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Effect of Potassium and Zinc Solubilizing Microorganisms on Growth, Yield and quality of Groundnut (*Arachis hypogaea* L.) in Coastal Zone of Karnataka

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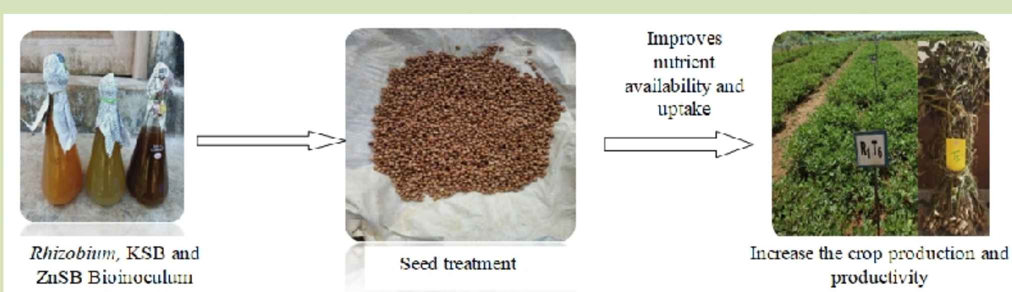
ABSTRACT: A field experiment was conducted during summer season of 2021 at ZAHRS, Brahmavara, KSNUAHS, Shivamogga, to study the effect of potassium and zinc solubilizing microorganisms on growth, yield and quality of groundnut (*Arachis hypogaea* L.) in Coastal Zone of Karnataka. Field experiment consisted of eight treatments *viz*., absolute control (T_1), RDF (T_2), RDF with KSB and ZnSB either alone (T_3 and T_4) or in combination (T_5), RDNP + 75 % RD of K and $ZnSO_4$ + seed treatment with KSB +ZnSB (T_6), RDNP + 50 % RD of K and $ZnSO_4$ + seed treatment with KSB +ZnSB (T_7) and RDNP + seed treatment with KSB + ZnSB (T_8) are replicated thrice was laid out in RCBD.

Among treatments tried, significantly higher plant height (68.35 and 67.17 cm), number of branches (9.84 and 9.5), leaf area (1186.7 and 1174.6cm^2 plant^{-1}), number of pods plant^{-1} (29.1 and 28.3), pod weight plant^{-1} (21.9 and 21.4 g), were recorded with recommended dose of fertilizer + seed treatment with KSB + ZnSB (T_5) and RDNP + 75 % RD of K and $ZnSO_4$ + seed treatment with KSB + ZnSB (T_6), respectively. The better values of these indices in T_5 and T_6 resulted in higher pod yield (1675 and 1654 kg ha^{-1}), kernel yield (1245 and 1224 kg ha^{-1}), protein content (26.75 and 26.63 %) and oil content (49.30 and 48.9 %), respectively, recorded in treatments T_5 and T_6. Seeds treatment with both potassium and zinc solubilizing microorganisms in addition to state recommended nutrient practices for groundnut resulted in better growth, pod yield, protein content and oil content, over package of practices.

Keywords: Dry matter, KSB, Oil content, Seed treatment and ZnSB.

Graphical abstract



INTRODUCTION

Groundnut is the second most important annual oilseed crop. It has 45 to 49 per cent oil content and 26 per cent protein content in the kernel. Hence, groundnut is called "king of oilseeds" and popularly known as 'poor men's cashew nut'. Though India ranks first in the area and second in production with respect to groundnut, the productivity is low. Inadequate and imbalanced use of nutrients is one of the major constraints for low productivity. In recent years, farmers have been applying nitrogenous and phosphorous fertilizers while ignoring potassium and micronutrients under intensive agriculture.

Furthermore, the importance of organic manures in crops such as peanuts is well documented. Manures provide vitamins and food for soil bacteria, allowing them to thrive. Because organic manures are scarce in Indian agriculture, only a small amount is applied to the soil, resulting in macro and micronutrient deficiencies. In the Coastal Zone as well, high rainfall causes nutrient leaching, resulting in corrosive soil. This could result in nutritional deficiencies in the soil.

