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Research Paper

Effect of varietal selection and nutrient management on productivity, soil fertility and economics of summer groundnut (*Arachis hypogaea*)

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ABSTRACT

A field experiment was conducted at research farm of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal, during 3 consecutive summer seasons of 2017, 2018 and 2019, to find out the influence of varietal differences and nutrient-management practices on crop productivity, soil fertility and economics in groundnut (*Arachis hypogaea* L.). The experiment was laid out in a split-plot design with 3 replications. Higher crop growth and yield were recorded under variety 'TAG 24'; and 125% recommended dose of fertilizer (RDF) with *Rhizobium* inoculation resulted higher growth, yield attributes and yield of groundnut followed by 100% RDF + *Rhizobium* inoculation. The nutrient (N, P and K) availability in soil after harvesting was also higher under 'TAG 24' variety with 125% RDF + *Rhizobium*. However, interaction effect of crop variety and fertilizer treatment was found insignificant. The pooled analysis of economics revealed that, higher benefit: cost ratio (2.73) was obtained under 'TAG 24' in combination with 100% RDF+ *Rhizobium*.

Key words: Economics, Fertilizer, Groundnut, *Rhizobium*, Soil fertility, Yield

Oilseeds are considered important commercial crops in our country and India ranks second in oilseed production globally. Oilseeds occupy an important part of our daily dietary nutrition. They are rich in proteins, carbohydrates, lipids, minerals and oils. Despite having large area under cultivation, India imports considerable amount of edible oils. Groundnut (*Arachis hypogaea* L.), among the different oilseeds contributes about 15% of the total vegetable oil production in India (Gharge *et al*., 2017). Recently, with expansion of food and confectionery industries, the demand of groundnut is also increasing. However, groundnut production/unit area is quite low in India

Though area and production of groundnut is higher in the rainy (*kharif*) season, productivity is quite higher in summer season, primarily owing to better utilization of fertilizer and improved cultivation and management practices particularly in marginal and sub-marginal lands where deficiency of different nutrient is predominant (Singh *et al*., 2020); and uncertain and irregular rainfall and prolonged dry spells during the growth period of groundnut during *kharif* and post-*kharif* season (Reddy *et al*., 2023). However, continuous cropping without proper nutrient management practice has led to deterioration of soil fertility, stagnation or even decline in crop production and productivity (Sathiya *et al*., 2020). Use of high analysis chemical fertilizers indiscriminately triggers the deficiency of other nutrients (Singh *et al*., 2020). However, integration of chemical, organic and biological sources of nutrients is the most efficient way to supply plant nutrients for sustained crop production and soil fertility (Dasgupta *et al*., 2017; Haldar *et al*., 2019). Biofertilizers play an important role in crop production, enhancing nutrient-supply capacity of the system (Sen *et al*., 2021; Singh *et al*., 2021). Studies have reported increased oil and protein content with biofertilizer application (Kundu *et al*., 2023).

Development of improved variety may increase the crop production and acts as an alternative method for sustainable crop production (Meena and Yadav, 2015). However, for higher crop production huge amount of inorganic fertilizers is required, which are very costly. Therefore, it is necessary to find out the performance of different groundnut varieties under integrated nutrient management. The main objective of the present study was to evaluate response of 2 groundnut varieties under various levels of nutrient

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management during the summer season. We hypothesized that higher level of fertilizers with biofertilizer would enhance crop nutrient uptake, improve growth and yield of the crop.

MATERIALS AND METHODS

The field experiment was conducted during 3 consecutive summer seasons of 2017, 2018 and 2019 at research farm of the Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal (22°97′ N, 88°43' E, 9.75 above mean sea-level), India. The site receives an average rainfall of 1,450–1,650 mm/annum. The South-West monsoon (June to September months) contributes more than 75% of the annual rainfall. The mean monthly temperature varies between 26.0 and 38.8°C in summer and 10.6 and 25.9°C in winter. The soils of the experimental site were sandy clay loam (sand 64.7%, silt 12.5% and clay 22.8%), with a neutral reaction *p*H of 7.3 and an electrical conductivity of 0.3 ds/m. It contained 0.6% organic carbon (OC), 152.8 kg available nitrogen (N)/ha, 24.3 kg available P_2O_5/ha and 129.2 kg available K_2O/ha. The field was medium in slope having well-irrigation facility.

