

Response of rainy-season groundnut (*Arachis hypogaea*) to varying fertility levels and bioformulations

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ABSTRACT

An experiment was conducted during the rainy (*kharif*) season of 2017 at Gwalior, Madhya Pradesh, to study the response of groundnut (*Arachis hypogaea* L.) to biofertilizers and inorganic sources of nutrient. The experiment consisting of 4 fertility levels, viz. 25% recommended dose of fertilizer (RDF), 50% RDF, 75% RDF and RDF allotted to main plots, and 3 bioformulations, viz. no bio-formulations, NPK liquid formulation + Zn-solubilizing bacteria and bio-grow allotted to subplots, was laid out in split-plot design with 3 replications. Results showed that an application of RDF resulted in significantly highest number of branches/plant, number of nodules/plant and dry-matter accumulation at 30, 60 and 90 days after sowing (DAS). Increasing dose of fertilizers up to RDF resulted in significant increase in haulm, pod yield and net returns. Among the bioformulations, seed inoculation with liquid bio NPK formulation with Zn solubilizing bacteria and bio-grow significantly increased the haulm, pod yield and net returns by 9.8, 8.6, 14.5% and 8.0, 4.3, 7.2%, respectively, over no bioformulation application. Besides, all growth attributes, pod yield and net returns were significantly influenced with combined application of liquid NPK + Zn-solubilizing bacteria and RDF. The integrated application of RDF with liquid NPK formulation + Zn-solubilizing bacteria ensured the highest pod yield followed by RDF application with bio-grow.

Key word: Biofertilizer, Economics, Groundnut, Inorganic fertilizer, Yield

In India groundnut is being cultivated on an area of about 4.91 million ha with production of 9.18 million tonnes of groundnut and productivity level of 1868 kg/ha (DAC&FW, 2018). The productivity of groundnut, in India, is still low mainly due to low consumption of fertilizers in spite of widespread nutrient deficiencies and tendency to grow groundnut under rainfed condition. Being an exhaustive crop groundnut removes large amount of macro and micro-nutrients from soil which cannot be met by single nutrient source. The grim situation of oilseed nutrition in the country indicates that only about 1/3 of fertilizer needs are actually applied. There is ample scope of increasing productivity through combined use of various nutrient sources (Arora, 2008; Joshi *et al.* 2018). Application of

biofertilizers can prevent the soil from degradation and can increase the efficiency of applied fertilizers. They provide a good substrate for crop growth and favourable nutrient-supply environment to the crops. These inoculants help to meet the additional N demand of the plant by increasing nodulation enabling realization of the yield potential to the plant. Phosphobacterium and phosphate-solubilizing bacteria are able to convert the phosphate present in soil from unavailable to available form and have indirect effect on nodulation (Ghosh and Poi, 1998) which contribute to increase in yield of legume crop like groundnut. Though biofertilizers helps to provide nutrients to crop but these cannot replace the inorganic fertilizers. Thus, integrated use of both will be more beneficial and environment friendly. In the past few decades increasing attention has been paid to the application of nutrient in different sources, i.e. chemical, organic and bio fertilizer (integrated), to increase yield. Palaniappan and Annadurai (2007) reported that, combining organic and inorganic fertilizer with biofertilizers resulted in high production than the individual application of both.

Despite economic significance and maximum food value of groundnut, very meager information is available on the combined use of biofertilizer and inorganic sources

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in Gird region of Madhya Pradesh. Thus, there is urgent need for steeping use of major, secondary and micronutrients (Hegde and Sudhakarbabu, 2009) which can be overcome by the use of bio fertilizers. Hence present experiment was conducted to study the effect of inorganic and bio-fertilizers application on growth and yield of rainy (*khariif*) season groundnut.

A field experiment was carried out at the research farm of Department of Agronomy, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, College of Agriculture, Gwalior, Madhya Pradesh, during *khariif* 2017. Soil was sandy clay loam in texture, low in available N (208.7 kg/ha), medium in available P (13.1 kg/ha) and high in available K (268.8 kg/ha), with 0.56% organic carbon, 7.3 pH and 0.37 dS/m electrical conductivity. During the experimentation period, a total amount of rainfall received (July–November 2017) was 387.6 mm. The actual rainfall was less than the normal, and uneven distribution was witnessed during the crop-growth period. The mean weekly maximum temperature recorded 42.1°C in June, while the minimum temperature 7.9°C in November, with 90–93.7% relative humidity. In general, the weather parameters prevailed during the crop-growth period of groundnut were favourable for the normal growth. The recommended dose of N-P-K used for groundnut was 20-60-20 kg/ha. The experiment had 12 treatments, set in a split plot design with 3 replications in fixed plots. The main plot treatments consisted of 4 fertility levels as 25, 50, 75 and 100% recommended rate of fertilizers (RDF) with 3 bioformulation applications as no bio-formulations, NPK liquid formulation + Zn-solubilizing bacteria and bio-grow in subplots. The N, P and K fertilizers were applied in full as basal dose through urea, single superphosphate and muriate of potash respectively. The gross plot size was 5.0 m × 4.5 m and the cultivar 'JGN 3' was sown on 6 July 2017 @ 100 kg/ha and harvested on 29 October 2017.

