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Response of Biofertilizers and Micronutrients on Growth and Yield of Garlic

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during winter season *(Rabi*) in the year 2023-24 at the Vegetable research farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar. The experiment was laid out in factorial RBD having three replications. The treatment factors consisted of two biofertilizers *viz.,* PSB, Azotobacter and their combination and two micronutrients *viz.,*0.2 % and 0.4 % zinc sulphate and 0.2% and 0.4% borax. Biofertilizers were applied via seed treatment and micronutrients by way of foliar application. The application of biofertilizers and micronutrients had a

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significant effect on growth and yield of garlic over control. The treatment B3M2 (PSB+Azotobacter+0.4% zinc sulphate) recorded maximum plant height (68.47 cm), number of leaves (11.23), leaf length (49.58 cm), leaf width (1.61 cm), fresh weight of bulb (35.59g), number of cloves per bulb (48.77), fresh weight of 50 cloves (40.12 g), bulb yield (2.62 kg/plot) while minimum were recorded in control.

Keywords: Biofertilizer, Micronutrient, Garlic, chemical fertilizers

1. INTRODUCTION

"Garlic (*Allium sativum* L.), belonging to the family Amaryllidaceae, is the second most widely cultivated bulb crop after onion. It has long been recognized as a valuable spice and condiments throughout India. Garlic possesses highly nutritive value and it is considered as a rich source of carbohydrate, proteins and phosphorus. The present day modern agriculture depends heavily on use of chemical fertilizers for boosting crop yield. The continuous use of higher doses of chemical fertilizer deteriorates the soil health and microorganisms' activity. So, to maintain the soil fertility status, soil health and microorganism activity of soil for longer duration use of biofertilizers is necessary. A biofertilizer is a substance which contain microorganism when applied to seed, plant surface, or soil, colonizes the rhizosphere or the interior of the plant and promote growth by increasing the supply or availability of primary nutrients to the host plant" (Vessey et al. 2003). "Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus and stimulating plant growth through the synthesis of growth promoting substances, Micronutrients are just as important in plant nutrition as the major nutrients. Micronutrients are more beneficial and play important role in plants such as Zn is involved in many enzymatic activities of plants. It helps in synthesis of tryptophan, a compound in some proteins needed for the production of growth hormones such as IAA and GA, which is essential for normal cell division and helps in the formation of chlorophyll. Boron is absorbed by plant in the form of boric acid (H_3BO_3). It plays an important role in the development and growth of new cells in plant meristem. It also acts as regulator of K/Ca ratio in plants and is necessary for the translocation of sugar, starch, phosphorus and synthesis of amino acid and proteins. Boric acid increases bulb size and bulb yield as well as the TSS content" (Srivastava et al., 2005).

2. MATERIALS AND METHODS

The field experiment was conducted during winter (*Rabi*) season of 2023-24 at the research farm of Bihar Agricultural University, Sabour, Bhagalpur, Bihar, located at a longitude of 87º 2' 42" East and latitude of 25º15'40 North. It is situated at an altitude of 45.57 meter above mean sea level in the heart of the vast Indo-Gangetic plains of North-eastern India. The experimental plot had well drained sandy loam soil of pH 7.2 with good fertility and levelled surface. The climate of this place is tropical to sub-tropical with slight semi-arid nature and is characterized by very dry summer, moderate rainfall and very cold winter. Plots of 1.5 × 1.0 m size were prepared for cultivation of garlic. The distance between plant to plant as well as row to row was kept at 15 × 10 cm. Thus, 100 plants were accommodated in each plot. The experiment was laid out in factorial RBD having three replications. The treatment factors consisted of 2 biofertilizers viz., PSB, Azotobacter and their combination and 2 micronutrient viz., 0.2 % and 0.4 % zinc sulphate and 0.2% and 0.4% borax with the total 20 treatments. Biofertilizers were applied *via* seed treatment and micronutrients via foliar application. Treatment combination were as followed (B0MO)Control,(B0M1),Control + 0.2% Zinc sulphate, (B0M2)Control + 0.4% Zinc sulphate, (B0M3)Control + 0.2% Borax, (B0M4)Control + 0.4% Borax, (B1M0)PSB + Control, (B1M1)PSB + 0.2% Zinc sulphate, (B1M2)PSB + 0.4% Zinc sulphate, (B1M3)PSB + 0.2% Borax, (B1M4)PSB + 0.4% Borax, (B2M0) Azotobacter + Control, (B2M1)Azotobacter + 0.2% Zinc sulphate, (B2M2)Azotobacter + 0.4% Zinc sulphate, (B2M3)Azotobacter + 0.2% Borax, (B2M4) Azotobacter + 0.4% Borax,(B3M0)PSB + Azotobacter + Control, (B3M1)PSB + Azotobacter + 0.2% Zinc sulphate, (B3M2)PSB + Azotobacter + 0.4% Zinc sulphate, (B3M3)PSB + Azotobacter + 0.2% Borax, (B3M4)PSB + Azotobacter + 0.4% Borax. All the growth and yield attributes data were collected with proper instruments or methods.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

