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Effect of phosphorus levels on growth, yield and quality of garlic (*Allium sativum* L.)

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Abstract
A field experiment was conducted at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Jaipur) during *Rabi* season 2015-16 on loamy sand soil. The experiment consisting four levels of each phosphorus (0, 25, 50 and 75 kg/ha). The Garlic variety G-282 was sown on 3rd November, 2015 at 15 x 8 cm spacing. The application of 75kg/ha phosphorus to the Garlic crop significantly increased the plant height (cm), number of leaves per plant, total chlorophyll content in leaves (mg/g), fresh weight of leaves, neck thickness of bulb, bulb diameter, Fresh weight of bulb (g), weight of bulb after curing (g), number of cloves per bulb, K content in bulb, bulb yield(kg/plot), bulb yield q/ha, net returns and B:C ratio as compared to control, and 25kg/ha Phosphorus but statistically at par with 50kg/ha Phosphorus, whereas nitrogen content in bulb, phosphorus content in bulb, sulphar content in bulb, T.S.S. content in bulb, were found maximum at 75kg/ha phosphorus to as compared to control and 25kg/ha phosphorus being statistically at par with 50kg/ha phosphorus. Application of 50 kg/ha Phosphorus significantly increased the available P_2O_5 in soil after harvest the crop over preceding levels of phosphorus.

Keywords: garlic, growth, quality, yield and phosphorus

Introduction
Garlic (*Allium sativum* L), a member of the Alliaceae family, is one of the most aromatic herbaceous annual spices (Kurian, 1995) [7]. It is the second most widely spice crop of the cultivated Allium crops, next to onion in the world (Purseglove, 1975) [12] with a characteristic pungent smell. Garlic is originated in central Asia where it was extended to the Mediterranean region in the pre-historic dates (Thompson and Kelly, 1957) [17].

Garlic is popular all over the world as a valuable spice for cooking different dishes. Besides, it is also used in preparing pickles, chutneys, curry powder, vegetables, tomato ketchup etc. According to the Unani and Ayurvedic medicines in the treatments of disease like chronic infection of the stomach and intestine, dysentery, typhoid, cholera and lungs disease, garlic is successfully used (Chopra *et al.*, 1958) [3]. Garlic contains amino acid which reduces cholesterol levels in human blood. Moreover, the aqueous extract of garlic cloves (containing allicin and related disulphides) reduces cholesterol level in humans (Augusti, 1977) [1]. Garlic also helps eliminating waste materials and dangerous free radicals from the human body (Durak *et al.*, 2004) [5].

Incorporate figures of 2015 India ranks second after China in area (247.52 thousand hectare) and production (1259.27 thousand tonnes) of garlic with an average productivity of 5.09 tonnes per hectare. The export was 29,046.86 MT (worth Rs 4,898.93 lakh) in 2012-13. This is only 2-3 per cent of the domestic garlic production. In Rajasthan an area of 59.45 thousand hectares with an annual production of 235.98 thousand tonnes. The productivity of garlic in Rajasthan is 3.97 t/ha (Gupta, 2014) [6]. This has caused decline in yield, quality of produce nutrient use efficiency soil fertility and overall factor productivity of the system.

Phosphorus acts as a structural component of membrane system of cells, chloroplasts and mitochondria. It is a constituent of energy phosphates like ADP and ATP, nucleic acid, nucleo proteins, purines, pyrimidine, nucleotides and several coenzymes. It involved in the basic reaction of photosynthesis and plays an important role in cell division, break down of carbohydrate, transfer of inherited characteristics and hastening the maturity of plants. It is also an essential constituent of majority of enzymes which are important in the transformation of energy in carbohydrate and fat metabolism and also in respiration of plants. About 93-99 per cent of the total phosphorus is insoluble and hence directly not available to plants.

Only about a quarter of water soluble phosphate is taken up by plants in the season of the application and the remaining is converted into insoluble (unavailable) forms (Verma, 1993) [18].

