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Kumawat Ajay

Department of Agriculture,
Mansarovar Global University,
Sehore, Madhya Pradesh, India

Monu

School of Studies, Agricultural
Sciences Vikaram University,
Ujjain, Madhya Pradesh, India

Maida Pankaj

Department of Agriculture,
Mansarovar Global University,
Sehore, Madhya Pradesh, India

Pandey K Devesh

Department of Agriculture,
Mansarovar Global University,
Sehore, Madhya Pradesh, India

Corresponding Author:

Kumawat Ajay

Department of Agriculture,
Mansarovar Global University,
Sehore, Madhya Pradesh, India

Response of bio-fertilizers on growth and yield of garlic (*Allium sativum* L.) garlic

Kumawat Ajay, Monu, Maida Pankaj and Pandey K Devesh

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Abstract

A field experiment entitled 'Response of Bio-Fertilizers on Growth and Yield of Garlic (*Allium sativum* L.)' was conducted during the rabi season in 2022-23 and 2023-24 at the Research Farm-I of the Department of Horticulture, Mansarovar Global University, Bilkishganj Sehore (Madhya Pradesh). The experiment was laid out in Randomized Block Design with ten treatments and three replications. The maximum plant height (65.62 cm), number of leaves (7.495), diameter of bulb (4.945 cm), number of cloves (28.375) per plant, length of cloves (4.94 cm) per plant, yield of bulb (81.75 q/ha), Dry matter content in bulb (36.42) and Total Soluble Solids (41.95) per plant, were recorded under T₉ (Azospirillum + Phosphobacteria) treatments. Application of T₉ (Azospirillum + Phosphobacteria) may be considered as best treatment in terms of all growth and yield characters.

Keywords: Garlic, bio-fertilizers, yield, total soluble solids

Introduction

Garlic is the second most widely used cultivated *Allium* after onion. It has long been recognized all over the world as a valuable spice for food and a popular remedy for various ailments and physiological disorder. It is grown throughout the plains of India and consumed by most of the people. It is used practically all over the world for flavoring various dishes. In America about 50% of the entire output of fresh garlic is dehydrated and sold to food processors. Recently, spray dried garlic products are also available for some year (Pruthi, 1979) ^[14].

The area covered by garlic exceeds 1,142,000 ha and its average productivity is estimated to be 12t ha⁻¹ in the world. World production of garlic is ranked 14th among vegetables with a total of 14.5 million ton (Trejo, 2006). In Mexico, its consumption is about 400 g per capita (Chavez, 2008), and the production is considered low as compared to other countries such as China (80% world production), India, Korea and (20%) the rest of the world.

Garlic contains moisture 62.8%, protein 6.3%, mineral matter 1.0%, carbohydrate 29.0%, fat 0.7%, fibre 0.8%, calcium 0.03%, phosphorus 0.31%, iron 0.0013%, calorific value 141, vitamin C 13 mg per 100 g, nicotinic acid 0.4 mg, thiamine 0.16 mg, riboflavin 0.23mg its 100 gyible portion contains: Na 32mg, Mg 36 mg and fibre 1.1% (Chatfield, 1954) ^[4].

Materials and Methods

The experiments was conducted during rabi season 2022-23 and 2023-24 at the field of Horticulture department, Mansarovar Global University, Bilkishganj Sehore (Madhya Pradesh) India. The site is situated in part of Madhya Pradesh and covers geographical area of 25.60 lakh ha and represents 8.71 per cent of the total geographical area of the state. The zone is located between 23°16' North latitudes and 77°36' East longitudes. This zone possesses typically sub-tropical climatic conditions characterized by mild winters and moderate summers associated with high relative humidity during the months of July to September. The annual rainfall of the region is 650 – 1000 mm, most of which is contributed by south west monsoon from July to September. The experiment consisting of 10 treatments viz., T₁- Control (No fertilizer), T₂- RDF 100%, T₃-RDF 90%, T₄- RDF 80%, T₅- Control (un-inoculated), T₆- *Azotobacter*, T₇- *Phosphobacteria*, T₈- *Azospirillum*, T₉- *Azospirillum* + *Phosphobacteria*, T₁₀ *Azotobacter* + *Phosphobacteria*, was laid out in RBD with three replications.

