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Nutrients Uptake by Groundnut (*Arachis hypogaea* L.) and Soil Fertility under the Influence of Enriched Vermicompost

Sarika Donga[1*] and R. K. Mathukia[2]
[1]Ph.D. Research Scholar, Department of Agronomy, JAU, Junagadh, (Gujarat) India.
[2]Professor and Head, Department of Agronomy, JAU, Junagadh, (Gujarat) India.

(Corresponding author: Sarika Donga)*
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ABSTRACT: Continuous use of inorganic fertilizers plays a vital role in deteriorating the soil health. Use of organic manure is the best remedy for maintaining soil quality as well as productivity and replacement of mineral fertilizers. Biofertilizers are the source of microbial inoculants, which have brought hopes for developing country like India to solve problem of high cost of fertilizers. *Azotobacter,* PSB, KSB and *Rhizobium* have provided high quality products free of harmful agro-chemicals for human safety. The biological and nutritional value of vermicompost can be improved by enrichment with microorganisms and micronutrients. In this context, a field experiment was conducted during *kharif* season of 2019 & 2020 on calcareous clayey soil at Junagadh (Gujarat) to study the effect of vermicompost enriched with biofertilizers, bioagents and micronutrients on nutrients uptake by *kharif* groundnut (*Arachis hypogaea* L.) and soil fertility.

Results indicated highest pod yield (23.05 q/ha) and haulm yield (38.89 q/ha) as well as highest uptake of nitrogen (155.11 kg/ha), phosphorus (13.73 kg/ha), potash (48.86 kg/ha), sulphur (17.0 kg/ha), iron (4113 g/ha), zinc (415.9 g/ha), copper (273.2 g/ha) and manganese (686.0 g/ha) were recorded with application of vermicompost 2 t/ha enriched with biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha), bioagents (*Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha) and micronutrients [(Fe + Zn + Cu + Mn) Grade-V @ 40 kg/ha]. It also improved post-harvest soil fertility by recording highest organic carbon (0.98%), available nitrogen (252 kg/ha), phosphorus (24.08 kg/ha), potash (184.9 kg/ha), sulphur (16.80 kg/ha), iron (5.20 ppm), zinc (0.67 ppm), copper (1.78 ppm) and manganese (7.24 ppm) in soil.

Keywords: Groundnut, Enriched Vermicompost, Biofertilizers, Bioagents, Micronutrients, Nutrient Uptake, Soil fertility.

INTRODUCTION

Biofertilizers are natural fertilizers, which are the preparations containing living cells of microorganism, which when inoculated into soil, provide essential nutrients to plants. Biofertilizers are biologically active products containing certain strains of bacteria, algae or fungi, as a single or composite culture. They produce hormones and anti-metabolites, which promote root growth. They decompose organic matter and help in mineralization in soil. When applied to seed or soil, biofertilizers increase the availability of nutrients and improve the yield by 10-25% without adversely affecting the soil and environment. Biofertilizers replace 25-30% chemical fertilizers, increase the yields by 10-40%, decompose plant residues, and stabilize C:N ratio of soil. It also improves structure, bulk density and water holding capacity of soil. It involves inoculation of beneficial microorganisms that help nutrient acquisition by plants through fixation of nitrogen, solubilization and mobilization of other nutrients.

Indian soils have poor to medium status in available phosphorus. Phosphorus is immobile in soil systems and hardly 15-20% of the applied phosphorus is utilized by a crop to which it is applied. While the rest remains in a fixed state in soil being influenced by various physico-chemical and biological properties of the soil (Raju *et al.,* 2005). Several bacteria belonging to genera *Pseudomonas* and *Bacillus* have the ability to solubilize inorganic phosphorus insoluble sources. Inoculation of seed with phosphate solubilizing bacteria (PSB) increases crop growth, nutrient availability, uptake and crop yield (Shrivastava *et al.*, 1995).

