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Short communication

Integrated nutrient management on growth and yield of garlic under sodic wasteland conditions

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ABSTRACT

An investigation was carried out to study the combined effect of PSB, *Trichoderma* and FYM with 100% recommended dose of NPK on plant growth and bulb yield of garlic under sodic wasteland condition. Significantly higher values of growth and yield parameters, *i.e.* plant height (60.7 cm), leaf length (22.43 cm), root length (7.84 cm), number of leaves per plant (9.2), bulb weight (52.43 g), number of cloves per bulb (37.66), dry weight of whole plant (53.24 g) and bulb yield (60.86 q ha^{-1}) was obtained with the application of 100% recommended dose of NPK supplemented with the application of FYM and clove (seed) treatment with *Trichoderma* and PSB.

Key words: Garlic, phosphorus solubilizing bacteria (PSB), sodic soil, *Trichoderma.*

Garlic (*Allium sativum* L.) is the second most important bulb crop grown after onion and contributes 14.0% of world area and 5.0% of production. In India, its area and production (during 2010-11) is around 200.70 thousand ha and 1,061.85 thousand tonnes, respectively with an average yield of 5.29 t/ha. It is grown in large quantities in the states of Madhya Pradesh, Gujarat, Odisha, Rajasthan, Karnataka, Tamil Nadu, Maharashtra and Bihar. In Uttar Pradesh, garlic is cultivated in an area of 32,776 ha (3rd place after Gujarat and MP) with a production of 1,75,851 tonnes (Srivastava *et al*., 11).

Used practically all over the world for flavouring and seasoning various vegetables and meat dishes. It is rich in proteins, minerals like phosphorus, calcium, magnesium and carbohydrates. It also contains fat, vitamin C and sulphur. It is already being used in several food preparations, notably in chutneys, pickles, curry powders, curried vegetables, meat preparations, tomato ketchup. The successful commercial cultivation of this crop is depending on many factors such as climate, soil fertility, and irrigation, fertilizer, spacing, season of growing *etc*.

Among the different management practices, nutrient management plays an important role for good growth, yield and quality. Application of all needed nutrients through chemical fertilizers are known to have deleterious effect on soil fertility leading to unsustainable yields, while integration of chemical fertilizers with organic manures and bio-fertilizers are able to maintain the soil health, productivity and fertility (Bhandari *et al*., 1). Increasing concern on the effects of agrochemicals and chemical fertilizers on the environment makes organic manure a safer and better available alternative source of nutrients to crop (Hamma *et al*., 5). Therefore, for better biometric observations, bulb characters and marketable bulb yield in garlic, combined use of inorganic and organic sources of nutrient supply is preferable (Kuldeep *et al*., 8*).*

Integrated nutrient management is the only option for increasing the crop yield and nutrient management and quality of the produce as well. Bio-fertilizer is also a good alternative for the modern agriculture with the objectives of increasing the number of micro-organisms and accelerating certain microbial process to augment the availability of nutrients in a form which can be assimilated by the plant. The main objective of this study was to evaluate the impact of integrated approach of inorganic fertilizers with organic manure (FYM) and bio-fertilizers like phosphorus solubilizing bacteria (PSB) and *Trichoderma*.

The experiment was conducted during 2009 to 2011 at the Aurawan Research Centre of National Botanical Research Institute, Lucknow, Uttar Pradesh. To study the effect of integrated nutrient management on growth and yield in garlic a field experiment was conducted for two subsequent cropping years during *rabi* season for two years. Initial properties of the soil were sand- 23.0%, silt- 59.0%, clay- 18.0% (silt loam), pH- 8.6, EC- 0.37, organic carbon- 4.1 g kg^{-1}, available N- 130 kg ha^{-1}, available P- 13.7 kg ha^{-1} and available K- 368 kg ha^{-1}. The experiment consisted of six treatments, *viz*. control (T_1), 100% NPK (100:50:50 kg ha^{-1}) (T_2), 100% NPK + 20 t ha^{-1} FYM (T_3), 100% NPK + 20 t ha^{-1} FYM + PSB (T_4), 100% NPK + 20 t ha^{-1}

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FYM + *Trichoderma* (T_5) and 100% NPK + 20 t ha^{-1} FYM + PSB + *Trichoderma* (T_6) with four replications in a randomized block design (RBD).

Garlic seed was used @ 400-500 kg ha^{-1} cloves for the experiment. After preparing the experimental plots, cloves of garlic were sown in rows in the field. Total organic supplement material (farmyard manure) to be used in each experimental plot was applied basal, 30 days before the sowing of garlic. Nitrogen fertilizer was applied through urea in three splits, half at the time of sowing, one fourth at active growth stage, and one fourth at the bulb stage (when garlic bulb began to take shape). Recommended doses of phosphorus and potassium fertilizer was applied through DAP and MOP respectively as a basal dose. Cloves were treated with PSB and *Trichoderma* as per treatments at the time of sowing.

Soil pH and EC were analyzed through 1: 2 (soil: water) suspension, organic carbon through Walkley and Black's (13) rapid titration method, available N through alkaline $KMnO_4$ method as described by Subbiah and Asija (12), available P through Olsen *et al.* (9) and available K through flame photometer as described by Jackson (6). Observations were recorded on five random plants and data was analyzed as described by Panse and Sukhatme (10).