Results and Discussion

Growth and yield attributes

Plant height (cm)

The data regarding the effect of different bio-fertilizers on the plant height of garlic has been presented in the (Table 1). The perusal of data revealed that the plant height at 90 DAP was significantly affected by various bio-fertilizers. The maximum plant height was recorded under T₉ (Azospirillum + Phosphobacteria) during investigation, while minimum plant height was recorded under T₁ (control) treatment during investigation showed in pool data.

Number of leaves

The data regarding the effect of different bio-fertilizers on the number of leaves of garlic has been presented in the (Table 2). The perusal of data revealed that the number of leaves at 90 DAP was significantly affected by various bio-fertilizers. The maximum number of leaves was recorded under T₉ (Azospirillum + Phosphobacteria), while minimum number of leaves was recorded under T₁ (control) treatments during investigation showed in pool data.

Diameter of bulb (cm)

Data ((Table 3). further showed that application of bio-fertilizers significantly enhanced the diameter of bulb. The maximum diameter of bulb was recorded under T₉ (Azospirillum + Phosphobacteria) during investigation, while minimum diameter of bulb was observed under T₁ (control) treatments during investigation showed in pool data.

Number of cloves per bulb

Data revealed in (Table 3) clearly showed that application of bio-fertilizers significantly enhanced the number of cloves over control. Treatment T₉ (Azospirillum + Phosphobacteria) recorded the maximum number of cloves per plant, and the minimum number of cloves per plant was recorded under T₁ (control) treatments during investigation showed in pool data.

Length of clove (cm)

It is apparent from the data (Table 3). further showed that application of bio-fertilizers significantly enhanced the length of cloves over control. Treatment T₉ (Azospirillum + Phosphobacteria) recorded the maximum length of cloves (4.98 cm) per plant during investigation. The minimum length of cloves (3.16cm) was observed under T₁ (control) treatments during investigation showed in pool data.

Bulb yield (q/ha)

It is obvious from the data (Table 3). further showed that application of bio-fertilizers significantly enhanced the yield of bulb over control. Treatment T₉ (Azospirillum + Phosphobacteria) recorded the maximum yield of bulb, while the minimum yield of bulb observed under T₁ (control) treatments during investigation showed in pool data.

Discussion

Observation on Diameter of bulb (cm), Number of cloves per bulb, Length of clove (cm) and Bulb yield (q/ha) influenced by various treatments was recorded at after harvest during 2022-23 and 2023-24. The maximum diameter of bulb (4.94 cm), the maximum number of cloves per plant (28.37), the maximum length of cloves (4.94 cm) and the maximum yield of bulb (81.75 q/ha) was recorded under T₉ (Azospirillum + Phosphobacteria), while minimum diameter of bulb (2.55cm), minimum number of cloves per plant (22.58), minimum length of cloves (3.14 cm) and minimum yield of bulb (67.44 q/ha) was recorded under T₁ (control) treatments during 2022-23- 2023-24 Pool mean. Similar findings were also reported by Singh *et al.* (2004) ^[17] in pea, Narayan *et al.* (2005) ^[13] in cauliflower, Dadhich *et al.* (2006) ^[9] in soybean.

Qualitative

Total Soluble Solids (TSS)

Data (Table 4) further revealed that application of bio-fertilizers significantly enhanced the Total Soluble Solids (TSS) over control. Treatment T₉ (Azospirillum + Phosphobacteria) recorded the maximum Total Soluble Solids per plant, while the minimum Total Soluble Solids was recorded under T₁ (control) treatments during investigation showed in pool data.

Dry matter content in bulb (%)

Data (Table 4) further revealed that application of bio-fertilizers significantly enhanced the dry matter content in bulb (%) over control. Treatment T₉ (Azospirillum + Phosphobacteria) recorded the maximum dry matter content in bulb, while the minimum dry matter content in bulb was recorded under T₆ (Azotobacter) treatments during investigation showed in pool data.