Before sowing, the kernels were treated with the fungicides dithane M-45 @ 2 g/kg seed, bavistin @ 1 g/kg seed and with biofertilizers as per the treatments. To control thrips infestation, dimethoate 30 EC @ 2 ml/litre water was sprayed at 45 days after sowing (DAS). Chlorpyrifos @ 1.5 liter a.i./ha was incorporated in to soil to control termite infestation before sowing and at 40 DAS. Mancozeb (@ 2 g/litre) was applied against the incidence of fungal diseases as early blight, late blight and stem rot at the time of disease occurrence. Three irrigations were provided to groundnut and 2 hand-weedings were done to control the weeds. Five plants in each plot were selected randomly and tagged for taking various biometric observations. Observations were made on number of primary branches/plant, nodules/plant and dry-matter accumulation at 30, 60 and 90 DAS and weight of mature pods/plant (g), mature pods/

plant, 100-kernel weight (g), pod yield (kg/ha), haulm yield (kg/ha), net returns and benefit: cost ratio at harvesting. Pods were sun-dried up to 9% moisture level. Statistical analysis of the data was carried out using analysis of variance technique (Gomez and Gomez, 1984).

All the observed growth parameters at 90 DAS were significantly influenced under different fertility treatments. Application of RDF resulted in the higher plant height and highest number of branches/plants at harvesting. It had significantly increased the root nodules formation and dry-matter production at 90 DAS over rest of the fertility levels. The findings are close with findings of Joshi *et al.* (2019), who reported that the abundant availability of nutrients in soil pool under higher fertilization might result in enhanced rate of assimilation which was reflected in higher biomass. The optimum mineral fertilization is known to help in developing extensive root-system and absorbing water, nutrients efficiently from the soil solution and provide larger root surface area for nodules formation. Besides, the higher dose of phosphorus enhances the nodule formulation in the crop by improving the root-system and thereby enabling the plants for higher water and nutrient absorption (Salve and Gunjal, 2011).

Similarly, the application of bio-formulations also significantly improved number of branches/plants at harvesting, number of root nodules and dry-matter accumulation/plant at 30, 60 and 90 DAS (Table 1). The nodule number and dry-matter accumulation varied significantly among the treatments at all growth stages and increased with-increase in age of the crop irrespective of the treatments. Amongst the liquid biofertilizers, application of liquid NPK formulation with Zn-solubilizing bacteria (B₂) and bio-grow application (B₃) resulted in significant improvement in all growth attributes as compared to no bio-formulation application, but maximum values were obtained when liquid NPK formulation and Zn-solubilizing bacteria were applied together. Our results are in accordance with the findings of Patil *et al.* (2014), Rahevar *et al.* (2015) and Sengupta *et al.* (2016), who reported that bio-fertilizer increased the solubility and availability of N in the rhizosphere and elongation of internode. This increased cell-division and cell-elongation thereby increased the plant height, branches and dry-matter accumulation at different growth stages, ultimately leading more photosynthetic area and finally yield of crop plant. The positive response of liquid biofertilizer to increase the nodulation might be owing to the organic matter provides energy for nodulation and N₂ fixation by microorganism. Similar observations were also made by Dhillon and Dev (1979).

Significantly highest number of pods/plant and pod weight/plant were obtained with the application of RDF, but was at par with 50% and 75% RDF application for

100-kernel weight. While the highest pod (2,258 kg/ha) and haulm (7,006 kg/ha) yields of groundnut were recorded with application of RDF, being statistically at par with 75% RDF application. This might be due to the enhanced absorption of nutrients from the soil solution, resulting from their abundance when higher fertilizer rates were applied, and hence promoted better assimilation leading to profuse growth and ultimately better yield of crop (Singh *et al.*, 2018). The lowest values of all yield attributes, pod and haulm yields were recorded with 25% RDF.

Seed inoculation with bio-formulations improved the yield attributes as number of pods/plant, pod weight/plant, 100-kernel weight, pod and haulm yields of groundnut as compared to no bio-formulation application (Table 2). Maximum number of pods/plant (27.8), pod weight/plant (13.9) and 100-seed weight (24.0) were recorded with the application of liquid NPK formulation + Zn-solubilizing bacteria followed by bio-grow application. Similarly, the highest pod (2114 kg/ha) and haulm yields (2,029 kg/ha) were noted where seeds were inoculated with liquid NPK

Table 1. Effect of fertility levels and bio-formulations on growth and yield attributes of groundnut

