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MANURIAL EXPERIMENT ON GROUNDNUT*

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Introduction.

Manurial experiments on groundnuts do not appear to have been conducted to any great extent in India, even though the crop attained commercial importance and occupied an area of two million acres as early as 1914 and over 8 million acres during 1938. The latest area statistics show that the acreage under groundnuts in India is roughly 7 millions. The few isolated experiments that were conducted in some of the Provinces indicate that the response of groundnuts to fertiliser application is to a large extent influenced by the nature and availability of plant food in the soil. On the black cotton soils of Bombay Presidency and the Central Provinces, nitrogenous manures are reported to have had no effect on the yield of groundnut(10) †. At Akola Experimental Station in Central Provinces, a definite response to the application of potassium sulphate has been obtained(10). On the Hebbal Farm in Mysore State, a combination of potassic and phosphatic manures has been found to be the best for application to red sandy loams (9). In Burma, in light sandy loam — alkaline and poor in all essential elements of plant food — nitrogenous manures alone have been found to have enhanced the yield(10).

Experiments conducted at Rhodesia have shown that nitrogenous fertilisers are not beneficial to groundnuts and that the response to phosphates is little unless the soil is of low fertiliy (1). Application of wood ash has resulted in increased yield and oil content in Philippine Islands (6). In North Carolina it has been found that potash is most essential for profitable production(3, 4 and 11). At Georgia Coastal Plain Station, the need for a complete fertiliser for peanuts was evident, but on lands having leguminous green manure turned under nitrogen was reported to have had no effect, while potassium and phosphorus profitably increased the yields(7). At the Georgia Experiment Station also, best increase in yield was obtained on most soils with a complete fertiliser mixture (5). In Florida no profitable response was found either with single elements or their combinations(8). Comparatively large quantities of potash were required on the light soils of the Virginia Experiment Station(2).

The results of the manurial experiments on groundnut being thus varied it was considered desirable to conduct a well laid out experiment which included N, P and K and all their combinations in Madras

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† The numbers within brackets refer to Literature citations.

Presidency which claims about 50% of the area under the crop in India, in the Scheme of Research on Groundnuts financed by the Indian Council of Agricultural Research.

2. Location of the Experiment.

The trials were conducted at the Agricultural Research Station, Tindivanam for three successive years from 1937—38 to 1939—40, during the main rainfed season extending from July to December in each year. The Station, which is mainly intended for research work on groundnuts, is located in South Arcot District — the premier groundnut growing tract of the Madras Presidency.

(i) *Soil.* — The soil of this Station is typical sandy loam and is representative of a large portion of the groundnut tract of the Presidency. Soil depths vary from about 12 to 18 inches with an underlying layer of weathered rock and *Kankar* through which the roots of groundnuts do not readily penetrate. Chemically the soil is poor in organic matter and nitrogen as can be expected of sandy soils. It is also poor in phosphoric acid and potash contents. Lime is present in fair quantity in the upper layer of the soil and especially in the subsoil it is more pronounced. The figures of chemical analysis of the soil where the experiment was conducted are given below:—

		(Percent)
Moisture.	...	2·38
Loss on ignition.	...	1·88
Insolubles.	...	89·09
Iron.	...	5·24
Alumina.	...	1·95
Lime.	...	0·51
Magnesia.	...	0·26
Potash.	...	0·08
Phosphoric acid.	...	0·003
Soda.	...	0·23
Sulphuric acid.	...	0·004
Carbon—dioxide.	...	0·177
	Total ...	99·424
Nitrogen.	...	0·029
Available Potash.	...	0·003
"	...	0·0003
pH value.	...	8·27

