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Effect of Bio-fertilizers and Micronutrients on Morpho-physiological and Biochemical parameters of Groundnut (*Arachis hypogia* L.)

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ABSTRACT: *A field experiment was conducted during the summer season of 2013 in Junagadh Agricultural University, Junagadh, to evaluate the effect of micro-nutrients and bio-fertilizers on morpho-physiological and biochemical parameters of summer groundnut (*Arachis hypogaea *L.) variety GJG-31. Evelen treatments of different combinations of biofertilzers and micro nutrients were applied in randomised block design. Among all treatments in treatment (T_{10}) i.e., the combined effect of Rhizobium and phosphate solubilizing bacteria and zinc sulphate and molybdenum showed the maximum values in all morpho-physiological and biochemical parameters i.e., number of leaves per plant, number of branches, plant height (cm), root length (cm), germination percentage, crop growth rate (CGR), net assimilation rate (NAR), Leaf Area Index (LI), chlorophyll content (SPAD) and Nitrogen content were recorded maximum at different days after sowing.*

INTRODUCTION

Groundnut (*Arachis hypogaea L.*) is an important oil seeds, as well as food crop ranking 13th among the principal economic crops of the world. Among the oilseed crop grown in India, groundnut occupies pre dominant position. Therefore, The groundnut is rightly called as "king of oilseeds" in India. Groundnut is one of the most nutritious foods because of its high protein and oil contents. The major reason for low yield of groundnut is mainly mineral deficiency. Among the micronutrients, the deficiency of zinc has been identified in all the groundnut growing states and, that of Mo has been found in Gujarat, Madhya Pradesh and NE states. The yield losses of 15-20% and 13-19% in groundnut due to Zn and Mo deficiency have been reported by Singh **[11]**. The molybdenum plays key role to catalase nitrate reduction and its fixation in legumes. It also increases the dry matter production along with improving nodulation in groundnut. The zinc is involved in many enzyme systems and carbonic anhydrate is a very specific.

Use of bio-fertilizers in integrated nutrient management is important for optimization of plant nutrition. The black calcareous soils are, even though, high in P content but plants face P deficiency due to low amount of available P. Therefore, to solublize and mobilize mineral bound P, use of Phosphorus solubilizing bacteria (PSB) can be helpful. 'Plants require all essential nutrients in balance proportion and deviation from this may results in mineral disorders. We conducted this study with the objectives of evaluating the effect of Zn, Mo, Rhizobium and PSB on morpho-physiological parameters and productivity of summer groundnut (*Arachis hypogaea* L.).

MATERIALS AND METHODS

A field experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during summer season of 2013. There were eleven treatment combinations consisting of Control, Recommended dose of fertilizers (RDF), RDF + Zn, RDF + Mo, RDF + PSB (Bacillus megaterium), RDF + Rhizobium (NC 92), RDF + Zn+ PSB, RDF + Zn + Rhizobium, RDF + Mo + PSB, RDF + Mo + Rhizobium, RDF + Mo + Zn + Rhizobium+ PSB. Experiment was laid out in randomized block design with three replications.

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Dry sowing of groundnut variety GJG 31 was done on raise bed with plastic mulching using seed rate of 5 kg/ha and maintaining spacing of 20 cm between rows and plants. The recommended dose of fertilizer was 25 kg Nha-1 and 50 kg P2O5 ha-1. N and P2O5 were applied using urea and single super phosphate, respectively. Plants were harvested after attaining physiological maturity. The data collected from the experiment were subjected to statistical test by following 'Analysis of variance technique' as suggested by Panse and Sukhatme **[9]**.

RESULTS AND DISCUSSION

MORPHOLOGICAL PARAMETERS

Number of Leaves Plant^{-1}

The maximum number of leaves were recorded in treatment T_{10} (RDF + Mo + Zn + *Rhizobium*+ PSB). This may be due to biofertilizer inoculated plants may be attributed to the symbiotic relationship of *Rhizobium* and phosphate solubilizing bacteria with the roots of leguminous crops, which fix the atmospheric nitrogen into the roots of groundnut and which in turn to increase the photo-synthetic activity of crop plants and later enhances the vegetative growth thus the number of leaves plant^{-1}, number of branches, plant height etc. were increased. Phosphorus hastened meristematic activity and the availability of sufficient phosphorus for rapid vegetative growth **[10]**. The micro-nutrients such as zinc and molybdenum is responsible for activation of many enzymes working as co factors **[4]**. These micro-nutrients are essential for the meristematic growth from which leaves arises.