Potassium solubilizing bacteria play vital role in making available insoluble forms of potassium by mineralization. In Indian soil, the soluble K form are present in approximately 2% and insoluble are present in range of 98% in form of minerals like biotite, feldspar, mica, muscovite, vermiculite (Goldstein, 1994). Potassium solubilizing bacteria solubilizes potassium from insoluble forms like mica, feldspar and others by producing organic acids, siderophores and also capsular polysaccharides. Potassium uptake of plants can be increased by using potassium solubilizers as bio-inoculants further increasing the crop production. *Trichoderma* spp. are the most frequently isolate soil fungi and present in plant root ecosystems. These fungi are opportunistic, avirulent plant symbionts and functions as parasites and antagonists of many phytopathogenic fungi, thus protecting plants from diseases. So far, these are among the most studied fungal bio-control agents and commercially marketed as biopesticides, biofertilizers and soil amendments (Harman *et al*., 2004). These organic materials help to improve physical, chemical and biological properties of soils and thereby help to increase fertility and productivity.

The traditional technology of vermicompost, if improved in terms of biological enrichment, may help in arresting trends of nutrient depletion and diseases/pest problem to a greater extent. Vermicompost is the best organic carrier for microbial cultures, hence it can be enriched by N fixing microorganisms like *Rhizobium*, *Azotobacter*, *Azospirillum* etc.; phosphate solubilizing microorganisms, namely, *Aspergillus awamori*, *Pseudomonas striata* and *Bacillus megaterium*; K solubilizing/mobilizing microorganisms, cellulolytic/waste decomposing microorganisms, and different microbial bioagents like *Trichoderma*, *Pseudomonas fluorescens*, *Beauveria*, *Metarhizium*, *Verticillium etc*. in a single product and to increase the manurial and biological value of the vermicompost. Looking to the above facts, this experiment was conducted with an aim to develop vermicompost enriched with microbial consortia and micronutrients and its field evaluation in *kharif* groundnut.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* season of the year 2019 and 2020 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh. The soil was clayey in texture and slightly alkaline in reaction. The soil was low in available nitrogen (225 and 230 kg/ha), medium in available phosphorus (30.25 and 33.50 kg/ha), medium in available potassium (280 and 288 kg ha), low in sulphur (98.94 and 9.80 mg/kg), low in iron (3.80 and 4.02 mg/kg), low in zinc (0.46 and 0.48 mg/kg), high in copper (1.26 and 1.30 mg/kg) and medium in manganese (6.50 and 7.15 mg/kg) in 2019 and 2020, respectively. Ten treatments *viz*., Absolute Control (T_1), 100% RDF (T_2), Vermicompost 2 t/ha (T_3), Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each @ 2 L/ha) (T_4), Vermicompost 2 t/ha + *Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha (T_5), Vermicompost 2 t/ha + *Beauveria bassiana* 3 kg/ha (T_6), Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha) + *Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha (T_7), Micronutrients (Fe + Zn + Cu + Mn) Grade-V @ 40 kg/ha (T_8), Vermicompost 2 t/ha + Micronutrients (Fe + Zn + Cu + Mn) Grade-V @ 40 kg/ha (T_9) and Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha) + *Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha + Micronutrients (Fe + Zn + Cu + Mn) Grade-V @ 40 kg/ha (T_{10}) were tested in randomised block design with three replications. The groundnut cv. GJG 22 was sown at a spacing of 60 cm × 10 cm with standard package of practices. The enrichment of vermicompost as per treatments was done 10 days before application to the field and kept in shade with maintaining 20-25% moisture. The plant and soil analysis were carried out following standard methods and procedures.The data were subjected to statistical analysis by adopting appropriate analysis of variance (Gomez and Gomez, 1984). Wherever the F values found significant at 5 percent level of probability, the Critical Difference (CD) values were computed for making comparison among the treatment means.