The experiment was laid out in a split-plot design and replicated thrice. The mainplot consisted of 2 popular and well-established variety of the region, viz. 'TAG 24' (V_1) and 'TG 51' (V_2) and the subplot contained 6 different level of fertilizer , viz. 75% recommended dose of fertilizer (RDF) (F_1), 100% RDF (F_2),125% RDF (F_3), 75% RDF + *Rhizobium*-seed treatment (F_4), 100% RDF + *Rhizobium*-seed treatment (F_5) and 125% RDF + *Rhizobium*-seed treatment (F_6). Recommended dose of fertilizer was applied at the rate of 20 kg N/ha, 60 kg P_2O_5/ha and 40 kg K_2O/ha in the form of urea, single superphosphate and muriate of potash respectively. Groundnut seeds were inoculated with *Rhizobium* inoculant (*Bradyrhizobium arachidis* @ 20 g/kg seed) before sowing in the field. Seeds were sown during the second fortnight of February of each experimental year at a depth of 3–4 cm with row-to-row spacing of 30 cm and seed-to-seed spacing of 10 cm. Other agronomic practices were followed as per the recommended package of practices for groundnut cultivation specified for this agro-ecological zone.

Five plants from each plot were selected randomly for measurement of growth and physiological parameters. Plant height, dry-matter accumulation (g/m^2), number of pods/plant, shelling (%), sound mature kernel percentage (SMK%), 100-kernel weight (g) were measured following standard methods. Crop harvested from the net plot were taken to threshing floor, dried, threshed and weighed to obtain the pod and kernel yield. The harvest index (HI) was calculated as per Donald (1963).

Composite surface soil samples (depth 0-15 cm) were collected each year after harvesting of the crop; dried at 60°C for 72 hours and ground in agate mortar before any chemical analysis. Soil-available N was determined following hot alkaline $KMnO_4$ method (Subbiah and Asija, 1956). Soil phosphorus was measured by Olsen's method (Olsen *et al*., 1954). Flame photometer was used to measure available K in soil (Jackson, 1973).

All the variables were subjected to ANOVA analysis meant for split-plot design (Gomez and Gomez, 1984) in SAS (v.9.3). The standard error of mean (SEm±) and the value of least significant difference (LSD) at 5% level of significance were indicated in the tables to compare the difference between the mean values.

RESULTS AND DISCUSSION

Growth parameters

No significant difference was found between the 2 varieties for the growth parameters (Table 1). Plant height and dry-matter accumulation were also comparable under both the varieties. Higher plant height was observed under the variety 'TAG 24' (43 cm), whereas variety 'TG 51' recorded greater dry-matter accumulation (362.3 g/m^2).

Increasing level of fertilizers resulted higher plant height and dry-matter accumulation in plants. The treatment with 125% RDF + *Rhizobium* inoculation recorded maximum plant height (44.1 cm) and dry-matter accumulation (384.7 g/m^2) during harvesting. However, *Rhizobium* inoculation did not change plant growth significantly at comparable level of nutrient addition.

Yield parameters

Yield attributes like number of pods/plant, SMK (%), pod yield, haulm yield, kernel yield and harvest index (HI) showed no significant difference between 2 varieties except shelling percentage (Table 1). Under the main plot treatment, 'TG 51' groundnut recorded higher pod number/plant (24.6), shelling% (70.3), SMK% (85.4), 100-kernel weight (44.8 g), pod yield (2,860 kg/ha), haulm yield (3,623 kg/ha) and kernel yield (2,012 kg/ha) than the other variety. However, higher HI was found under variety 'TAG 24' (44.8%) than variety 'TG 51' (44.1%).

