

STUDIES ON THE NUTRIENT STATUS OF SOME COCONUT SOILS IN CEYLON

3. The Forest Soil at Ambakelley

(B) Optimum requirements of deficient nutrients

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1. Introduction

This paper is No. 3 B in a series recording experiments with the more important coconut soils in Ceylon. The first paper on this soil (C.R.I. Bulletin No. 14) recorded preliminary experiments carried out to determine the deficient nutrients.

The three experiments recorded there showed that plants growing on this soil would suffer from an acute deficiency of nitrogen, phosphorus and potassium. During the early stages of growth, there was no apparent deficiency of calcium, but with age there was some improvement from an original dressing of 10 cwt./acre calcium carbonate. There was no evidence of any deficiency of magnesium, sulphur, or of the trace elements.

The deficiencies of N, P and K were acute and omission of any one of these nutrients from the complete fertilizer caused a very heavy reduction in yield. In the absence of phosphorus, yields were reduced by 60 per cent. Omission of nitrogen caused an 85 per cent reduction, and with no potassium yields declined steadily from an initial value of 95 per cent to a final value of 2.5 per cent.

In this paper, results of two experiments carried out to determine the optimum requirements of the deficient nutrients are reported. The general technique and procedure adopted were essentially the same as reported in the first publication of these series (C.R.I. Bulletin No. 11).

2. Experimental

A. Experiment 1

- (a) *Objective.*—To determine the optimum requirements of N, P, K and Ca, for the growth of *Paspalum commersonii* on the forest soil at Ambakelley.
- (b) *Design and Procedure.*—This was $4^2 \times 2$ factorial experiment of four levels of N, P and K and two levels of Ca. With one replicate of all treatments.

Nitrogen was applied at 0, $2\frac{1}{2}$, 5 and $7\frac{1}{2}$ cwt./acre $(\text{NH}_4)_2\text{SO}_4$. Phosphorus was applied at 0, $1\frac{1}{2}$, 3 and 6 cwt./acre. $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$. Potassium was applied at 0, 3, $4\frac{1}{2}$ and 6 cwt./acre K_2SO_4 . Calcium was applied at 0 and 10 cwt./acre CaCO_3 .

Except for calcium which was applied as powder and mixed with the top $1\frac{1}{2}$ " of soil, the other nutrients were applied as solutions.

The Experiment was planted on 25th July, 1957 and harvested three times *viz.* 2nd September, 2nd October and 4th November. A further application of nitrogen was made on 18th August, bringing the levels of N to 0, 5, 10 and 15 cwt./acre.

Results.—In this experiment the data from successive harvests showed that there had been a change in the nutrient status of this soil. Potassium had no significant effect at the first harvest but in later harvests, there was a progressive increase in yield with increasing levels of K. Calcium was responsible for some depression in yield at the first harvest. This effect was less marked at the second and there was no reponse at the third harvest.

1st Harvest.—At this harvest both nitrogen and phosphorus increased yields. Calcium was responsible for a significant depression. Potassium was without effect; relative yields for the four levels being 100; 117; 106; 114 for K₀, K₃, K_{4½} and K₆ respectively.

The data for all treatments and all harvests are given in the appendix.

2nd Harvest.—At this harvest all treatments were effective, and responses to N, P and Ca were essentially similar to those of the first harvest. Potassium which was without effect in the first harvest was responsible for a significant increase in yields specially at the first added level (K₃).

3rd Harvest.—At this harvest responses to N, P and K were similar to those of the second harvest. Calcium had no effect on the yield and there were no significant interactions with other nutrients.

(iv) *Discussion.*—In the preliminary experiments with this soil calcium had improved the yield from late harvests, but in this experiment 10 cwt./acre CaCO₃ caused some depression of yield in the first two harvests, and it had no effect in the third harvest. Under these circumstances, and because there were a number of negative interactions between Ca and other nutrients, all Ca + treatments were discarded and the data were re-analysed as for a 4 × 4 × 4 N.P.K. Experiment (see Table I).

These data showed that all three nutrients had significant effects in the first harvest, and there were no interactions between nutrients. The data for the first harvest are given in Table I.