Discussion

Significantly increase in TSS content in the crop was also observed with PSB inoculation. PSB enhance the availability of phosphorus to plant which might have utilized by the crop for greater root development and nodulation which in turn resulted in high nitrogen fixation in the soil by nodules. Sinde and Saraf (1992) ^[20] in chick pea, Moduket *et al.* (1993) ^[12] in pigeon pea, Shrivastava and Ahlawat (1993) ^[19] in pea, Chalka (1999) ^[7] in cowpea, Gaur (1990) ^[8] in mungbean and Yogita and Ram (2012) ^[21] in onion reported similar kind of results.

VAM inoculation helps in uniform crop growth, increased yield of crop and also enhance resistance to root disease and improve hardiness of transplant stock. So due to its obligatory symbiotic nature and above discussed characteristics, increases its use in various crops (Yawalkaret. *al.*, 1996). Similar results were also reported by Bahadur *et al.* (2006) ^[1] in pea, Biswas and Patra (2007) ^[2] in green gram, Djebaliet *et al.* (2010) ^[10] in common bean, pea, alfalfa and Ramana *et al.* (2010) ^[16] in French bean, who observed significantly higher plant height, root nodules and other growth attributes due to inoculation with VAM over uninoculated (control).

Table 1: Effect of Bio-Fertilizers on the plant height (cm) of garlic.

Treatment	30 DAP		Pool mean	60 DAP		Pool mean	90 DAP		Pool mean
	2022-23	2023-24		2022-23	2023-24		2022-23	2023-24	
T1-Control (No fertilizer)	12.01	14.53	13.27	29.95	34.35	32.15	40.73	45.54	43.13
T2-100% RDF	13.08	14.69	13.885	34.62	38.86	36.74	49.23	56.35	52.79
T3-90% RDF	16.78	18.33	17.555	33.89	38.75	36.32	51.51	58.18	54.84
T4-80% RDF	15.92	17.86	16.89	34.55	38.79	36.67	51.33	57.93	54.63
T5-Control (un-inoculated)	16.29	16.02	16.155	36.81	39.73	38.27	53.49	59.99	56.74
T6-Azotobacter	13.88	16.68	15.28	34.62	38.86	36.74	55.11	61.96	58.53
T7-Phosphobacteria	16.88	18.94	17.91	35.83	41.32	38.575	53.46	62.54	58
T8-Azospirillum	18.41	21.25	19.83	33.55	37.65	35.6	57.3	62.99	60.14
T9-Azospirillum + Phosphobacteria	18.84	21.18	20.01	38.79	43.62	41.205	62.02	69.23	65.62
T10-Azotobacter + Phosphobacteria	18.13	20.42	19.275	37.25	42.9	40.075	59.04	68.08	63.56
S.Em+	0.460	0.510	0.485	1.01	1.14		1.53	5.22	
CD	1.376	1.528	1.452	3.03	3.42		4.58	1.74	

Table 2: Effect of Bio-Fertilizers on the number of leaves of garlic.

Treatment	30 DAP		Pool mean	60 DAP		Pool mean	90 DAP		Pool mean
	2022-23	2023-24		2022-23	2023-24		2022-23	2023-24	
T1-Control (No fertilizer)	3.06	3.45	3.255	4.04	4.65	4.345	5.04	5.63	5.335
T2-100% RDF	4.15	4.65	4.4	5.04	5.73	5.385	5.48	6.01	5.745
T3-90% RDF	3.49	3.92	3.705	4.43	4.97	4.7	5.13	5.72	5.425
T4-80% RDF	4.47	4.9	4.685	5.13	5.75	5.44	6	6.85	6.425
T5-Control (un-inoculated)	4.43	4.95	4.69	5.02	5.63	5.325	6.11	6.88	6.495
T6-Azotobacter	5.11	5.71	5.41	6.03	5.67	5.85	6.62	7.37	6.995
T7-Phosphobacteria	4.36	4.91	4.635	5.34	6	5.67	6.38	7.49	6.935
T8-Azospirillum	4.58	5.14	4.86	5.39	6.05	5.72	6.98	7.86	7.42
T9-Azospirillum + Phosphobacteria	5.74	6.36	6.05	6.11	6.82	6.465	7.07	7.92	7.495
T10-Azotobacter + Phosphobacteria	5.02	5.65	5.335	5.99	6.73	6.36	6.9	7.8	7.35
S.Em+	0.38	0.14		0.15	0.16		0.17	0.20	
CD	1.12	0.42		0.45	0.50		0.53	0.60	

Table 3: Effect of Bio-Fertilizers on Diameter of bulb (cm), Number of cloves per bulb, Length of clove (cm) and Bulb yield (q/ha) of Garlic.