Different level of fertilizers resulted on considerable influence on yield parameters (Table 1). An increase in pod number/plant, SMK%, 100-kernel weight, pod yield, haulm yield, and kernel yield was observed when fertilizer dose was higher. However, inoculation with *Rhizobium* did not influence the yield attributes significantly at similar level of nutrient addition. The treatment with 125% RDF and *Rhizobium* inoculation showed the highest number of pods/plant (27), SMK (86.3%), 100 kernel weight (45.6 g), pod yield (3,059 kg/ha), haulm yield (3,847 kg/ha), kernel yield (2,152 kg/ha) and HI (44.3%). In terms of yield

Table 1. Effect of variety and nutrient management on the crop characteristics of groundnut (pooled)

	Plant height (cm) at harvest	Dry-matter production (g/m^2)				Pods/ plant	Shelling (%)	SMK (%)	100-KW (g)	Yield (kg/ha)			Harvest Index (%)
		45 DAE	60 DAE	75 DAE	At harvest					Pod	Haulm	Kernel	
Varieties													
'TAG 24'	43.0	60.9	95.5	223.3	357.8	23.4	69.7	84.2	44.2	2,827	3,578	1,972	44.8
'TG 51'	42.6	62.2	96.7	224.8	362.3	24.6	70.3	85.4	44.8	2,860	3,623	2,012	44.1
SEm±	0.26	0.39	0.49	1.35	3.99	0.41	0.16	0.35	0.25	40.02	39.94	29.78	0.06
CD (P=0.05)	NS	1.22	NS	NS	NS	NS	0.50	NS	NS	NS	NS	NS	NS
Nutrient management													
75% RDF	41.8	57.0	89.4	207.4	322.6	19.2	69.2	82.3	43.3	2,535	3,226	1,754	44.0
100% RDF	42.4	62.0	94.3	226.6	363.1	25.0	70.0	84.9	44.8	2,861	3,631	2,004	44.1
125% RDF	43.4	63.8	97.6	230.3	372.2	26.3	70.2	85.8	44.7	2,937	3,722	2,062	44.1
75% RDF + R	42.2	58.8	93.6	214.6	338.4	20.3	69.5	83.7	43.7	2,661	3,383	1,850	44.0
100% RDF + R	42.7	62.8	97.1	231.2	379.2	26.2	70.8	85.8	45.1	3,011	3,792	2,131	44.3
125% RDF + R	44.1	64.9	101.4	234.2	384.7	27.0	70.3	86.3	45.6	3,059	3,847	2,152	44.3
SEm±	0.27	0.50	0.50	1.47	6.02	0.45	0.42	0.51	0.34	59.65	60.26	42.40	0.11
CD (P=0.05)	0.76	1.41	1.41	4.16	17.02	1.27	NS	1.44	0.96	168.69	170.42	119.91	NS

RDF, Recommended dose of fertilizer; R: *Rhizobium* (seed treatment); DAE, days after emergence; SMK, sound mature kernel; KW, kernel weight

parameters, there was no significant difference between the 100% RDF and 125% RDF treatments.

Soil-fertility status

Changes in soil N, P and K nutrient status under different groundnut variety and fertilizer level is reported in Table 2. Post-harvest soil fertility levels were found similar under both the varieties. Available N status of soil under variety 'TAG 24' increased from 126.7 kg/ha in 2017 to 135.9 kg/ha in 2019 and under variety 'TG 51' available N content increased from 128.8 kg/ha in 2017 to 135.1 kg/ha in 2019. Higher N content in soil was possibly owing to atmospheric nitrogen fixation in presence of *Rhizobium* in groundnut nodules (Sathiya *et al*., 2020). Higher N content of soil may favour higher biomass accumulation which increased the uptake of P and K form soil-available pool (Pasley *et al*., 2019; Haldar *et al*., 2019). As a result available P and K contents of the soil reduced over the year (Table 2).

