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Nutrient Concentrations and Their Total Uptake as Affected by Liquid Bio-Fertilizers in Groundnut (*Arachis hypogaea* L.)

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Abstract

A field experiment entitled "Nutrient concentrations and their total uptake as affected by liquid bio-fertilizers in groundnut (*Arachis hypogaea* L.)" was conducted during kharif season of 2017 at research farm, COA, Gwalior on sandy clay loam soil to study the response of groundnut to chemical fertilizers and liquid bio-formulations. Four fertility levels *viz*., 25, 50, 75 and 100% RDF and three biofertilizer inoculation *viz*., no bio-formulations (B1), liquid Bio-NPK + Zn solubilizing bacteria (B2) and bio-grow (B3) to groundnut in 12 treatment combinations replicated thrice in split plot design. The yield and nutrient concentrations and their total uptake (N, P, K, Zn) was significantly highest with 100% RDF and liquid Bio-NPK + Zn solubilizing bacteria. However, their interaction had no significant influence on these parameters. But the highest values were observed when 100% RDF was applied in combination with liquid Bio-NPK + Zn solubilizing bacteria.

Keywords: Groundnut, Interaction, Nutrient, Uptake, Zinc

Introduction

Groundnut has a significant contribution to the Indian agricultural economy. Being an important oilseed crop of India, it occupies a predominant position among the oilseeds in terms of both area and production. However, monoculture with improper nutrient management has given rise to many problems including declined production and productivity of the crop. Groundnut is a highly exhaustive crop which requires proper and sufficient amount of macro-micronutrient for its proper growth and development. It has been indicated by the grim situation of the oilseed nutrition in the country that only about 1/3 of the fertilizer needs are actually applied (Singh *et al.,* 2021). During the post-kharif and kharif seasons, the area, production and productivity of the crop is much smaller in comparison to that grown in summer season. The injudicious use of chemical fertilizers leads to various macro and micro nutrient deficiency in soil disturbing their natural equilibrium. Although, chemical fertilizers cannot be completely replaced as they have a vital role in crop production. But, to address various concerns as rising price, environmental pollution, declining soil fertility and stagnant productivity prompt us to explore and adopt an environment friendly technology.

Therefore, nutrient management is critically an important concept to achieve sustainability in crop production. There is a need of strategies which will not just help to increase the crop productivity but will also play an important role in enhancing overall soil health. Thus, bio-fertilizers liquid formulation which is an updated technology can be beneficially utilized for enhancing yield, growth and most importantly soil fertility. The bio-fertilizers help in improving microbial community in soil and also have a beneficial residual effect on subsequent crops. Keeping these aspects in view, the present investigation was done to determine the influence of integrated nutrient management on nutrient concentrations, their total uptake, productivity of groundnut crop.

Materials and Methods

A field experiment was conducted at the research farm, College of Agriculture, Gwalior during *kharif* 2017. The soil

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of the experimental site was sandy clay loam in texture, neutral in pH (7.3) with low nitrogen (268.8 kg ha^{-1}), medium organic carbon (0.56%), and phosphorus (13.1 kg ha^{-1}), high potassium (554 kg ha^{-1}) and zinc (0.76 ppm) content. The experiment was laid out in split plot design with 12 treatment combinations replicated thrice. The treatment combinations comprised of four fertility levels *viz*., 25, 50, 75 and 100% recommended dose of fertilizers (RDF) as main plots and three bioformulation applications *viz*., no bioformulations, NPK liquid formulation + Zn solubilizing bacteria and bio-grow as sub-plots. Variety 'JGN-23' of groundnut @ 100 kg ha^{-1} was sown at 30 cm × 10 cm spacing on 6th July 2017. The gross plot size was 5.0 m × 4.5 m. The recommended dose of fertilizers was applied in full as basal dose through urea, single super phosphate and muriate of potash. All the cultural practices were followed as per the recommended package of practices for groundnut. The kernels were treated with the fungicides dithane M-45 @ 2 g ha^{-1} seed, bavistin @ 1 g ha^{-1} seed to prevent seed borne diseases and with biofertilizers as per the treatments before sowing. Termite infestation was controlled by application of Chlorpyrifos @ 1.5 litre ha^{-1} in soil before sowing and at 40 DAS. On the occurrence of incidence of thrips and bud necrosis virus, dimethoate 30 EC @ 2 ml $litre^{-1}$ water was sprayed at 45 DAS. The fungal diseases were kept under check by applying Imidacloprid (@ 1 ml $litre^{-1}$ water) + Mancozeb (@ 2 g $litre^{-1}$). Three irrigations were provided to the crop and two hand weedings were done to control the weeds. Five plants selected randomly from each plot at harvest were dried in an electric oven at 65 °C for 48 hours, ground and analyzed for concentration of N, P, K (Jackson, 1973) and Zn (Lindsay and Norvell, 1978) in kernel and haulm and the uptake of nutrients was computed by multiplying kernel/ haulm yield of groundnut by their respective nutrient concentrations. Finally the crop was harvested and produce were dried, threshed, cleaned and weighed. Statistical analysis of the data was carried out using analysis of variance technique (Gomez and Gomez, 1984).

