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Original Research Article

Response of Kharif Maize (*Zea mays* L.) to Liquid and Carrier based Bioinoculants in Vertisols of Marathwada

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A B S T R A C T

A field experiment was conducted to access the response of *kharif* maize (*Zea mays* L.) to liquid and carrier based bio-inoculants during *kharif*, 2014-2015 at Research farm of Department of Agronomy, College of Agriculture, Latur. The experiment was laid out in randomized block design with eight treatments and three replications. The results in nut-shell indicated that the growth and yield of maize were significantly influenced by liquid and carrier based bio-inoculants application. The growth, yield attributes and yield of maize significantly influenced due to application of RDF + liquid *Azotobacter* + PSB. Significant improvement in all growth parameters *viz.*, height of plant (253.60 cm), number of leaves (14.27 plant^{-1}), yield contributing characters *viz.*, weight of cob (302.21 g), test weight (36.02 g plant^{-1}), grain yield (57.13 qha^{-1}), fodder yield (66.58 qha^{-1}) and total biomass (123.72 qha^{-1}) were observed due to application of RDF + liquid *Azotobacter* + PSB. Significantly higher uptake of nutrients N (120.77 kg ha^{-1}), P (24.76 kgha^{-1}), K (145.18 kg ha^{-1}), at harvest stage of maize were recorded due to application RDF + liquid *Azotobacter* + PSB. Protein content (10.46%), ash content (3.70%), reducing sugar (1.57%) and non-reducing sugar of maize were also increased with treatment RDF + liquid *Azotobacter* + PSB. The available nutrient status of soil after harvest of maize crop was also improved due to the application of RDF along with liquid and carrier based bio-inoculants. Application of RDF + liquid *Azotobacter* and RDF + liquid PSB significantly influenced the microbial population of *Azotobacter* and PSB in soil after harvest of *kharif* maize.

Keywords

Kharif Maize (*Zea mays* L.), Bioinoculants, Marathwada

Introduction

Maize (*Zea mays* L.) is an annual plant which belongs to family Graminaceae and Genus *Zea. Zea mays* L., cultivated globally being one of the most important cereal crop worldwide. Maize is a versatile crop grown over a range of agro climatic zones, apart from its industrial uses like production of starch, protein, oil, dextrose, gum, paints etc. Maize contains about 70-75% starch, 8-12% protein, 3-18% oil and other carbohydrates 1-3%. Maize is considered as the "Queen of Cereals" as it has a lot higher grain protein content than our staple food rice. Being a C4 plant, it is capable to utilize solar radiation more efficiently even at higher radiation intensity. In India, Maize (*Zea mays* L.) is the third most important cereal crop after rice and wheat. It provides food, feed, fodder and serves as a sources of basic raw material for the number of industrial

products *viz.*, starch, protein, oil, alcoholic beverages, food sweeteners, cosmetics, bio-fuel etc. No other cereal is being used in as many ways as maize.

Maize being of an exhaustive nature it requires balanced supply of the three plant nutrients (NPK) in most of soils. With the short supply and escalating price of chemical fertilizer, there is an increasing awareness in favour of adopting biological routes of soil fertility management for preventing soil degradation for sustaining crop production. Nitrogen as the most important vital elements of plant in quality and quantity production of cultivation products plays important role. On the other hand, the economical and environmental problems of unduly consumption of chemical nitrogen fertilizers and considering the main aspects of earth creatures and microorganisms caused that one of the most and applied research fields in update scientific studies are attempts for biofertilizer. *Azotobacter* and *Azospirillum* as fixing bacteria of nitrogen and be considered as biological fertilizer. In view of hike in the chemical fertilizers, it is necessary to popularize an use of bio-fertilizers as they are cheap, handy and eco-friendly to reduce the dependence of fertilizers. They can successfully be used as supplementary source of nutrients and microbes like *Azotobacter* and PSB are well known to release of hormones, vitamins and enzymes which enhances germination and improves growth of crop. PSB also helps insolubilization of fixed nutrients like P which otherwise is not easily available to growing plants.

It is important to work on effect of different combinations of chemical fertilizers in combination with different forms of biofertilizers. The experiment was designed in order to study the efficient utilization of chemical fertilizers and bioinoculants for improvement in yield potential and quality of cereal crops.

Materials and Methods

The experiment was conducted during *kharif* season, 2014 at farm, Department of Agronomy, College of Agriculture, Latur. The topography of experimental field was uniform and levelled. The soil of the experimental site was deep, black in colour with good drainage.