Soil-N status varied significantly under different fertilizer treatments. Higher fertilizer dose and *Rhizobium* inoculation favoured the N accumulation in soil. The maximum available N was found in soil under 125% RDF with *Rhizobium* inoculation (136.8 kg/ha); however, it was statistically at par with 100% RDF with *Rhizobium* inoculation. Also, influence of *Rhizobium* inoculation on available P and K content was found insignificant. The experimental sites belongs to new alluvial zone of West Bengal and shows low to medium in fertility status, showing excellent response to fertilizer addition (Dasgupta *et al*., 2017; Ghosh, 2021; Haldar *et al*., 2019).

The net fertility status of the groundnut field showed a negative balance after completion of 3 years of experimentation for all the 3 nutrients (N, P and K) irrespective of variety and nutrient-management strategy (Table 3). Of the 2 varieties, 'TG 51' recorded higher net negative soil-fertility status over 'TAG 24' except P fertility. Among the different nutrient management, 75% RDF followed by 75% RDF + *Rhizobium* resulted higher net- nutrient depletion over the other treatments in the experiment. Variation in soil-fertility status and change in nutrient balance sheet in soil over years due to different nutrient management in field crop, confirming the findings of (Rana *et al.,* 2017).

Economics

Details of economic analysis under different fertilizer management practice is presented in Table 4. Both the varieties 'TAG 24' and 'TG 51' showed similar benefit: cost ratio. Moderate level of fertilizer (100% RDF) with *Rhizobium* inoculation resulted in the maximum benefit: cost ratio in variety 'TAG 24' (2.73), and variety 'TG 51' (2.71), being statistically at par. Though increasing level of

Table 2. Effect of variety and different nutrient levels on available nutrient in soil after groundnut harvesting

Treatment	Available N, P and K (kg/ha) in soil at harvesting											
	N				P				K			
	2016–17	2017–18	2018–19	Pooled	2016–17	2017–18	2018–19	Pooled	2016–17	2017–18	2018–19	Pooled
Varieties												
'TAG 24'	126.7	125.6	135.9	129.4	21.5	21.2	18.3	20.3	83.7	79.8	80.9	81.5
'TG 51'	128.8	124.3	135.1	129.3	21.6	21.7	19.0	20.8	82.0	78.1	77.5	79.2
SEm±	0.89	0.40	1.61	0.54	0.73	0.23	0.20	0.44	0.13	0.13	0.29	0.23
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.76	0.72
Nutrient management												
75% RDF	119.0	115.4	126.3	120.2	18.1	17.2	16.4	17.2	78.4	71.9	73.6	74.6
100% RDF	122.7	124.4	134.9	127.3	21.1	20.8	19.4	20.4	84.2	81.3	81.3	82.3
125% RDF	127.3	130.7	139.8	132.6	23.6	23.6	19.7	22.3	83.6	82.2	80.6	82.1
75% RDF + R	125.8	120.0	129.7	125.2	18.7	18.0	17.2	18.0	78.5	72.3	74.6	75.1
100% RDF + R	135.8	128.1	139.8	134.6	22.7	23.4	19.3	21.8	86.3	82.7	82.8	83.9
125% RDF + R	135.8	132.0	142.6	136.8	25.2	25.6	20.0	23.6	86.3	83.5	82.4	84.1
SEm±	1.12	0.73	1.13	0.80	1.02	0.68	0.62	0.50	0.54	0.54	0.59	0.51
CD (P=0.05)	3.29	2.15	3.33	2.26	2.99	2.00	1.83	1.41	NS	NS	1.74	1.44

RDF, Recommended dose of fertilizer; R, *Rhizobium* (seed treatment)

Table 3. Effect of groundnut variety and different nutrient levels on net soil-fertility status after completion of 3 years of experiment

