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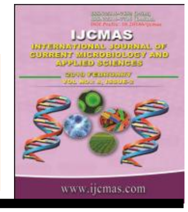

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Potential of Plant Growth Promoting Bacteria on Nutrient Availability in Soil, Nutrient Uptake and Yield of Summer Groundnut Grown on Entisol

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ABSTRACT

A field experiment was conducted during the year 2017-18 at Post Graduate Institute Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri**.** The experiment was laid out in Randomised block design with three replication and eleven treatments. The treatments comprised of T_1: Absolute control, T_2: only ZnSB, T_3: GRDF(25:50 kg ha^{-1} $N:P_2O_5$ + FYM @ 5 t ha^{-1}), T_4 to T_7 were GRDF + 100%, 75%, 50% and 25% RD of Zn through $ZnSO_4$+ ZnSB and T_8 to T_{11} were GRDF + 100 %, 75%, 50% and 25% RD of Zn through ZnO + ZnSB. The biofertilizer zinc solubilizing bacteria was given as a seed treatment as well as soil drenching @ 5% at 30 days of sowing. The soil pH, EC, organic carbon and calcium carbonate content in soil at initial as well as at harvest did not find any differences amongst treatments. The available N, P and K status of soil at harvest were found to be significantly improved due to application of 100% Zn through $ZnSO_4$ along with ZnSB and GRDF. The DTPA-Fe, Zn, Mn and Cu status of soil at harvest was also found to be significantly increased due to application of 100% Zn through $ZnSO_4$ + GRDF. Total uptake of nitrogen, phosphorus and potassium by groundnut crop was significantly increased (132.29, 15.60 and 65.63 kg ha^{-1}, respectively) due to application of 100% Zn through $ZnSO_4$ + ZnSB along with GRDF. The same trend was also observed in above treatment in respect of total uptake of Fe, Zn, Mn and Cu (1352, 377, 619 and 67 g ha^{-1}, respectively). The oil per cent was significantly increased in treatment of T_4 (40.96 %) over all the treatment. The pod yield of groundnut was significantly increased in treatment of T_4 (30.63 q ha^{-1}) over all the treatments except treatment T_5 (29.44 q ha^{-1}) which was at par with T_4. Haulm yield of groundnut was significantly increased (62.70 q ha^{-1}) in treatment of T_3 (100% GRDF (25:50:00 kg ha^{-1} $N:P_2O_5$ + FYM @ 5 t ha^{-1}) over all the treatments. It can be thus concluded that, the application of 100% recommended dose of Zn through Zinc sulphate @ 20 kg ha^{-1} + 5 % ZnSB to seed treatment at sowing and through drenching at 30 DAS along with 100% recommended dose of nutrients (25:50 kg ha^{-1} $N:P_2O_5$ + FYM @ 5 t ha^{-1}) to *summer* groundnut was found beneficial for increased in available macro and micronutrients status of soil, total uptake of macro and micronutrient.

Introduction

India is blessed with the agro-ecological condition favourable for growing nine major oilseeds including seven edible oilseed namely groundnut, rapeseed, mustard, soybean, sunflower, safflower, sesame and niger and two non-edible sources, namely castor and linseed, apart from wide range of other minor oilseeds and oil bearing species. Among all the oilseed crops, groundnut occupies the first place in India accounting for more than 28% of acreage and 32% of production in the country. However, except for castor, the productivity of oilseed crops in India is one of the lowest in the world.

Groundnut or peanuts originated in South America. Groundnut is grown in five states namely Andhra Pradesh, Gujarat, Tamilnadu, Karnataka and Maharashtra and together they account for about 90% per cent of the cultivated area. Andhra Pradesh and Gujarat states share about 28 and 24 per cent of the total cultivated area, respectively. About 8% of the total groundnut area is in the state of Maharashtra.

Zinc is one of the most important micronutrients. It plays vital role in the plant life. It has vital role in transformation of carbohydrates, regulation of consumption of sugar and increase source of energy for the production of chlorophyll. Zinc is also required for maintenance of auxin in an active state. The zinc is essential for the synthesis of tryptophan a precursor of auxin. Zinc deficiency in groundnut crop causes chlorotic strips on leaves and this band on the leaf portion nearest to petiole. Also it result in stunted growth while, the young leaves smaller than normal. This deficiency similar to iron deficiency only the difference is that chlorosis occur full length of the leaves and in peanut lower half of the leaves.