RESULTS AND DISCUSSION

A. Effect of enriched vermicompost on yield of groundnut

The highest pod yield and haulm yield (Table 1) were noticed under the treatment of Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha) + *Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha + Micronutrients (Fe + Zn + Cu + Mn) Grade-V @ 40 kg/ha (T_{10}), which remained statistically comparable to the treatment of Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha) +*Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha (T_7). Same results were observed by Zalate and Padmani (2010); Manivannan and Daniel (2009), Pradeepa *et al.,* (2010); Verma *et al*., (2017). It could ascribe to beneficial and combined effects of vermicompost, biofertilizers, bioagents and micronutrients which can enhance nutrient transformations in soil by improving physical, chemical and biological properties of soil. Whereas, the lowest values of pod yield and haulm yield were recorded under the absolute control (T_1). These findings are in agreement with those of Kamdi *et al*., (2014); Kumar *et al*., (2014); Ravikumar *et al*., (2019).

B. Effect of enriched vermicompost on uptake of nutrient by groundnut

The experimental results revealed that significantly highest uptake of nitrogen (155.11 kg/ha), phosphorus (13.73 kg/ha), potash (48.86 kg/ha) and sulphur (17.0 kg/ha) (Table 1) were recorded under the treatment of Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha) + *Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha + Micronutrients (Fe + Zn + Cu + Mn) Grade-V @ 40 kg/ha (T_{10}), followed by Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha) + *Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha (T_7). The highest uptake of micronutrients *viz*., Fe (4113 g/ha), Zn (415.9 g/ha), Cu (273.2 g/ha) and Mn (686.0 g/ha), (Table 1) were registered under the treatment of Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha) + *Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha +

Micronutrients (Fe + Zn + Cu + Mn) Grade-V @ 40 kg/ha (T_{10}). This was due to influence of vermicompost on addition and retention of nutrients in soil along with enrichment lead to increased availability of nutrients in soil through symbiosis and solubilizing the fixed and unavailable forms. The absolute control (T_1) registered the lowest uptake of nitrogen, phosphorus, potash, sulphur and micronutrients (Fe, Zn, Mn and Cu) by groundnut. These results confirm the findings of Zalate and Padmani (2010); Patra *et al.* (2011); Singh *et al.* (2013); Sharma *et al*., (2014).

Table 1: Effect of enriched vermicompost on uptake of nutrients by groundnut (Pooled over two years).

Treatment	Pod yield (q/ha)	Haulm yield (q/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)	Fe (g/ha)	Zn (g/ha)	Cu (g/ha)	Mn (g/ha)
T_1	11.27	18.75	59.16	4.87	17.50	6.9	1691	152.3	96.4	256.5
T_2	18.92	32.47	120.67	10.46	37.28	14.0	2984	276.7	181.4	466.7
T_3	15.90	27.26	101.34	8.23	31.22	10.6	2593	243.5	164.3	412.8
T_4	18.32	31.25	116.16	10.31	36.50	12.3	2950	284.9	193.0	483.6
T_5	16.96	29.34	97.63	9.51	29.17	11.3	2732	244.8	163.8	433.4
T_6	17.71	29.86	101.63	8.64	29.90	11.7	2828	255.5	176.5	447.8
T_7	21.16	36.46	139.90	12.14	42.68	15.5	3428	334.7	221.7	564.6
T_8	13.20	22.92	74.99	6.31	21.72	9.1	2364	231.7	150.0	390.0
T_9	20.05	33.85	111.73	9.89	33.83	14.2	3554	350.4	229.6	587.5
T_{10}	23.05	38.89	155.11	13.73	46.86	17.0	4113	415.9	273.2	686.0
S.Em.	0.94	1.37	5.00	0.45	1.88	0.62	153	13.5	9.0	23.7
CD. at 5%	2.70	3.93	14.35	1.28	5.40	1.78	440	38.6	26.0	68.0

