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Effect of different phosphorus levels and bio-fertilizers on yield and quality parameters of garlic (*Allium sativum* L.) cv. G-1 (Yamuna safed)

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Abstract
A present experiment was conducted during *rabi* season of the year 2017 at Horticulture Research Farm-II, Department of Horticulture, Babasaheb Bhimrao Ambedkar university (A Central University), Vidya Vihar Rae Bareli road, Lucknow 226025 (U.P.) India. "Effect of different phosphorus Levels and bio-fertilizers on yield and quality parameters of garlic (*Allium sativum* L.) cv. G-1(Yamuna safed)", revealed that Neck thickness of bulb, Bulb diameter, Number of cloves per bulb, Average weight, Bulb yield, Total soluble solids was maximized when dose was done with phosphorus levels 40,60,80 kg/ha and bio-fertilizers PSB, Azotobacter and PSB + Azotobacter inoculation.

Keywords: Garlic, phosphorus, bio-fertilizers, PSB, Azotobacter and yield and quality parameter

Introduction
Garlic (*Allium sativum* L.) having diploid chromosome number 2n=2x=16 belongs to the family Amaryllidaceae (Alliaceae); known as Lahsun in Hindi, is one of the important bulb crops grown in India. It has long been recognized as a valuable spice and condiments in India. It is a frost hardy bulbous, erect annual herb with narrow flat leaves and bears small white flowers and bulbils (Janick, 1979) [3]. Garlic is a scapigerous foetid perennial medicinal herb with underground compound bulbs covered by outer white thin scales with simple smooth round stem surrounded by the bottom by tubular leaf sheath. The leaves are simple, long, flat and linear. The flowers are small and white, arranged in round umbels mixed with small bulbils. The entire umbels are enclosed in a tear-drop shaped membranous spathe. Flowers are usually sterile. The seed stalk bears terminal inflorescence, which in terms bear bulbils instead of flowers. The shoot of garlic become flat and finally aborts after the development of bulbils in the inflorescence. (Kothari and Shah, 1974). A compound bulb consists of smaller bulbils or a segment called "cloves" which are formed from auxiliary bulbs of the young foliage leaves and is surrounded by a thin white or pinkish papery sheath. Garlic is the second most important bulb crop after onion. It is an important spice crop belonging to family Alliaceae and botanically known as (*Allium sativum* L.). Garlic belongs to be central Asia and Southern Europe, especially Mediterranean region (Thompson and Kelly, 1957) [11]. The economic yield is obtained from its underground bulb, which is consisted of bulblets, popularly called as cloves. Garlic is used in flavoring foods, preparing chutneys, pickles, curry powder, tomato ketchup etc. It contains protein (6.3%), phosphorus (0.31%), potash (0.40%), calcium (0.03%), magnesium (0.025%), carbohydrates (29%) and a colourless as well as odourless water soluble amino acid called allicin. On crushing the blub clove, an enzyme allinase acts upon allicin and breaks down to produce allicin. Garlic contains volatile oil known as diallel - disulphide which is the major flavouring component in garlic. Garlic possesses insecticidal action whereby 0.1 per cent garlic extract gives protection against mosquitoes for 8 hours. Extract of garlic along with chilli and ginger has beneficial action against soil nematodes. Beneficial use of garlic extract has been found against many fungi and bacteria. Allicin present in aqueous extract of garlic reduce blood cholesterol concentration in human blood (Shankaracharya, 1974) [8]. Garlic oil or its juice is recommended to inhale in cases of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and redness of eyes (Pruthi, 1979) [6].

Material and Methods

The experimental material for the present study consisted of one cultivar of garlic obtained from NHRDF, Karnal (Haryana). The experiment was conducted using Randomized Block Design (RBD) with three replications at Horticultural Research Farm-II of the Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow during the year 2016-17. Observations were recorded for Neck thickness of bulb, Bulb diameter, Number of cloves per bulb, Average weight, Bulb yield, Total soluble solids. The data so obtained were analysed statically.