Among the bacterial species, strains belonging to the genera *Acinetobacter, Bacillus, Gluconacetobacter and Pseudomonas have* been reported (Simine Di *et al.*, 1998; Fasim *et al.*, 2002; Saravanan *et al.*, 2007) as zinc solubilizers, fertilizers and manures, to enhance soil fertility and crop productivity has often negatively affected the complex biogeochemical cycles (Perrott *et al.*,1992; Steinshamn *et al.*, 2004). Continuous application of fertilizers as well as their low use efficiency has caused leaching and runoff of nutrients, especially N and P leading to environmental degradation (Tilman, 1998 and Gyaneshwar *et al.*, 2002). On the other hand, high cost associated with the application of Zn fertilizers in order to correct Zn deficiency places considerable burden on resource poor farmers (Wissuwa *et al.*, 2006). One of the possible ways to increase crop productivity as well as food quality without creating the environmental issues is by the use of plant growth promoting rhizobacteria (PGPR). The PGPR were capable of colonizing the rhizosphere, root surface and internal tissues in plants. The main microbial mechanisms by which PGPR improved plant growth include N-fixation, inorganic P solubilisation, siderophore production, phytohormone synthesis and by controlling plant pathogens (Lugtenberg and Kamilova, 2009). Different plant growth promoting bacteria including free living and associative such as *Azospirillum, Azotobacter, Bacillus* and *Pseudomonas* have been used in agricultural systems as biofertiloops. Various crizers for their beneficial effects on plant growth (Tilak *et al.*, 1982). Hitchins *et al.*, (1986) reported that *Thiobacillus thioxidance*, *T. ferroxidance* and facultative thermophilic iron oxidizers solubilized zinc from sulphideore (sphalerite). Exogenous application of zinc sources, similar to fertilizer application has been advocated to various crops. This causes transformation of about 96 to 99 per cent of applied available zinc to various unavailable forms. The zinc thus, made unavailable can be reverted back to available form by inoculating bacterial strain capable of solubilizing it. Since zinc is a limiting factor in crop production, this study on zinc solubilization by bacteria has an immense importance in zinc nutrition to plant.

Materials and Methods

The field experiment was conducted on groundnut (CV: TG - 26) during *Summer* in 2016-17 in randomized block design with three replication on the soil belonging to order *Entisol* (Typic Ustorthent) at Post Graduate Institute, Mahatma Phule Agricultural University, Rahuri, Maharashtra, located between $19^{0}34'$ N latitude and $74^{0}64'$ E longitude. The treatment comprised of T_1: Absolute control,T_2: only ZnSB, T_3: GRDF(25:50 kg ha^{-1} $N:P_2O_5$ + FYM @ 5 t ha^{-1}), T_4 to T_7 were GRDF + 100%, 75%, 50% and 25% RD of Zn through $ZnSO_4$+ ZnSB and T_8 to T_{11} were GRDF + 100 %, 75%, 50% and 25% RD of Zn through ZnO + ZnSB. ZnSB was given through seed treatment at the time of sowing @ 5% and second 5% ZnSB was given by drenching in soil at 30 DAS. The experimental soil for groundnut crop had pH, 8.16, EC, 0.28 dSm^{-1}, Org. C, 0.44%, $CaCO_3$,5.41%, Available N, 205 kg ha^{-1}, Available P,13.8 kg ha^{-1}, Available K, 410 kg ha^{-1}, DTPA-Fe 4.02 mg kg^{-1}, Mn 10.70 mg kg^{-1}, Zn 0.49 mg $kg^{-1}$and Cu 1.92 mg kg^{-1}.The seed of groundnut was coated with a consortia of zinc solubilizing bacteria culture viz., *Bacillus polymyxa, Bacillus megaterium, Pseudomonas striata, Pseudomonas fluroscence, Gluconoacetobacter diazotrophicus* and *Aspergillus awamori*. The recommended dose of $N:P_2O_5:K_2O$ @ 25:50:00 kg ha^{-1} was applied to groundnut. The soil samples were collected before sowing and harvest of groundnut analysed as perstandard methods. The plant and pod samples were analysed for Total N by micro-Kjedahl method (Jackson 1958), Total P by vanodomolybdate yellow colour method (Chapman and Pratt 1961) in diacid mixture of HNO_3:$HCLO_4$ (9:4) and Total K by Flame photometer (Chapman and Pratt, 1961) in HNO_3:$HCLO_4$ (9:4).