Though the Indian soils have sufficient potassium, only one to two per cent is readily available to plants. Similarly, Zn is known to play a vital role in plants metabolism and is present in the enzyme system as a cofactor and involved in crop growth and development. In India, zinc deficiency was recorded is about 50 per cent of the groundnut growing soils, causing considerable yield losses (Singh, 1999; Singh *et al.*, 2004). However, only 20 per cent of applied zinc is available for plant uptake and rest of the zinc is converted to various unavailable forms.

In this case, biofertilizers came in handy to rectify these nutrients by converting inaccessible organic acids to available forms, making it easier for plants to absorb nutrients. Hence, the present investigation was taken up to study the effect of potassium and zinc solubilizing microorganisms on the growth, yield and quality of groundnut.

MATERIAL AND METHODS

A field study was conducted during summer2020-21 at Zonal Agricultural and Horticultural Research Station, Brahmavara, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga. The experimental site soil was low in available nitrogen (270 kg ha^{-1}), medium in available phosphorous (41.65 kg ha^{-1}), low in available potassium (88.42 kg ha^{-1}) and insufficient in available zinc (0.42 mg ha^{-1}).

The experiment was consisting eight treatments *viz*., T_1: Absolute control, T_2 : POP (25:75:37.5) kg NPK ha^{-1} + $ZnSO_4$@ 10 kg ha^{-1}, T_3: T_2 + Seed treatment with Potassium Solubilising Bacteria (KSB), T_4: T_2 + Seed treatment with Zinc Solubilising Bacteria (ZnSB), T_5: T_2 + Seed treatment with both KSB and ZnSB, T_6: RDNP + 75% RD of K and $ZnSO_4$ + seed treatment with both KSB and ZnSB, T_7: RDNP + 50% RD of K + $ZnSO_4$ + Seed treatment with both KSB and ZnSB, T_8: RDNP Seed treatment with both KSB and ZnSB.

The groundnut variety used in the experiment was TMV-2. It is a Spanish bunch type derived by the mass selection from 'Gudhiathum bunch' released in 1946. The crop duration is 110-115 days, with 76 per cent shelling and oil content of 49 per cent.

Potassium Solubilizing Bacteria (KSB), *Frateuria aurantia* used in the experiment is an acidophile, rod-shaped, gram-negative and belongs to proteobacteria, identified by colorless zone of solubilization in Aleksandrow agar media.ZincSolubilizing Bacteria (ZnSB) used is *Psudomonas* spp (ZnSB-4 strain) which can be identified by brownish zone of solubilization in Mineral salt supplemented ZnO agar media.

The land was ploughed with disc plough and farm yard manure along with lime@ 10 t ha^{-1}and 500 kg ha^{-1}was applied to plots three weeks before sowing and incorporated into the soil. Soil was finally smoothened with the help of a wooden plank to prepare the fine seedbed. The sowing was done on 18th December 2020. Matured and healthy kernels of groundnut variety TMV-2 @ 100 kg per ha were used for sowing. Groundnut seeds were treated with *Rhizobium*, Potassium and Zinc Solubilizing Bacteria @ 4g, 5 ml and 5 ml kg^{-1} seeds, respectively, as per treatment details following standard protocol. Sowing was done by hand dibbling at one seed per hill to a depth of five cm at row spacing 30 cm and 10 cm between plants. The seeds were covered by soil immediately after sowing. Groundnut harvested manually on first April 2021.

Method of measuring growth parameters. Leaf area was measured at 60 and 90 DAS and at harvest by using Standard LI-COR leaf area meter (Model LI-3100, LICOR Inc. Nebaraska, USA) and expressed in cm^2 per plant.