During the investigation, the values of plant height (60.70 cm) and leaf length (22.43 cm) were obtained significantly higher than the rest treatments by application of 100% NPK + 20 t FYM + PSB + *Trichoderma* (T_6). Maximum No. of leaves (9.2) and average root length (7.84 cm) was also obtained by application of 100% NPK + 20 t FYM + PSB + *Trichoderma* (T_6). Gaiki *et al.* (3) also reported that *Azotobacter* + PSB + 75% RDF significantly increased plant height and leaf number. The data clearly indicates that vegetative growth was higher by application of 100% NPK + 20 t FYM + PSB + *Trichoderma* (T_6) that receives integrated (organic, inorganic and biofertilizer) nutrient supply. Bhandari *et al.* (1) also reported that the maximum plant height and number of leaves per plant was recorded with the application of 100-40-60 NPK kg ha^{-1} + 100 kg N ha^{-1} through C.C. + *Azotobacter* + PSB. It shows that the use of bio-fertilizer along with recommended doses of fertilizers and organic manures performed better than use of only chemical fertilizers. As biofertilizer and organic fertilizers are responsible for adequate and steady supply of all essential nutrients, associated with vigorous vegetative growth and more efficient use of available inputs, leading to higher productivity. The findings of this investigation are in close conformity with Farooqui *et al.* (2). Gowda *et al.* (4), also reported that 100% NPK + biofertilizer + vermicompost to record significantly higher plant height, number of leaves and a maximum plant girth.

Treatments receiving NPK from only chemical sources, recorded lower values of yield attributes compared to its integration with FYM and bio-fertilizers. This might be the result of improved supply of nutrients by bio-fertilizers at the later stages of crop growth. Significant difference was found between treatments for garlic yield parameters (Table 1), *viz*., bulb weight, number of cloves per bulb, dry matter of whole plant and bulb yield (q ha^{-1}). Maximum bulb weight (52.43 g) and the maximum number of cloves per bulb (37.66) were recorded by application of 100% NPK + 20t FYM + PSB + *Trichoderma* (T_6). However, average bulb weight of garlic by application of 100% NPK + 20 t FYM + PSB + *Trichoderma* (T_6) was approximate 59.33, 14.72, 12.97, 2.23 and 4.27% more than the rest of treatments, respectively. The total dry matter weight per plant was found significant between treatments. The maximum dry matter weight (53.28 g) of a whole plant was obtained by application of 100% NPK + 20 t FYM + PSB + *Trichoderma* (T_6) followed by rest of treatments. The maximum bulb yield (60.86 q ha^{-1}) was recorded by application of

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

Treatment	Plant height (cm)	Leaf length (cm)	Root length (cm)	No. of leaves $plant^{-1}$	Bulb wt. (g)	No. of cloves $bulb^{-1}$	Dry matter whole plant (g)	Yield (q ha^{-1})
T_1	29.60	5.02	2.14	4.9	21.32	28.52	17.63	26.87
T_2	50.50	12.31	3.45	7.1	44.71	32.91	39.58	50.44
T_3	55.60	19.37	4.32	8.2	45.63	34.12	40.19	56.82
T_4	59.80	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	60.70	22.43	7.84	9.2	52.43	37.66	53.24	60.86
CD at 5%	3.72	1.09	0.71	0.9	1.16	0.66	1.79	2.21

FYM = Farmyard manure, PSB = phosphate solubilizing bacteria

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

Treatment	pH_2	EC_2 (dS m^{-1})	OC (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

100% NPK + 20 t FYM + PSB + *Trichoderma* (T_6) followed by rest of treatments. Jawadagi *et al.* (7) also reported that the bulb yield, net returns and B: C was maximum in the crop nourished with 50% FYM (12.50 t ha^{-1}) + 50% vermicompost (2 t ha^{-1}) + bio-fertilizers (*Azospirillum* and phosphate solubilizing bacteria). Gowda *et al.* (4) reported that 100% NPK + bio-fertilizer + vermicompost recorded significantly maximum bulb yield from treatment combination of 100% NPK + biofertilizer + vermicompost. Gaiki *et al.* (3) reported that *Azotobacter* + PSB + 75% RDF significantly increased bulb diameter, clove number/ bulb, fresh bulb weight, cured bulb weight and yield ha^{-1}. Application of 20 t FYM slightly decreased the pH (8.4) from its initial pH value of 8.6 and electrical conductivity also decreased from 0.37 dSm^{-1} to 0.24, 0.25 by the application of 20 t FYM. Application of 20 t FYM was also found effective for increasing the organic carbon status from 4.1 g kg^{-1} to 4.3 g kg^{-1}. Available NPK also increased through 20 t FYM application along with inoculation of *Trichoderma* and PSB (Table 2).

Present results confirm the hypothesis that the combination of PSB + *Trichoderma* with chemical fertilizer and farmyard manure increases the soil micronutrients and promotes microbial population, which ultimately promotes the plant growth and production at sustainable basis. The sodic land improvement and production could be sustained via successive removal of chemical fertilizer by organic and bio-fertilizer in duration of 4-5 years without affecting annual crop production. Moreover, bio-fertilizer and organic inputs basis agriculture practices not only restore/ the soil physio-chemical structure, which has been destroyed due to intensive agriculture practices, but at the same time also enhance the biological nutrient transformation in the soils for sustainable land productivity.

The PSB, *Trichoderma* and farmyard manure with combinations of NPK was applied in sodic waste land condition on *Allium sativum* to test its importance in the improvement of sodic waste land, plant growth and productivity. There was significant plant growth as well as bulb yield in garlic plants that received PSB, *Trichoderma* and farmyard manure as nutrient supplier in garlic under sodic waste land. The data clearly indicates that PSB, *Trichoderma* and farmyard manure may be an efficient plant growth source for sustainable plant production and improvement of sodic waste land, if applied in combinations with inorganic fertilizers.

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