Results and Discussion

Nutrient Concentration in Kernel and Haulm (%)

The data (Table 1) revealed that due to application of different levels of fertilizers a significant variation in nitrogen concentration in kernel and haulm of groundnut was observed. The treatment where 100% RDF was applied recorded significantly highest N content (4.9% and 2.4%) in kernel and haulm, respectively. The lowest N% was recorded with the lowest dose *i.e.*, 25% RDF. It was further observed that bio-fertilizers significantly increased the N content in groundnut. Among different bio-formulations, significantly highest N concentration in kernel (3.6%) and haulm (1.7%) was recorded with the application of Bio-NPK + Zn-solubilizing bacteria which was at par with Bio-grow.

Table 1: Effect of chemical fertilizers and liquid bio-formulations on nutrient concentration in kernel and haulm of groundnut

Treatment	N concentration (%)		Zn concentration (ppm)		K concentration (%)		Zn concentration (ppm)	
	Kernel	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel	Haulm
Main Plots: Fertility levels								
F_1: 25% RDF	1.9	0.9	0.64	0.14	0.38	1.18	23.5	18.6
F_2: 50% RDF	2.9	1.4	0.66	0.15	0.42	1.31	24.5	18.9
F_3: 75% RDF	3.9	1.9	0.72	0.16	0.44	1.37	24.9	18.7
F_4: 100% RDF	4.9	2.4	0.73	0.16	0.45	1.40	25.2	19.2
S.Em +	0.06	0.02	0.004	0.001	0.004	0.011	0.20	0.21
LSD (P=0.05)	0.20	0.06	0.015	0.003	0.013	0.040	0.71	NS
Sub Plots: Bioformulations								
B_1: No Bio-formulations	3.3	1.6	0.67	0.15	0.41	1.29	21.9	16.6
B_2: NPK liquid formulation + Zn solubilizing bacteria	3.6	1.7	0.69	0.15	0.42	1.32	25.6	19.9
B_3: Bio-grow	3.4	1.6	0.69	0.15	0.42	1.33	26.0	20.0
S.Em +	0.03	0.01	0.004	0.001	0.001	0.004	0.45	0.12
LSD (P=0.05)	0.08	0.04	0.013	0.003	0.004	0.012	1.35	0.36
Interaction								
S.Em +	0.06	0.03	0.009	0.002	0.003	0.008	0.90	0.24
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Similarly, the increasing levels of fertilizer dose and application of different bio-fertilizers significantly increased the phosphorus concentration in both kernel and haulm. Applying 100% RDF registered the highest P content in both kernel (0.73%) and haulm (0.16%) which was significantly superior to rest of the treatments but on par with 75% RDF. Further, application of Bio-NPK + Zn-solubilizing bacteria resulted in highest concentration of P in kernel (0.69%) as well as in haulm (0.15%) but remained at par with Bio-grow application.

With respect to concentration of potassium in kernel and haulm of groundnut, significantly highest K content (0.45% and 1.40%, respectively) was obtained with application of 100% RDF which was at par with 75% RDF application. Similarly, significant variation was observed in the concentration of potassium in both kernel and haulm due to application of biofertilizers. Inoculation with Bio-grow recorded the maximum concentration in both kernel (1.33%) and haulm (0.42%) which remained at par with Bio-NPK + Zn-solubilizing bacteria.

No significant effect on Zn content in haulm was recorded due to different levels of fertilizers. However, significantly highest concentration of 25.2 ppm in kernel was obtained with application of 100% RDF. The zinc content in both kernel and haulm was significantly highest with inoculation of Bio-NPK + Zn-solubilizing bacteria and Bio-grow. These treatments remained on par with each other and recorded the maximum concentration in both kernel (26 ppm) and haulm (20 ppm).

A significant increase in N, P, K and Zn content in both kernel and haulm were observed due to application of fertilizers up to 100% RDF and different bio-formulations. This might be ascribed to the fact that improved nutritional environment both in the rhizosphere and in the plant system led to enhanced translocation of N and P in plant parts. These findings are in close conformity with those reported by Patra (2001), Chaithanya *et al.* (2003), Sujathamma *et al*. (2003), Chitdeshwari *et al.* (2007), Kushwaha (2013) and Uike *et al.* (2013).

Total Uptake of N, P, K (kg ha^{-1}) and Zn Uptake (g ha^{-1})

A glimpse of data (Table 2) shows that increasing fertility levels significantly increased total nitrogen, phosphorus, potassium and zinc uptake by the crop. Application of 100% RDF registered the highest total uptake of 237 kg N ha^{-1}, and total uptake of 22 kg P ha^{-1}, total uptake of 104.3 kg K ha^{-1}, total uptake of 171.2 g Zn ha^{-1} which was significantly superior to rest of the treatments but at par with 75% RDF.

