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Residual effect of micronutrients and bio inoculants on growth of groundnut in sweet corn - Groundnut cropping system

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Abstract
An investigation was carried out at Post Graduate Institute Research Farm, MPKV, Rahuri Maharashtra (India) on “Response of *rabi* sweet corn - *summer* groundnut cropping system to micronutrients and bio inoculants” was conducted during 2021-22 and 2022-23. The result were revealed that among the residual effect of micronutrients the treatment GRDF + residual effect of $ZnSO_4$ + $FeSO_4$ + Borax (M_6) recorded significantly higher growth attributes *viz*., plant height (27.05 and 30.27 cm), number of compound leaves plant^{-1} (62.51 and 70.33), leaf area plant^{-1} (8.21 and 8.69 dm^{-2}), number of branches plant^{-1} (11.24 and 12.73) and dry matter plant^{-1} (40.20 and 43.20 g) and in treatment of bio inoculants the seed treatment with *Rhizobium* + PSB + KSB + drenching at 30 DAS liquid *Rhizobium* + PSB + KSB were recorded significantly higher growth attributes *viz*., plant height (24.90 and 26.81 cm), number of compound leaves plant^{-1} (51.95 and 58.84), leaf area plant^{-1} (7.28 and 8.03 dm^{-2}), number of branches plant^{-1} (10.27 and 11.25) and dry matter plant^{-1} (35.35 and 38.80 g) at harvest stage during both years for *summer* groundnut.

Keywords: Residual, Micronutrient, bio inoculants, groundnut

Introduction

Groundnut (*Arachis hypogaea* L.) is a leguminous plant that is widely cultivated in the tropics and subtropics between 40°N and 40°S latitudes. It is valued for its high oil content and edible seeds. It is the fourth most important source of edible oil and a third most important source of vegetable protein in the world. Globally, groundnut covers 327 lakh hectares with the production of 539 lakh tonnes with the productivity of 1648 kg ha^{-1} with annual all season coverage of 54.2 lakh hectares, globally; India ranks first in groundnut area under cultivation and is the second largest producer in the world with 101 lakh tonnes with productivity of 1863 kg ha^{-1} in 2021-22. Groundnut is cultivated *kharif*, *rabi* and *summer* seasons, but nearly 90 % of acreage and production comes from *kharif* and *summer* season. In *summer* 2022 - 23, groundnut production was 83.69 lakh tonnes in an area of 45.53 lakh hectares. India ranks first in respect of area and second in production after China. In India, it is cultivated over an area of 5705 hectares with production of 10135 tons with an average productivity is 1777 kg ha^{-1} (Anonymous, 2022-23). Gujarat is the largest producer contributing 36 percent of the total production of groundnut followed by Rajasthan (17 %), Tamil Nadu (7.5 %), Andhra Pradesh (5.13 %) and Telangana (3.23 %). (Rai *et al*., 2016) [15].

