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Effect of integrated nutrient management on growth and yield of garlic (*Allium sativum* L.) CV.AAS-2

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Abstract
The experiment was laid out in a Randomized Block Design with eleven treatments and replicated three times. The result indicated that Plants supplied with 75% RD N + RD PK + RD FYM + *Azatobacter beijerinckii* + PSB + *Trichoderma viride* registered maximum plant height (52.83 cm), maximum number of leaves (7.53), maximum collar diameterc (0.36) and Highest bulb yield per plot (3.90 kg) and per hectare (10.39 t /ha) was recorded with the application of 75 % RD N + RD PK + RD FYM + *Azatobacter beijerinckii*+ PSB + *Trichoderma viride*. Higher benefit cost ratio (3.4:1) was recorded with plants rcieved Vermicompost (2.5 t/ha) + *Azospirullum brasilense* (325g/ha) + PSB (325 g/ha) + *Trichoderma viride* (5 kg/ha).

Keywords: Garlic, *Allium sativum*, Organic, in organic, Bio- fertilizers, growth, Yield, cloves, *Azatobacter, Azospirullum, Trichoderma.*

Introduction
Garlic (*Allium sativum* L.) is one of the most important and widely consumed bulbous spice crops belong to the family Alliaceae. West Asia and Mediterranean region is considered to be the centre of origin of garlic. The bulb can be consumed as spice or condiment in the form of garlic paste, pickle, chutney, curried vegetables, curry powders and meat preparation, *etc.*
Garlic has higher nutritive value than other Alliums. It is rich in protein, phosphorus, calcium, magnesium, carbohydrates and vitamin C. Garlic bulb contains colourless and odourless water soluble amino acid called allin. On crushing the garlic, the enzyme allinase breaks down allin to produce allicin in which the principle ingredient is the odoriferous diallyl disulphide. Garlic contains 0.1 per cent volatile oil. The chief constituents of the oil are diallyldisulphide (60%), diallyl trisulphide (20%) and allyl propyl disulphide (6%). Garlic possesses insecticidal, nematicidal, bactericidal and fungicidal properties. Garlic extracts and oil have potential uses as an effective insecticide and fungicide in the present scenario of organic farming.
The area under garlic was 13.71 lakh hectares in the world with an annual production of 222.82 lakh MT during 2011. China, India, Korea, Spain, Egypt and USA are the major garlic producing countries. China ranks first with an area of 7.79 lakh hectares and production of 179.68 lakh tonnes. India ranks second with an area of 2.47 lakh hectares and with the production of 12.49 lakh tonnes. (Anon., 2013) [4]. In India, Madhya Pradesh is the leading state in area (60,000 ha) and Gujarat is the leading state in production (2,77,000MT), whereas maximum productivity is in Jammu and Kashmir (13.91 MT ha^{-1}). In Karnataka, garlic is cultivated in an area of 42,000 hectares with a production of 30,200 MT and a productivity of 7.19 tonnes per hectare. The average productivity in India is low (5.22 t ha^{-1}) compared to other countries.

Material and Method
The study was laid out in RBD with eleven treatment combinations having three replications having T_1 : RD NPK (125:62.5:62.5 kg NPK/ ha) + RD FYM (25 t /ha), T_2 : RD NPK (125:62.5:62.5 kg NPK /ha)+ Vermicompost (2.5 t /ha), T_3 : 100 % RD NPK + RD FYM (25 t/ ha)+PSB (325 g/ha) + *Trichoderma viride*(5 kg/ha) + *Azospirillum*(325 g/ha), T_4:75% RDN

+ RD PK + Vermicompost (2.5 t/ha) +*Azospirullumbrasilense* (325 g/ha) + PSB (325 g/ha) + *Trichoderma viride* (5 kg/ha), T_5: 75 % RD N + RD PK + RD FYM (25 t/ha) + *Azatobacter beijerinckii* (325 g/ha) + PSB (325 g/ha). + *Trichoderma viride* (5 kg/ha), T_6: 50% RD N + RD PK + RD FYM (25 t/ha) + *Azospirullum brasilense* (325 g/ha) + PSB (325 g/ha) + *Trichoderma viride* (5 kg/ha), T_7: 50% RD N + RD PK + Vermicompost (2.5 t/ ha) + *Azospirullum brasilense* (325 g/ha) + PSB (325 g/ha) + *Trichoderma viride*(5 kg/ha), T_8: 50% N + RD PK + RD FYM (25 t/ha) + *Azatobacter beijerinckii* (325 g/ha) + PSB (325 g/ha) + *Trichoderma viride* (5 kg/ha), T_9: 100% RDF + RD FYM (25 t/ha) + *Azospirullum brasilense* (325 g/ha) + PSB (325 g/ha) + *Trichoderma viride* (5 kg/ha), T_{10}: RD FYM (25 t/ha) + *Azospirullum brasilense* (325 g/ha) + PSB (325 g/ha) + *Trichoderma viride* (5 kg/ha), T_{11}: Vermicompost (2.5 t /ha) + *Azospirullum brasilense* (325 g/ha) + PSB (325 g/ha) + *Trichoderma viride* (5 kg/ha).