Materials and Methods

The field experiment was conducted at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Jaipur) during *Rabi* season 2015-16 entitled "Effect of phosphorus and bio-fertilizers on Growth, Yield and Quality of Garlic (*Allium sativum* L.) var. G -282". Geographically, Jobner is situated 45 km West of Jaipur at 26^0 05' North latitude, 75^0 58' East longitudes and at an altitude of 427 metres above mean sea level. In Rajasthan, this region falls under agro-climatic zone-IIIA (Semi-Arid Eastern Plains). The experiment was laid out in Randomized Block Design with four levels of Phosphorus (P_0 - control, P_1 - 25 kg Phosphorus /ha, P_2 - 50 kg Phosphorus/ha and P_3 - 75 kg Phosphorus /ha) with three replications. The entire experimental field was divided into three blocks of equal size and each block possessed 12 plots. Each plot measured 1.5 × 1.2 m^2 area. The variety was sowed at the spacing between plants to plant as well as row to row was kept at 15 x 8 cm. All the cultural operations were followed which were necessary to raise the good crop. The observations like Plant height, Average number of leaves per plant, Total chlorophyll content of leaves (mg/g) at 50 DAS, Fresh weight of leaves (g), Neck thickness (cm), Bulb diameter (cm), Weight of bulb (g), Number of cloves per bulb, Bulb yield (kg/plot and q/ha), Sulphur content (%), N content in bulb (mg/g), P content in bulb (mg/g), K content in bulb (mg/g), Total soluble solids (%),P content in soil were worked out adopting recommended procedures and recorded. The data of the trial obtained were subjected to statistical analysis and the results were documented, analysed and presented in tabular form.

Results and Discussion

Effect of Phosphorus on Growth attributes

It is revealed from the Table 1 and Fig 1 that the maximum plant height (32.80 cm), number of leaves (8.89) at harvest, chlorophyll content of leaves (1.14 mg/g), with application of 75 kg phosphorus per ha whereas, minimum were recorded in control but it was statistically at par with 50 kg Phosphorus/ha. Phosphorus plays an important role in the conservation and transfer of energy in the metabolic reactions of living cells including biological energy transformation. It acts as energy currency because it is the main constituent of co-enzymes, ATP and ADP. Thus, phosphorus influences photosynthesis, biosynthesis of proteins and phospholipids, nucleic acid synthesis, membrane transport and cytoplasmic streaming. Increase in availability of phosphorus owing to its application in the soil which was otherwise low (16.25 kg P_2O_5 ha^{-1}) in its content improved the nutrient availability status resulting increased photosynthetic and carbohydrate synthesis in garlic. The energy obtained from photosynthesis and metabolisms of carbohydrates is stored in storage compound (ADP and ATP) and then translocation to different parts for promoting meristemic development in potential apical buds and inter calary meristems which ultimately increased in vigour or growth of plants. The results obtained in this investigation are in close conformity with those of Mulatu *et al*. (2014) [9], Bhandari *et al.* (2012) [2] in garlic and Singh *et al*. (2000) [16] in onion,

Effect of phosphorus on yield Parameters

The analysis of variance revealed highly significant differences for all yield characters. The data presented in Table 1 and fig 1 that the maximum fresh weight of leaves (21.93 g), Neck thickness of bulb (0.72 cm), Bulb diameter (6.49cm), fresh weight of bulb (57.95 g), weight of bulb (39.58g) after curing, number of cloves per bulb (19.76), Bulb yield (2.899 kg/ plot), bulb yield (161.06 q/ha), with application of 75 kg phosphorus per ha whereas, minimum were recorded in control but it was statistically at par with 50 kg Phosphorus/ha. The regulatory functions of phosphorus in photosynthesis and carbohydrate metabolism can be considered to be one of the major factors limiting the plant growth particularly during the reproductive phase. 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 higher garlic production and seed formation. These findings corroborate the results of Mallanagouda *et al.* (1995) [8], Nasreen *et al.* (2009) [10] in garlic.