The optimum dose of nitrogen was 5 cwt./acre and the difference between N_{2½} and N₅ was significant at the 0.1 per cent level; there was no significant difference between N₅ and N_{7½}. Phosphorus gave maximum yield at P_{1½} and there was no further increase from P₃ or P₆. There was also a marked response to K₃ (significant at 1.0 per cent) with no further increment from higher dosage.

	K ₀	K ₃	K _{4½}	K ₆	Total
N ₀ ..	6.89	8.65	7.43	8.16	31.13
N _{2½} ..	13.83	14.65	13.39	13.93	55.80
N ₅ ..	15.19	20.09	18.36	18.15	71.79
N _{7½} ..	14.04	20.87	18.67	19.67	73.21
<i>Total</i> ..	49.95	64.26	57.85	59.87	231.93

		<i>K</i> ₀	<i>K</i> ₃	<i>K</i> _{4½}	<i>K</i> ₆	<i>Total</i>
<i>P</i> ₀	..	5.32	5.65	7.25	7.26	25.48
<i>P</i> _{1½}	..	17.42	19.52	18.39	20.81	76.14
<i>P</i> ₃	..	12.33	20.81	13.75	16.63	63.52
<i>P</i> ₆	..	14.88	18.28	18.46	15.17	66.79
<i>Total</i>	..	49.95	64.26	57.85	59.87	231.93

		<i>N</i> ₀	<i>N</i> _{2½}	<i>N</i> ₅	<i>N</i> _{7½}	<i>Total</i>
<i>P</i> ₀	..	2.95	6.76	7.40	8.37	25.48
<i>P</i> _{1½}	..	8.74	20.02	22.84	24.54	76.14
<i>P</i> ₃	..	10.18	12.67	23.05	17.62	63.52
<i>P</i> ₆	..	9.26	16.35	18.50	22.68	66.79
<i>Total</i>	..	31.13	55.80	71.79	73.21	231.93

		1.0%	0.1%
Minimum difference for significance	Main effects	.. 10.33	13.76
	Interaction	.. 5.16	6.88

Table I—Experiment I—Showing total yields of 1st Harvest.

At the second harvest all three nutrients were significant at the 0.1 per cent level. The optimum response to nitrogen was obtained at the *N*_{2½} level, and there were no significant effects from higher dosage.

		<i>K</i> ₀	<i>K</i> ₃	<i>K</i> _{4½}	<i>K</i> ₆	<i>Total</i>
<i>N</i> ₀	..	7.39	6.09	5.86	6.14	25.48
<i>N</i> _{2½}	..	13.91	22.37	21.63	24.72	82.63
<i>N</i> ₅	..	11.93	25.97	27.16	26.88	91.94
<i>N</i> _{7½}	..	10.29	23.79	25.48	35.23	94.79
<i>Total</i>	..	43.52	78.22	80.13	92.97	294.84

		<i>K</i> ₀	<i>K</i> ₃	<i>K</i> _{4½}	<i>K</i> ₆	<i>Total</i>
<i>P</i> ₀	..	10.55	13.86	13.46	15.22	52.49
<i>P</i> _{1½}	..	10.63	19.86	19.75	25.21	75.45
<i>P</i> ₃	..	9.28	19.94	19.25	25.01	73.48
<i>P</i> ₆	..	13.06	25.16	27.67	27.53	93.42
<i>Total</i>	..	43.52	78.22	80.13	92.97	294.84

		<i>N</i> 0	<i>N</i> 2½	<i>N</i> 5	<i>N</i> 7½	<i>Total</i>
<i>P</i> 0	..	7.17	15.38	13.47	16.47	52.49
<i>P</i> 1½	..	6.35	21.97	24.96	22.17	75.45
<i>P</i> 3	..	5.73	20.35	24.94	22.46	73.48
<i>P</i> 6	..	6.23	24.93	28.57	33.69	93.42
<i>Total</i>	..	25.48	82.63	91.94	94.79	294.84

		1.0%	0.1%
Minimum difference for significance	Main effects	16.62	22.14
	Interactions	8.31	11.07

Table II—Experiment I—Showing total yield from second harvest.

The shift from maximum yields at *N*5 (first harvest) to *N*2½ (second harvest) could be attributed to the additional *N*2 applied on August 18th (see design and procedure paragraph 4 line 3).