Treatment	Diameter of bulb (cm)		Pool mean	Number of cloves per bulb		Pool mean	Length of clove (cm)		Pool mean		Bulb yield (q/ha.)	Pool mean
	2022-23	2023-24		2022-23	2023-24		2022-23	2023-24		2022-23	2023-24	
T1-Control (No fertilizer)	2.40	2.70	2.55	20.12	23.29	21.705	3.12	3.16	3.14	63.34	71.54	67.44
T2-100% RDF	3.16	3.50	3.33	20.83	24.33	22.58	3.72	3.62	3.67	66.12	75.04	70.58
T3-90% RDF	3.38	4.52	3.95	22.25	25.94	24.095	4.02	3.68	3.85	73.10	82.61	77.85
T4-80% RDF	3.63	3.47	3.55	23.83	26.00	24.915	3.74	4.04	3.89	74.63	83.02	78.82
T5-Control (un-inoculated)	3.41	3.67	3.54	23.85	26.98	25.415	3.21	3.92	3.56	74.80	83.79	79.29
T6-Azotobacter	3.14	3.54	3.34	23.02	26.59	24.805	4.27	4.53	4.40	74.98	83.26	79.12
T7-Phosphobacteria	3.96	4.87	4.415	24.77	27.92	26.345	4.22	4.18	4.20	76.54	84.70	80.62
T8-Azospirillum	3.38	4.44	3.91	25.79	29.10	27.445	4.45	4.33	4.39	76.08	85.49	80.78
T9-Azospirillum + Phosphobacteria	4.90	4.99	4.945	26.87	29.88	28.375	4.98	4.90	4.94	77.15	86.36	81.75
T10-Azotobacter + Phosphobacteria	4.30	4.51	4.405	26.10	28.49	27.295	4.35	4.40	4.37	76.65	86.12	81.38
S.Em+	0.10	0.11		0.67	0.77		0.11	0.11		2.97	2.35	
CD	0.30	0.35		2.03	2.30		0.34	0.34		6.29	7.05	

Table 4: Effect of Bio-Fertilizers on Dry matter content in bulb (%) and Total Soluble Solids (TSS)

Treatment	Dry matter content in bulb (%)		Pool date	Total Soluble Solids (TSS)		Pool date
	2022-23	2023-24		2022-23	2023-24	
T1-Control (No fertilizer)	33.33	36.88	35.11	31.57	34.99	33.28
T2-100% RDF	30.82	34.96	32.89	32.78	36.26	34.52
T3-90% RDF	32.46	35.65	34.06	35.61	38.99	37.30
T4-80% RDF	31.8	36.1	33.95	34.83	38.98	36.91
T5-Control (un-inoculated)	30.63	35.02	32.83	35.87	40.47	38.17
T6-Azotobacter	31.61	34.65	33.13	36.78	41.85	39.32
T7-Phosphobacteria	32.78	37	34.89	37.66	41.30	39.48
T8-Azospirillum	30.82	35.16	32.99	36.86	41.90	39.38
T9-Azospirillum + Phosphobacteria	34.74	38.1	36.42	39.51	44.39	41.95
T10-Azotobacter + Phosphobacteria	32.42	35.86	34.14	37.59	41.70	39.65
S.Em+	0.015	0.68	0.35	0.054	0.053	0.05
CD	0.046	2.04	1.04	0.160	0.157	0.16

Conclusion

On the basis of the results obtained in the present investigation, it may be concluded that application of different RDF and bio-fertilizers enhanced the growth; yield and quality of garlic except days take bulb initiation in comparison to control. Application of T9 (Azospirillum +Phosphobacteria) may be considered as best treatment in terms of all growth and yield characters. It is recommended for higher production of garlic under Bilkishganj Sehore (Madhya Pradesh) conditions.

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