Interactive Effect of Phosphorus and Zinc on the Growth, Yield and Nutrient Uptake of Garlic (*Allium sativum* L.) Variety Gulabi

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ABSTRACT---- ***The present study entitled "Interactive effect of phosphorus and zinc on the growth, yield and nutrient uptake of garlic (Allium sativum L.) var. Gulabi, was conducted at vegetable Research Farm Rawalakot, during the year 2013-14. Phosphorus was applied in the form of SSP (Single supper phosphate) while zinc was applied as zinc sulphate. Three levels of phosphorus 30, 50 and 70 kg ha^{-1} and three level of zinc i.e. 3 ppm, 4 ppm and 5 ppm were compared with control. The experiment was conducted in Randomized Complete Block Design (RCBD) with sixteen treatments and three replications with two factors. Minimum number of days to germination (18.567), maximum leaf length (40.96 cm) was found when phosphorus @ 50 kg ha^{-1} was used. Maximum plant height (67.500 cm), maximum number of leaves plant^{-1} (6.85), maximum dry weight of leaves (0.49 g), maximum weight of bulb (42.58 g), maximum bulb diameter (4.4 cm^2), maximum numbers of cloves bulb^{-1} (8.500), maximum chlorophyll content of leaves (12.527 mg cm^{-2}) and maximum average yield ha^{-1} (4549.6 kg) were observed in T_{11} (P @ 50 kg ha^{-1} & Zn @ 4 ppm ha^{-1}). Maximum leaf area (93.93 cm^2) and maximum fresh weight of leaves (2.88 g) was observed in T_{10} (P @ 50 kg ha^{-1} Zn @ 3 ppm ha^{-1}). pH of extract and ascorbic acid showed non significant results for different levels of phosphorus and zinc.***

Keywords---- Garlic, Phosphorus, Single Super Phosphate, Zinc, Zinc Sulphate

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1. INTRODUCTION

Garlic (*Allium sativum* L.) belongs to the family *Alliaceae* having chromosome no 2n=16. It is the second most widely cultivated bulb crop after onion (Bozzini, 1991). Garlic is an erect annual herb with the height of 75-90 cm and best grown in dry and mild winter (Brewster, 1994). Garlic requires rich, moist, sandy soil, but can be grown in a loam or clay soil. (Bozzini, 1991). Ideal soil pH for garlic is 6.5 to 7.5 (Kelly *et al*., 2000).

In addition to vitamins, garlic is rich source of sugar, protein, fat, potassium, calcium, sulfur, phosphorus, fiber and iodine. 100 g of edible portion of garlic contains 59 % moisture, 6.4 g protein, 1469 k cal energy, 0.5 g fats, 33.1 g carbohydrates, 1.5 g fiber, 181 mg Ca, 153 mg P, 1.7 mg Fe, 17 mg Na, 401 mg K, 0.08 mg riboflavin, 0.25 mg thiamine, 0.06 mg nicotinamide and 10.8 mg ascorbic acid (Lorenz and Maynard, 1988). Garlic prevent many diseases known to influences risk factors associated with heart disease. Feeding garlic to patients with coronary heart disease decreased serum cholesterol (Dubick, 1986). Garlic has a higher nutritive value than other bulb crops. It is beneficial for the treatment of lingering stomach disease, earache and sore ear (Saleem *et al*., 2002). Garlic extracts had been used in the treatment of wide range of diseases. Garlic oil is used against fat infiltration of liver. Garlic preparations contain allicin that reduced blood clotting and act as antimicrobial agents. Allicin is a reactive compound and the odour of garlic is due to this compound (Block, 1985).

Continuous cropping without the proper application of fertilizers cause dramatically decrease in crop yield, therefore the basic nutrients especially nitrogen, phosphorus and potash must be supplied through fertilizer application which increase the garlic growth and yield (Abbas *et al.,* 2006). Limited phosphorus in bulb crops reduced root growth, leaf growth, bulb size, yield and delayed maturation (Stone *et al*., 2001). Phosphorus had shown a strong response of bulb when applied on loamy sandy soils (Ladebusch, 1999). Phosphorus has a primary importance for root enlargement. The movement of phosphorus in the soil is very slow and its uptake is usually depend on the concentration gradient and diffusion in the soil close to the roots, so sufficient amount of phosphorus should be available in the soil for optimal yield (Robertson, 1999).