Results and Discussion

Soil chemical properties

The data regarding chemical properties of groundnut revealed that (Table 1) there was no significant differences in case of pH, EC, Org. C and $CaCO_3$ due to different treatment combinations.

Soil available nutrients

Soil available nitrogen content at initial stage was low in status (143 kg ha^{-1}), however, at harvest was significantly increased in treatment of T_4 (198 kg ha^{-1}) over all the treatments except T_9 (192 kg ha^{-1}), which was at par with treatment T_4, Overall, available nitrogen status showed low in soil at harvest. The increase in the available nitrogen content in soil at harvest might be due to 100% fertilizer nitrogen dose and 100% RD of Zn through $ZnSO_4$ along with ZnSB. Similar results were also reported by Kayalvizhi *et al.*, (2001) in sugarcane and Kumar *et al.*, (2004) (Table 2).

Available phosphorus in soil at initial showed low status (10.89 kg ha^{-1}), however, at harvest, it significantly increased in treatment T_4 (11.02 kg ha^{-1}) over all the treatments. This might be due to increased in P use efficiency by the application of $ZnSO_4$ @ 20 kg ha^{-1} in soil + ZnSB along with 100% GRDF. Overall, available P showed low status in soil at harvest in all the treatment under study, which might be due to higher fixation of P under alkaline condition. Low phosphorus availability in calcareous soil might be due to their transformation to more complicated forms with $CaCO_3$ and these changed forms are rendered less available to growing plants. Similar results were also recorded by Bashour *et al.*, (1983). The effect of low P solubility in alkaline and calcareous soil was due to poor fertilizer P efficiency. The similar results were also supported by Stark and Westermann (2003) and Javid and Rowell (2003).

Available potassium content in soil at initial stage was medium status (185 kg ha^{-1}), however, at harvest the treatment T_4 was found to be significantly increased (198 kg ha^{-1}) over all the treatment T_3, T_4, T_5, T_6, T_7, T_9, T_{10} and T_{11} except treatment T_2 and T_8 which were at par. Overall, available potassium showed medium status at harvest in all the treatment under study.

Soil available micronutrients

DTPA micronutrients content in soil at soil Zn, However, sufficient in available Mn and Cu. The soils were deficient in DTPA- iron as the critical limit of DTPA-iron is 4.5 ppm. The soil available Fe at initial stage was deficient (4.11 mg kg^{-1}), however, at harvest it showed significantly higher content in treatment of T_4 (3.91 mg kg^{-1}) over T_1, T_3, T_7, T_{10} and T_{11} treatment however, treatment T_4 were at par with treatments of T_2, T_5, T_6, T_8 and T_9. The same trend of increasing in micronutrients status was observed at harvest stage with slight decrease in the values which may be due to uptake of micronutrients. Similar results have been reported by Stein (2010) (Table 3).

The soil of experimental site was deficient in available Zn (0.35 mg kg^{-1}) as the critical limit of DTPA-Zn in soil is 0.6 ppm. At harvest, available Zn in soil found to be significantly increased in T_4 (0.58 mg kg^{-1}) over all the treatment. The increase in DTPA-Zn content in soil was slightly higher in treatments of application of $ZnSO_4$ as compared to ZnO treatments along with seed treatment and soil drenching treatment of ZnSB @ 5%. Similar results were also reported by Fasim *et al.,* (2002).

The soil available Mn content at initial and at harvest, it showed non significant results. The soil available Cu content at initial showed sufficient status (1.82 mg kg^{-1}), however, at harvest it did not influenced. Application of $ZnSO_4$ fertilizer treatment showed the higher values of DTPA-Cu in soil as compared to application of ZnO fertilizer, it may be due to limited solubility of ZnO fertilizer in soil.

Nutrient uptake by groundnut

The effect of application of zinc fertilizer and zinc solubilizing bacteria on total nutrient uptake of N, P and K as influenced by different treatments are presented in table 4.

The data in respect of total nitrogen uptake by groundnut was found significant results. However, treatment T_4 showed higher uptake of total N (132.29 kg ha^{-1}) over all the treatment. Higher uptake of nitrogen was due to application of $ZnSO_4$ and use of ZnSB as a seed treatment and drenching treatment. Potarzycki and Grzebisz (2009) also reported similar result that zinc exerts a great influence on basic plant life processes such as nitrogen metabolism and uptake of nitrogen.