The present experiment was laid out by using randomized block design with three replications and eight treatments. Treatments were T1: Control, T2: RDF (150:75:75 kg NPK ha-1), T3: RDF+ Carrier based *Azotobacter,* T4: RDF + Carrier based PSB, T5: RDF + Carrier based *Azotobacter*+ PSB, T6: RDF + liquid *Azotobacter*, T7: RDF + liquid PSB and T8: RDF + liquid *Azotobacter*+ PSB in *Kharif* 2014 on maize crop (Variety Rajashree).

Fertilizer *viz.,* nitrogen, phosphorus and potassium were applied in respective plots as per the recommendation by using the urea, DAP and murate of potash, and bio-inoculants (liquid and carrier based *Azotobacter* and PSB). Soil samples were collected separately from each plot after harvest of maize crop. These soil samples were processed and analysed as per standard procedures mentioned by A.O.A.C. (1975) for pH, EC, O.C, N, P and K.

Results and Discussion

Growth and yield parameters *viz*, plant height, number of leaves per plant, number of cobs per plant, weight of cobs per plant, grain yield, fodder yield, final plant stand and total biomass recorded during experimentation.

Number of leaves

The data pertaining to number of leaves per plant of maize recorded at different stages are presented in table 1. From the data it was evident that bio-inoculants treatments significantly influenced the number of leaves in maize crop due to various treatments at all stages of crop. The treatment T8 recorded higher number of leaves at 30 DAS (5.40), 60 DAS (14.27), 90 DAS (11.93) and at harvest (11.03) in maize than recorded T1,T2, T3, T4, T5, T6, T7 while, it was at par with treatment T3 (RDF+ carrier based *Azotobacter*), T4 (RDF + carrier based PSB), T5 (RDF + carrier based *Azotobacter* + PSB), T6 (RDF + liquid *Azotobacter*) andT7 (RDF + liquid PSB), whereas minimum number of leaves were recorded with T1 (Control).

Phosphate solubilizing micro-organism are helpful to plant in term of increase plant height by producing plant growth promoting hormones, specially auxines and activating hormone that plays important role in increasing height. Similar findings was also reported by Naserirad *et al.,* (2011) that double inoculation of *Azotobacter* and *Azospirillum* caused to 21% increasing in height, main cause was increasing nutrients up take by plant, improving soil properties The plant height was influenced by water and nutrient availability through increasing number of nodes middle nodes length.

Plant height

The data regarding plant height recorded at 30, 60, 90 DAS and at harvest are presented in table 2. It is evident from the results that plant height was significantly affected due to different treatments. Highest plant heights of plants was observed with treatment T8 (RDF + liquid *Azotobacter* + PSB) at all the growth stages of maize. The treatment T8 recorded significantly higher plant height at 30 DAS (16.27 cm), 60 DAS (163.14 cm), 90 DAS (249.60 cm) and at harvest (253.63 cm) and was found at par with treatment T3 (RDF + carrier based *Azotobacter*), T4 (RDF + carrier based PSB), T5 (RDF + carrier based *Azotobacter* + PSB), T6 (RDF + liquid *Azotobacter*) and T7 (RDF + liquid PSB) and significantly superior over rest of the treatments. Whereas the minimum height of plants was observed at 30 DAS (12.70 cm), 60 DAS (124.75 cm), 90 DAS (190.10 cm) and at harvest (190.37 cm) with treatment T1 (control).

Table.1 Effect of liquid and carrier based bio-inoculants on number of leaves per plant of *Kharif* maize

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1: Control	4.20	10.87	8.53	7.23
T2: RDF	4.40	11.80	9.80	8.30
T3: RDF + carrier based *Azotobacter*	5.07	12.67	10.67	9.77
T4: RDF + carrier based PSB	4.87	12.60	10.60	9.20
T5: RDF + carrier based *Azotobacter* + PSB	5.20	13.47	11.47	10.27
T6: RDF + liquid *Azotobacter*	5.20	13.77	11.77	10.50
T7: RDF + liquid PSB	5.07	12.87	10.87	9.80
T8: RDF + liquid *Azotobacter*+ PSB	5.40	14.27	11.93	11.03
SE +	0.22	0.61	0.62	0.62
C.D. at 5%	0.66	1.85	1.90	1.89