According to the present study, foliar application of micronutrients and biofertilizer inoculation showed a significant increase in growth attributes in comparison to control. The maximum value of growth attributes *i.e* plant height (68.470 cm),(Table1),number of leaves per plant (11.230),(Table 2),length of leaf (49.577 cm),(Table 3), width of leaf (1.610 cm), (Table 4),were recorded with the application of PSB+ Azotobacter+ 0.4% ZnSo4 (B3M2) and minimum was recorded under control (B0M0). These results are in conformity with the findings of Ramakrishnan and Selvakumar (2012), Mahfouz and Sharaf-Eldin. (2007), Bareth, (1998). The inoculation of biofertilizers and foliar spraying of micronutrients may be the cause of the rise in plant growth indices. Azotobacter plays important role in growth attributes by making nitrogen in available form for plants which is required in large amount. It improves root development and produces phytohormones required by plants for their growth, PSB may have improved the quantity of phosphorus that was accessible in the root zone for plant growth and development. These bacteria have the ability to mineralise organic phosphorus into a soluble state in addition to solubilising phosphate. The rhizosphere is where these reactions occur, and the microorganisms release more phosphorus into the soil, which is necessary for their healthy growth and metabolism.It also produces growth promoting substances, like auxins, gibberellins, cytokinin etc. which influence the plant growth parameters by enhancing cell division, cell elongation and thus increasing the metabolic activity. The micronutrients (Zn) produced the highest value of vegetative growth in addition to biofertilizers since they are essential for numerous physiological processes and plant cellular development. Additionally, it plays a

Table 1. Effect of biofertilizers and micronutrients on plant height (cm)

Treatment	Control (M0)	Zinc (0.2%) (M1)	Zinc (0.4%) (M2)	Boron (0.2%) (M2)	Boron (0.4%) (M4)	MEAN
Control (B0)	50.850	51.180	53.260	51.077	52.640	51.801
PSB (B1)	53.240	54.760	58.850	56.120	55.650	55.724
Azotobacter (B2)	53.363	57.650	58.600	57.660	57.820	57.019
PSB+Azoto (B3)	52.047	58.420	68.470	59.280	66.750	60.993
MEAN	52.375	55.503	59.795	56.034	58.215	
	Biofertilizer	**Micronutrient**	**Biofertilizer×Micronutrient**			
SEM (±)	0.764	0.854	1.709			
C.D at 5%	2.196	2.455	4.910			
C.V	5.25					

Table 2. Effect of biofertilizers and micronutrients on number of leaves

Treatment	Control (M0)	Zinc (0.2%) (M1)	Zinc (0.4%) (M2)	Boron (0.2%) (M2)	Boron (0.4%) (M4)	MEAN
Control (B0)	8.493	8.543	8.877	8.530	8.777	8.644
PSB (B1)	8.870	9.100	9.643	9.287	9.223	9.225
Azotobacter (B2)	8.890	9.490	9.613	9.493	9.517	9.401
PSB+Azoto (B3)	8.687	9.590	11.230	9.697	10.910	10.023
MEAN	8.735	9.181	9.841	9.252	9.607	
	Biofertilizer	**Micronutrient**	**Biofertilizer×Micronutrient**			
SEM (±)	0.128	0.143	0.286			
C.D at 5%	0.368	0.411	0.823			
C.V	5.32					