The highest total P uptake by groundnut plant was significantly found to be observed in treatment of T_4 (15.60 kg ha^{-1}) over all the treatment except total uptake of P in treatment T_3 which was at par with T_4. This is because of soil application of $ZnSO_4$ @ 20 kg ha^{-1} with ZnSB increased the availability of P in soil. These finding are in consonance with Manna *et al.,* (2007) who reported that the activity of alkaline phosphates was significantly increased with increase in FYM levels and PSM inoculation resulting more solubilization of P and uptake by soybean plant. The total K uptake by groundnut was significantly higher in T_4 treatment (65.63 kg ha^{-1}) over all the treatment. The increase in total N and K uptake could be attributed to synergistic effect between N and Zn and due to the positive interaction of K and Zn, respectively. The present findings support the results of Ashoka *et al.,* (2008), Morshedi and Farahbakhsh (2010).

Total micronutrients

The total uptake of Fe, Zn, Mn and Cu by groundnut as influenced by different treatment are presented in table 5.

Table.1 Effect of zinc fertilizer and zinc solubilizing bacteria on soil properties

Tr. No	Treatment	pH (1:2.5)	EC (dSm^{-1})	Organic carbon (%)	$CaCO_3$ (%)
T_1 :	Absolute control	8.17	0.26	0.40	5.40
T_2 :	ZnSB alone	8.14	0.24	0.41	5.41
T_3 :	100% GRDF (25:50 kg ha^{-1} N:P_2O_5FYM+ @ 5 t ha^{-1})	8.06	0.27	0.49	5.54
T_4 :	T_3 + 100 % RD of Zn through Zinc sulphate ZnSB	8.02	0.30	0.50	5.33
T_5 :	T_3 + 75 % RD of Zn through Zinc sulphate + ZnSB	8.04	0.28	0.48	5.17
T_6 :	T_3 + 50 % RD of Zn through Zinc sulphate + ZnSB	8.04	0.27	0.46	5.21
T_7 :	T_3 + 25 % RD of Zn through Zinc sulphate + ZnSB	8.08	0.25	0.44	5.08
T_8 :	T_3 + 100 % RD of Zn through Zinc oxide + ZnSB	8.16	0.26	0.46	5.71
T_9 :	T_3 + 75 % RD of Zn through Zinc oxide + ZnSB	8.16	0.27	0.44	5.75
T_{10}:	T_3 + 50 % RD of Zn through Zinc oxide + ZnSB	8.14	0.28	0.48	5.87
T_{11}:	T_3 + 25 % RD of Zn through Zinc oxide + ZnSB	8.16	0.27	0.49	5.08
S.E.m±		**0.016**	**0.011**	**0.013**	**0.023**
CD at 5%		**NS**	**NS**	**NS**	**NS**

Table.2 Effect of zinc fertilizer and zinc solubilizing bacteria on residual soil available nitrogen, phosphorus and potassium

Tr. No	Treatment	Av. N (kg ha^{-1})	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})
T_1 :	Absolute control	178	9.12	171
T_2 :	ZnSB alone	170	8.95	182
T_3 :	100% GRDF (25:50 kg ha^{-1} N:P_2O_5FYM+ @ 5 t ha^{-1})	186	9.78	190
T_4 :	T_3 + 100 % RD of Zn through Zinc sulphate ZnSB	198	11.02	198
T_5 :	T_3 + 75 % RD of Zn through Zinc sulphate + ZnSB	184	9.51	184
T_6 :	T_3 + 50 % RD of Zn through Zinc sulphate + ZnSB	180	9.24	186
T_7 :	T_3 + 25 % RD of Zn through Zinc sulphate + ZnSB	174	8.96	180
T_8 :	T_3 + 100 % RD of Zn through Zinc oxide + ZnSB	190	9.46	190
T_9 :	T_3 + 75 % RD of Zn through Zinc oxide + ZnSB	192	8.24	178
T_{10}:	T_3 + 50 % RD of Zn through Zinc oxide + ZnSB	190	8.92	180
T_{11}:	T_3 + 25 % RD of Zn through Zinc oxide + ZnSB	180	8.98	174
S.E.m±		**2.32**	**0.047**	**3.724**
CD at 5%		**6.92**	**0.14**	**10.98**

Table.3 Effect of zinc fertilizer and zinc solubilizing bacteria on available micronutrient content in soil (mg kg^{-1})

