QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

DIVISION OF PLANT INDUSTRY BULLETIN No. 655

FERTILIZING PINEAPPLES ON A SOIL HIGH IN POTASSIUM

By K. R. JORGENSEN, B.Agr.Sc.

SUMMARY

Potassium was applied at rates of 5·7 kg and 11·3 kg per 1,000 plants as preplant base dressings, as side-dressings during the second summer of growth and as potassium sulphate sprays from planting to ratoon crop flowering. On a soil containing 0·57 m-equiv. replaceable K per 100 g there was no worthwhile response in total yield to any of these treatments and no reduction in yield compared with a nil control. Two frequencies of spraying with 10% urea were also applied. Spraying every 8 weeks produced the best plant crop yields but spraying every 4 weeks was needed for maximum ratoon crop yields.

I. INTRODUCTION

Pineapple growth and nutrition studies have emphasized the importance of potassium in pineapple nutrition by showing that the plant's potential for uptake of this element is greater than that for either nitrogen or phosphorus (Black and Page 1969). These studies have also shown that under Queensland conditions the plant takes up potassium mainly during two periods: (a) the first summer when it is becoming established and making growth leading to the plant crop, and (b) the second summer when it is making growth leading to the ratoon crop.

In fertilizer trials, yield responses to potassium applications have occurred on a range of soil types although the degree of response has generally decreased with increasing levels of replaceable potassium (Cannon 1957; Mitchell and Nicholson 1965; Su 1969).

In the Yeppoon district of Queensland, levels of potassium in the soils used for pineapples are generally quite high (0.5 to 0.9 m-equiv. replaceable K per 100 g).

On these soils, the question arises: is there sufficient potassium already available for this important nutrient to be left out of the fertilizer programme altogether or could a response be obtained if it was applied so as to be available during the major uptake periods?

To answer this question two concurrent trials were conducted. The first combined factorially three rates of potassium applied in preplant base dressings with three rates of potassium applied during the second summer of growth. The second trial combined a low rate of potassium applied either preplant or in the second summer with three rates of potassium applied in foliar sprays. Pineapple growers in the Yeppoon district have recently started to use potassium sulphate sprays as an economical means of applying their potassium fertilizer. Both trials include zero rates of each factor.

To determine whether there was any interaction between nitrogen rate and potassium response, one trial also included two and the other three rates of nitrogen applied as urea sprays.

II. MATERIALS AND METHODS

(a) Soil and Site

The trials were located on virgin land on the property of W. Edwards, Bungundarra, *via* Yeppoon. The soil was a red brown clay loam with the following chemical analysis:

pH : 6·7 (1 : 2·5 soil/water suspension).
Total N : 0·11%.
Available P : 10 p.p.m. (0·01N H_2SO_4 extraction).
Replaceable K : 0·57 m-equiv. per 100 g (0·05N HCl extraction).

(b) Design and Treatments

Trial 1 compared the following treatments in a 3 x 3 x 3 factorial design with two replications. All rates are per 1,000 plants.

Basal Potassium	Second Summer Potassium	Nitrogen
B_0 : Nil	S_0 : Nil	N_0 : Nil
B_1 : 5·7 kg (12·5 lb) K	S_1 : 5·7 kg (12·5 lb) K	N_1 : Urea spray every 8 weeks
B_2 : 11·3 kg (25 lb) K	S_2 : 11·3 kg (25 lb) K	N_2 : Urea spray every 4 weeks

Trial 2 compared the following treatments in a 3 x 3 x 2 factorial design with two replications. All rates are per 1,000 plants.

Solid Potassium	Spray Potassium	Nitrogen
T_0 : Nil	C_0 : Nil	
T_1 : Basal application of 5·7 kg (12·5 lb) K	C_1 : 5·7 kg (12·5 lb) K	N_1 : Urea spray every 8 weeks
T_2 : Second summer application 5·7 kg (12·5 lb) K	C_2 : 11·3 kg (25 lb) K	N_2 : Urea spray every 4 weeks

The details of the treatments are as follows:

Basal potassium.—After a first run with tractor-drawn discs to raise the base of the beds, the required amount of potassium as potassium sulphate was evenly distributed over the half-formed bed. A second run with the discs covered the basal fertilizer and formed the beds on which the plants were grown.

Second summer potassium.—The total amount of potassium was split into three equal dressings. These were made in early October, early December and late March of the second summer after planting; i.e. the first application was made 13 months after planting. At each date, the required amount of potassium as potassium sulphate was thrown by hand onto the top of the bed along the outer edges of the double row.