As in the first harvest there was a significant response to phosphorus, with *P*1½ significantly greater than *P*0, there was also a trend towards higher yields from increasing dosage. (Significant at 1.0 per cent for *P*6).

The response to potassium was much greater than in the first harvest, and there was a trend towards higher yields from increasing dosage. However there was no significant difference between *K*3, *K*4½ and *K*6.

At the third and final harvest there was a very big response to all levels of nitrogen, and there were significant differences between yields at all four levels.

		<i>K</i> 0	<i>K</i> 3	<i>K</i> 4½	<i>K</i> 6	<i>Total</i>
<i>N</i> 0	..	5.96	5.34	5.59	4.98	21.87
<i>N</i> 2½	..	10.09	10.29	9.30	10.27	39.95
<i>N</i> 5	..	7.93	19.98	19.45	21.61	68.97
<i>N</i> 7½	..	6.26	27.97	26.67	35.09	96.09
<i>Total</i>	..	30.24	63.58	61.11	71.95	226.88

		<i>K</i> 0	<i>K</i> 3	<i>K</i> 4½	<i>K</i> 6	<i>Total</i>
<i>P</i> 0	..	8.60	14.19	11.44	13.31	47.54
<i>P</i> 1½	..	7.07	15.86	15.58	18.95	57.46
<i>P</i> 3	..	8.66	17.08	15.56	20.36	61.66
<i>P</i> 6	..	5.91	16.45	18.53	19.33	60.22
<i>Total</i>	..	30.24	63.58	61.11	71.95	226.88

	No	N2½	N5	N7½	Total
P0 ..	4.95	11.07	13.82	17.70	47.54
P1½ ..	5.92	9.26	17.60	24.68	57.46
P3 ..	5.48	10.71	19.59	25.88	61.66
P6 ..	5.52	8.91	17.96	27.83	60.22
Total ..	21.87	39.95	68.97	96.09	226.88

	1.0%	0.1%
Minimum difference for significance Main effects	14.74	19.63
Interaction	7.37	9.86

Table II—Experiment I—Showing total yield for third harvest.

The response to P. was much less marked than in the previous harvests and no significant differences were recorded. There was again a very big response to K₃, with no significant increments from higher dosage.

Summary for Experiment I.—The pattern of responses in this experiment is shown diagrammatically in Fig. I, II and III.

Nitrogen.—In the first harvest, optimum yields were obtained from 5 cwt./acre of (NH₄)₂SO₄ and there was no further increment from 7½ cwt./acre. In the second harvest, and after duplication of all N. treatments, optimum yields were recorded for N2½ (=5 cwt./acre of (NH₄)₂SO₄ and there was no further increment from N₅ (10 cwt./acre) or N7½ (15 cwt.). In the third harvest there was a progressive response to increasing dosage with highest yields from N7½ (15 cwt. (NH₄)₂SO₄/acre).

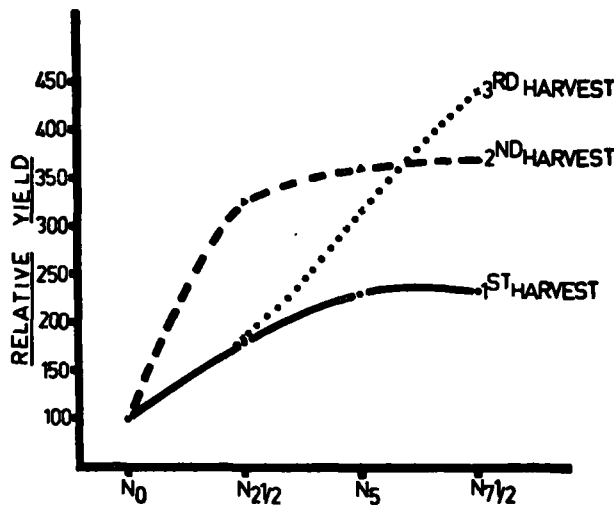


Fig. I

Since that amount of N (approx. 19 cwt./acre, for N7½) would far exceed the amount assimilated by plants (1 cwt./acre) it must be assumed that much of the applied nitrogen was in the form of gaseous NH₃. It is suggested that small and frequent applications of (NH₄)₂SO₄ would be a more efficient way of applying nitrogen (C.R.I. Bulletin, No. 12).