Tr. No	Treatment	DTPA-Fe	DTPA-Zn	DTPA-Mn	DTPA-Cu
T_1 :	Absolute control	3.82	0.40	5.16	1.21
T_2 :	ZnSB alone	3.88	0.46	5.20	1.30
T_3 :	100% GRDF (25:50 kg ha^{-1} N:P_2O_5FYM+ @ 5 t ha^{-1})	3.80	0.52	5.89	1.26
T_4 :	T_3 + 100 % RD of Zn through Zinc sulphate ZnSB	3.91	0.58	5.17	1.44
T_5 :	T_3 + 75 % RD of Zn through Zinc sulphate + ZnSB	3.86	0.54	5.81	1.39
T_6 :	T_3 + 50 % RD of Zn through Zinc sulphate + ZnSB	3.88	0.51	5.58	1.38
T_7 :	T_3 + 25 % RD of Zn through Zinc sulphate + ZnSB	3.74	0.48	5.73	1.38
T_8 :	T_3 + 100 % RD of Zn through Zinc oxide + ZnSB	3.90	0.50	5.12	1.41
T_9 :	T_3 + 75 % RD of Zn through Zinc oxide + ZnSB	3.87	0.48	5.05	1.32
T_{10}:	T_3 + 50 % RD of Zn through Zinc oxide + ZnSB	3.80	0.46	5.75	1.28
T_{11}:	T_3 + 25 % RD of Zn through Zinc oxide + ZnSB	3.81	0.49	5.60	1.30
S.E.m±		**0.02**	**0.01**	**0.38**	**0.046**
CD at 5%		**0.06**	**0.03**	**NS**	**NS**

Table.4 Effect of zinc fertilizer and zinc solubilizing bacteria on Total nutrient uptake (kg ha-1)

Tr. No	Treatment	Total uptake of macronutrient (kg ha^{-1})		
		N	P	K
T_1	Absolute control	72.80	9.81	44.40
T_2	ZnSB alone	93.40	11.66	47.51
T_3	100% GRDF (25:50kg ha^{-1} N:P_2O_5 + FYM@ 5 t ha^{-1})	114.62	15.19	62.18
T_4	T_3 + 100 % RD of Zn through Zinc sulphate + ZnSB	132.29	15.60	65.63
T_5	T_3 + 75 % RD of Zn through Zinc sulphate + ZnSB	119.27	14.26	54.51
T_6	T_3 + 50 % RD of Zn through Zinc sulphate + ZnSB	91.12	13.73	50.71
T_7	T_3 + 25 % RD of Zn through Zinc sulphate + ZnSB	94.77	12.41	49.97
T_8	T_3 + 100 % RD of Zn through Zinc oxide + ZnSB	105.64	14.50	50.77
T_9	T_3 + 75 % RD of Zn through Zinc oxide + ZnSB	105.59	13.38	51.50
T_{10}	T_3 + 50 % RD of Zn through Zinc oxide + ZnSB	100.03	11.97	50.71
T_{11}	T_3 + 25 % RD of Zn through Zinc oxide + ZnSB	84.60	11.33	49.17
S.E.m±		**19.90**	**1.405**	**0.419**
CD at 5%		**59.11**	**4.175**	**1.245**

Table.5 Effect of zinc fertilizer and zinc solubilizing bacteria on Total micronutrient uptake (g ha^{-1})

Tr. No	Treatment	Total uptake of micronutrient (g ha^{-1})			
		Fe	Zn	Mn	Cu
T_1	Absolute control	897	207	401	36
T_2	ZnSB alone	972	235	431	43
T_3	100% GRDF (25:50kg ha^{-1} N:P_2O_5 + FYM@ 5 t ha^{-1})	1344	307	598	53
T_4	T_3 + 100 % RD of Zn through Zinc sulphate + ZnSB	1352	377	619	67
T_5	T_3 + 75 % RD of Zn through Zinc sulphate + ZnSB	1213	336	504	61
T_6	T_3 + 50 % RD of Zn through Zinc sulphate + ZnSB	1107	292	485	48
T_7	T_3 + 25 % RD of Zn through Zinc sulphate + ZnSB	1051	265	457	47
T_8	T_3 + 100 % RD of Zn through Zinc oxide + ZnSB	1130	311	498	54
T_9	T_3 + 75 % RD of Zn through Zinc oxide + ZnSB	1069	286	455	45
T_{10}	T_3 + 50 % RD of Zn through Zinc oxide + ZnSB	1060	276	451	49
T_{11}	T_3 + 25 % RD of Zn through Zinc oxide + ZnSB	1007	260	441	43
S.E.m±		**19.90**	**4.13**	**8.58**	**0.74**
CD at 5%		**59.11**	**12.26**	**25.47**	**2.19**

