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Response of garlic to integrated nutrient management practices in a sodic soil of Uttar Pradesh, India

R C Nainwal*, D Singh, R S Katiyar, L Sharma & S K Tewari

CSIR-National Botanical Research Institute
Rana Pratap Marg, Lucknow-226 001, Uttar Pradesh.
**E-mail: nainwal.rakesh@gmail.com*

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Abstract

An investigation was carried out to study the combined effect of biofertilizers *viz*., phosphate solubilizing bacteria (PSB) and *Trichoderma* supplemented with FYM and chemical fertilizers on plant growth and bulb yield of garlic (*Allium sativum*) under degraded land condition. Significantly higher values of plant growth and yield parameters were obtained with the application of 100% recommended dose of NPK supplemented with FYM along with seed treatment with *Trichoderma* and PSB. Seed treatment with PSB was effective for all the parameters. However, PSB and *Trichoderma* were more effective when applied along with 100% NPK and FYM @ 20 t ha^{-1}. It can, therefore, be concluded that for sustainable production of garlic, application of recommended dose of inorganic fertilizer (NPK) supplemented with 20 t ha^{-1} of FYM coupled with inoculation of PSB and *Trichoderma* can enhance yield and profitability of garlic.

Keywords: farmyard manure, garlic, phosphorus solubilizing bacteria, *Trichoderma*

Introduction

Garlic (*Allium sativum* L.) is a bulbiferous crop belonging to the family *Alliaceae*. It is the second most widely cultivated crop in the family after onion (*Allium cepa*) and contributes 14% of the world area and 5% of production. Though, India ranks second in area and production, it is the lowest as far as productivity is concerned (5.29 t ha^{-1}). The area and production of garlic in India during 2010-11 was 2.007 lakh ha and 10.62 lakh t with an average productivity of 5.29 t ha^{-1}. Successful commercial cultivation of this crop depends up on many factors such as climate, soil fertility, irrigation, fertilizer management, spacing, growing season etc.

Application of the required nutrients through chemical fertilizers alone can have deleterious effect on soil health and can lead to unsustainable yields, while integration of chemical fertilizers with organic manures and biofertilizers can maintain soil health and soil productivity (Bhandari *et al*. 2012). Furthermore, the increasing concern on the effects of agrochemicals especially chemical fertilizers on the environment makes organic manures a safer and better alternative source of nutrients to crop (Hamma *et al*. 2013). Hence, for better growth, bulb characters and marketable bulb yield in garlic, integrated use of inorganic and organic sources of nutrients are preferred (Sevak *et al.* 2012). It is in this light that this research

work was carried out to study the effect of intergrated nutrient management involving farm yard manure (FYM), biofertilizers and inorganic fertilizers on the growth and yield of garlic.

Materials and methods

The present experiment was conducted at the Aurawan Research Centre of National Botanical Research Institute, Lucknow. The climate of this region is primarily long and intensive hot summer with low and irregular rainfall and long mild winter. The area receives an annual rainfall of 80-100 cm, 70% of which is available during the months of July-September.

The study involved field experiments for two consecutive rabi cropping seasons of 2008-09 and 2009-10. The soil of the experimental site contained 23% sand, 59% silt and 18% clay. The pH, EC, organic carbon (OC), available nitrogen (N), phosphorus (P) and potassium (K) of the soil was 8.6, 0.37 dSm^{-1}, 4.1 g kg^{-1}, 130 kg ha^{-1}, 13.7 kg ha^{-1} and 368 kg ha^{-1}, respectively. The experiment consisted of six treatments involving an absolute control (T_1), 100% NPK (100:50:50 kg ha^{-1}) (T_2), 100% NPK + FYM @20 ha^{-1} (T_3), 100% NPK + FYM @20 ha^{-1} + PSB (T_4), 100% NPK + FYM @20 ha^{-1} + *Trichoderma* (T_5) and 100% NPK + FYM @20 ha^{-1} + PSB + *Trichoderma* (T_6) with four replications in a randomized block design (RBD).

Garlic seed was used @ 400-500 kg ha^{-1} for the experiment. The ripe fruit was used as a seed for the new crop of garlic. After preparing the experimental plots, cloves of garlic fruit were sown in rows. FYM was applied as basal at 10 days before planting. N fertilizer in the form of urea was applied in three splits *viz*., half at the time of sowing, one fourth at active growth stage and one fourth at the fruit ripening stage. The recommended doses of P and K fertilizers were applied through DAP and MOP respectively, as basal dose. The cloves were treated with PSB and *Trichoderma harzianum* as per treatments at the time of sowing and planted at a spacing of 15 cm × 10 cm.

The soil pH and EC were analyzed using 1:2 (soil: water) suspension, organic carbon by the Walkley & Black (1934) rapid titration method, available N using alkaline $KMnO_4$ method (Subbiah & Asija 1956), available P as per the method suggested by Olsen *et al*. (1954) and available K using flame photometer (Jackson 1973). The different observations were recorded in five random plants and the data were statistically analyzed as per the methodology suggested by Panse & Sukhatme (1961).

Results and discussion

Effect of PSB, Trichoderma*, FYM and NPK on plant growth*

A significant increase in plant growth parameters *viz*., plant height, leaf length, root length and number of leaves was seen under integrated application of inorganic and organic manures. This might be due to steady release of nutrients through out the crop growth period. The above finding is in conformity with the reports of Farooqui *et al.* (2009).