(ii) *Rainfall.* — In the South Arcot District, groundnut is sown immediately after the receipt of the south—west monsoon rains in July—August and is harvested with the closing rains of the north—east monsoon in December. The crop depends for its successful growth and yields on the even distribution of the two monsoons. In the three years the manurial experiment was in progress, the rainfall and its distribution have not been quite normal and were different from year to year with its consequent effect on yield. In 1937—38, the south—west monsoon broke out late in August and was characterised by heavy precipitations in the initial stages. The monsoon weakened later resulting in a period of

drought which in its wake brought about a severe insect attack by *Stomopteryx nerteria*. The heavy north—east monsoon affected the setting of pods and the yields were low averaging to only 800 lb. of pods per acre. In the second year, the sowing rains were received towards the end of July and south—west monsoon was well distributed. The north—east monsoon failed completely in the beginning and the few showers received late in the season totalled to only about 6 inches as against an average of 24 inches. The crop, however, put forth a second flush with the later rains and gave an acre yield of 1200 lb. of pods. In 1939—40, the monsoon was delayed till the second week of August. The north—east monsoon broke out towards the middle of September and proved normal both in the incidence of rainfall and its distribution. The yield averaged to 1,800 lb. of pods per acre. The actual rainfall received during the three cropping seasons is given in Table I.

Table I. Rainfall from Sowing to Harvest, Agricultural Research Station, Tindivanam.

Period in weeks.		1937—'38.		1938—'39.		1939—'40.	
		No. of Rainy days.	Rainfall in inches.	No. of Rainy days.	Rainfall in inches.	No. of Rainy days.	Rainfall in inches.
July–Aug.	26— 1						
	2— 8					*Sown on 10-8-'39.*	
	9—15			*Sown on 16-8-'38.*		4	1·23
	16—22	*Sown on 24-8-'37.*		4	3·79	–	—
	23—29	1	3·30	2	0·13	–	—
Aug–Sep.	30— 5	3	1·09	1	0·27	1	0·12
	6—12	1	0·05	4	3·53	–	—
	13—19	1	1·15	2	1·18	2	2·70
	20—26	3	3·00	4	0·28	5	0·46
Sep–Oct.	27— 3	4	8·17	1	0·94	2	1·93
	4—10	2	0·45	1	0·04	1	0·17
	11—17	3	1.32	–	—	7	8·43
	18—24	1	0·28	1	0·10	4	0·67
	25—31	7	2·23	5	2·12	3	0·97
November.	1— 7	6	6·47	1	1·07	4	3·26
	8—14	3	5·52	–	—	6	1·83
	15—21	3	13·49	–	—	4	6·64
	22—28	–	—	1	0·12	–	—
Nov–Dec.	29— 5	2	0·56	–	—	–	—
	6—12	3	3·35	2	0·99	–	—
	13—19	1	0·14	–	—	1	0·24
	20—26	2	0·16	–	—	–	—
Dec–Jan.	27— 3	1	0·18	–	—	–	—
	4—10	–	—	1	0·14	2	0·11
	11—17	–	—	4	0·51	–	—
	18—24	*Harvested on*		*Harvested on*		*Harvested on*	
	25—31	22—1—1938.		11—1—1939.		18—1—1940.	
Total.		47	50·91	34	15·21	46	28·76

3. Experimental Details.

(i) Treatments. — The experiment was designed on an N, K, P basis and included combinations of them with and without a basal dressing of cattle manure. The different treatments and the rates of application of the different manures are given hereunder:

Sub-block (i)	*Sub-block (ii)*
Without a basal dressing of cattle manure.	With a basal dressing of cattle manure at the rate of three tons of cattle manure (loose box) per acre, i. e., 50 lb. N per acre.
CONTROL.	CONTROL.
n	*n*
p	*p*
k	*k*
np	*np*
nk	*nk*
pk	*pk*
npk	*npk*

Doses per acre:—

N.	11 lb.	about ½ cwt. of ammonium sulphate.
P_2O_5	42 lb.	about 2 cwt. of superphosphate (ordinary)
K_2O	54 lb.	about 1 cwt. of potassium sulphate.

(ii) Layout. — A split plot design randomised block layout replicated five times was adopted. The position of the sub-blocks receiving cattle manure within each block was fixed by randomisation. The eight treatments were also allocated at random in each sub-block. The gross size of plot was 60′ x 4½′ and the ultimate size at harvest after the rejection of border rows all round was 58½′ x3′ or 1/248 of an acre.

Between plots, a foot and half wide bund was raised and at the lower end of each plot a small outlet opened into a drainage channel. Manures were weighed correct to a gramme and applied uniformly to the well cultivated plot just before sowing and incorporated into the soil by working a hand junior hoe. The improved variety A. H. 25 (TMV.I) was sown with a spacing of 9″ either way.