Table.6 Effect of application of zinc fertilizer and zinc solubilzing bacteria on pod and haulm Yield

Tr. No	Treatment	Pod yield (q ha^{-1})	Haulm yield (q ha^{-1})	Per cent increased pod yield over T_3
T_1	Absolute control	20.82	42.50	-
T_2	ZnSB alone	21.77	44.20	-
T_3	100% GRDF (25:50 kg ha^{-1} N:P_2O_5 + FYM @ 5 t ha^{-1})	26.56	62.70	-
T_4	T_3 + 100 % RD of Zn through Zinc sulphate + ZnSB	30.63	58.90	15.32
T_5	T_3 + 75 % RD of Zn through Zinc sulphate + ZnSB	29.44	53.72	10.84
T_6	T_3 + 50 % RD of Zn through Zinc sulphate + ZnSB	27.41	48.60	3.20
T_7	T_3 + 25 % RD of Zn through Zinc sulphate + ZnSB	26.65	45.90	0.33
T_8	T_3 + 100 % RD of Zn through Zinc oxide + ZnSB	27.22	50.42	2.48
T_9	T_3 + 75 % RD of Zn through Zinc oxide + ZnSB	27.06	47.34	1.88
T_{10}	T_3 + 50 % RD of Zn through Zinc oxide + ZnSB	26.90	46.91	1.28
T_{11}	T_3 + 25 % RD of Zn through Zinc oxide + ZnSB	26.41	44.98	1.43
S.Em±		**0.478**	**1.027**	
CD at 5%		**1.42**	**3.05**	

The total uptake of Fe was found to be significantly higher in T_4 treatment (1352 gha^{-1}) over all the treatment except T_3 (1344 g ha^{-1}) which was at par with T_4. Total uptake of Zn significantly higher in treatment of T_4 (377 g ha^{-1}) over all the treatment. Amalraj *et* *al.*, (2012) also reported increase in zinc uptake by soybean due to seed inoculation of PSB and solubilizers. The total uptake of Mn was significantly increased in T_4 treatment (619 g ha^{-1}) over all the treatment except treatment T_3 (598 g ha^{-1}) which was at par with T_4 in respect of Mn uptake. This might be due to exudation of phytase which is important for Mn uptake from high pH soils. Similar results were also observed by George *et al.*,(2014).The total uptake of Cu was observed significantly higher in T_4 (67 g ha^{-1}) over all the treatment. The zinc sulphate treatment was higher than the other treatment. Gururmurthy *et al.*, (2009) reported increase in uptake in grain and straw with N, P and K application of PSB to soybean.

Pod and haulm yield

Pod and haulm yield of groundnut as influenced by different treatments are presented in table 6 The pod yield of groundnut was found to be significantly increased (30.63 q ha^{-1}) in treatment of T_4 over all the treatment except treatment T_5 (29.44 q ha^{-1}) which was at par. Overall, the per cent increased in treatments of application of $ZnSO_4$ + ZnSB were found higher in pod and haulm yield of groundnut as compare to treatments of application of ZnO + ZnSB. Application of zinc in soil resulted in increased in yield of groundnut was in the range of 15.32 to 0.33 % in treatments of soil application of $ZnSO_4$ over GRDF (T_3).

The haulm yield of groundnut was found to be significantly increased (62.70 q ha^{-1}) in treatment of GRDF T_3 over all the treatments under study. However, the treatments of application of $ZnSO_4$ + ZnSB were increased in pod and haulm yield of groundnut as compare to treatments of application of ZnO + ZnSB. Application of zinc in soil resulted in increased in yield of groundnut was reported by Talukdar and Islam (1982).

From the above findings, It is concluded that, the application of 100 % recommended dose of Zn through Zinc sulphate @ 20 kg ha^{-1} + 5% ZnSB to seed treatment at sowing and through drenching at 30 DAS along with 100 % (25:50:0 kg ha^{-1} $N:P_2O_5:K_2O$ + FYM @ 5t ha^{-1}) to *summer* groundnut was found beneficial for increased in available macro and micronutrients status of soil, total uptake of macro and micronutrient and pod yield of groundnut in Entisol.

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