Leaf area duration, which indicate the consistency of leaf over period of time was estimated using the formula given below

$$\mathrm{LAD} = \frac{\mathrm{L_1} + \mathrm{L_2}}{2} \times (\mathrm{t_2} - \mathrm{t_1})$$

Where,

L_1= Leaf area index at ith stage

L_2= Leaf area index at (i+1)th stage

(t_2 - t_1)= time interval in days

Crop growth rate (CGR) is the rate of total dry matter (TDM) produced per unit time per unit area. It was worked out by using the formula given by Watson (1952) and expressed in g m^{-1} day^{-1}.

$$\mathrm{CGR} = \frac{\mathrm{W_2} - \mathrm{W_1}}{\mathrm{t_2} - \mathrm{t_1}} \times \frac{1}{\mathrm{A}}$$

Where,

W_1 and W_2 = TDM (g m^{-2}) at time t_1 and t_2, respectively

A= Ground area covered by the plant or spacing.

t_2 - t_1= Time interval between two stages (days)

Protein and oil content. Protein and oil content were estimated by kjeldal (AOAC, 2000) and Soxhlet method (Ajayi *et al*., 2004), respectively.

RESULTS AND DISCUSSION

Effect on growth parameters. Taller plants (68.35 cm) with have higher number of branches (9.84) were recorded with plots receiving seed treatment with both potassium (KSB) and zinc solubilizing bacteria (ZnSB) in addition to the recommended dose of fertilizer. Further, significantly high leaf area (1120 and 1187 cm^2 plant^{-1}, respectively at 60 and 90 DAS), LAD (128.0 days), total dry matter (148.69 g plant^{-1}) and rate of crop growth (25.26) were also noticed with the same treatment (T_5) which was closely followed by treatment RDNP +75% RD of K and $ZnSO_4$ + Seed treatment with both KSB and ZnSB (T_6) (Table 1). Higher plant height, number of branches, leaf area and dry matter production was due to an adequate supply of nutrients registered for optimum growth and development of groundnut plants under microbial inoculated plots (T_5 and T_6). Organic acids secreted by microbes helped in improving soil condition required for better root proliferation, better availability of nutrients *viz*., N, P, K, Zn, Mn, Fe and Cu at early stages. This caused for better nutrient uptake and subsequent utilization of nutrients for synthesis of biomolecules, protein metabolism and production of auxins, gibberlins and cytokinens which help in cell division and cell elongationin early stage of the crop growth. This act as initial capital for subsequent growth in terms of dry matter production. Such results were also observed in soybean plants by Mengal and Arneke (1982). Similarly, Prajapati (2016) observed the positive effect of microbial inoculation on seed germination, root and shoot growth in cucumber. Sheng and Haung (2002) in sorghum reported higher biomass due to uptake of K and Zn in treatments as a result of uptake of P and K. Higher dry matter production was also reason for higher uptake of other nutrients like Fe and Mn as reported by Amalraj *et al*. (2012) and Cu uptake by Gurumurthy *et al*. (2009) due to zinc application along with ZnSB. Similarly, Sheng (2005) have obtained increased biomass and P and K content in plant than control.

Effect on yield and yield parameters. Higher number of pods (29.2 plant^{-1}), pod weight (21.9 g plant^{1}), pod yield (1675 kg ha^{-1}), kernel yield (1104 kg ha^{-1}) and shelling percentage (74.3 %) were recorded with treatment RDF + Seed treatment with KSB + ZnSB (T_5). This was closely followed by treatment RDNP +75% RD of K and $ZnSO_4$ + Seed treatment with both KSB and ZnSB (T_6) (Table 2).

Higher yield with KSB and ZnSB seed treatment was due to increased soil microbial population, thereby improving nutrient availability and nutrient uptake by crops. This resulted in greater utilization of native K and Zn, as well as a good influence on nutrient uptake. Similar results were found in groundnut by earlier workers (Choudary *et al*., 2019; Nomen *et al.*, 2015; Verma *et al*., 2016) who reported that KSB treated groundnut plant showed maximum pods of 16 and kernel 50 per plant as compared to control having pods seven and kernel 21. Further, Prajapati and Modi (2016) in cucumber (fruit setting, fruit maturity), Vaid *et al.* (2014) in wheat (Productive tiller, Panicle plant^{-1}, grains per panicle) and Chishi (2010) in maize have realized better yield components. Better yield might be due to the solubility of potassium and zinc as well as other beneficial hormones, enzymes which might have helped in better nutrient uptake and optimum growth. These results are in accordance with the findings of Chandra *et al*. (2005).