Spray potassium.—The total amount of potassium was split into 22 equal applications which were made every 4 weeks from planting until ratoon crop forcing. For each application the following concentrations of potassium sulphate in water were prepared and applied by knapsack spray at the rate of 16 litres (3.5 gal) per 1,000 plants: C_1:3·7%, C_2:7·4% w/v.

Urea sprays.—These sprays were of 10% w/v urea in water applied at the rate of 16 litres (3·5 gal) per 1,000 plants. Each spray applied 0·73 kg (1·61 lb) N per 1,000 plants. (Treatment N_1 provided for 11 sprays and N_2 for 22 urea sprays during the trial). Potassium and urea sprays were applied on the same dates from planting to ratoon crop forcing and were combined in the same spray where possible.

Other nutrients.—All plots received a basal application of 0·68 kg (1·5 lb) phosphorus as superphosphate per 1,000 plants and zinc and iron sprays as required.

(c) Cultural Details

Graded slips of the Smooth Cayenne variety were planted in September 1967. Planting distances were 0·3 m (1 ft) between plants in the row, 0·51 m (1 ft 8 in.) between rows in the double row and 1·83 m (6 ft) between the double rows (centre to centre). This gave a planting rate of 36,000 plants per hectare (14,500 per acre).

Each plot consisted of a length of double row containing 50 datum plants with an external guard area 0·61 m (2 ft) long at each end. Each double row was planted on a raised bed 0·23 m (9 in.) high and 0·66 m (2 ft 2 in.) wide.

Flowering was forced with beta hydroxy ethyl hydrazine (BOH) in May 1968 for the plant crop and in June 1969 for the ratoon crop. The plant crop was harvested in January and February 1969 and the ratoon crop in January and February 1970.

III. RESULTS

Yield.—Yield data covering the number of fruit harvested, the mean fruit mass and the fruit yield per hectare for both crops and the total yield are presented for trial 1 in Table 1 and for trial 2 in Table 2.

TABLE 1

TRIAL 1: FRUIT NUMBER, FRUIT MASS AND YIELD OF PLANT AND RATOON CROPS

—		Plant Crop			Ratoon Crop			Total
Treatment		No. of Fruit per hectare	Mean Fruit Mass (kg) (tops off)	Yield of Fruit (tonnes per hectare)	No. of Fruit per hectare	Mean Fruit Mass (kg) (tops off)	Yield of Fruit (tonnes per hectare)	Yield of Fruit (tonnes per hectare)
Basal K	B_0	34,000	1·553	52·85	42,720	1·081	46·15	99·03
	B_1	34,520	1·625	56·05	39,400	1·149	45·22	101·24
	B_2	33,800	1·625	54·94	37,840	1·149	43·81	98·74
2nd summer K	S_0	33,960	1·602	54·54	37,840	1·130	42·88	97·42
	S_1	34,280	1·602	54·94	39,520	1·149	45·50	100·39
	S_2	34,080	1·598	54·40	42,600	1·103	46·80	101·20
Nitrogen	N_0	35,280	1·403	49·64	32,760	1·062	34·27	83·91
	N_1	35,840	1·653	59·44	41,800	1·167	48·82	108·25
	N_2	31,200	1·748	54·72	45,400	1·149	52·13	106·86
Necessary differences for significance	5%	1,200	0·050	2·52	3,630	0·077	4·32	6·13
	1%	1,600	0·064	3·38	4,860	0·104	5·80	8·23
		$N_1, N_0 \gg N_2$	$B_1, B_2 \gg B_0$ $N_2 \gg N_1 \gg N_0$	$B_1 > B_0$ $N_1 \gg N_2 \gg N_0$	$B_0 \gg B_2$ $S_2 > S_0$ $N_2, N_1 \gg N_0$	$N_1 \gg N_0$ $N_2 > N_0$	$N_2, N_1 \gg N_0$	$N_1, N_2 \gg N_0$