Phosphorus.—In the first harvest there was a big response to 1½ cwt./acre NaH₂PO₄·2H₂O but in subsequent harvests the response was progressively and appreciably smaller. The data therefore suggest that there had been a significant improvement in the supply of naturally occurring available phosphorus in this soil. In all three harvests there was no further increment (over P1½) from higher dosage.

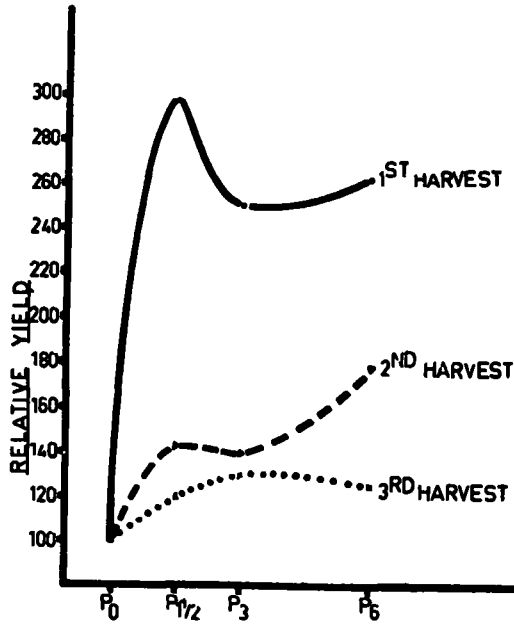


Fig. II

Potassium.—At the first harvest there was no significant response to K, but in subsequent harvests there were progressively greater and significant increments from 3 cwt./acre K_2SO_4 . There was no further increment from higher dosage.

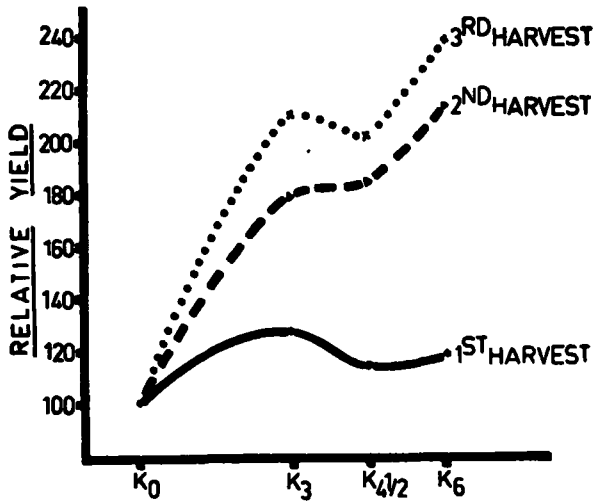


Fig. III

B. Experiment II.

(a) *Objective.*—To determine the optimum requirements of P. and K. for the growth of *Paspalum commersonii* with particular reference to lower rates of application.

(b) *Design and Procedure.*—This was a 4^2 factorial with two replicates of all treatments.

Phosphorus was applied as $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$ (Nil, $1\frac{1}{2}$, 3 and $4\frac{1}{2}$ cwt./acre) and Potassium as K_2SO_4 (Nil, $1\frac{1}{2}$, 3 and $4\frac{1}{2}$ cwt./acre). All pots received a basal dressing of nitrogen as $(\text{NH}_4)_2\text{SO}_4$ at 5 cwt./acre.

The experiment was planted on 4th January, 1958, and harvested three times *viz.* 10th February, 13th March and 10th April. During the progress of the experiment nitrogen was applied at intervals as follows :—

Date of application	Rate	Total to-date
28th February	$2\frac{1}{2}$ cwt.	$7\frac{1}{2}$ cwt. $(\text{NH}_4)_2\text{SO}_4$
10th March	$1\frac{1}{4}$ cwt.	$8\frac{3}{4}$ cwt. $(\text{NH}_4)_2\text{SO}_4$
5th April	$2\frac{1}{2}$ cwt.	$11\frac{1}{4}$ cwt. $(\text{NH}_4)_2\text{SO}_4$

(c) *Results.*—The response to both nutrients was similar to that obtained in experiment I. and total yields from the three harvests showed both nutrients to be significant at the 0.1 per cent level. The optimum level for each nutrient was $1\frac{1}{2}$ cwt./acre.