Zinc is crucial for plant growth because it controls the synthesis of indoleacetic acid, which noticeably regulates plant growth and also active many enzymatic reactions which is necessary for chlorophyll synthesis and carbohydrate formation (Vitosh, 1994). It is well known that zinc act as a cofactor of many enzymes and effect many biological processes such as photosynthesis, nucleic acid, catabolism, biosynthesis of protein and carbohydrates (Marschner, 1995). Zinc deficiency symptoms are widespread, deficient leaves of tree fruits are easily identified by their characteristic interveinal chlorosis, small leaves, and the rosette formation which results from insufficient synthesis of IAA, and short internodes. Zinc deficiency may be corrected by foliar application of .3-.4 % solution of zinc sulphate (Kausar, 1979).

Keeping in view these facts, the present experiment was planned to study the effect of different doses of phosphorus and zinc on growth, yield and nutrient uptake of garlic under rain fed conditions of Rawalakot, Azad Jammu and Kashmir and also to assess the suitability of different set of treatments of phosphorus and zinc for garlic producers of district Rawalakot, Azad Jammu and Kashmir.

2. MATERIALS AND METHODS

A field experiment was conducted during crop seasons 2013-2014 at Vegetable Research Farm, Faculty of Agriculture, University of Poonch to evaluate the suitable doses of phosphorus and zinc for cultivation of local garlic var. Leshon gulabi at Rawalakot. Seeds of garlic cultivar "Lehson Gulabi" were collected from local farmers. Phosphorus was applied in the form of SSP (Single supper phosphate) while zinc was applied as zinc sulphate. Three levels of phosphorus 30, 50 and 70 kg ha^{-1} and three level of zinc i.e. 3 ppm, 4 ppm and 5 ppm were used. Variable doses of phosphorus (SSP) and zinc (zinc sulphate) in different combinations were used as given in Table 1.

Following treatments from the above combination were tested:

T_1 = P_0 (P @ 0 kg ha^{-1}) Z_0 (Z @ 0 ppm ha^{-1}), **T_2 =** P_0 (P @ 0 kg ha^{-1}) Z_1 (Z @ 3 ppm ha^{-1}), **T_3 =** P_0 (P @ 0 kg ha^{-1}) Z_2 (Z @ 4 ppm ha^{-1}), **T_4 =** P_0 (P @ 0 kg ha^{-1}) Z_3 (Z @ 5 ppm ha^{-1}), **T_5 =** P_1 (P @ 30 kg ha^{-1}) Z_0 (Z @ 0 ppm ha^{-1}), **T_6 =** P_1 (P @ 30 kg ha^{-1}) Z_1 (Z @ 3 ppm ha^{-1}), **T_7 =** P_1 (P @ 30 kg ha^{-1}) Z_2 (Z @ 4 ppm ha^{-1}), **T_8 =** P_1 (P @ 30 kg ha^{-1}) Z_3 (Z @ 5 ppm ha^{-1}), **T_9 =** P_2 (P @ 50 kg ha^{-1}) Z_0 (Z @ 0 ppm ha^{-1}), **T_{10} =** P_2 (P @ 50 kg ha^{-1}) Z_1 (Z @ 3 ppm ha^{-1}), **T_{11} =** P_2 (P @ 50 kg ha^{-1}) Z_2 (Z @ 4 ppm ha^{-1}), **T_{12} =** P_2 (P @ 50 kg ha^{-1}) Z_3 (Z @ 5 ppm ha^{-1}), **T_{13} =** P_3 (P @ 70 kg ha^{-1}) Z_0 (Z @ 0 ppm ha^{-1}), **T_{14} =** P_3 (P @ 70 kg ha^{-1}) Z_1 (Z @ 3 ppm ha^{-1}), **T_{15} =** P_3 (P @ 70 kg ha^{-1}) Z_2 (Z @ 4 ppm ha^{-1}) and **T_{16} =** P_3 (P @ 70 kg ha^{-1}) Z_3 (Z @ 5 ppm ha^{-1})

