

Fertiliser Studies with Potatoes — (*Studies on the reduction of manure without detriment to crop yield or the productivity of the soil*)

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Introduction: The potato cultivation in this State, unlike in most of the other States, is confined mainly to the hills of Nilgiris, barring some few hundreds of acres in Kodaikanal and Hosur. The climate of the Nilgiris being equitable and mild, the potatoes can be grown throughout the year. However, the most favourable season is March to June. The total area as per the latest available statistics is about 19,500 acres with an yield of over 52,000 tons. The area under cultivation has steadily been increasing since 1923-'29 when it was fluctuating between 8,111 and 8,644 acres. In 1930-'31 it was 10,600 acres but rose gradually to 15,400 acres in 1937-'38 and to 19,500 in 1945-'46 which level is being maintained at present. The object of the experiment was to study the possibilities of reducing the dosage of manure for growing potatoes in the Nilgiris without impairing the efficiency of yields or the productive capacity of the soil.

Soil Condition: The soils of the Nilgiris are of laterite origin. They are open soil though the clay content is high, deficient in lime (0.04 to 0.09%), and are acidic, pH ranging from 4.5 to 5.2. The sesquioxide content is very high, iron and alumina varying from 7 to 10% and 11 to 15% respectively. These and the lateritic nature of the soils render the added phosphate unavailable and therefore require large doses of it.

Further, the slopes on which potato is grown coupled with high rainfall results in washing out of the soluble manures and hence high doses of manures have to be applied to secure good yields. Therefore, experiments were designed to cut down the manurial bill without impairment of either the yields or the productive potentiality of the soils.

Materials and Method: The Great Scot variety of potato which is the most popular and high yielding one on these hills, was grown.

Treatments:(a) *Two rates of nitrogen application:*

(1) 40 lb. of nitrogen per acre in the form of ammonium sulphate and groundnut cake.

(2) 80 lb. of nitrogen per acre as above.

(b) *Three levels of P_2O_5 and no phosphoric acid:*(1) No P_2O_5 application.(2) 40 lb. of P_2O_5 in the form of superphosphate and bone meal.

(3) 120 " " "

(4) 200 " " "

(c) *Lime vs. No lime application:*

(1) No lime application.

(2) Lime at 2 tons per acre (slaked lime).

(d) *All plots received potash at 100 lb. K_2O per acre as potassium sulphate.*

This was a complex manurial experiment of $2 \times 4 \times 2 = 16$ treatments. Each treatment was replicated 8 times resulting in 128 plots. Each plot consisted of 6 rows—20 feet in length by 12' width or 0.55, cents in area. All the plots received a basal dressing of 5 tons of cattle manure at the time of preparation of the field for the lay out. There were two series of plots in the same field with identical treatments so that in three seasons, three crops of potato could be raised with the usual rotation followed on the hills:—

	Series I	Series II
I year:	potato — Lupin	Samai — Lupin
II year:	samai — Lupin	Potato — Lupin
III year:	potato — Lupin	Samai — Lupin

Soil Analyses: Samples of soils from the field were taken at three depths viz. 0–12", 12"–24" and 24" to 36" before the beginning of the experiment in 1949 for complete mechanical and chemical analyses (vide table III). The soil contained on an average 0.167% of nitrogen, 0.013% of available P_2O_5 and 0.0096% of available K_2O with a total lime content of 0.114% and organic carbon content of 1.77%. The soil reaction was pH 5.52.

Samples of soils were also collected from all the plots immediately after the harvest of potatoes in all the three years and

analysed for nitrogen, total lime, total and available P_2O_5 , organic carbon and pH. The methods as described in A. O. A. C. was adopted for all analyses except for organic carbon for which Walkley and Black's method was adopted.

Results: Three crops of potatoes were raised during the three years of trial. The yield data are presented in table I. The statistical interpretation of the yields are given in table II. The data on the analysis of soil samples taken after the harvest of the potatoes to study the changes in the productive capacity of the soil are presented in tables IV and V. The formula of the usually prescribed manure applied to potatoes, known as the Nanjanad mixture, is given below:—

Groundnut cake 500 lb.; Ammonium sulphate 200 lb.; Concentrated super 336 lb.; Steamed bone meal 224; Potassium sulphate 224 lb.