The experiment was run for three seasons during 1937—38, 1938—39 and 1939—40. A field 2·40 acres in extent was divided into three portions for this purpose and one portion utilized for each year's experiment. The variation in the fertility of the land used for the three successive years was thus kept at a minimum.

4. Results and Discussion.

The effects of the different treatments on yield, vegetative development of plants, flowering and fruiting and the various qualitative characters of the produce are discussed below :

(*i*) *Yield.* — The yield of well-dried pods under the different treatments in each of the years of the experiment is given in Table II.

Table II. Acre yield of pods in pounds.

Year.	Details.	No manure.	*n*	*p*	*k*	*np*	*nk*	*pk*	*npk*	Average.
1937-'38.	Sub-block without cattle manure ...	752	782	760	749	725	817	857	854	786
	Sub-block with cattle manure ...	728	686	801	802	763	797	806	866	781
	Average	740	734	780	775	744	807	831	860	784
1938-'39.	Sub-block without cattle manure ...	1119	1191	1110	1170	1179	1248	1209	1240	1183
	Sub-block with cattle manure ...	1227	1244	1227	1311	1269	1294	1336	1286	1274
	Average	1172	1218	1168	1241	1224	1271	1272	1263	1229
1939-'40.	Sub-block without cattle manure ...	1659	1652	1765	1793	1849	1827	1917	1928	1799
	Sub-block with cattle manure. ...	1714	1922	1991	1827	1965	1911	1933	1944	1901
	Average	1687	1786	1878	1809	1807	1969	1925	1936	1850

It is found that annual variations in yield have been very pronounced in this series of experiments. The average yield per acre of all the plots was 784 lb. in 1937-38, 1229 lb. in 1938—39 and 1850 lb. in 1939—40.

The yield data were statistically analysed every year. Except for P and K in the first and third years and K alone in the second year, all the other main effects and interactions did not attain the level of significance, A summary of the results in terms of main effects and interactions is furnished in Table III.

Table III. Main Effects and Interactions in pounds per acre.

Effect	1937—38	1938—39	1939—40	Three-year Average.
n	4·4	30·3	50·0	28·2
p	40·0*	6·4	123·4*	56·6
k	69·0*	66·2*	70·5*	68·6
np	–8·3	–7·3	–30·4	–15·3
nk	25·7	–20·0	–14·6	–3·0
pk	14·8	5·2	–32·5	–4·2
npk	6·9	–12·3	5·6	0·1
Standard error	19·4	18·1	32·5	13·1
Critical difference (P = 0. 05) 38·0	38·0	35·5	63·8	

* Significant at 5 per cent level.

A substantial response to potash is indicated in all the years. In 1937—38 it has given an average increase in yield of 69 lb. per acre, in 1938—39, 66 lb., and in 1939—40, 71 lb., the three—year average being 69 lb. Phosphate gave 40 lb. per acre in 1937—38 and 123 lb. in 1939—40. In 1938—39, however, the response was very low. The average increase in yield due to phosphate during the three-year period came to 57 lb. per acre.

In order to examine as to how far the conclusions of the separate seasons can be regarded as generally true for the locality in question a combined analysis of the three years' data was also carried out. The results were more or less in conformity with the inferences drawn from the results of individual years. A significant *phosphate* x *years* interaction was also obtained showing a marked differential response of phosphate to seasons. Probably the yield response of groundnuts to phosphate is dependent upon the receipt of adequate and well-distributed rainfall during the period of crop-growth. In the year 1938—39 when no significant effect due to P was noticeable the rainfall received during the crop season was very low and badly distributed. By far the major effect on yields was found to be due to the season.

To sum up K is found beneficial. Application of P has failed to supplement the yields in certain seasons. N does not appear to be of any advantage. Cattle manure, which was applied as basal dressing though it failed to show any significant effect on yield, seems to exert some beneficial effect in years of deficient rainfall.

(ii) Vegetative growth. — To study the effect of the different treatments on vegetative growth, measurements of the length of main axis and primaries, and counts of nodes for 25 plants per treatment were noted at flowering, two months after flowering, and at harvest time. No appreciable difference in growth of plants under the treatments could be detected.

