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Effect of potassium and zinc solubilizing microorganisms on yield and quality of groundnut (*Arachis hypogaea* L.) in coastal zone of Karnataka

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Abstract
A field experiment was conducted during the summer season of 2021 at ZAHRS, Brahmavara, KSNUAHS, Shivamogga to study the "Effect of potassium and zinc solubilizing microorganisms on 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 pod yield (1675 and 1654 kg ha^{-1}), kernel yield (1245 and 1224 kg ha^{-1}), 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 protein yield (333.04 and 325.95 kg ha^{-1}) and oil content (613.79 and 598.54 kg ha^{-1}), 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 pod yield, protein yield and oil yield, over package of practices.

Keywords: KSB, kernel yield, oil yield, pod yield, protein yield, seed treatment and ZnSB

Introduction
Oilseeds are the second most important agricultural crop grown in the country after cereals. India stands fifth among the largest vegetable oil production globally after the USA, China, Brazil, and Argentina. India is blessed with diverse agro-climatic conditions. All the nine edible annual oilseeds are being cultivated, which accounts for 13 to 15 per cent and 8 to 9 per cent of the world's area and production of oilseeds, respectively.
In India, groundnut ranks first in the area with 48.25 lakh ha and second in production (99.52 lakh tonnes), with a productivity of 2063 kg ha^{-1}. In Karnataka, groundnut is cultivated in an area of 5.04 lakh ha, having a production of 5.02 lakh tons productivity of 998 kg ha^{-1} (Annon, 2020) [4]. The low level of groundnut productivity in India is due to several constraints. Inadequate and imbalanced use of nutrients is one of the major constraints for low productivity (Rao and Shaktawat, 2005) [6]. In recent years under intensive agriculture, farmers are applying nitrogenous and phosphorous fertilizers by neglecting potassium and micronutrients. This results in imbalanced nutrient management. In the Coastal Zone as well, high rainfall causes nutrient leaching, resulting in corrosive soil. This could result in nutritional deficiencies in the soil.
To supplement nutrient deficiencies, biofertilizers have come to stay in Indian agriculture for the last three decades in view of their cost-effectiveness, contribution to crop productivity, soil sustainability and eco-friendly nature. The use of biofertilizers is one of the important components of integrated nutrient management as these three play a significant role in mineralization of complex form of nutrients in soil and make them available to plants. Further, they also help in modifying the soil pH and improve the nutrient uptake by crops. Also involve release growth-promoting Harmones and enzyme activity which intern improves the quality of oilseed crops. Biofertilizers include nitrogen-fixing bacteria, phosphate solubilizing bacteria (PSB), phosphate mobilizers, plant growth-promoting biofertilizers, potassium solubilizing bacteria and zinc solubilizing bacteria.

Groundnut being a leguminous oilseed crop, protein and oil content are important quality parameters of economic importance in groundnut. The importance of potassium and zinc nutrition in groundnut is well known. Potassium is one of the three main pillars of balanced fertilizer use, along with N and P. In addition to increasing plant resistance to biotic and abiotic stresses, K is known to involve in the activation of over 80 different enzymes responsible for plant and animal physiological processes such as energy metabolism, starch synthesis, nitrate reduction, photosynthesis, sugar degradation And quality. With respect to Zn, it is one of the essential micronutrients required in small proportion for the proper growth and development of living organisms (Hafeez *et al*., 2013) [10]. In plants, specifically, it is involved in carbohydrate and auxin metabolism (Alloway, 2004) [3] also acts as a significant anti-oxidant. Zinc-finger transcription factors play an important role in the normal development of floral tissues, flowering, fertilization, fruiting and oil synthesis (Epstein and Bloom, 2005) [9]. By knowing the role of these nutrients, there is a need to increase the native soil nutrients availability and uptake in balanced condition.

Potassium levels in Indian soils: Potassium levels in Indian soils are sufficient to support crops cultivated there, but ironically most of it is in an unavailable form to plants (which accounts for 90 to 98 percent of total potassium in soil) and Zinc is ionic or organically complexed on exchange sites of organic and inorganic colloids, complexed with organic matter and occulated in Fe, Al, and Mn oxides and hydroxides, as well as entrapped in primary and secondary silicate minerals in soil solution. (Han *et al*., 2011; Behra *et al*., 2011) [11, 6]. In this case, biofertilizers came in handy to rectify these nutrients by converting inaccessible organic nutrients to available forms and making it easier for plants to absorb nutrients.

In view of the facts mentioned above, the investigation was carried out on effect of potassium and zinc solubilizing microorganisms on pod, protein and oil yield of groundnut in Coastal Zone of Karnataka.