TABLE 2

TRIAL 2: FRUIT NUMBER, FRUIT MASS AND YIELD OF PLANT AND RATOON CROPS

—		Plant Crop			Ratoon Crop			Total
Treatment		No. of Fruit per hectare	Mean Fruit Mass (kg) (tops off)	Yield of Fruit (tonnes per hectare)	No. of Fruit per hectare	Mean Fruit Mass (kg) (tops off)	Yield of Fruit (tonnes per hectare)	Yield of Fruit (tonnes per hectare)
Solid K	T_0	34,140	1·684	57·64	43,260	1·126	48·64	106·30
	T_1	33,360	1·721	57·38	41,580	1·162	48·17	105·57
	T_2	34,320	1·671	57·46	43,500	1·149	50·00	107·48
Spray K	C_0	33,600	1·662	56·05	43,680	1·126	49·18	105·17
	C_1	34,860	1·684	58·79	44,340	1·140	50·58	109·35
	C_2	33,360	1·725	57·67	40,320	1·167	47·16	104·84
Necessary differences for significance	5%	1,460	0·059	3·13	4,450	0·095	5·29	7·53
	1%	1,960	0·082	4·14	5,950	0·127	7·09	10·10
Nitrogen	N_1	34,240	1·657	56·88	40,040	1·158	46·33	103·22
	N_2	33,640	1·721	58·10	45,520	1·130	51·59	109·68
Necessary differences for significance	5%	1,200	0·050	2·52	3,630	0·077	4·32	6·13
	1%	1,600	0·064	3·38	4,860	0·104	5·80	8·23
		$C_1 > C_2$	$C_2 > C_0$ $N_2 > N_1$	N.S.	$N_2 \gg N_1$	N.S.	$N_2 > N_1$	$N_2 > N_1$

Slip production.—Slips were removed from the plant crop fruit stalks on May 30, 1969, counted and weighed fresh. These data from trial 1 are presented in Table 3 and from trial 2 in Table 4.

TABLE 3

TRIAL 1: SLIP COUNT AND MASS

Treatment		No. of Slips per hectare	Mean Slip Mass (g)
Basal K	B_0	45,000	284·7
	B_1	52,960	307·8
	B_2	54,800	330·5
2nd summer K	S_0	57,440	295·6
	S_1	48,680	306·0
	S_2	46,640	321·4
Nitrogen	N_0	50,000	269·2
	N_1	56,960	308·7
	N_2	45,800	345·5
Necessary differences for significance	5%	7,210	24·5
	1%	9,660	33·1
		$B_2 \gg B_0$ $B_1 > B_0$ $S_0 \gg S_2$ $S_0 > S_1$ $N_1 \gg N_2$	$B_2 \gg B_0$ $S_2 > S_0$ $N_2 \gg N_1 \gg N_0$

TABLE 4

TRIAL 2: SLIP COUNT AND MASS

Treatment		No. of Slips per hectare	Mean Slip Mass (g)
Solid K	T_0	50,280	309·6
	T_1	63,900	313·7
	T_2	45,480	313·7
Spray K	C_0	49,260	300·1
	C_1	57,960	298·7
	C_2	52,440	338·2
Necessary differences for significance	5%	8,830	30·4
	1%	11,830	40·4
Nitrogen	N_1	60,680	311·4
	N_2	45,760	313·3
Necessary differences for significance	5%	7,210	24·5
	1%	9,660	33·1
		$T_1 \gg T_0$, T_2 $N_1 \gg N_2$	$C_2 > C_0$, C_1

TABLE 5

TRIAL 1: LEAF ANALYSES

Treatment		Leaf Nitrogen (%)			Leaf Potassium (%)		
		30.i.68	19.v.68	3.vi.69	30.i.68	19.v.68	3.vi.69
Basal K	B_0	1·844	1·176	1·069	3·678	2·052	2·516
	B_1	1·851	1·098	1·109	4·382	2·813	2·904
	B_2	1·817	1·069	1·007	4·458	3·192	3·057
2nd summer K	S_0	1·816	1·128	1·086	4·070	2·742	2·546
	S_1	1·807	1·116	1·113	4·302	2·708	2·886
	S_2	1·888	1·100	1·087	4·147	2·607	3·046
Nitrogen	N_0	1·641	0·951	0·999	4·344	2·823	3·219
	N_1	1·727	1·097	1·092	4·141	2·621	2·698
	N_2	2·144	1·296	1·196	4·033	2·613	2·561
Necessary differences for significance	5%	0·096	0·064	0·049	0·256	0·177	0·124
	1%	0·129	0·085	0·065	0·343	0·237	0·166
		$N_2 \gg N_1 N_0$	$B_0 > B_1$ $B_0 \gg B_2$ $N_2 \gg N_1 \gg N_0$	$N_2 \gg N_1 \gg N_0$	$B_2, B_1 \gg B_0$ $N_0 > N_2$	$B_2 \gg B_1 \gg B_0$ $N_0 > N_1 N_2$	$B_2 > B_1 \gg B_0$ $S_2 > S_1 \gg S_0$ $N_0 \gg N_1 > N_2$