Method of imposing the treatments

Full dose of FYM applied one week before sowing and mixed well with soil. Nitrogen in the form of urea, phosphorous in the form of single super phosphate and potash in the form of muriate of potash were applied. Fifty per cent of nitrogen and full dose of phosphorous and potassium were applied to plot at 7-10 cm depth in the lines just before sowing of cloves and remaining fifty per cent of nitrogen was top dressed at 45 days after sowing.

The bulbs from net plot area (4.5 m^2) were harvested and cured completely and were weighed separately. The net plot yield was used to compute the yield per hectare.

Result and Discussion

The plant height was significantly influenced by integrated source of nutrients at all the stages of crop growth. The maximum plant height was found with plants provided 75% RD N + RD PK + RD FYM + *Azatobacter beijerinckii* + PSB + *Trichoderma viride* (T_5) registered maximum plant height (52.83 cm) at 90 DAS, which was on par with T_6 (50.00 cm) Increase in plant height was registered in the treatment (T_5) might be dueto enhanced availability of nutrients and production of some growth promoting substances that might have caused cell elongation and multiplication. Further, nitrogen might have increased the chlorophyll content of leaves and resulted in increased synthesis of carbohydrates, which inturn has influenced cell elongation and multiplication and hence accelerated the vegetative growth Yadav (2003) [19]. The least plant height (42.67 cm) was recorded in plants received RD NPK + RD FYM ($T_{1)}$ which could be attributed to in adequate and imbalance nutrients to the plants. The results of this study are in agreement with the findings of Wange (1995) [18] in garlic, Patil (1995) [15] and Sharma *et al.* (2003) [15] in onion.Maximum number of leaves produced per plant (7.53) was found with plants received 75% RD N + RD PK + RD FYM + *Azatobacter beijerinckii* + PSB + *Trichoderma viride* (T_5) which was on par with T_6 (7.30) followed by T_3 (7.09) T_8 (6.96) and T_{10} (6.96) compare to other treatments. This increase in number of leaves per plant in T_5treatment might be attributed to the effective functioning of bio-fertilizers, in terms of nitrogen fixation, Phosphate solubilization and its mobilization and production of plant growth promoting substances and enhanced the availability of nutrients at appropriate time. Increase in number of leaves, might have resulted in increased photosynthetic rate and accumulation of photosynthates. The number of leaves per plant at 30DAS did not show significant difference among the treatments, which might be due to time requirement for acquaintance of introduced microbial inoculants at initial stages of crop growth. These results are in accordance with the findings of Sharma *et al.* (2003) [16], Ashok *et al.* (2001) [5], Patil (1995) [15] in onion and Suresh (1997) [17] in garlic. There was no significant differences were observed during 30, 60 and 90 DAS of different treatments with reference to collar diameter at all the stages of crop growth. There was no significant differences were observed during 30, 60 and 90 DAS of different treatments with reference to collar diameter at all the stages of crop growth. Integrated nutrient management on number of bulbs per plot showed significant difference among the treatments. The highest bulb yield per plot (3.90 kg) was registered in T_5-75% RDN + RD PK + RD FYM + *Azatobacter beijerinckii* + PSB + *Trichoderma viride* and was on par with T_6 (3.70 kg) and T_9 (3.66 kg), T_{11} (3.43 kg) and least bulb yield per plot (2.66 kg) was observed in T_1 - RD NPK + FYM. These results are in conformity with the findings of Fenthaun and Singh (1999).Bulb yield per hectare was significantly influenced by the treatments. The highest bulb yield per hectare (10.39 t/ha) was obtained in T_5 -75% RD N + RD PK + RD FYM + *Azatobacter beijerinckii* + PSB + *Trichoderma viride* and was on par with T_6 (9.86 t/ha) and T_9 (9.77 t/ha), T_{11} (9.15 t/ha) while least bulb yield per hectare (7.10 t/ha) was found in T_1 -RD NPK + RD FYM. Increase in yield could be attributes to balances nutrition with different sources increases soil microbial activity which facilitate increased nutrient uptake, increased root proliferation, increased vegetative growth, more photosynthesis and enhanced photosynthate accumulation and better yield attributes. The results are in conformity with the findings of Gurubatham *et al.* (1989) [9] and Patil (1995) [15] in onion, Mahendran and Kumar (1996) [12]; Suresh (1997) [17]; Wange (1995) [18] and Mallanagouda *et al.* (1995) [13] in garlic The highest bulb diameter (27.04 mm) was recorded in the plants provided with75% RD N + RD PK + RD FYM + *Azatobacter beijerinckii* + PSB + *Trichoderma viride* ($T_{5)}$ which was on par with T_8 (26.42 mm), T_7 (25.78 mm), T_3 (25.75 mm), T_9 (25.61 mm), T_6 (25.38 mm), T_4 (25.24 mm) and the lowest bulb diameter (23.14 mm) was found with RD NPK + RD FYM (T_1). Increased vegetative growth, dry matter production and translocation of photosynthates contributed better development of bulbs, which resulted in increased diameter of bulbs. Similar findings are reported by Suresh (1997) [17] and Mallanagouda *et al.* (1995) [13] in Garlic; Sharma *et al.* (2003) [16] and Patil (1995) [15] in onion. The maximum number of cloves per bulb (20.77) was observed in T_6-50% RD N + RD PK + RD FYM + *Azospirullum brasilense* + PSB + *Trichoderma viride* which was on par with T_3 (20.40),T_2 (20.39), T_4 (19.82), T_{10} (19.50), T_5 (19.46) and minimum number of cloves per bulb (15.75) was recorded in T_{11}-VC + *Azospirullum brasilense* + PSB + *Trichoderma viride*. Similar findings are reported by Suresh (1997) [17] and Mallanagouda *et al.* (1995) [13] in Garlic.

