices commonly include a side-dressing of sodium potassium nitrate through the spray lines at budding or later stages of crop development and in this third season cultivation and fertilizer placement treatments were examined under similar fertilizer practices. At budding, 21 lb N and 16 lb K/ac were applied by hand as sodium potassium nitrate.

Field growth in 1966 was comparable to that of the first season and as in that year chloride accumulation on the soil surface was observed adjacent to the plants irrespective of treatment. As found in the previous two seasons, neither yield nor quality rating was modified by treatment (Table 6). The cured leaf level of phosphorus was increased by broadcasting, being significantly greater ($P<0·05$) than that obtained where phosphorus was banded in the planting fertilizer. The overall higher level of P in cured leaf in the third season could possibly be attributed to the use of second-year tobacco land, where uptake of residual phosphorus could be expected.

TABLE 6

CURED LEAF DATA—1966 SEASON

	Yield (lb/ac)	Quality Rating	% N		% P		% K		% Cl	
			(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Ridged tobacco ..	1,516	42·9	1·67	1·39	·43	·31	3·67	2·71	1·71	1·22
Flat cultivation ..	1,562	44·0	1·64	1·39	·39	·32	3·90	2·82	1·67	1·30
Furrow-planted ..	1,661	43·8	1·82	1·27	·37	·28	4·01	2·85	2·04	1·22
Necessary differences for significance 5%	n.s.	n.s.	·15	·08	n.s.	n.s.	n.s.	n.s.	·30	n.s.
Necessary differences for significance 1%			·23	·12					·46	
Banded fertilizer ..	1,618	43·1	1·72	1·36	·38	·28	3·87	2·84	1·74	1·16
Broadcast fertilizer ..	1,541	44·0	1·70	1·34	·41	·33	3·86	2·75	1·87	1·34
Necessary differences for significance 5%	n.s.	n.s.	n.s.	n.s.	·03	·04	n.s.	n.s.	n.s.	·18
Necessary differences for significance 1%					·04	·05				·26

(a) Lugs. (b) Middle of plant.

(d) All Seasons

During this 3-year period no lodging of plants was observed, although strong winds were recorded in both 1964 and 1966 when crop growth was well advanced. This absence of lodging would indicate that ridging as a counter-measure to strong winds has no advantage over flat cultivation. In comparing leaf chlorides from season to season, the mean results reflected seasonal conditions (Table 7). The chloride content of lugs varied only slightly (1·70, 1·75 and 1·81% Cl in 1964, 1965 and 1966 respectively), as would be expected with all three crops being dependent primarily on irrigation up to the stage of lug maturation. For leaves maturing later, however, incidence of rainfall caused variations in leaf chloride content.

TABLE 7

LEAF CHLORIDES IN RELATION TO SEASONAL CONDITIONS

Season	Rainfall (in.) Oct.-Dec.	% Cl*—Cured Leaf	
		Lugs	Middle of Plant
1964	10·4	1·70	0·83
1965	2·6	1·75	1·06
1966	1·9	1·81	1·25

* Moisture-free lamina.

IV. DISCUSSION

The practice of ridging is widely used and on poorly drained soils is required for improving soil drainage. However, on better-drained soils, ridging would serve more as a means of plant support against lodging caused either by blue mould (*Peronospora tabacina* Adam) or strong winds. Fungicides are available for controlling blue mould, while with judicious watering practices

root penetration can be enhanced. In studies over 5 years, Britt and Slater (1957) found no appreciable differences between ridged and flat-cultivated tobacco in comparatively dry seasons, while in wet seasons yield and value of tobacco were increased by ridging.

With ridging, the exposed soil surface area is increased, thereby promoting increased water loss by evaporation. On sloping land a ridge can serve to some extent as a counter-measure to soil erosion. However, under such conditions only a small ridge would be required, with contour banks acting as the main means of control.

Method of fertilizer placement did not influence yield or quality rating at the levels of nutrients applied. These levels were comparable with district practices except that phosphorus was applied at a slightly higher level at this particular site. On the basis of accepted levels of nutrients in cured leaf in Queensland (Green 1966), nitrogen and potassium from the 1964 and 1966 seasons were within acceptable limits, while in 1965 leaf from the middle part of the plant was low in both these nutrients. Chloride levels were satisfactory and reflected seasonal conditions. Cured leaf phosphorus levels were within acceptable limits under both fertilizer placement methods.

The comparative availability of nitrogen and potassium from either banded or broadcast fertilizer may be attributed to the mobility of these elements in the soil (Whitty, McCants and Shaw 1966). However, in view of the extensive nature of roots of a well-developed tobacco plant (Keefer *et al.* 1965), utilization of much of the broadcast fertilizer would undoubtedly occur. Unfortunately, no comparison was made of nutrient levels in young plants although plant heights, before topping, indicated better early growth with banded fertilizer. Whitty, McCants and Shaw (1966), in comparing different widths of fertilizer bands, also noted an enhancement of early field growth with a narrow band (8 in.), but final yield and value were comparable irrespective of width of fertilizer band.

Chloride accumulation at the soil surface adjacent to the plant stem was not modified by treatment. This accumulation near the plant stem possibly resulted from a combination of a high root density in this zone, partial shedding of water by the leaves, thus reducing leaching, and relatively high evaporation rates averaging 0·26, 0·28 and 0·23 in. per day from a free water surface during November, December and January.

Although ridging is widely practised, this study showed that for a well-drained soil it has no advantage over flat cultivation. Method of fertilizer placement was not critical under the fertilizer practices compared, indicating that broadcasting would be desirable should transplant burn occur with banding.

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