Material and Methods

The field experiment was conducted during *rabi*- *summer* season 2021 and 2022 at the Research Farm of Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.), situated at 19°48’ and 19°57’ North latitude and between 74° 32’ and 74° 10’ East longitude. The altitude is 511 meter above mean sea level. The topography of experimental field was levelled and well drained. The experiment was conducted in split plot design with three replications during *summer* season in a fixed layout. The treatments consist of six main plot treatments of micronutrients *viz*., M_1- Absolute control, M_2-GRDF only, M_3-GRDF + residual effect of $ZnSO_4$, M_4-GRDF + residual effect of $FeSO_4$, M_5-GRDF + residual effect of Borax and M_6-GRDF + residual effect of $ZnSO_4$ + $FeSO_4$ + Borax were split into three sub plot treatments of bio inoculants *viz*., B_1-seed treatment with *Rhizobium* + PSB + KSB, B_2-drenching at 30 DAS liquid *Rhizobium* + PSB + KSB and B_3-seed treatment with *Rhizobium* + PSB + KSB + drenching at 30 DAS liquid *Rhizobium* + PSB + KSB for *summer* groundnut. Farm yard manure was applied @ 10 t ha^{-1} to groundnut 10 days before sowing. The recommended dose of fertilizer (25: 50: 00 kg N, P_2O_5 and K_2O ha^{-1}) was by using urea (46 % N), Single super phosphate (16 % P_2O_5) and $ZnSO_4$, $FeSO_4$ and borax were not applied to groundnut during both of years it was applied to preceding sweet corn during both years. Full dose of nitrogen and phosphorus was applied at the time of sowing. Groundnut seed was treated with *Rhizobium*, phosphate solubilizing bacteria (PSB) and potassium solubilizing bacteria (KSB) @ 25 g kg^{-1} seeds according to treatments, drenching of liquid *Rhizobium* + PSB + KSB was done @ 5 lit. of bio inoculant for 500 lit. of water ha^{-1} during both years to *summer* groundnut. The various growth parameters *viz*., plant height (cm), number of compound leaves plant^{-1}, leaf area plant^{-1} (dm^2), number of branches plant^{-1} and dry matter plant^{-1} (g) in groundnut were recorded on five randomly selected plants. The growth observations were recorded at an interval of 30 days commencing from 30 DAS till at harvest during both years.

Result and Discussion

Plant height (cm)

Residual effect of micronutrients

Data presented in Table 1 illustrated that the plant height of groundnut was influenced significantly due to residual effect of micronutrient to the preceding sweet corn crop during both years. The treatment GRDF + residual effect of $ZnSO_4$ + $FeSO_4$ + Borax (M_6) registered significantly higher plant height at harvest during both years. The higher plant height might be due to more availability of unutilized nutrients enhancement of auxin biosynthesis and the synergistic relationship between zinc and nitrogen, which leads to vigorous growth increasing plant height due to the improvement in the availability of native soil nutrients and synchronized uptake of nutrients. The results are in accordance with the findings of by Gunjal *et al*. (2017) [6] Sayem *et al*. (2018) [17] and Prajapati and Kewalanand (2019) [17].

Effect of Bio inoculants

Data presented in Table 1 implicated that the plant height of groundnut was influenced significantly due to different bio inoculants during both the years. The seed treatment with *Rhizobium* + PSB + KSB + drenching at 30 DAS liquid *Rhizobium* + PSB + KSB (B_3) recorded significantly higher plant height at harvest during both years than rest bio-inoculant treatments. Increment in plant height may be due to increased uptake of nitrogen and phosphorus by the plants, which was made available through N fixation and P solubilisation by the *Rhizobium* and PSB microorganisms. These results are in corroborated with Khan *et al.* (2017) [9], Kumawat *et al.* (2017) [10] and Banu *et al.* (2017) [3].

Number of compound leaves plant^{-1}

Residual effect of micronutrients

The maximum number of compound leaves of groundnut was influenced significantly due to residual effect of micronutrient to the preceding sweet corn crop during both years. The treatment GRDF + residual effect of $ZnSO_4$ + $FeSO_4$ + Borax (M_6) registered significantly higher number of compound leaves harvest during both years. The maximum number of functional compound leaves plant^{-1} might be due to iron plays an important role in respiration, photosynthesis and the production of healthy green leaves. These results are in accordance with Deepika and Anita (2015) [5] and Akbar *et al.* (2019) [2].

Effect of Bio inoculants

Data presented in Table 1 showed that number of compound leaves of groundnut was influenced significantly due to different bio inoculants. The seed treatment with *Rhizobium* + PSB + KSB + drenching at 30 DAS liquid *Rhizobium* + PSB + KSB (B_3) recorded significantly higher number of compound leaves at harvest during both the years. Higher number of leaves might be due to the enhanced biological nitrogen fixation and transformation of N in plants as application of liquid formulation *Rhizobium* + PSB + KSB that resulted in better crop growth manifested by higher number of leaves and number branches plant^{-1}. These results are obtained by Khan *et al.* (2017) [9], Muley and Shinde (2017) [13] and Khan *et al.* (2017) [9].