The first crop of potatoes raised in 1949 gave an average yield of 15,240 lb. per acre in the plots receiving 80 lb. nitrogen, 200 lb. phosphoric acid and 100 lb. potash, which is the control used for comparing the yields when the different ingredients were reduced systematically. From the yield data it is seen that (1) the effect of liming was not in any way significant on the yields. In fact lime had a depressing effect on the high levels of phosphoric acid and nitrogen. Eighty pound dose of nitrogen proved superior to 40 lb. dose of the same. The yield response to phosphoric acid increased proportionately with higher doses of the ingredient. However, there was no significant variations in yield due to the various combinations of the manurial ingredients used.

The second crop raised in 1950 gave a poor yield due to the failure of seasonal rains. The yield recorded in the whole of the Nilgiris was generally low. The average yield of potatoes receiving the maximum quantity of nitrogen and phosphoric acid was only 8,860 lb., a figure about 56% of the first year's yield from plots receiving similar treatments. The yield was statistically significant to the main effects of phosphoric acid and its interactions with nitrogen only. The effect due to other treatments were not significant. In the second year also the yield due to phosphoric acid increased with the dosage.

The third crop of potato planted in 1951 gave an average yield of 10,000 lb. per acre in the plots receiving the Nanjanad

mixture. The data reveal that higher doses of nitrogen in combination with the higher doses of phosphoric acid have given increased yields. There are indications that when the level of nitrogen was low, lime had better influence. This is evidently due to the effect of lime in rendering the insoluble organic nitrogen present in the soil to nearly 0.2% available to the growing crop. Again it was seen that phosphoric acid gave increased yield as the dosage was raised.

The statistical examination of the yield data revealed that there was significance for the main effects of nitrogen and phosphoric acid only. The effects due to other treatments were not significant. Limed plots did not give any better yield than the unlimed plots.

Soil analyses indicate that the fertility status of the soil after potato harvest had improved. There was not much variation in the different treatments. The summary of results are given in table VI.

Conclusions: From the three years trials the following conclusions may be drawn. (1) The higher the dose of nitrogen the greater is the yield of potatoes. (2) The yield of potatoes increases with the increase in dosage of phosphoric acid. (3) Lime by itself or in conjunction with either nitrogen or phosphoric acid does not influence to any great extent the yield of potatoes. (4) There is no indication to show that there was any impairment to the fertility status of the soil after a crop of potato.

Summary: (1) Experiments were conducted with potatoes to see the yield relationship with the different levels of nitrogen and phosphoric acid alone and, in combination with lime, for three years.

(2) The tangible conclusion derived from the trials is that the Nanjanad mixture with 80 lb. of nitrogen, 200 lb. of phosphoric acid and 100 lb. of potash seems to contain the minimum of ingredients necessary for good yield of potatoes on the hills and no further reduction in either the nitrogen or phosphoric acid seems possible consistent with good yields.

(3) Lime, even at two tons per acre, which would tell on the cost of manuring to a high degree, never gave any sizable increase in the crop yield and hence seems unnecessary in the existing scheme of manurial practice

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TABLE I. Average yield of potatoes in the different series during the three years of experiments

Treatment (Ingredients in lb. per acre)			1949 — '50		1950 — '51		1951 — '52	
Nitro- gen	Phosphoric acid	Potash	Un- limed	Limed	Un- limed	Limed	Un- limed	Limed
80	200	100	15,240	13,880	8,660	7,865	11,450	10,718
80	120	100	14,280	14,340	6,705	7,956	9,850	10,442
80	40	100	12,580	11,360	7,342	7,478	9,707	9,137
80	0	100	8,908	10,070	4,999	4,000	7,051	7,341
40	200	100	14,010	15,250	6,887	7,820	9,661	10,273
40	120	100	13,140	13,900	6,842	8,569	9,160	10,436
40	40	100	11,140	10,470	5,862	6,744	7,992	8,124
40	0	100	7,745	9,051	5,047	6,138	6,188	7,380

TABLE II. Complex Manurial Experiments—(Potatoes) Summary of Results
FIRST YEAR (1949—1950) LIME VERSUS NO LIME