Higher yield components and yield is due to higher dry matter production, crop growth rate and better translocation of photosynthetic materials from source to sink. This was reflected in shelling percentage (Table 2), as a result of improvement in vegetative structures for nutrient absorption and photosynthesis, strong sink strength through the development of reproductive parts and production of assimilates under the influence of applied NPK and Zn as well as KSB and ZnSB. As a result, the yield under these treatments improved.

Effect on quality parameters. The quality parameters are greatly influenced by crop nutrition. Better the nutrient uptake, better the quality. The experimental results indicate that seed treatment with both KSB and ZnSB inoculums along with RDF (T_5) lead to significantly higher protein content of 26.75 per cent which was closely followed by treatment RDNP +75% RD of K and $ZnSO_4$ + Seed treatment with both KSB and ZnSB (T_6) over RDF alone (Table 3). Better availability of K due to microbial release caused for better nitrogen uptake and assimilation of photosynthates. Further, higher K and Zn availability and their uptake caused for release of growth hormones like IAA, which is a precursor for certain amino acids and protein synthesis. Thus Zn known to increase the protein content and calorific value.

Table 1: Effect of Potassium and Zinc Solubilizing microorganisms on growth parameters of groundnut.

Treatments		Plant height	No. of branches	Leaf area		LAD	TDM	CGR
		cm	plant^{-1}	cm^2 plant^{-1}		days	g plant^{-1}	g m^{-2} day^{-1}
		At harvest	At harvest	60 DAS	90 DAS	0-At harvest	90 DAS	0-At harvest
T_1	Absolute control	43.00	7.33	7.61	9.49	97.0	85.50	16.06
T_2	RDF	64.03	8.66	10.32	11.18	120.5	140.48	23.38
T_3	RDF + ST with KSB	66.67	9.00	10.71	11.54	125.0	145.07	24.12
T_4	RDF + ST with ZnSB	65.00	8.83	10.65	11.41	122.5	143.25	23.59
T_5	RDF + ST with KSB + ZnSB	68.35	9.84	11.19	11.86	128.0	148.69	25.26
T_6	RDNP + 75% RD of K and $ZnSO_4$ + ST with KSB and ZnSB	67.17	9.50	10.88	11.74	126.5	147.32	24.93
T_7	RDNP + 50% RD of K and $ZnSO_4$ + ST with KSB and ZnSB	64.32	8.50	10.23	11.09	120.0	139.56	23.33
T_8	RDNP + ST with KSB and ZnSB	63.21	8.00	10.12	11.04	119.5	138.85	23.06
S.Em.±		1.17	0.37	0.183	0.22	2.36	2.59	0.60
C.D.@ 5%		3.57	1.11	0.55	0.64	7.06	7.78	1.80

NOTE: FYM at 10 tons per ha and *Rhizobium* seed treatment is common for all treatments except T_1.

RDF- Recommended dose of fertilizer (25:75:37.5) NPK kg ha^{-1}+ $ZnSO_4$@ 10 kg ha^{-1}.

ST- Seed treatment, KSB- Potassium solubilizing bacteria (*Frateuria aurantia*)

ZnSB – Zinc solubilizing bacteria (ZnSB-4)

Table 2: Effect of Potassium and Zinc Solubilizing microorganisms on yield and yield parameters of groundnut.