Leaf area (dm^2) plant^{-1}

Residual effect of micronutrients

Data presented in Table1 revealed that the leaf area plant^{-1} of groundnut was influenced significantly due to residual effect of micronutrient to the preceding sweet corn. The GRDF + residual effect of $ZnSO_4$ + $FeSO_4$ + Borax (M_6) recorded significantly higher leaf area plant^{-1} at harvest during both years. This was might be due increased concentration of photosynthates in the shoot. These results are in accordance with Gunjal *et al*. (2017) [6], Lakshmipathi *et al.* (2018) [11] and Daphade *et al.* (2019) [4].

Effect of Bio inoculants

Data presented in Table 3 revealed that leaf area plant^{-1} of groundnut was influenced significantly due to different bio inoculants. The seed treatment with *Rhizobium* + PSB + KSB + drenching at 30 DAS liquid *Rhizobium* + PSB + KSB (B_3) recorded significantly higher leaf area plant^{-1} at harvest during both the years. Maximum leaf area plant^{-1} recorded might be due fact that corresponding increase in vegetative growth with higher availability of atmospheric nitrogen through root nodules to the plant at grand growth stage, thereby increasing the number of leaves increases the cell division, cell elongation. These results are similar to those reported by Muley and Shinde (2017) [13], Reddy *et al.* (2018) [16] and Joshi *et al.* (2018) [7].

Number of branches plant^{-1}

Residual effect of micronutrients

The number of branches plant^{-1} of groundnut Table 1 was influenced significantly due to residual effect of micronutrient to the preceding sweet corn crop. The treatment GRDF + residual effect of $ZnSO_4$ + $FeSO_4$ + Borax (M_6) registered significantly higher number of branches plant^{-1} at harvest during both years. The highest number of branches plant^{-1} recorded due to these treatments has got better nutrient availability of specially zinc and boron at branching stage for their growth and development there by increasing the number of branches plant^{-1}. These results are in accordance with Sayem *et al*. (2018) [17], Singh *et al.* (2021) and Ajjannavar *et al.* (2021) [1].

Effect of Bio inoculants

Data presented in Table 1 revealed that number of branches plant^{-1} of groundnut was influenced significantly due to combined application different bio inoculants.

Table 1: Growth attributes of groundnut at harvest stage during both years as influenced by different treatment

Treatment	Plant height (cm)		Number of compound leaves plant $^{-1}$		Leaf area (dm^{-2}) plant^{-1}		Number of branches plant^{-1}		Dry matter plant^{-1} (g)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
(A) Residual effect of micronutrients (M)										
M1- Absolute control	20.48	21.01	39.56	45.01	5.18	5.34	8.09	8.43	28.50	30.56
M_2-GRDF only	21.42	22.09	43.11	49.88	5.72	6.28	8.43	9.13	30.35	34.79
M_3-GRDF + Residual effect of $ZnSO_4$	25.83	28.62	61.46	68.19	7.62	8.29	11.10	12.35	39.90	41.35