Treatment	Net change in soil fertility status								
	N (kg/ha)			P (kg/ha)			K (kg/ha)		
	Initial	Final	Net gain/loss	Initial	Final	Net gain/loss	Initial	Final	Net gain/loss
Varieties									
'TAG 24'	152.8	135.9	-16.9	24.3	18.3	-6.0	129.2	80.9	-48.3
'TG 51'	152.8	135.1	-17.7	24.3	19.0	-5.3	129.2	77.5	-51.7
Nutrient Management (NM)									
75% RDF	152.8	126.3	-26.5	24.3	16.4	-7.9	129.2	73.6	-55.6
100% RDF	152.8	134.9	-17.9	24.3	19.4	-4.9	129.2	81.3	-47.9
125% RDF	152.8	139.8	-13.0	24.3	19.7	-4.6	129.2	80.6	-48.6
75% RDF + R	152.8	129.7	-23.1	24.3	17.2	-7.1	129.2	74.6	-54.6
100% RDF + R	152.8	139.8	-13.0	24.3	19.3	-5.0	129.2	82.8	-46.4
125% RDF + R	152.8	142.6	-10.2	24.3	20.0	-4.3	129.2	82.4	-46.8

RDF, Recommended dose of fertilizer; R, *Rhizobium*

Table 4. Effect of variety and different nutrient levels on the economics of groundnut

Treatment	Economics											
	Cost of cultivation (₹/ha)				Gross returns (₹/ha)				Benefit: cost ratio			
	2016–17	2017–18	2018–19	Pooled	2016–17	2017–18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled
'TAG 24' × 75% RDF	35,313	35,916	36,429	35,938	82,985	85,120	86,336	84,814	2.35	2.37	2.37	2.36
'TAG 24' × 100% RDF	36,521	36,998	37,553	36,967	97,510	99,155	95,008	97,224	2.67	2.68	2.53	2.63
'TAG 24' × 125% RDF	37,549	38,105	38,653	38,143	99,505	101,360	97,792	99,552	2.65	2.66	2.53	2.61
'TAG 24' × 75% RDF + R	35,787	36,380	36,927	36,357	89,110	87,675	88,256	88,347	2.49	2.41	2.39	2.43
'TAG 24' × 100% RDF + R	36,989	37,586	38,078	37,499	102,830	102,235	102,048	102,371	2.78	2.72	2.68	2.73
'TAG 24' × 125% RDF + R	38,110	38,696	39,158	38,604	102,515	103,705	104,160	103,460	2.69	2.68	2.66	2.68
'TG 51' × 75% RDF	35,330	35,979	36,488	35,881	86,205	87,430	87,936	87,190	2.44	2.43	2.41	2.43
'TG 51' × 100% RDF	36,434	37,002	37,579	37,000	98,735	92,505	99,584	96,941	2.71	2.50	2.65	2.62
'TG 51' × 125% RDF	37,596	38,119	38,629	38,063	101,885	94,535	102,752	99,724	2.71	2.48	2.66	2.62
'TG 51' × 75% RDF + R	35,912	36,471	36,996	36,454	93,730	89,355	93,600	92,228	2.61	2.45	2.53	2.53
'TG 51' × 100% RDF + R	37,023	37,494	38,124	37,592	104,405	95,235	105,984	101,875	2.82	2.54	2.78	2.71
'TG 51' × 125% RDF + R	38,067	38,625	39,237	38,646	104,685	97,720	109,472	103,959	2.75	2.53	2.79	2.69

RDF, Recommended dose of fertilizer; R, *Rhizobium* (seed treatment)

fertilizer over 100% RDF resulted higher gross return, benefit: cost ratio was lower in 100% RDF treatment. This was possibly due to higher cost involved in application of higher dose fertilizer. Fixation of atmospheric N and subsequent reduction in fertilizer N requirement under *Rhizobium* inoculation substantially improved the benefit: cost ratio as was evident in our experiment. Similar findings were reported by Kundu *et al*. (2023), where higher net returns were recorded with increasing application rate of fertilizer and biofertilizers. Higher crop growth and productivity with better uptake of nutrients resulted in higher return and benefit: cost ratio.

Better crop response was recorded when higher level of fertilizer was added to soil along with *Rhizobium* inoculation. However, the responses, including revenue generated and benefit: cost ratio were statistically at par even when fertilizer dose was increased after a certain level (100% RDF). It was concluded that, groundnut variety, 'TAG 24' along with 100% RDF + *Rhizobium* inoculation resulted better in terms of growth, yield and benefit: cost ratio, and may be recommended for this region for higher economic returns.

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