Table 1: Growth and yield of garlic as influenced by integrated nutrient management

	Treatments	Plant height (cm)	Number of leaves per plant	collar diameter (cm)	Bulb diameter (mm)	Number of cloves	Yield (Kg/plot)	Yield (t/ha)
T_1	RD NPK (125:62.5:62.5 kg/ ha) + FYM (25 t/ ha)	42.67	6.46	0.27	23.14	17.91	2.66	7.10
T_2	RD NPK + VC (2.5 t /ha)	40.33	6.78	0.31	24.38	20.39	3.23	8.61
T_3	100 % RD NPK + RD FYM + PSB + *T.v* + *Azo.*	43.00	7.09	0.36	25.75	20.40	3.20	8.52
T_4	75% RD N + RD PK + VC + *Azo.* + *PSB* + *T. v*	44.00	6.86	0.32	25.24	19.82	3.03	8.08
T_5	75 % RD N + RD PK + RD FYM + *Aza.* + PSB + *T. v*	52.83	7.53	0.36	27.04	19.46	3.90	10.39
T_6	50 % RD N + RD PK + RD FYM + *Azo.* + PSB + *T. v*	50.00	7.30	0.34	25.38	20.77	3.70	9.86
T_7	50% RD N + RD PK + VC + *Azo.*+ PSB + *T. v*	47.67	6.83	0.36	25.79	16.88	3.06	8.17
T_8	50% RD N + RD PK + RD FYM + *Aza.* + PSB + *T.v*	46.00	6.96	0.27	26.43	19.07	3.10	8.26
T_9	100% RDF +RD FYM + *Azo.* + PSB + *T. V*	45.67	6.82	0.28	25.61	18.56	3.66	9.77
T_{10}	RD FYM + *Azo.* + PSB + *T.v*	44.17	6.96	0.30	25.22	19.50	2.93	7.81
T_{11}	VC + *Azo.*+ PSB + *T.v*	44.00	6.83	0.28	23.63	15.75	3.43	9.15
	S.Em±	1.00	0.08	0.09	0.72	0.50	0.22	0.59
	CD @ 5%	2.96	0.26	0.26	2.13	1.50	0.65	1.74
	CV (%)	7.91	10.23	13.39	4.95	4.64	11.78	11.79

Note: RD= Recommended Dose, FYM= Farm yard manure VC= Vermicompost, PSB= Phosphorous soluble bacteria, *T.v*= *Trichoderma viride*, *Azo*= *Azospirillum brasilense, Aza*= *Azatobacter beijerinckii*, DAS= Days after sowing

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