Treatment	Branches/ plant at harvest	Plant height at harvesting (cm)	Nodules/ plant at 90 DAS	DMA (g/plant) at 90 DAS	Pods/ plant	Pod weight/ plant (g)	100-kernel weight (g)
<i>Fertility levels</i>							
F ₁ , 25% RDF	5.3	44.8	56	24.3	19.7	9.0	22.8
F ₂ , 50% RDF	5.5	47.6	62	30.6	24.9	10.8	23.2
F ₃ , 75% RDF	5.6	49.5	68	32.4	28.0	13.8	24.1
F ₄ , 100% RDF	5.9	50.0	76	38.7	32.8	17.2	24.9
SEm±	0.15	1.16	0.81	0.30	0.38	0.44	0.56
CD (P=0.05)	0.53	4.02	2.81	1.05	1.30	1.53	NS
<i>Bio-formulations</i>							
B ₁ , No bio-formulations	5.4	47.3	51.8	28.4	24.8	11.7	23.5
B ₂ , NPK liquid formulation + Zn solubilizing bacteria	5.7	48.7	75.9	33.5	27.8	13.9	24.0
B ₃ , Bio-grow	5.6	48.0	69.6	32.6	26.3	12.5	23.8
SEm±	0.10	0.58	0.85	0.36	0.73	0.42	0.49
CD (P=0.05)	0.30	NS	2.55	1.08	2.19	1.25	1.47

RDF, Recommended dose of fertilizers; DAS, days after sowing; DMA, dry-matter accumulation

Table 2 Effect of fertility levels and bio formulations on yield and economics of groundnut

Treatment	Pod yield (t/ha)	Haulm yield (t/ha)	Net returns (10 ³ ×₹/ha)	Benefit cost ratio
<i>Fertility levels</i>				
F ₁ , 25% RDF	1.80	5.75	46.9	1.38
F ₂ , 50% RDF	1.98	6.05	54.0	1.54
F ₃ , 75% RDF	2.08	6.96	57.5	1.60
F ₄ , 100% RDF	2.26	7.00	64.6	1.74
SEm±	0.040	0.262	1.78	0.051
CD (P=0.05)	0.137	0.908	6.16	0.176
<i>Bio-formulations</i>				
B ₁ , No bio-formulations	1.95	6.08	52.0	1.46
B ₂ , NPK liquid formulation + Zn solubilizing bacteria	2.11	6.68	59.6	1.67
B ₃ , Bio-grow	2.03	6.57	55.7	1.56
SEm±	0.024	0.141	1.09	0.030
CD (P=0.05)	0.073	0.422	3.28	0.091
<i>Interaction</i>				
SEm±	0.049	0.281	2.187	0.061
CD (P=0.05)	0.146	NS	6.556	0.182

RDF, Recommended dose of fertilizer

Table 3. Interaction effects of fertility levels and bioformulations on pod yield (t/ha) of groundnut

Fertility levels	25% RDF(F ₁)	50% RDF(F ₂)	75% RDF(F ₃)	100% RDF(F ₄)
Bio-formulations				
(B ₁) No bio-formulations	1.71	1.99	1.90	2.18
(B ₂) NPK liquid formulation + Zn solubilizing bacteria	1.91	1.97	2.17	2.40
(B ₃) Bio-grow	1.78	1.98	2.16	2.19
SEm±	0.049			
CD (P=0.05)	0.146			

RDF, Recommended dose of fertilizer

formulation + Zn-solubilizing bacteria, but was statistically at par with bio-grow and no bio-formulation application. Increased values in these yield attributes and yield might be attributed to an overall improvement in vegetative growth and nodulation, which favourably influenced the flowering and fruiting. This ultimately resulted in increased number of matured pods, pod weight/plant, pod and haulm yields. These findings are in agreement with the results obtained by Chaudhary *et al.* (2015), Madhu Bala and Kedar Nath (2015).

The integrated use of inorganic and liquid biofertilizers had significant effect on growth and pod yield of groundnut. The integrated application of RDF with liquid NPK formulation + Zn solubilizing bacteria ensued the highest pod yield followed by RDF application with bio-grow (Table 3). Increased pod yield may be attributed to the reason that integrated use (inorganic and liquid biofertilizers) plays very important role due to their synergistic effect. It improves the soil environment encouraging better root-system for absorption of water and nutrients from lower layers leading to better development of plant growth. This resulted in higher photosynthetic activity and translocation of photosynthates to the sink which in turn resulted in better development of yield attributes and finally higher pod yield. Our findings confirm the results of Patil *et al.* (2014) and Rahevar *et al.* (2015).

Similarly, the application of RDF being at par with 75% RDF showed significantly highest net returns (64561 ₹/ha) and benefit: cost ratio (1.74) over the other fertility levels. The seed inoculation with liquid NPK formulation + Zn solubilizing bacteria fetched significantly highest net returns (₹59,559 /ha) and benefit cost ratio (1.67) over control and bio-grow bioformulation.

Thus, it can be concluded that application of recommended dose of NPK and seed inoculation with liquid NPK formulation + Zn-solubilizing bacteria was found effective in improving productivity and profitability of groundnut crop.

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