Particulars	Mean Yield of Potatoes		General Mean	S. E. of Treatment	Whether Significant or Not	Critical Difference P = 0.05
	Lime	No lime				
Yield in Pounds per acre	.. 12,290	12,130	12,210	253.4	No	—
As percentage on general mean	.. 100.7	99.3	100	—	—	—
As percentage on control	.. 101.4	100	—	—	—	—
Conclusions: Yields Not significant for lime.						
NITROGEN						
Particulars	Mean Yield of Potatoes		General Mean	S. E. of Treatment	Whether Significant or Not	Critical Difference P = 0.05
	1N	2N				
Yield in Pounds per acre	.. 11,840	12,530	12,210	253.4	Yes	710.9
As percentage on general mean	.. 96.9	103.0	100	—	—	—
As percentage on control	.. 100	106.3	—	—	—	—
Conclusions: 2N, 1N.						

TABLE II (Contd.)
PHOSPHORIC ACID

Particulars	Mean Yield of Potatoes				G. M.	S. E.	Significant or Not *P = 0.05	C. D.
	OP	1P	3P	5P				
Yield in Pounds per acre	9,910	11,300	13,920	14,600	12,455	358.3	Yes	852.3
As percentage on general mean	79.5	91.4	111.7	117.1	100	—	—	—
As percentage on control	100	111.9	140.5	147.3	—	—	—	—

Conclusions: 5P, 3P, 1P, OP

SECOND YEAR (1950—1951) The yield in the experiment was significant for the main effect of P₂O₅ and its interaction with nitrogen. All other main effects and interactions were not significant.

PHOSPHORIC ACID

Particulars	Mean Yield of Potatoes				G. M.	S. E.	Significant or Not	C. D.
	OP	1P	3P	5P				
Yield in Pounds per acre	5,224	7,119	7,784	8,093	6,811	304	Yes	852.3
Percentage on G. M.	76.7	104.5	114.3	118.8	100	—	—	—

Conclusions: 5P, 3P, 1P, OP

TABLE II (Contd.)
 THIRD YEAR (1951-1952) Experiment significant for main effects of nitrogen and phosphoric acid only.
 PHOSPHORIC ACID

Particulars	OP	IP	3P	5P	G. M.	S. E.	Significant or Not	C. D.
Yield in pounds per acre	.. 6,982	7,993	8,217	9,181	8,092	275.0	Yes	824.4
Percentage on general mean	.. 86.3	98.8	101.5	113.5	100	—	—	—
Conclusions: 5P, 3P, <u>1P</u> , OP								
NITROGEN								
Particulars	IN	N2	G. M.	S. E.	Significant or Not	C. D.		
Yield in pounds per acre	.. 7,257	8,928	8,092	184.0	Significant	573.2		
Percentage on general mean	.. 89.8	110.4	100	—	—	—		
Conclusion: 2N, IN								

TABLE III. Showing the results of soil analysis of the Experimental Plots, Agricultural Research Station, Nanjanad (Nilgiris)

Serial No.	HEADS OF ANALYSIS	Major Plot 1 0-12"	Major Plot 2 0-12"	Major Plot 3 0-12"	Major Plot 4 0-12"
MECHANICAL COMPOSITION					
1.	Clay	56.82	63.39	59.48	49.52
2.	Silt	17.50	16.70	14.09	16.16
3.	Fine sand	8.97	8.39	8.66	8.18
4.	Coarse sand	16.85	13.59	17.95	24.19
	Total	100.14	101.07	100.18	98.05
CHEMICAL COMPOSITION					
1.	Loss on ignition	11.70	11.94	13.46	15.78
2.	HCl insolubles	57.85	56.58	55.46	51.76
3.	Al ₂ O ₃	18.50	19.92	19.52	20.65
4.	Fe ₂ O ₃	10.87	10.54	10.43	10.17
5.	CaO	0.135	0.115	0.104	0.10
6.	MgO	0.285	0.388	0.254	0.20
7.	K ₂ O	0.679	0.706	0.414	0.307
8.	Na ₂ O	0.253	0.283	0.141	0.20
	Total	100.27	100.47	99.78	99.18
9.	So ₃	0.024	0.068	0.067	0.08
10.	P ₂ O ₅ (total)	0.187	0.191	0.196	0.18
11.	Nitrogen	0.177	0.134	0.154	0.20
12.	Available K ₂ O	0.014	0.008	0.007	0.01
13.	Available P ₂ O ₅	0.008	0.007	0.019	0.017
14.	pH	5.33	4.93	5.80	5.91