Table 3. Effect of biofertilizers and micronutrients on length of leaf (cm)

Treatment	Control (M0)	Zinc (0.2%) (M1)	Zinc (0.4%) (M2)	Boron (0.2%) (M2)	Boron (0.4%) (M4)	MEAN
Control (B0)	36.253	36.483	37.890	36.413	37.483	36.905
PSB (B1)	37.877	38.840	41.180	39.653	39.373	39.385
Azotobacter (B2)	37.957	40.527	41.043	40.533	40.617	40.135
PSB+Azoto (B3)	37.083	40.947	49.577	41.403	47.887	43.379
MEAN	37.293	39.199	42.423	39.501	41.340	
	Biofertilizer	**Micronutrient**	**Biofertilizer×Micronutrient**			
SEM (±)	0.675	0.755	1.509			
C.D at 5%	2.180	2.437	4.874			
C.V	6.54					

Table 4. Effect of biofertilizers and micronutrients on width of leaf (cm)

Treatment	Control (M0)	Zinc (0.2%) (M1)	Zinc (0.4%) (M2)	Boron (0.2%) (M2)	Boron (0.4%) (M4)	MEAN
Control (B0)	1.230	1.237	1.287	1.237	1.273	1.253
PSB (B1)	1.287	1.317	1.397	1.347	1.337	1.337
Azotobacter (B2)	1.287	1.373	1.393	1.373	1.380	1.361
PSB+Azoto (B3)	1.257	1.390	1.610	1.407	1.580	1.449
MEAN	1.265	1.329	1.422	1.341	1.393	
	Biofertilizer	**Micronutrient**	**Biofertilizer×Micronutrient**			
SEM (±)	0.018	0.020	0.041			
C.D at 5%	0.052	0.058	0.117			
C.V	6.95					

crucial function in enhancing plant growth by facilitating the biosynthesis of endogenous hormones, which strengthen plant cell walls, encourage plant growth, and facilitate the movement of glucose from leaves to other plant components (Battal, 2004). Numerous scientists have also noted similar patterns: El-Tohamy et al. (2009), Sliman et al. (1999), and El-Gamelli (2000) in onion.Yield and Yield attributes.

The fresh weight of bulb, number of cloves per bulb, fresh weight of 50 cloves, and bulb yield per plot increased significantly with application of biofertilizers and micronutrients over control. The maximum values of yield and yield attributes *i.e.* fresh weight of bulb (35.590 g),(Table 5),number of cloves per bulb (48.773 cloves),(Table 6), fresh weight of 50 cloves (40.117 g), (Table 7)and bulb yield per plot (2.623 kg)(Table 8),was recorded with the inoculation of PSB+ Azotobacter+ 0.4% $ZnSo_4$ (B_3M_2)and minimum was recorded under control (B_0M_0).The increase in yield and yield attributes by the application of biofertilizer and micronutrient might be due to sufficient availability of nitrogen and phosphorus by solubilisation which increased uptake of nutrients and its effective utilization for efficient metabolism. It also helps in synthesis of carbohydrates, greater vegetative growth and subsequent partitioning and translocation from leaf (source) to the head (sink). It also facilitates release of energy rich organic compounds by the biofertilizers which ultimately increased auxin activities, growth and activity of microbial saprophytes and phosphates activity which ultimately influenced the yield and yield attributes. Furthermore, the micronutrient zinc (Zn) may have affected the production of certain growth hormones in plants due to its association with water relations, involvement in auxin metabolism (such as tryptophane synthetase and tryptomine metabolism), influence on the activity of dehydrogenase enzymes (such as pyridine

nucleotide, glucose-6 phosphate, and triose phosphate), and synthesis of tryptophane, a protein compound required for the synthesis of growth hormones like IAA and GA. Similar findings were recorded by Noggle and Fritz. (1980), Vimala and Natarajan (2000) in pea, Raghav and Sharma (2003) in tomato, Abd-El-Moneem et al. (2005) in garlic Mahfouz and Sharaf-Eldin (2007) in fennel, Upadhyay et al. (2012) in cabbage.