TABLE 6

TRIAL 2: LEAF ANALYSES

Treatment		Leaf Nitrogen (%)			Leaf Potassium (%)		
		30.i.68	19.v.68	3.vi.69	30.i.68	19.v.68	3.vi.69
Solid K	T_0	1·912	1·266	1·133	3·606	2·374	2·514
	T_1	1·858	1·193	1·096	4·252	3·003	2·776
	T_2	1·934	1·243	1·053	4·013	2·296	2·708
Spray K	C_0	1·962	1·223	1·103	3·780	2·278	2·218
	C_1	1·882	1·227	1·088	4·038	2·526	2·731
	C_2	1·860	1·252	1·091	4·052	2·868	3·050
Necessary differences for significance	5%	0·118	0·078	0·059	0·314	0·217	0·151
	1%	0·158	0·104	0·080	0·420	0·290	0·203
Nitrogen	N_1	1·768	1·116	1·022	4·001	2·584	2·693
	N_2	2·034	1·352	1·166	3·912	2·531	2·639
Necessary differences for significance	5%	0·096	0·064	0·049	0·256	0·177	0·124
	1%	0·129	0·085	0·065	0·343	0·237	0·166
		$N_2 \gg N_1$	$N_2 \gg N_1$	$T_0 \gg T_2$ $N_2 > N_1$	$T_1 \gg T_0$ $T_2 > T_0$	$T_1 \gg T_0 T_2$ $C_2 \gg C_1 > C_0$	$T_1 \gg T_0$ $T_2 > T_0$ $C_2 \gg C_1 \gg C_0$

Leaf analysis.—Leaf samples for analysis were taken on three occasions by removing the longest leaf from six plants per plot. The sampling dates were January 30, 1968 (post-establishment stage), May 19, 1968 (at the time of plant crop forcing) and June 3, 1969 (at the time of ratoon crop forcing).

The whole-leaf samples were dried, ground and analysed for nitrogen by a micro-Kjeldahl method and for potassium by flame photometry (Bould, Bradfield and Clarke 1960).

The results of these analyses from trial 1 are listed in Table 5 and from trial 2 in Table 6.

IV. DISCUSSION

(a) Basal Potassium

The low rate of basal potassium (B_1) in trial 1 produced a significant increase in plant crop yield over the nil control (B_0). In the ratoon crop, however, B_1 produced about the same yield as the control, so in total yield there was no significant increase over the control. In trial 2, there was no yield response to this same low rate of application (T_1) even in the plant crop.

The high rate of basal potassium (B_2) in trial 2 produced a plant crop yield intermediate between B_0 and B_1, while in the ratoon crop its yield tended to be lower than B_0 and B_1 although not by enough to be significant.

It would seem then that, on this high potassium soil, basal potassium applied at a moderate rate is not able to produce a worthwhile increase in total yield and at a high rate it has no overall effect on yields compared with the control.

In previous trials in the Yeppoon district, the results suggested that high rates of basal potassium applied to high potassium soils depressed yield due to a toxic effect (Jorgensen and Page 1969). In this trial the following facts suggest rather that basal potassium restricted yield by promoting vegetative growth at the expense of flowering.

Analysis of leaf samples taken on all three dates showed that the basal potassium was certainly taken up in proportion to its rate of application. Slip counts and mean slip weights showed significant positive responses to increasing rate of basal potassium. Fresh weight of leaves sampled for analysis also showed the same trend (data not presented).

In fruit production the general trend is for basal potassium to reduce the number of fruit harvested. Only on one occasion, the plant crop from B_1, was there a tendency for the number of fruit to increase and this resulted in a significant yield increase. On the other hand, basal potassium tended to increase mean fruit mass in both trials and in both crops. Although the ratoon crop lodged, the reduction in number of fruit harvested from basal potassium plots was not due to fruit lost by lodging. Lodging was uniform throughout the trial and almost no fruit was lost.

In the trial situation, basal potassium appeared therefore to promote vegetative growth, reduce flowering and hence reduce yield.

(b) Second Summer Potassium

Second summer applications of potassium were made during the growth of the plant crop to provide nutrients for the ratoon crop. They had no effect on the plant crop yield.

In trial 1, there was a tendency for ratoon crop yields to increase with increasing rate of second summer potassium, although the differences were not quite large enough to reach significance. In trial 2 there was no effect on yield from T_2, the low rate of second summer potassium.

(c) Spray Potassium

Overall, there was no significant yield response to spray applications of potassium although the low rate (C_1) tended to give higher yields than the nil control.