Table.2 Effect of liquid and carrier based bio-inoculants on plant height of *kharif* maize

Treatments	30 DAS	60 DAS	90 DAS	At Harvest
T1: Control	12.70	124.75	190.10	190.37
T2: RDF	13.90	138.96	210.00	206.57
T3: RDF + carrier based *Azotobacter*	14.33	154.84	222.33	229.63
T4: RDF + carrier based PSB	14.30	151.37	221.83	228.97
T5: RDF + carrier based *Azotobacter* + PSB	15.57	158.10	228.53	233.05
T6: RDF + liquid *Azotobacter*	16.03	160.23	239.17	239.67
T7: RDF + liquid PSB	15.47	155.00	226.60	231.64
T8: RDF + liquid *Azotobacter*+ PSB	16.27	163.14	249.60	253.63
SE +	0.67	4.81	9.22	8.02
C.D. at 5%	2.05	14.59	27.58	24.49

Table.3 Effect of liquid and carrier based bio-inoculants on yield attributes of *kharif* maize

Treatments	Test weight (gm)	Grain yield (q ha^{-1})	Fodder yield (q ha^{-1})	Total biomass (q ha^{-1})	Harvest index (%)
T1: Control	28.15	27.16	33.31	60.47	44.01
T2: RDF	29.61	38.39	44.91	83.31	46.21
T3: RDF + carrier based *Azotobacter*	30.93	39.50	44.56	84.07	46.47
T4: RDF + carrier based PSB	30.84	37.30	45.32	82.63	45.03
T5: RDF + carrier based *Azotobacter* + PSB	33.33	51.56	60.86	112.42	45.83
T6: RDF + liquid *Azotobacter*	34.82	55.67	63.78	119.46	46.23
T7: RDF + liquid PSB	31.34	49.52	59.97	109.50	45.19
T8: RDF + liquid *Azotobacter*+ PSB	36.02	57.13	66.58	123.72	46.62
SE +	0.94	2.60	2.30	4.91	2.24
C.D. at 5%	2.85	7.82	6.90	14.73	NS

Total biomass

The effect of liquid and carrier based bio-inoculants influenced total biomass of maize significantly. It was observed that the application of treatment T8 (RDF + liquid *Azotobacter* + PSB) recorded highest total biomass (123.72 qha^{-1}) and was found at par with treatments T5 (RDF + carrier based *Azotobacter* + PSB), T6 (RDF + liquid *Azotobacter*), T7 (RDF + liquid PSB) and significantly superior over rest of treatments. However, the lowest total biomass (60.47 qha^{-1}) was obtained with treatment T1 (control) in maize. Probable reason mentioned by Nanda *et al.*, (1995) that inoculating maize seed with *Azotobacter* and *Azospirillum* increasing biological yield and this may be due attention to gibberlic cause to increasing cells growth specially middle nodes and Auxines cause to more cell divisions and as a result plant height, stem diameter and leaves increase.

Test weight

The data on test weight of maize revealed that the test weight affected significantly by different treatments of bio-inoculants. Test weight was recorded significantly maximum (36.02 gm) in treatment T8 (RDF + liquid *Azotobacter* + PSB) compared to the other treatments, while the minimum test weight (28.15 gm) was observed with treatment T1 (Control).

Grain yield

The data presented in table 3 indicated that effect of bio-inoculants influenced grain yield of maize significantly. It was observed that the application of treatment T8 (RDF + liquid *Azotobacter* + PSB) recorded highest grain yield (57.13 qha^{-1}) and was found at parwith treatments T5 (RDF + carrier based *Azotobacter* + PSB), T6 (RDF + liquid *Azotobacter*), T7 (RDF + liquid PSB) and significantly superior over rest of treatments. However, the lowest grain yield (27.16 qha^{-1}) was obtained with treatment T1 (Control) in maize. Results described by Suke *et al.*, (2011) about effect of *Azotobacter* and PSB with recommended dose of fertilizer increased grain yield of maize. The combination of *Azotobacter* and PSB, which helped to solubilize the soil phosphorus and got available it for plant growth. *Azotobacter* + PSB showed superiority which might be due to fixation of major nutrients and NP by plant roots. When nutrients required by the plants are fixed by plants themselves due to inoculation with bio-fertilizers there is enhancement in nutrient uptake, translocation and synthesis of photosynthetic assimilates which results into increase in plant growth characters and also in economic yield character like grain yield kg plant^{-1}.

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