Table 5. Effect of biofertilizers and micronutrients on fresh weight of bulb (g)

Treatment	Control (M0)	Zinc (0.2%) (M1)	Zinc (0.4%) (M2)	Boron (0.2%) (M2)	Boron (0.4%) (M4)	MEAN
Control (B0)	26.280	26.487	27.740	26.430	27.377	26.863
PSB (B1)	27.730	28.580	30.670	29.310	29.060	29.070
Azotobacter (B2)	27.803	30.090	30.550	30.090	30.170	29.741
PSB+Azoto (B3)	27.017	30.460	35.590	30.870	34.970	31.781
MEAN	27.208	28.904	31.138	29.175	30.394	
	Biofertilizer	**Micronutrient**	**Biofertilizer×Micronutrient**			
SEM (±)	0.444	0.497	0.994			
C.D at 5%	1.274	1.424	2.847			
C.V	5.87					

Table 6. Effect of biofertilizers and micronutrients on number of cloves per bulb

Treatment	Control (M0)	Zinc (0.2%) (M1)	Zinc (0.4%) (M2)	Boron (0.2%) (M2)	Boron (0.4%) (M4)	MEAN
Control (B0)	35.610	35.837	37.223	35.770	36.820	36.252
PSB (B1)	37.210	38.150	40.453	38.953	38.680	38.689
Azotobacter (B2)	37.283	39.810	40.320	39.813	39.903	39.426
PSB+Azoto (B3)	36.433	40.223	48.773	40.673	46.090	42.439
MEAN	36.634	38.505	41.693	38.803	40.373	
	Biofertilizer	**Micronutrient**	**Biofertilizer×Micronutrient**			
SEM (±)	0.569	0.636	1.273			
C.D at 5%	1.630	1.823	3.645			
C.V	5.63					

Table 7. Effect of biofertilizers and micronutrients on fresh weight of 50 cloves

Treatment	Control (M0)	Zinc (0.2%) (M1)	Zinc (0.4%) (M2)	Boron (0.2%) (M2)	Boron (0.4%) (M4)	MEAN
Control (B0)	29.510	29.713	30.857	29.653	30.527	30.052
PSB (B1)	30.843	31.630	33.533	32.293	32.067	32.073
Azotobacter (B2)	30.910	33.000	33.423	33.007	33.077	32.683
PSB+Azoto (B3)	30.200	33.343	40.117	33.717	39.553	35.386
MEAN	30.366	31.922	34.483	32.168	33.806	
	Biofertilizer	**Micronutrient**	**Biofertilizer×Micronutrient**			
SEM (±)	0.435	0.487	0.974			
C.D at 5%	1.248	1.395	2.790			
C.V	5.19					

Table 8. Effect of biofertilizers and micronutrients on bulb yield per plot

Treatment	Control (M0)	Zinc (0.2%) (M1)	Zinc (0.4%) (M2)	Boron (0.2%) (M2)	Boron (0.4%) (M4)	MEAN
Control (B0)	1.600	1.620	1.743	1.617	1.707	1.657
PSB (B1)	1.743	1.827	2.037	1.900	1.877	1.877
Azotobacter (B2)	1.750	1.977	2.023	1.980	1.983	1.943
PSB+Azoto (B3)	1.677	2.017	2.623	2.057	2.463	2.167
MEAN	1.693	1.860	2.107	1.888	2.008	
	Biofertilizer	**Micronutrient**	**Biofertilizer×Micronutrient**			
SEM (±)	0.0261	0.0291	0.0583			
C.D at 5%	0.075	0.083	0.167			
C.V	5.28					

4. CONCLUSION

On the basis of results and discussion made, it may be concluded that application of PSB + Azotobacter + Zn 0.4 % (B_3M_2) was found to be outstanding, being superior to rest of the treatment in respect to all growth and most of the yield parameters having highest yield of 174.87 q/ha followed by the treatment PSB + Azotobacter + Borax 0.4 % (B_3M_4). Therefore the treatment, PSB + Azotobacter + Zn 0.4 % (B_3M_2) may be recommended for higher yield performance of garlic crop. Moreover, the inputs being organic, the soil health is also not adversely affected.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.\

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