Effect of phosphorus on quality Parameters

It is evident from the data (Table 2 and fig 2) that the application of different levels of phosphorus significantly influenced the maximum N_2 content (0.844 %), P content (0.346%), S content (1.46 %), available phosphorus (17.04) in soil at harvest, and TSS (42.31%) were observed under 50 kg phosphorus /ha which was statistically at par with 75 kg phosphorus /ha. The maximum K content (0.057 %) was observed under 75kg phosphorus /ha where as the minimum was observed in control. As started earlier in preceding paragraphs that application of phosphorus might have improved the nutritional environment in rhizosphere as well as in the plant system, leading to increased uptake and translocation of nutrients especially of nitrogen and phosphorus in reproductive structure which led to higher nutrient content in seed. It is already discussed that phosphorus influences photosynthesis, biosynthesis of protein and phospholipids. Increased availability of phosphorus owing its application might have increased the photosynthesis and carbohydrate synthesis resulting into greater accumulation of food material which ultimately increased the total soluble solids (T.S.S.) content in seed. These result are in close conformity with finding of Singh and Paliwal (2003) [15] in cowpea, Rathore *et al.* (2007) [14] in clusterbean, Rathore *et al.* (2010) [13] in urdbean and Puniya (2011) [11] in mothbean.

The increase in available P content of soil with application of P could be due to the utilization of native phosphorus with increasing rates of P which resulted in building up of higher soil P status. The positive effect of P on its availability was also reported by Shrivastava and Verma (1985) in pea who also observed beneficial effect of phosphorus fertilization on nitrogen fixation by legumes. The results find support from the work of Dass *et al.* (2005) [4] in vegetable pea.

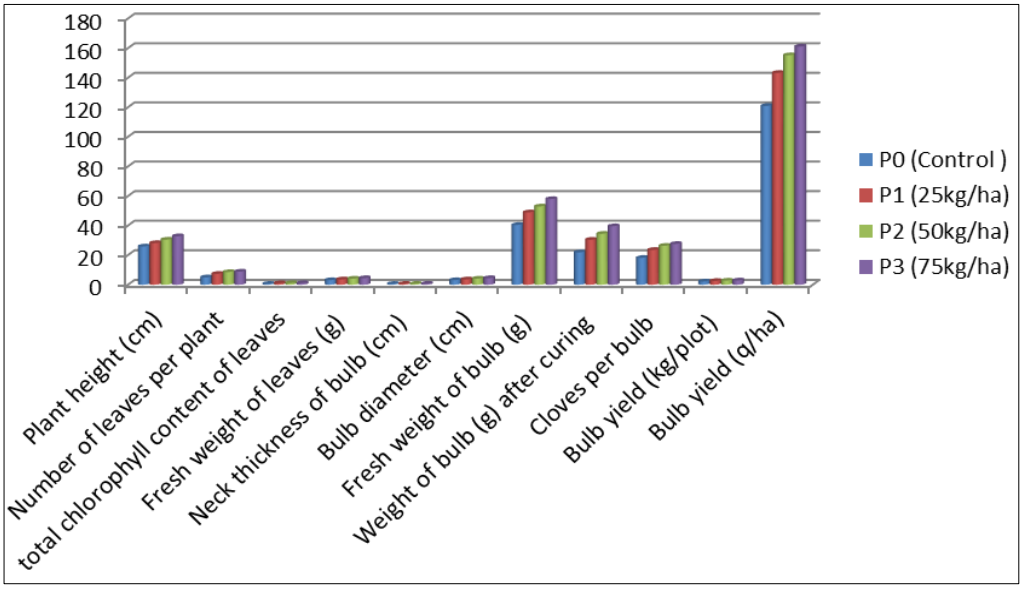

Fig 1: Effect of phosphorus fertilization on Growth and yield characters of Knol-Khol

Table 1: Effect of phosphorus fertilization on growth and yield character of Garlic