Table 2: Effect of chemical fertilizers and liquid bio formulations on total uptake of nutrients and pod and haulm yields of groundnut

Treatment	Total N uptake (kg ha^{-1})	Total P uptake (kg ha^{-1})	Total K uptake (kg ha^{-1})	Total Zn uptake (g ha^{-1})	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
Main Plots: Fertility levels						
F_1: 25% RDF	75	15	72.4	134.8	1800	5746
F_2: 50% RDF	123	17	84.9	146.6	1980	6049
F_3: 75% RDF	187	21	101.3	165.6	2080	6962
F_4: 100% RDF	237	22	104.3	171.2	2258	7006
S.Em +	4.6	0.5	3.73	5.42	39.6	262.4
LSD (P=0.05)	16.0	1.6	12.91	18.76	136.9	907.9
Sub Plots: Bioformulations						
B_1: No Bio-formulations	141	18	84.1	128.8	1946	6080
B_2: NPK liquid formulation + Zn solubilizing bacteria	168	20	94.8	169.3	2114	6676
B_3: Bio-grow	157	19	93.2	165.5	2029	6566
S.Em +	1.9	0.2	1.78	3.16	24.3	140.6
LSD (P=0.05)	5.6	0.7	5.33	9.46	72.8	421.7
Interaction						
S.Em +	3.7	0.5	3.55	6.31	48.6	281.3
LSD (P=0.05)	NS	NS	NS	NS	145.7	NS

Further, it was found bio-fertilizer treatments also showed significant influence on total nutrients uptake. Significantly, highest total uptake of N (168 kg ha^{-1}), P (20 kg ha^{-1}), K (94.8 kg ha^{-1}) and Zn (169.3 g ha^{-1}) by groundnut was recorded when the seed was inoculated with Bio-NPK + Zn-solubilizing bacteria. This treatment was significantly superior over control but remained at par with Bio-grow.

The nutrient uptake is a function of its content in crop plant

and kernel and haulm yield of the crop. The increase in these parameters due to fertilization led to an increased uptake of nutrients. The significant increase in uptake of these nutrients due to inoculation with different bio-formulations might be due to more nitrogen fixation by bacteria which in turn helped in better absorption and utilization of all other plant nutrients, thus resulting in more nutrient content in both kernel and haulm. These results are in line with the findings of Dubey (2001), Basu *et al.* (2006) and Singh *et al.* (2013).

Pod and Haulm Yield

Significantly highest pod (2,258 kg ha^{-1}) and haulm (7,006 kg ha^{-1}) yield of groundnut was obtained with the application of 100% RDF (Table 2). The lowest dose *i.e.*, 25% RDF resulted in lowest pod and haulm yields. Among bio-fertilizers, seed inoculation with liquid Bio-NPK + Zn solubilizing bacteria gave the highest pod (2,114 kg ha^{-1}) and haulm yield (2,029 kg ha^{-1}). However, this treatment remained statistically at par with bio-grow and no bio formulation application.

This could be due to the fact that application of fertilizers and bio-fertilizers led to balanced nutrition and better utilization of the nutrients and improved overall vegetative growth and nodulation in groundnut ultimately resulting in enhanced pod and haulm yield. The findings are in conformity with the results obtained by Bala and Nath (2015) and Rahevar *et al*. (2015).

Thus, the integrated application of 100% RDF with liquid NPK formulation + Zn solubilizing bacteria gave highest pod and haulm yield followed by 100% RDF application with bio-grow. This could be attributed to the synergistic effect of inorganic and liquid bio-fertilizers (Singh *et al.,* 2018). Integrated application of multistrain bio-fertilizers with different levels of fertilizers helped in better water absorption, nutrient assimilation and higher photosynthetic activity and ultimately resulted in higher pod and haulm yield. The present findings are in close agreement with the results obtained by Patil *et al*. (2014) and Rahevar *et al*. (2015).

Interaction Effect

Interaction effect between chemical fertilizers and bio-formulations with respect to N, P, K and Zn concentrations in kernel and haulm of groundnut as well as total uptake of these nutrients by the crop was found non-significant. This indicated that fertilizers and bio-fertilizers behaved independently without showing any complementary effect. This could be due to the reason that the nutrients from fertilizers were made available to the crop at early stages while due to due to slow release of nutrients through bio-fertilizers, they were available to plants at later stages of the crop growth. The results are in close vicinity with the findings of Saxena *et al.* (2001) and Bachhav and Sable (1996) who reported such non significant interaction effect of fertilizers and bio-fertilizers. Though the interaction effect was not found significant, the treatment combination F_4B_2 where 100% RDF with liquid Bio-NPK + Zn-solubilizing bacteria was applied gave maximum values. Similar results were also obtained by Singh and Rai (2004).

Conclusion

Thus, it can be concluded that integrated application of recommended dose of NPK and liquid Bio-NPK + Zn-solubilizing bacteria was found to be more effective in enhancing nutrient concentration in both kernel and haulm of groundnut, their uptake and thereby resulted in highest productivity and profitability.

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