C. Effect of enriched vermicompost on soil fertility

Application of Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha) + *Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha + Micronutrients (Fe + Zn + Cu + Mn) Grade-V @ 40 kg/ha (T_{10}) registered significantly the highest organic carbon (0.98%), available nitrogen (252 kg/ha), phosphorus (24.08 kg/ha), potash (184.9 kg/ha) and sulphur (16.80 kg/ha) in soil at harvest (Table 2), which was found at par with the treatment of Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha) + *Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha (T_7). The highest content of micronutrients *viz.*, Fe (5.20 mg/kg), Zn (0.67 mg/kg), Cu (1.78 mg/kg) and Mn (7.24 mg/kg) were recorded with the application of Vermicompost 2 t/ha + Biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha) + *Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha + Micronutrients (Fe + Zn + Cu + Mn) Grade-V @ 40 kg/ha (T_{10}), followed by the treatment of Vermicompost 2 t/ha + Micronutrients (Fe + Zn+ Cu + Mn) Grade-V @ 40 kg/ha (T_9) and Micronutrients (Fe + Zn + Cu + Mn) Grade-V @ 40 kg/ha (T_8). The lowest organic carbon, nitrogen, phosphorus, potash, sulphur and micronutrients (Fe, Zn, Mn and Cu) content in soil at harvest were recorded under the absolute control (T_1). The findings are in conformity with those of Murugappa, (2007); Tharmaraj *et al.,* (2011); Tetarwal *et al.,* (2011).

Table 2: Effect of enriched vermicompost on post-harvest soil fertility (Pooled over two years).

Treatment	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	S (kg/ha)	Fe (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Mn (mg/kg)
T_1	0.75	216	18.55	156.1	11.31	3.53	0.50	1.32	6.36
T_2	0.78	223	20.09	158.9	12.32	4.10	0.51	1.35	6.46
T_3	0.85	218	18.92	160.9	12.50	4.14	0.52	1.38	6.50
T_4	0.88	241	19.93	162.6	14.08	4.21	0.59	1.45	6.57
T_5	0.84	230	22.68	169.2	12.72	3.89	0.57	1.49	6.46
T_6	0.86	230	20.40	167.8	14.54	4.11	0.55	1.46	6.51
T_7	0.93	243	22.91	176.2	14.78	4.40	0.60	1.56	6.95
T_8	0.81	225	20.17	161.2	12.69	5.04	0.64	1.67	7.06
T_9	0.95	235	21.55	165.9	13.70	5.12	0.65	1.72	7.10
T_{10}	0.98	252	24.08	184.9	16.80	5.20	0.67	1.78	7.24
S.Em.±	0.03	5.00	0.51	3.31	0.36	0.10	0.01	0.04	0.14
C.D. at 5%	0.08	14.34	1.45	9.48	1.03	0.29	0.04	0.11	0.40

CONCLUSION

On the basis of the results obtained from the present two-year field experimentation, it can be concluded that application of vermicompost 2 t/ha enriched with biofertilizers (*Rhizobium* + PSB + KSB each 2 L/ha), bioagents (*Trichoderma harzianum* 3 kg/ha + *Pseudomonas fluorescens* 3 L/ha + *Beauveria bassiana* 3 kg/ha) and micronutrients [(Fe + Zn + Cu + Mn) Grade-V @ 40kg/ha] increased soil fertility and uptake of nutrients by groundnut and ultimately enhanced pod and haulm yields on calcareous clayey soil under South Saurashtra Agro-climatic Zone.

FUTURE SCOPE

Presently there are so many microbial cultures recommended and used as biofertilizers, waste decomposers and bioagents for crop production. Accordingly, farmers have to use all these microbial cultures simultaneously, which is very cumbersome or rather impracticable at field level. The traditional technology of vermicompost, if improved in terms of biological enrichment, may help in arresting trends of nutrient depletion and diseases/pest problem to a greater extent. Vermicompost is best organic carrier for microbial cultures, hence it can be enriched by to combining biofertilizers, bioagents and micronutrients in a single product and to increase the manurial and biological value of the vermicompost.

Conflicts of Interest. Nil.

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