Material and Methods

A field study was conducted during summer 2020-21 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 consisting eight treatments *viz*.,: T_1: Absolute control, T_2: POP (25:75:37.5) kg NPK ha^{-1} + ZnSO4 @ 10 kg ha^{-1}, T_3: T_2 + seed treatment with Potassium Solubilizing Bacteria (KSB), T_4: T_2 + Seed treatment with Zinc Solubilizing Bacteria (ZnSB), T_5: T_2 + Seed treatment with both KSB and ZnSB, T_6: RDNP +75% RD of K and ZnSO4 + Seed treatment with both KSB and ZnSB, T_7: RDNP + 50% RD of K + ZnSO4 + 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 duration of the crop 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. Zinc Solubilizing 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 the standard protocol. Sowing was done by hand dibbling @ 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 quality parameters

Protein and oil content

Protein and oil content were estimated by Kjeldal (AOAC, 2000) and Soxhlet method (Ajay *et al*., 2004) [2], respectively. Protein and oil yield were estimated by following formulae.

Protein yield

$$\text{Protein yield (kg ha}^{-1}) = \text{Kernel yield (kg ha}^{-1}) \times \frac{\text{Protein content (\%)}}{100}$$

Oil yield

$$\text{Protein yield (kg ha}^{-1}) = \text{Kernel yield (kg ha}^{-1}) \times \frac{\text{oil content (\%)}}{100}$$

Result and Discussion

Effect on pod yield: Any new technology has to concentrate on increasing quantity and quality of the product. In groundnut, kernel yield is an economic part. Whereas, protein and oil yield express the quality aspects.

Significantly higher pod yield (1675 kg ha^{-1}) and kernel yield (1245 kg ha^{-1}) was 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) (1654 kg ha^{-1} and 1224 kg ha^{-1}) over RDF alone (1545 kg ha^{-1} and 1104 kg ha^{-1}) (Table 1). Higher yield with KSB and ZnSB seed treatment was due to role of inoculums in increasing of microbial population in soil thereby increases the nutrient availability, nutrient uptake by crops and better utilization of native K and Zn and also influence the positive effect on uptake of other nutrients. Similar results were obtained by Verma *et al.* (2016) [20], Prajapati and Modi (2016) [15], Han *et al*. (2006) [12], Meena *et al*. (2013) [13], Archana *et al*. (2008) reported that all the inoculated bacterial isolates increased plant growth, nutrient uptake, and yield component of maize plant significantly over absolute fertilizer control. Nomen *et al*. (2015), due to the application of Zn bio-fertilizer, have recorded 4.7 per cent higher pod yield of groundnut, over control.

Effect on quality parameters

The quality parameters are greatly influenced by crop nutrition. Better the nutrition, better the quality. The present study showed that significantly higher protein yield (325.95 kg ha^{-1}) recorded in treatment seed treatment with both KSB and ZnSB inoculums along with RDF (T_5) over RDF alone (125.96 kg ha^{-1}). The higher protein yield was attributed to the groundnut's higher kernel yield and protein content. Better availability of K due to microbial release caused better nitrogen uptake and assimilation of photosynthates. Further, higher K and Zn availability and uptake caused for release of growth hormones like IAA, which is a precursor for certain amino acid and protein synthesis. Thus Zn known to increases the protein content, calorific value and amino acids.

Similarly, significantly higher oil yield was also realized in the treatment of receiving seed treatment with KSB + ZnSB along with RDF (598.54 kg ha^{-1}) over RDF alone (275.67 kg ha^{-1}). Higher oil yield 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 and Sanadi *et al*., 2018) [8, 18]. Sugumaran and Janarthanam (2007) [19] have also reported higher oil content in groundnut due to inoculation of *B. mucilaginosus* (KSB) than in the control plot. Saha *et al*. (2015) [17] have also opined the same. Bhagyalakshmi *et al*. (2012) [7] have too revealed improvement in tea quality parameters *viz*., theaflavin, thearubigin, highly polymerized substances, total liquor color, caffeine, briskness, color and flavor indices with KSB treated plants.

Table 1: Effect of Potassium and Zinc Solubilizing Microorganisms on Pod yield, Kernel yield, Protein and Oil yield of Groundnut

Treatments		Pod yield	Kernel yield	Protein yield	Oil yield
		kg ha^{-1}			
T_1	Absolute control	950	622	125.96	275.67
T_2	RDF	1545	1104	264.96	518.88
T_3	RDF + ST with KSB	1600	1168	298.54	566.48
T_4	RDF + ST with ZnSB	1590	1145	291.06	551.89
T_5	RDF + ST with KSB + ZnSB	1675	1245	333.04	613.79
T_6	RDNP + 75% RD of K and $ZnSO_4$ + ST with KSB and ZnSB	1654	1224	325.95	598.54
T_7	RDNP + 50% RD of K and $ZnSO_4$ + ST with KSB and ZnSB	1480	1054	250.85	492.22
T_8	RDNP + ST with KSB and ZnSB	1440	1002	236.47	460.92
S.Em.±		46.00	37.00	5.555	12.067
C.D.@ 5%		135.70	107.30	16.147	35.077

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)

Conclusion

According to the present field experiment findings, seed treatment with potassium and zinc solubilizing microorganisms in addition to state-recommended fertiliser to groundnut resulted in higher pod yield (8.41%), protein yield (25.69%), and oil yield (18.29%) over a package of practises.

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