	K ₀	K _{1½}	K ₃	K _{4½}	Total
P ₀	18.79	22.55	25.54	24.98	91.86
P _{1½}	24.82	30.88	30.03	36.34	122.07
P ₃	23.39	30.98	37.10	42.70	134.17
P _{4½}	24.06	34.29	33.21	32.54	124.10
Total	91.06	118.70	125.88	136.56	472.20

	1%	0.1%
Minimum difference for significance at Main effects	17.80	24.60
Interaction	8.95	12.30

Table IV—Experiment II—Showing total yield from the three harvests.

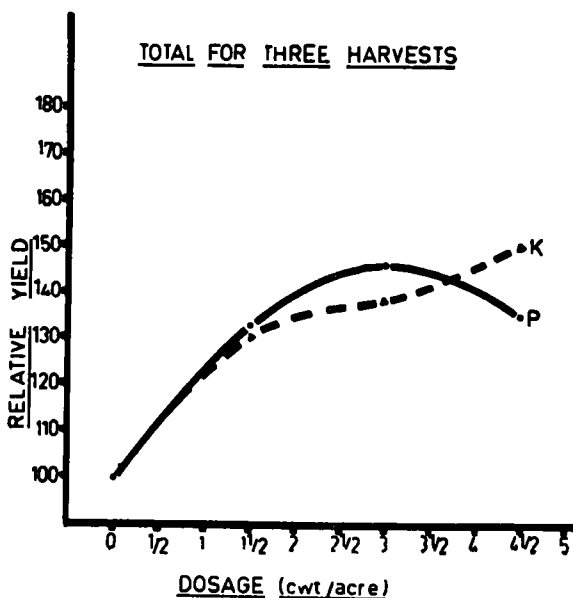


Fig. IV

Discussion.—In the first harvest neither nutrient had any significant effect. The lack of any response to K. was in conformity with Experiment I, but it was somewhat surprising to find no significant effect from P.A trend towards increased yields (max. at P₃) was however clearly apparent; (Fig. VII) and non-significance could be attributed to fewer degrees of freedom.

		K ₀	K _{1½}	K ₃	K _{4½}	Total
P ₀	..	6.14	7.25	10.32	8.42	32.13
P _{1½}	..	13.89	9.11	8.71	12.65	44.36
P ₃	..	12.40	11.90	11.35	15.27	56.68
P ₆	..	12.23	15.12	15.97	13.02	50.58
<i>Total.</i>	..	44.66	43.38	46.35	49.36	183.75

		1%	0.1%
Minimum difference for significant at Main effects..	..	20.86	28.83
Interaction..	..	10.43	14.41

Table V—Experiment II—Showing total yields from the 1st harvest.

		K ₀	K _{1½}	K ₃	K _{4½}	Total
P ₀	..	7.77	9.56	8.85	10.83	37.01
P _{1½}	..	8.01	14.42	12.72	14.13	49.28
P ₃	..	9.45	12.28	14.58	14.90	51.21
P _{4½}	..	9.50	12.11	11.37	13.15	46.13
<i>Total</i>	..	34.73	48.37	47.52	53.01	183.64

		1%	0.1%
Minimum difference for significance at Main effects..	..	9.51	13.15
Interaction..	..	4.74	6.55

Table VI—Experiment II—Showing yields from the 2nd harvest.

In later harvests there were even less effect from P₁ but again a steadily increasing effect from K.

		K ₀	K _{1½}	K ₃	K _{4½}	Total
P ₀	..	4.88	5.74	4.37	5.73	20.72
P _{1½}	..	2.92	7.35	8.60	9.56	28.43
P ₃	..	1.54	6.80	8.95	8.99	26.28
P _{4½}	..	2.33	7.06	8.09	9.91	27.39
<i>Total</i>	..	11.67	26.95	30.01	34.19	102.82

		1%	0.1%
Minimum difference for significance at Main effects	..	11.55	15.96
Interaction	..	5.74	9.94

Table VII—Experiment II—Showing yields from the 3rd harvest.