As with the high rates of basal potassium, high rates of spray potassium tended to reduce yield by reducing flowering. There did not seem to be any toxic effect from the high concentration of spray potassium because it increased leaf levels of potassium and increased slip production.

(d) Nitrogen

The low frequency of urea spray (N_1) produced a significant yield response over the control (N_0) in both crops from trial 1. The response was due to larger mean fruit mass and to larger number of fruit harvested.

The high frequency of urea spray (N_2) produced a yield improvement over N_1 in the ratoon crop from both trials but not in the plant crop. In trial 1, the plant crop from N_2 was significantly less than N_1 and in trial 2 it was not significantly different from N_1. The increase in ratoon crop yield from N_2 was due exclusively to the larger number of fruit harvested.

(e) Interactions

There were no interactions between factors with respect to yield, fruit number or fruit mass. Leaf analyses showed the well known N: K interaction in which potassium applications reduced leaf nitrogen content and *vice versa.*

(f) Conclusions

Potassium recommendations.—On this soil with a replaceable potassium content of 0·57 m-equiv. per 100 g soil, no worthwhile yield benefit has resulted from potassium applications even when made at the time of major potassium uptake.

This result is in general agreement with the conclusion of Cannon (1957) in Queensland that no yield response from pineapples can be expected on soils above the level of 0·5 m-equiv. repl. K per 100 g (K extracted by 0·05 N HCl). Magistad (1934) reported that, in Hawaii, no response was obtained on soils with above 0·5 m-equiv. repl. K_2O per 100 g (K extracted by N NH_4Cl). While replaceable K figures from 0·05 N HCl extract and N NH_4Cl extract are not necessarily the same, they are usually of the same order.

Su (1969) indicated that in Taiwan no response was obtained on soils with above 140 p.p.m. exchangeable K (method of analysis not given). This is equivalent to 0·36 m-equiv. K per 100 g, an even lower limit of response.

It would therefore seem appropriate to recommend that no potassium be applied to pineapples growing on soils with more than 0·5 m-equiv. repl. K per 100 g. A check should, however, be maintained on soil potassium levels so that application of this important nutrient can be introduced if continual cropping reduces the soil level.

Nitrogen recommendations.—Although the total soil nitrogen level was only fair (0·11%) prior to the commencement of the trial, there was no advantage in the plant crop from applying 10% urea sprays at a greater rate than 16 litres (3·5 gal) per 1,000 plants every 8 weeks.

The ratoon crop, however, benefited from sprays applied at twice this frequency. This was due entirely to an increase in the number of fruit harvested from the high nitrogen treatment. Cannon (1957) recorded a similar response.

Urea sprays every 8 weeks would therefore seem adequate up to the time of plant crop flowering but from then on sprays should be applied every 4 weeks to encourage sucker growth and thus maximize ratoon crop yields.

V. ACKNOWLEDGEMENTS

The author wishes to thank officers of the Horticulture Branch of the Department of Primary Industries stationed at Rockhampton from 1967 to 1970 who assisted in all field work and Mr. W. Edwards on whose property the trial was conducted.

REFERENCES

BLACK, R. F., and PAGE, P. E. (1969).—Pineapple growth and nutrition over a plant crop cycle in south-eastern Queensland. 2. Uptake and concentrations of nitrogen, phosphorus and potassium. *Qd J. agric. Anim. Sci.* 26:385-405.

BOULD, C., BRADFIELD, E. G., and CLARKE, G. M. (1960).—Leaf analysis as a guide to nutrition of fruit crops. I—General principles, sampling techniques and analytical methods. *J. Sci. Fd Agric.* 11:229-42.

CANNON, R. C. (1957).—Pineapple fertilizer investigations in south-eastern Queensland. *Qd J. agric. Sci.* 14:93-110.

JORGENSEN, K. R., and PAGE, P. E. (1969).—Comparison of four fertilizer schedules for pineapples in central Queensland. *Qd J. agric. Anim. Sci.* 26:495-508.

MAGISTAD, D. C. (1934).—Relation between replaceable potassium and field response to potash in Hawaiian soils. *Soil Sci.* 37:99-103.

MITCHELL, A. R., and NICHOLSON, M. E. (1965).—Pineapple growth and yield as influenced by urea spray schedules and potassium levels at three plant spacings. *Qd J. agric. Anim. Sci.* 22:409-17.

SU, N. R. (1969).—Recommendations on the nutritional management of pineapple in Taiwan. *Pot. Rev.* Subj. 27, Suite 48.

(Received for publication April 6, 1973)

The author is an officer of Horticulture Branch, Queensland Department of Primary Industries, stationed at Maryborough.