(iii) Flowering and fruiting. — Fifty plants under each treatment were observed for daily flower production. These were separately harvested and counts of undeveloped 'pegs' (gynophores), 'tender pods', 'immature pods' and 'good pods' were made. The average number of flowers, total number of good pods, percentage of setting of good pods in individual treatments were worked out. The data are furnished in Table IV.

Table IV—Manurial experiment on Groundnut 1937—38—1939—40 Flowering and Fruiting Studies.

	1937-'38.				1938-'39.				1939-'40.			
	Average No. of Flowers.	Average No. of good pods.	Percentage of fertilisation.	Percentage of setting.	Average No. of Flowers.	Average No. of good pods.	Percentage of fertilisation.	Percentage of setting.	Average No. of Flowers.	Average No. of good pods.	Percentage of fertilisation.	Percentage of setting.
No manure.	22·6	5·2	49·2	25·2	39·6	8·3	49·1	19·5	36·2	10·7	42·2	25·8
n	25·8	5·6	43·8	21·6	47·7	8 9	40·0	17·5	33·9	10·5	48·7 *	32·7 *
p	28·7	5·0	43.3	24·6	41·0	8·0	48·7	18·8	34·7	9.8	51·5 *	34·3 *
k	24·1	5·0	42·1	21·3	48·9	8·4	42·9	18·6	34 3	11·5	47·4	31·2 *
np	25·1	5·4	42·7	21·2	44·8	9·2	48·0	20·2	41·3	10·3	42·3	29 6
nk	26·3	5·0	47·5	25·3	44·4	9·5*	47·9	19·6	38·9	11·5	43·3	27·7
pk	27·9	5·7	45 0	22·7	47·2	8·6	44·9	18·4	39·8	11·8	43·6	30·3 *
npk	25·2	6·0	45·1	24·9	47·1	9·1	45·6	18·6	40·0	8·7	46·8	31·6 *
cm	19·7	5·0	40·1	22·9	47·6	9·3	49·3	20 9	33·4	11·0	50·6 *	33·5 *
cm + *n*	20·7	4·5	36 8	21·7	44·8	7·8	48·8	18·6	38·2	11·0	48·1	31·8 *
cm + *p*	22·8	5·6	28·8	17·6	48 0	9·0	47·0	19·5	36·8	10·5	50·7 *	33·0 *
cm + *k*	23·6	5·0	41·9	20 9	50·0	9·3	45·5	17·2	37·0	10·8	48·5 *	30 4 *
cm + *np*	24·3	5·2	38·1	21·6	47·9	10·1*	50·4	20·5	38·1	11 0	47·0	31·1 *
cm + *nk*	21·8	5·5	38·9	18·9	48·9	9·6*	46·8	21·5	40·1	11·1	48·8 *	30·2 *
cm + *pk*	21·1	5·5	37·0	20·3	49·3	9·1	48·2	18·0	36·0	11·0	51·3 *	31·8 *
cm + *npk*	23·7	5·9	43·7	23'9	54·3	10·1*	44·6	19·3	43·0*	10·8	43 6	26·6
Significant or not	No	No	No	No	No	Yes	No	No	Yes	No	Yes	Yes
Critical difference (P = 0·05)						1·18			5·79		6·26	4·38

* Significant over no manure at 5 percent level

Table V. Manurial experiment on groundnut 1937—38 to 1939—40.

QUALITATIVE DETERMINATIONS.