Number of Branches Plant^{-1}

The more number of branches per plant is observed in the T_{10} treatment *i,e.* Combined application biofertilizers and micronutrient. Inoculation of *Rhizobium* and PSB increased the nitrogen and phosphorus content of the plant. Phosphorus being an essential constituent of cellular proteins and nucleic acid encourages the meristematic activities in plants. The increases in the height, number of branches and leaves might be due to hastened meristematic activity and the availability of sufficient phosphorus for rapid vegetative growth **[13]**. Phosphorus is important for cell division activity, leading to the increase of plant height and number of branches.

Plant Height (cm) Plant^{-1}

The maximum plant height is recorded in combined application of biofertilizer and micronutrients (T_{10}). The maximum plant height may be due to the adequate amount of nitrogen fixed by the rhizobia **[7]**. More number of leaves per plant may also be positively contributed to more plant height in the inoculated plant with phosphorus solubilizing bacteria by giving sufficient phosphorus for leaves formation and growth. The micro-nutrients such as zinc and molybdenum increase the plant height due to the synthesis of growth promoting substance (Auxin) which in turn stimulated the efficiency of nutrient uptake and thus lead to increased plant height **[12]**.

Table 1
Effect of bio-fertilizers and micro-nutrients on number of leaves plant-^{1}, number of branches plant-^{1}, plant height and root length of groundnut at different days after sowing.

Treatment	*Number of leaves plant^{-1}*			*Number of branches plant^{-1}*			*Plant height (cm)*			*Root length (cm)*		
	30 DAS	*60 DAS*	*90 DAS*	*30 DAS*	*60 DAS*	*90 DAS*	*30 DAS*	*60 DAS*	*90 DAS*	*30 DAS*	*60 DAS*	*90 DAS*
T_0	48	134	180	5.1	6.3	7.22	6.87	15.22	16.89	5.82	11.17	12.78
T_1	53	135	207	6.2	6.8	8.18	7.08	16.11	20.00	6.86	12.67	13.67
T_2	49	177	188	5.9	6.4	7.33	7.59	15.23	19.56	7.16	11.71	12.89
T_3	39	141	200	6.2	6.5	7.78	7.09	16.44	18.67	6.98	11.94	13.33
T_4	49	191	189	5.2	6.7	7.77	7.54	16.22	18.17	8.44	14.29	14.23
T_5	54	194	269	6.8	7.5	9.58	7.96	17.01	20.67	6.70	13.81	14.90
T_6	56	152	260	6.5	7.2	8.33	7.91	16.56	21.44	7.67	11.44	12.96
T_7	48	147	252	6.1	7.1	7.56	7.16	15.41	19.00	6.80	12.33	14.07
T_8	53	172	185	6.0	6.7	8.00	7.39	16.49	18.78	6.91	12.11	15.22
T_9	52	189	191	6.3	6.8	7.80	6.98	16.72	19.00	6.91	11.89	12.98
T_{10}	59	207	268	7.2	8.7	10.14	8.49	19.09	25.89	11.38	15.09	17.49
S.Em±	2.94	13.29	15.48	0.31	0.28	0.64	0.28	0.68	1.37	0.55	0.717	0.68
C.D. at 5%	8.66	39.20	45.67	0.91	0.83	1.89	0.82	2.01	4.05	1.63	2.11	2.02
C.V.%	9.92	13.74	12.35	8.06	7.30	13.57	6.51	7.19	11.93	12.99	9.86	8.44

Root Length (cm) Plant^{-1}

The maximum root length was recorded in treatment T_{10} (RDF + Mo + Zn + *Rhizobium*+ PSB). Increased cell elongation and multiplication is due to enhanced nutrient uptake by plants following inoculation of phophate solubilizing microorganisms. Induction of longer roots with increased number of root hairs and root laterals is a growth response attributed to IAA production by other rhizobacteria **[5]**.

PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS

Germination percentage (%)

The maximum germination percentage were recorded at 7 and 21 DAS was respectively with the treatment no. T_{10} (RDF + Mo + Zn + *Rhizobium*+ PSB). That application of biofertilizers and micro-nutrients as seed treatment or as soil application in different crops help to produce metabolites such as phytohormones, antibiotics and siderophores which further improves the imbibitions of water inside the seeds and activate the metabolic processes required for establishment of healthy seed germination **[3]**.