TABLE IV. Summary of Results of Post-Harvest Soil Analysis—1949—1950—Surface Soils (percentages)

Treatment Pounds Ingredient per acre	UNLIMED SERIES						LIMED SERIES							
	pH	Nitrogen %	Total P ₂ O ₅ %	Avail- able P ₂ O ₅ %	Limo %	Organic Carbon %	pH	Nitrogen %	Total P ₂ O ₅ %	Avail- able P ₂ O ₅ %	Lime %	Organic Carbon %		
N														
40 ÷	0 ÷	100	5.04	0.193	0.185	0.021	0.137	1.81	5.28	0.161	0.176	0.023	0.217	1.91
40	40	100	5.08	0.207	0.171	0.015	0.156	2.00	5.36	0.164	0.182	0.010	0.177	2.13
40	120	100	5.06	0.192	0.173	0.020	0.120	1.88	5.45	0.184	0.197	0.016	0.174	2.27
40	200	100	5.22	0.182	0.272	0.022	0.157	2.24	5.36	0.192	0.208	0.020	0.193	2.14
80	0	100	5.25	0.206	0.207	0.022	0.141	2.25	5.28	0.199	0.184	0.034	0.197	2.63
80	40	100	5.24	0.202	0.243	0.022	0.211	2.50	5.14	0.180	0.202	0.021	0.198	2.30
80	120	100	5.28	0.199	0.191	0.024	0.136	2.27	5.31	0.189	0.194	0.023	0.252	2.29
80	200	100	5.29	0.180	0.168	0.023	0.190	2.22	5.08*	0.167	0.193	0.016	0.203	1.74
Average	..	5.20	0.195	0.221	0.021	0.156	2.00	5.10	0.180	0.192	0.022	0.201	2.10	

TABLE V. Summary of results of post harvest soil analysis 1950 — '51 surface soil

Treatment Pounds ingredients per acre	UNLIMED SERIES (Percentages)					LIMED SERIES (Percentages)							
	N ÷ P ₂ O ₅ ÷ K ₂ O	pH	Nitro- gen	Total P ₂ O ₅	Available P ₂ O ₅	Lime	Organic carbon	pH	Nitro- gen	Total P ₂ O ₅	Available P ₂ O ₅	Limo	Organic carbon
40 0	100	4.92	0.173	0.231	0.018	0.154	1.56	5.00	0.154	0.200	0.014	0.201	1.96
40 40	100	5.00	0.168	0.173	0.021	0.163	1.43	5.18	0.170	0.204	0.015	0.196	1.77
40 120	100	5.08	0.151	0.208	0.014	0.137	1.36	5.64	0.160	0.157	0.020	0.193	1.62
40 200	100	5.20	0.141	0.172	0.020	0.181	2.00	5.30	0.135	0.201	0.017	0.157	1.51
80 0	100	5.40	0.160	0.219	0.014	0.187	1.60	4.50	0.150	0.206	0.013	0.196	1.90
80 40	100	5.18	0.165	0.190	0.016	0.200	1.75	5.00	0.128	0.161	0.018	0.187	1.87
80 120	100	4.99	0.159	0.186	0.013	0.152	1.48	5.20	0.160	0.190	0.016	0.198	2.01
80 200	100	5.34	0.164	0.197	0.011	0.142	1.95	5.10	0.161	0.193	0.012	0.200	1.68
Average		5.15	0.156	0.200	0.016	0.190	1.70	5.11	0.152	0.190	0.016	0.191	1.80

TABLE VI. Showing the results of soil analysis both before and after cropping — average values

Heads of analysis	PRE-CROPPING		POST HARVEST SAMPLES				Total %
	Available %	Total %	Available %	Lime series Available %	No lime series Available %	Total %	
(1) Nitrogen		0.167				0.167	0.180
(2) Phosphoric acid	0.013	0.190	0.019		0.011	0.191	0.210
(3) Lime (CaO)	..	0.114	0.196	0.173
(4) pH		5.52		5.10			5.18
(5) Organic carbon		1.77				1.95	1.85

Increase in fertility status after harvest of potatoes.		Percent
Nitrogen		0.013
Phosphoric acid (available)		0.0064
" total		0.020
Lime		0.082
Organic carbon		0.18