Treatments		Total pods plant^{-1}	Pod weight g plant^{-1}	Pod yield kg ha^{-1}	Kernel yield kg ha^{-1}	Shelling percentage %
T_1	Absolute control	19.00	10.5	950	622	65.5
T_2	RDF	27.00	20.2	1545	1104	71.4
T_3	RDF + ST with KSB	27.5	20.5	1600	1168	73.0
T_4	RDF + ST with ZnSB	27.8	20.8	1590	1145	72.0
T_5	RDF + ST with KSB + ZnSB	29.2	21.9	1675	1245	74.3
T_6	RDNP + 75% RD of K and $ZnSO_4$ + ST with KSB and ZnSB	28.3	21.4	1654	1224	74.0
T_7	RDNP + 50% RD of K and $ZnSO_4$ + ST with KSB and ZnSB	26.3	19.8	1480	1054	71.2
T_8	RDNP + ST with KSB and ZnSB	25.9	18.3	1440	1002	69.8
S.Em.±		0.63	0.54	46.00	37.00	0.96
C.D.@ 5%		1.89	1.61	135.70	107.30	2.84

NOTE: FYM at 10 tons per ha and *Rhizobium* seed treatment is common for all treatments except T_1.
RDF- Recommended dose of fertilizer (25:75:37.5) NPK kg ha^{-1}+ $ZnSO_4$@ 10 kg ha^{-1}.
ST- Seed treatment, KSB- Potassium solubilizing bacteria (*Frateuria aurantia*)
ZnSB – Zinc solubilizing bacteria (ZnSB-4)

Table 3: Effect of Potassium and Zinc Solubilizing microorganisms on quality parameters of groundnut.

Treatments		Protein content (%)	Oil content (%)
T_1	Absolute control	20.25	44.32
T_2	RDF	24.00	47.00
T_3	RDF + ST with KSB	25.56	48.50
T_4	RDF + ST with ZnSB	25.42	48.20
T_5	RDF + ST with KSB + ZnSB	26.75	49.30
T_6	RDNP + 75% RD of K and $ZnSO_4$ + ST with KSB and ZnSB	26.63	48.90
T_7	RDNP + 50% RD of K and $ZnSO_4$ + ST with KSB and ZnSB	23.80	46.70
T_8	RDNP + ST with KSB and ZnSB	23.60	46.00
S.Em.±		0.57	0.76
C.D.@ 5%		1.65	2.20

NOTE: FYM at 10 tons per ha and *Rhizobium* seed treatment is common for all treatments except T_1.
RDF- Recommended dose of fertilizer (25:75:37.5) NPK kg ha^{-1}+ $ZnSO_4$@ 10 kg ha^{-1}.
ST- Seed treatment, KSB- Potassium solubilizing bacteria (*Frateuria aurantia*)
ZnSB – Zinc solubilizing bacteria (ZnSB-4)

Again, significantly higher oil content was also realized in the treatment receiving seed treatment with KSB + ZnSB along with RDF (49.3 %) which was closely followed by treatment RDNP +75% RD of K and $ZnSO_4$ + Seed treatment with both KSB and ZnSB (T_6) over RDF alone (Table 3). It is due to the involvement of potassium solubilizing bacteria in the functioning of many enzymes, formation of glucosides, glucosinolates and sulphydryl – linkage, activation of biochemical reaction enzymes within the plants which help in the biosynthesis of oil. Potassium is also known to enhance the activity of mallic dehydrogenase enzyme, which is responsible for the synthesis of fatty acids such as malate and oxaloacetate in groundnut results in higher oil content (Choudary *et al*., 2019; Sanadi *et al*., 2018). Sugumaran and Janarthanam (2007) have also reported higher oil content in groundnut due to inoculation of *B. mucilaginosus* (KSB) than in the control plot. Bhagyalakshmi *et al.* (2012) have revealed improvement in tea quality parameters *viz*., theaflavin, thearubigin, highly polymerized substances, total liquor color, caffeine, briskness, color and flavour indices with KSB treated plants.

CONCLUSION

From the present investigation, it can be inferred that treating seeds with both potassium and zinc solubilizing microorganisms in addition to state recommended nutrient practices for groundnut resulted in better growth, improvement to the extent of 8.41, 11.45 and 5.32 per cent in pod yield, protein content and oil content, respectively, over package of practices. Further, by seed treatment with both KSB and ZnSB, the cost on K and Zn fertilizers can be saved to the extent of 25 per cent, as treatments T_5 and T_6 are on par.

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Conflict of Interest. None.

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