Characters	Treatments					
	P_0 (Control)	P_1 (25kg/ha)	P_2 (50kg/ha)	P_3 (75kg/ha)	SEm±	CD at 5%
Plant height (cm)	25.89	28.19	30.49	32.80	0.63	1.83
Number of leaves per plant	5.00	7.40	8.59	8.89	0.16	0.47
total chlorophyll content of leaves	0.63	1.05	1.11	1.14	0.02	0.06
Fresh weight of leaves (g)	15.18	18.41	21.08	21.93	0.35	1.01
Neck thickness of bulb (cm)	0.58	0.63	0.67	0.72	0.01	0.04
Bulb diameter (cm)	5.10	5.64	6.22	6.49	0.137	0.36
Fresh weight of bulb (g)	40.43	48.94	52.94	57.95	0.64	1.85
Weight of bulb (g) after curing	21.89	30.43	34.44	39.58	0.38	1.11
No. Cloves per bulb	15.15	16.74	18.21	1976	0.34	0.97
Bulb yield (kg/plot)	2.18	2.58	2.79	2.90	0.02	0.06
Bulb yield (q/ha)	120.88	143.22	155.21	161.06	1.35	3.91

Table 2: Effect of phosphorus fertilization on growth and yield character of Garlic

Characters	Treatments					
	P_0 (Control)	P_1 (25kg/h)	P_2 (50kg/ha)	P_3 (75kg/ha)	SEm±	CD at 5%
N content (%)	0.76	0.82	0.84	0.87	0.02	0.05
P content (%)	0.275	0.320	0.342	0.357	0.007	0.020
K content (%)	0.040	0.049	0.054	0.057	0.001	0.002
S content (%)	1.31	1.39	1.46	1.48	0.03	0.08
Available phosphorus (kg/ha)	12.55	15.20	17.04	18.04	0.35	1.00
TSS (%)	38.00	40.21	42.31	42.71	0.68	1.95
Net returns (Rs/ha)	395660	484358	531645	554333	5176	14951
B:C ratio	5.09	5.30	5.77	5.94	0.05	0.14

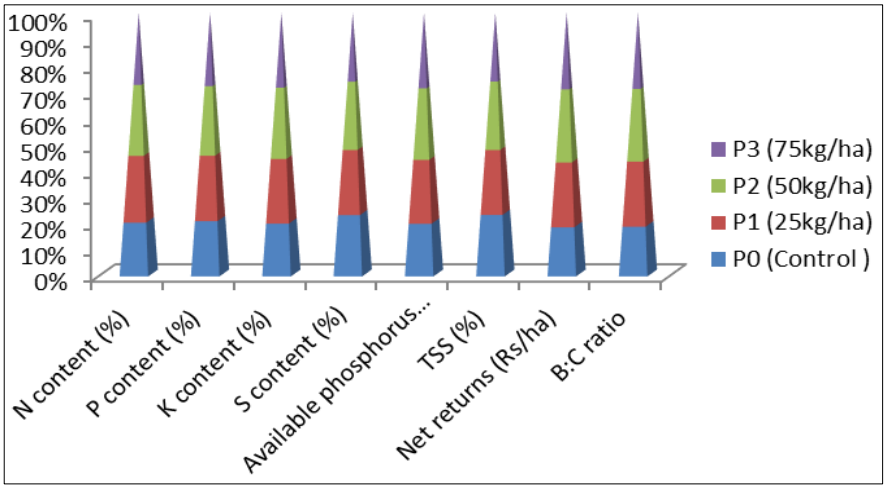

Fig 2: Effect of phosphorus fertilization on quality and economic characters of Garlic.

Effect of phosphorus on economic parameters

A perusal of data (Table 2, Fig 2) indicated that the higher net returns (Rs 554333) and B:C ratio (5.94) obtained under the75 kg phosphorus/ha treatment whereas the minimum net returns of Rs 153081 with B: C ratio of 1.36 was obtained in the treatment combination control.

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