	1937—'38.					1938—'39.					1939—'40.				
	Percentage of kernels to pods.	Natural test weight of 1 M. M. of pods (in gms.)	Natural test weight of 1, M. M. of kernels (in gms.)	No. of kernels per pound	Oil content. (per cent)	Percentage of kernels to pods.	Natural test weight of 1. M. M. of pods (in gms.)	Natural test weight of 1, M, M. of kernels (gms.)	No. of kernels per pound.	Oil content (per cent.)	Percentage of kernels to pods.	Natural test weight 1. M. M. of pods (in gems)	Natural test weight of 1. M. M. of kernels (in gms)	No. of kernels per pound	Oil content (per cent.)
No manure.	71·7	553	1262	1028	51·39	70·1	566	1181	953	48·56	74·5	607	1260	879	49·12
n	71·7	560	1247	1026	51·60	67 2	560	1178	988	49·11	74·7	613	1263	878	48·95.
p	71·7	577	1269	1038	52·13	66·0	563	1174	967	47·94	74·8	612	1257	875	49·63
k	71·6	584	1262	1037	51·69	68·7	566	1176	938	49·78	74·4	614	1260	872	49·14
np	71·6	560	1262	1017	51·89	70·0	558	1176	955	48·98	74 7	612	1259	868	50·12
nk	71·6	577	1262	1023	52·03	70 3	578	1176	957	48·90	73·9	614	1259	877	50·71
pk	71·4	553	1255	1010	52·03	68·4	576	1180	942	49·14	73·9	610	1262	885	50·32
npk	71·5	577	1255	1015	51·91	71·8	555	1174	943	47·77	74·2	611	1258	884	50·69
cm	71·7	577	1255	1050	51·50	69·4	571	1178	936	49·14	74·7	611	1257	898	49·51
cm+n	71·7	577	1262	1032	51·73	71·1	565	1174	959	49·89	74·9	612	1259	884	50·83
cm+p	71·7	577	1262	1023	51·60	72·1	566	1180	957	48·51	75·2	615	1262	872	50.53
cm+k	71·5	584	1255	1030	51·76	69·8	570	1184	950	48·78	75·0	610	1260	906	49·25
cm+np	71.6	584	1262	987	50·55	69·2	571	1180	978	49·31	74·8	612	1258	884	49·73
cm+nk	71·6	577	1262	1012	51·20	68·3	564	1175	970	48·94	74·6	611	1258	880	49·96
cm+pk	71·6	577	1255	1044	51·95	71·0	573	1182	975	48·47	75·1	615	1260	883	50·48
cm+npk	71·6	577	1255	1034	51·61	68·5	564	1176	942	48·32	74·1	617	1260	871	49·95.

(*) M, M. — Madras Measure — It is 108 cubic inches in capacity.

In the first two years of the experiment when the seasons were not normal, the effect of the different treatments on flowering and fruiting phases of the crop was not quite clear. However, in the second year the average number of 'good pods' per plant under *np*, *nk* and *npk* with cattle manure and *nk* without cattle manure showed significant increase over no manure. In the final year of this trial the beneficial effects of cattle manure and its combination with artificials were largely in evidence. The artificials alone and in combinations (excepting *npk*) over a basal dressing of cattle manure have significantly improved the setting of good pods while in the absence of cattle manure, *np* and *nk* proved no better than no manure.

(iv) Qualitative characters. — Qualitative analysis of the produce such as natural test weight (weight per unit volume) of pods and kernels, percentage of kernels to pods by weight (shelling percentage), number of kernels per pound and oil content of kernels for each treatment was carried out in all the three years and the results are given in Table V.

There are no great differences in favour of any manurial treatment. They are almost negligible when compared to the effect due to the season. The differences in the total rainfall and its distribution which have markedly affected the yields have also affected most of the qualitative characters.

5. Economics of Manuring.

The economics of manuring was worked out based on the cost of manures and the value of the produce that prevailed during the prewar period when the experiments were in progress. It was found that the value of the extra produce obtained as a result of the application of manures did not cover the cost of the manures used. The doses adopted in the experiment are also not remunerative even at current rates.

6. Conclusions.

The present series of experiments have been more of a preliminary nature indicating the way for future experiments. Application of potassium sulphate at 1 cwt. per acre has given significant increase in yield but the cost of manuring is not met by the value of the extra produce obtained. Smaller doses of potassium sulphate must be tried to find out if the optimum required is below 1 cwt. per acre. Cheaper sources of potassium must also be explored. Superphosphate has given significant increase in two years and it has increased the flowering and fruiting of groundnut. Its use in future trials, therefore, narrows down to finding the optimum dose per acre. Application of ammonium sulphate has not been found to be beneficial. Cattle manure at 3 tons per acre has not been able to show its beneficial effects on yields. A higher dose may probably result in increased yields, particularly in years of deficient rainfall.

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