Result and Discussion

The results revealed that application of 80 kg/ha phosphorus had significant effect on growth attributes of garlic. All the growth parameters *viz.* neck thickness, bulb diameter, number of cloves per bulb, average weight of bulb, bulb yield (q ha^{-1}), Total soluble solids (TSS) increased linearly with the corresponding increase in levels of phosphorus up to 80 kg phosphorus per ha. However, 60 kg phosphorus per ha was found statistically at par to it. The minimum value was found in the control.

The regulatory functions of phosphorus in photosynthesis and carbohydrate metabolism can be considered one of the major factors limiting the plant growth particularly during the reproductive phase. The levels of phosphorus during this period regulates starch/sucrose ratio in the source leaves and the reproductive organ (Giaquinta and Quebedeaux, 1980) [2]. Phosphorus deficiency limits N_2 fixation mainly by reducing the growth of host plant. Thus, application of phosphorus might have resulted in increased carbohydrate accumulation and their remobilization to reproductive part of the plant, being the closest sink and hence higher bulb diameter and garlic production.

Cloves inoculation with PSB + Azotobacter significantly increased the all the yield and quality parameters *viz.* neck thickness, bulb diameter, number of cloves per bulb, average weight of bulb, bulb yield (q ha^{-1}), Total soluble solids (TSS) over rest of treatments whereas, total chlorophyll content in leaves was recorded significantly higher with PSB + Azotobacter and Azotobacter alone over no inoculation and PSB alone. The minimum value was found in the control.

Azotobacter inoculation plays significant and unique role in phosphate mobilization and uptake of phosphorus, zinc, sulphur and water by plant. Although, there is limitation with the use of Azotobacter due to difficulty in producing clean pure inoculation on a large scale as the fungi are obligatory symbiotic and have to be maintained and multiplied on living plant. Azotobacter 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 (Yawalkar *et al.*, 1996) [12].

Table 1: Effect of different phosphorus levels and bio-fertilizers on yield and quality parameters of garlic.

Treatment	Neck thickness of bulb (mm)		Bulb diameter (mm)	No. of cloves per bulb	Average weight (gm.)	Bulb yield (q ha^{-1})		Total soluble solids (%)
Phosphorus Levels								
Control	P_0	6.93	44.33		26.44	19.50	124.03	31.5
40 kg/ha	P_1	6.33	41.67		26.11	20.21	135.77	38.3
60 kg/ha	P_2	7.32	41.12		23.04	24.96	138.32	37.8
80 kg/ha	P_3	7.72	44.33		27.38	22.42	145.84	37.2
SEm±	0.214		0.995	0 .068	0.111	2.804		1.097
CD(P=0.05)	0.621		N/A	0.198	0.228	8.139		3.184
Bio-fertilizers								
Control	B_0	7.16	43.33		25.79	21.33	122.57	35.5
PSB inoculation	B_1	8.02	44.67		26.67	23.71	131.74	36.5
Azotobacter inoculation	B_2	8.32	45.34		26.63	20.5	140.59	37.6
PSB+ Azotobacter inoculation	B_3	8.49	45.67		27.38	23.79	149.06	38.4
SEm±	0.214		0.995	0 .068	0.111	2.804		1.097
CD(P=0.05)	0 .621		N/A	0.198	.228	8.139		3.184

Conclusion

On the basis of the results obtained in the present investigation, it may be concluded that application of different phosphorus levels and bio-fertilizers enhanced the yield and quality parameters of garlic except days take bulb initiation in comparison to control.

The application of 80 kg Phosphorus ha^{-1} and different bio-fertilizers the inoculation of PSB + Azotobacter leads to maximum significantly the Neck thickness of bulb, Bulb diameter, Number of cloves per bulb, Average weight, Bulb yield, Total soluble solid at 30, 60, 90 and 120 DAP, over control and 40 and 60 kg Phosphorus ha^{-1} and PSB + Azotobacter over rest of the treatments. It is recommended for higher production of garlic under Lucknow conditions.

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