In this experiment a smaller dose of potassium ($K_{1\frac{1}{2}}$) gave optimum yields, and there were no significant differences between $K_{1\frac{1}{2}}$ and K_3 . Hence it is likely that under practical conditions the optimum dosage would be $\sim 1\frac{1}{2}$ cwt. K_2SO_4 /acre.

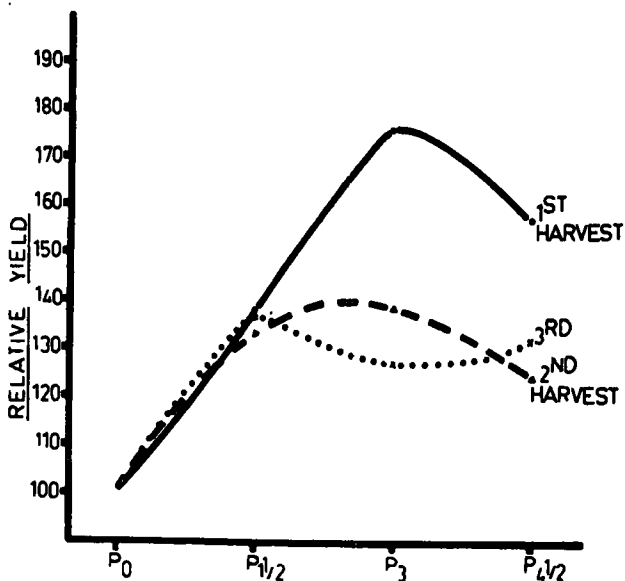


Fig. V

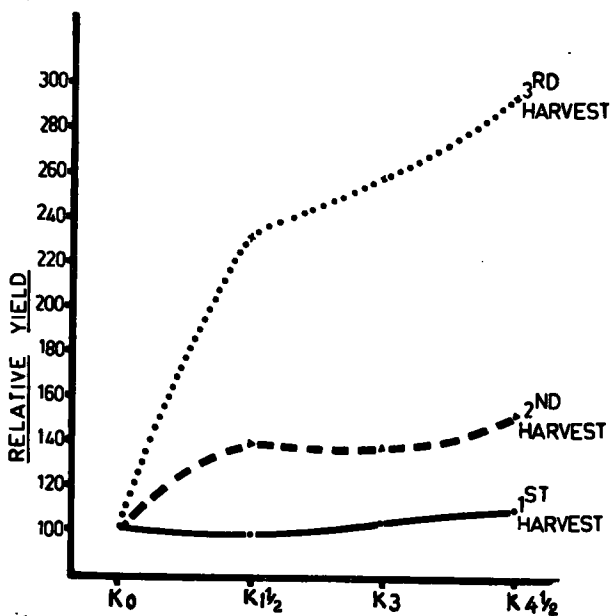


Fig. VI

3. Summary and Conclusions

- (a) Two factorial experiments to determine the optimum dosage of nutrients that are deficient in the forest soil at Ambakelley are described.
- (b) The results of the preliminary experiments with this soil (deficiency of N. P. and K.) are confirmed.
- (c) In successive harvests there was a very big and increasing response to N. and the amounts of nitrogen applied greatly exceeded the N. contents of plants grown. It is suggested that repeated small dosage with $(\text{NH}_4)_2\text{SO}_4$ would be a more efficient technique for maintaining an adequate supply of available nitrogen.
- (d) The optimum response to phosphorus was obtained from application of $1\frac{1}{2}$ cwt./acre of $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$. Equivalent amounts of other forms of phosphatic fertilizers should have similar effects.
- (e) An application of $1\frac{1}{2}$ cwt. of K_2SO_4 was sufficient to meet all requirements for plant growth.

4. Acknowledgements

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5. Bibliography

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Legend to Figures

- Fig. I — Experiment I — Response to the various levels of nitrogen at successive harvests.
- Fig. II — Experiment I — Response to the various levels of phosphorus at successive harvests.
- Fig. III — Experiment I — Response to the various levels of potassium at successive harvests.
- Fig. IV — Experiment II — Response to the various levels of P. and K. (Total yield from the three harvests).
- Fig. V — Experiment II — Response to the various levels of phosphorus at successive harvests.
- Fig. VI — Experiment II — Response to the various levels of potassium at successive harvests.