Crop Growth Rate (CGR)

The maximum crop growth rate in between 30-60 DAS and 60-90 DAS were recorded in treatment T_{10} (RDF + Mo + Zn + *Rhizobium*+ PSB). The application of *Rhizobium* increases the avaibilty of nitrogen resulting in de-novo synthesis for new photosynthetic organs mean while fertigation with micro-nutrient (such as Zn and Mo) helps to synthesis growth promoting hormones and increases the nitrogen fixation rate in legumes respectively. The presence of biological fertilizers had an important role in increasing durability of photosynthetic organs. Mog and Meenachi **[6]** repoted that the increase in CGR with seed inoculation may be due to the acceleration of photosynthesis activity and the positive response of crop plants to PGPR and PSB.

Net Assimilation Rate (NAR)

The highest net assimilation rate were recorded in between 30-60 DAS and 60-90 DAS respectively with the treatment T_{10} (RDF + Mo + Zn + *Rhizobium*+ PSB). NAR fairly gives a good idea of photosynthetic capacity of the crop plant which is dependent on LAI. Araei and Mojaddam **[1]** reported that increase in LAI up to 60 DAS in groundnut crop is due to better nitrogen fixation and readily available of PO_4 by the application of biofertilizers and Mo. Leaf area increase also promoted by addition of $ZnSO_4$ due to its metabolic activity towards growth promoting hormone synthesis. The NAR was found to decrease from 60 DAS to harvest in all the treatments and such a decline at later stages could be attributed to the mutual shading of leaves with an advancement of crop phenology.

Leaf Area Index (LAI)

The highest leaf area index was recorded at 30, 60 and 90 DAS respectively in treatment T_{10} (RDF + Mo + Zn

Table 2
Effect of bio-fertilizers and micro-nutrients on crop growth rate (CGR), net assimiltation rate (NAR), germination percent and leaf area index of groundnut at different days after sowing

S. No	*Treatments*	*Germination (%)*		*CGR (gm^{-2} day^{-1})*		*NAR(gdm^{-2} day^{-1})*		*LAI*		
		7 DAS	*21 DAS*	*30-60 DAS*	*60-90 DAS*	*30-60 DAS*	*60-90 DAS*	*30 DAS*	*60 DAS*	*90 DAS*
T_0	Control	39.2	60.7	3.53	1.34	0.21	0.072	0.615	1.12	2.79
T_1	RDF	41.7	65.5	3.76	1.60	0.25	0.081	0.696	1.22	2.92
T_2	RDF + $ZnSO_4$	46.0	65.4	3.81	1.69	0.31	0.079	0.812	1.55	2.87
T_3	RDF + Mo	43.3	64.9	3.74	1.72	0.32	0.083	0.769	1.53	2.83
T_4	RDF + Phosphorus Solubilizing Bacteria (PSB)	44.0	62.1	4.17	1.40	0.34	0.085	0.675	1.39	3.09
T_5	RDF + *Rhizobium*	47.3	68.4	4.42	2.00	0.38	0.096	0.781	1.57	3.40
T_6	RDF + Zn+ PSB	42.9	62.3	4.25	1.87	0.35	0.090	0.727	1.56	3.84
T_7	RDF + Zn + *Rhizobium*	40.2	66.1	4.18	1.80	0.31	0.086	0.700	1.16	3.00
T_8	RDF + Mo + PSB	45.6	65.0	3.65	1.55	0.27	0.079	0.727	1.37	3.01
T_9	RDF + Mo + *Rhizobium*	42.1	62.2	4.07	1.72	0.22	0.088	0.721	1.51	2.92
T_{10}	RDF + Mo + Zn + *Rhizobium*+ PSB	48.6	72.0	4.85	2.19	0.39	0.098	0.871	1.66	3.29
	S.Em±	0.23	1.6	0.23	0.16	2.0	0.005	0.04	0.06	0.12
	C.D. at 5%	0.69	4.7	0.69	0.47	5.9	0.014	0.12	0.17	0.36
	C.V.%	10.03	6.4	10.03	16.30	5.3	9.401	10.18	7.33	6.93

+ *Rhizobium*+ PSB). Basu **[2]** showed that at first the increasing trend of LAI at early growth stages was slow and then it was increased with faster rate up to certain period. The increase in leaf area index could be attributed to increased cell division and increased leaf expansion. While more number of leaves were recorded due to beneficial influence of biofertilizers which release growth promoting substances along with enhancement of nitrogen availability **[1]**.

CONCLUSION

The performance of groundnut crop in respect to application of biofertilizers and micro-nutrients in well irrigated conditions may improve most of all parameters regarding physiological and morphological parameters. Therefore, biofertilizers such as *Rhizobium* (NC 92) and phosphorus solubilizing bacterium (*Bacillus megaterium*) and micro-nutrients such as zinc ($ZnSO_4$) and molybdenum ($(NH_4)_6Mo_7O_{24}$) may be boon for groundnut growers.

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