Among the growth parameters, plant height (60.70 cm) and leaf length (22.43 cm) were significantly higher under T_6, where 100% NPK + FYM @ 20 t ha^{-1} + PSB + *Trichoderma* were used. This agreed with the findings of Jawadagi *et al*. (2012) that plant height and leaf length could be increased with the application of 50% FYM (12.50 t ha^{-1}) + 50% vermicompost (2 t ha^{-1}) + bio-fertilizers (*Azospirillum* and phosphate solubalizing bacteria) in garlic. Moreover, higher number of leaves (9.2) and average root length (7.84 cm) were requested by the treatment T_6, which in turn is in agreement with the report of Gaiki *et al*. (2006) that *Azotobacter* + PSB + 75% NPK significantly increased the plant height and leaf number in garlic. These result clearly indicated that vegetative growth can be enhanced through the application of 100% NPK + FYM @20 t ha^{-1} + PSB + *Trichoderma*. The combined application of *Trichoderma* and PSB was much more effective in comparison to independent application of either of the above. These findings are also supported by Gowda *et al*. (2007), who reported that 100% NPK + biofertilizer + vermicompost recorded significantly higher plant height,

number of leaves and a maximum girth of the plant.

Effect of PSB, Trichoderma, *FYM and NPK on yield of garlic*

Treatments receiving only NPK from chemical fertilizer recorded low yield and yield attributes compared to the yield obtained by integration of chemical fertilizers with FYM and biofertilizers. This might be due to the supply of nutrients from all the three sources during the entire growth period of the crop. The treatments differed significantly with respect to yield attributes *viz*., fruit weight, number of cloves fruit^{-1}, dry matter of whole plant and bulb yield (Table 1). Obviously the control treatment where no manures and fertilizer were applied was significantly poor with respect to all growth and yield characters. Fruit weight (52.43 g) and number of cloves fruit^{-1} (37.66) were significantly higher under T_6. However, fruit weight of garlic through application of 100% NPK + FYM @ 20 t ha^{-1} + PSB + *Trichoderma* (T_6) was about 59.33%, 14.72%, 12.97%, 2.23% and 4.27% higher compared to treatments *viz*., T_1, T_2, T_3, T_4 and T_5, respectively. The total dry matter also showed significant differences among treatments with maximum plant dry matter in T_6 (53.28 g). Similarly, bulb yield (60.86 q ha^{-1}) was also maximum with T_6. The above finding corroborated with the reports of Jawadagi *et al*. (2012), Gowda *et al*. (2007) and Gaiki *et al*. (2006) that integrated application of chemical fertilizers, organic manure and bio fertilizers can significantly improve both bulb character and bulb yield including B:C ratio in garlic.

Effect of PSB, Trichoderma, *FYM and NPK on chemical properties of the soil*

Owing to the nature and the pattern of mineralization, combined use of organic manures improved the physico-chemical properties of the soil rather than application of only inorganic fertilizers. Among all treatments, T_6 showed the best result. Organic matter status of soil was improved with application of FYM and chemical fertilizer. Application of FYM @ 20 t ha^{-1} was also effective in marginally increasing the OC status of the soil from 4.1 g kg^{-1} to 4.3 g kg^{-1} (Table 2). Maximum available N (163 Kg ha^{-1}) was observed under the treatment receiving 100% NPK + FYM @20 t ha^{-1} + PSB (T_4). The increase in the availability of N in soil under the treatments having combination of chemical fertilizers and FYM might be because of buildup of organic matter due to application of organic manure, besides reducing losses of N. Similar observations were made by Sharma & Ghosh (2000). Maximum available P (22.2 kg ha^{-1}) and K (368 kg ha^{-1}) was registered in the treatment

Table 1. Effect of phosphate solubilizing bacteria, *Trichoderma*, FYM and NPK on growth and yield of garlic (mean data of two years)

Treatments	Plant height (cm)	Leaf length (cm)	Root length (cm)	No. of leaves plant^{-1}	Fruit weight (g)	No. of cloves plant^{-1}	Dry matter whole plant (g)	Yield (q ha^{-1})
T_1	29.6	5.02	2.14	4.9	21.32	28.52	17.63	26.87
T_2	50.5	12.31	3.45	7.1	44.71	32.91	39.58	50.44
T_3	55.6	19.37	4.32	8.2	45.63	34.12	40.19	56.82
T_4	59.8	21.29	6.62	8.5	51.26	36.74	47.40	59.46
T_5	57.5	20.39	4.58	8.3	50.19	35.82	43.62	58.24
T_6	60.7	22.43	7.84	9.2	52.43	37.66	53.24	60.86
SEm±	1.74	0.51	0.33	0.41	0.54	0.28	0.84	1.04
CD (P<0.05)	3.72	1.09	0.71	0.87	1.16	0.66	1.79	2.21

T=ton; FYM=Farmyard manure; PSB=phosphate solubilizing bacteria

Table 2. Changes in soil properties after harvest of the garlic (mean data of two years)

Treatments	pH	EC ($dS\ m^{-1}$)	O.C. ($g\ kg^{-1}$)	Avail. N ($kg\ ha^{-1}$)	Avail. P ($kg\ ha^{-1}$)	Avail. K ($kg\ ha^{-1}$)
T_1	8.6	0.32	4.0	108	13.1	335
T_2	8.5	0.30	4.1	131	14.2	349
T_3	8.4	0.24	4.3	153	15.7	353
T_4	8.4	0.25	4.3	163	18.2	362
T_5	8.4	0.24	4.3	155	18.6	366
T_6	8.4	0.24	4.3	162	22.2	390
Initial	8.6	0.37	4.1	130	13.7	368

in which 100% NPK + FYM @20 t ha^{-1} + PSB + *Trichoderma* (T_6) was applied.

Overall, it can be concluded from the present study that in sodic soil, integrated nutrient management practice involving recommended dose of inorganic fertilizer along with FYM@ 20 t ha^{-1} and PSB and *Trichoderma* would be effective in increasing the plant growth and productivity of garlic besides improving the physico-chemical properties of soils.

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