M_4-GRDF + Residual effect of $FeSO_4$	22.55	24.34	51.40	58.13	6.39	7.23	9.57	10.51	35.00	38.62
M_5-GRDF + Residual effect of Borax	22.32	23.78	47.29	54.36	5.95	6.79	8.90	10.17	32.90	36.20
M_6-GRDF + Residual effect of $ZnSO_4$ + $FeSO_4$ + Borax	27.05	30.27	62.51	70.33	8.21	8.69	11.24	12.73	40.20	43.20
SE m ±	0.62	0.76	0.45	0.68	0.21	0.19	0.09	0.18	0.38	0.65
CD (P = 0.05)	1.94	2.40	1.43	2.13	0.66	0.61	0.29	0.56	1.20	2.04
(B) Bio inoculants- (B)										
B_1-Seed treatment with *Rhizobium* + PSB + KSB	22.98	24.59	50.82	57.46	6.58	7.12	9.73	10.52	33.93	36.87
B_2-Drenching at 30 DAS liquid *Rhizobium* + PSB + KSB	21.94	23.66	49.89	56.66	5.67	6.16	8.67	9.89	33.70	36.68
B_3-Seed treatment with *Rhizobium* + PSB + KSB + Drenching at 30 DAS liquid *Rhizobium* + PSB + KSB	24.90	26.81	51.95	58.84	7.28	8.03	10.27	11.25	35.35	38.80
SE m ±	0.45	0.47	0.30	0.34	0.17	0.17	0.07	0.12	0.25	0.44
CD (P = 0.05)	1.31	1.38	0.89	1.00	0.48	0.50	0.21	0.35	0.74	1.27
Interaction (M x B)										
Between two sub plots means at same level of main plot means										
SE m ±	1.09	1.15	0.74	0.84	0.40	0.41	0.17	0.29	0.62	1.07
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Between two main plots means at same level of sub plot means										
SE m ±	1.09	1.21	0.76	0.96	0.39	0.39	0.17	0.30	0.63	1.09
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
General mean	23.28	25.02	50.88	57.65	6.51	7.10	9.55	10.55	34.32	37.45

The seed treatment with *Rhizobium* + PSB + KSB + drenching at 30 DAS liquid *Rhizobium* + PSB + KSB (B_3) recorded significantly higher number of branches plant^{-1} at harvest during both the years. The maximum number of branches plant^{-1} recorded due to the enhanced biological nitrogen fixation and transformation of N in plants as application of liquid formulation *Rhizobium* + PSB that resulted in better crop growth manifested by higher number of branches plant^{-1}. These results are similar to those reported by Kant *et al.* (2016) [8], Kumawat *et al.* (2017) [10] and Muley and Shinde (2017) [13].

Dry matter plant^{-1} (g)

Residual effect of micronutrients

Data presented in Table 1 revealed that dry matter plant^{-1} of groundnut was influenced significantly due to residual effect of micronutrient to the preceding sweet corn crop. The treatment GRDF + residual effect of $ZnSO_4$ + $FeSO_4$ + Borax (M_6) registered significantly higher dry matter plant^{-1} at harvest during both years might be due to activation of different physiological processes like stomatal regulation, chlorophyll formation, enzyme activation and biochemical processes due to soil application of micronutrients which resulted in increased dry matter production. These results are in accordance with Gunjal *et al.* (2017) [6], Muley and Shinde (2017) [13] and Ajjannavar *et al.* (2021) [1].

Effect of Bio inoculants

Data presented in Table 1 indicated that dry matter plant^{-1} of groundnut was influenced significantly due to bio inoculants at all the stages of crop growth. The seed treatment with *Rhizobium* + PSB + KSB + drenching at 30 DAS liquid *Rhizobium* + PSB + KSB (B_3) recorded significantly higher dry matter plant^{-1} at harvest during both the years. The highest dry matter plant^{-1} recorded might be due the production of more chlorophyll content with inoculation of nitrogen fixers. The other reason for increased vegetative growth may be the production of plant growth regulators by bacteria around rhizosphere, which are absorbed by the roots and better translocation of photosynthates from source to sink. Therefore, increased dry matter may be attributed to the increased biological nitrogen fixation have also reported by Kant *et al.* (2016) [8], Muley and Shinde (2017) [13] and Mohammadi *et al.* (2019) [12].

Conclusion

Based on two years of experimentation it could be concluded that the treatment GRDF + residual effect of $ZnSO_4$ + $FeSO_4$ + Borax (M_6) and seed treatment with *Rhizobium* + PSB + KSB + drenching at 30 DAS liquid *Rhizobium* + PSB + KSB (B_3) to the *summer* groundnut obtained higher growth parameters *viz.*, plant height (cm), number of compound leaves plant^{-1}, leaf area plant^{-1} (dm^2), number of branches plant^{-1} and dry matter plant^{-1} (g) of groundnut in sweet corn - groundnut cropping sequence.

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