The experiment was designed in accordance to RCBD (randomized complete block design) with sixteen treatments and three replications. The total area was 80 m^2. Bed size was 1 m^2. The total numbers of plots were 48. The row to row and plant to plant distance was 30 cm and 15 cm respectively. Phosphorus was applied at the time of sowing in single dose and zinc was applied after two weeks of sprouting. First irrigation was applied after planting of cloves. Over flooding was avoided and consequent irrigations were applied at an interval of 7 days keeping in view the weather conditions. All usual cultural practices were provided throughout the growth period. Manual hoeing and weeding was done according to requirement. Data was collected on various growth stages of garlic crop, average plant height (cm), number of leaves $plant^{-1}$, fresh weight of leaves (g), leaf area (cm^2), weight of bulb $plant^{-1}$ (g), diameter of the bulb (cm), number of cloves $bulb^{-1}$, and average yield ha^{-1}.

Statistical analysis

The calculated data were statistically analyzed for analysis of variance (ANOVA) by using Statistix 8.1 computer software. Analysis of variance techniques were employed to test the overall significance of the data, while the least significant difference (LSD) test ($P \leq 0.05$) was used to compare the treatment means (Steel *et al.*, 1997).

3. RESULTS AND DISCUSSION

Plant Height (cm)

The results regarding to plant height of garlic were significantly influenced by the application of phosphorus as shown in Table 2. This may be because phosphorus has a vital role in almost every plant process that includes energy transfer. High energy phosphate, held as a part of the chemical structures of adenosine diphosphate (ADP) and ATP, is the source of energy that drives the chemical reactions within the plant. This may be the reason that phosphorus increased the plant height of the plant. These results are similar matched with the findings of Abbas *et al*. (2006). Zinc also significantly enhanced the plant height of garlic and is described in Table 3. Zinc is an essential trace element for plant, being involved in many enzymatic reactions and is necessary for their good growth and development. Zinc is also involved in regulating the protein and carbohydrate metabolism (Swietlik, 1999). These results are in conformity with the finding of Arshad *et al.* (2007). They found that application of zinc significantly increased plant height.

Number of Leaves $Plant^{-1}$

The result regarding to number of leaves $plant^{-1}$ of garlic significantly increased by application of phosphorus and are presented in Table 1. This may be because phosphorus involves in many plant growth development processes that cause increased in number of leaves $plant^{-1}$. Low level of phosphorus results in reduction in leaf expansion and leaf surface area, as well as the number of leaves. Islam *et al*. (2007) found that number of leaves $plant^{-1}$ of garlic was significantly increased by application of phosphorus. Zinc also significantly increased the number of leaves $plant^{-1}$ and is described in Table 3. Zinc increases the vegetative growth and development process of the plant that result in the more number of leaves $plant^{-1}$. The photosynthesis occurs in leaf cells and carbohydrates are formed here. Rohidas *et al*. (2007) found that number of leaves plant of garlic was significantly increased by application of zinc.

Leaf Area (cm^2)

Leaf area of garlic showed significant difference to phosphorus because phosphorus is important for plant growth and is found in every living plant cell. Phosphorus involved in many key plant functions, including energy transfer, photosynthesis, and conversion of sugars, starches and nutrient movement within the plant that results in more leaf expansion. Abbas *et al*. (2006) depicted that all the growth and developmental processes were significantly increased by the application of phosphorus. It is well known that zinc as a cofactor of many enzymes and effect many biological processes such as photosynthesis, nucleic acid, catabolism, biosynthesis of protein and carbohydrates (Marchner, 1995). Arshad *et al*. (2007), also recorded that varying levels of zinc affected the leaf area.

Fresh weight of Leaves (g)

Fresh weight of leaves plant^{-1} showed significant difference to phosphorus because phosphorus has a precise role in capturing and converting the sun energy in to useful plant compound that helps in vegetative growth and phosphorus is a basic structural part of the cell, notably in the form of nucleic acid, and phospholipids that may cause an increase in the fresh weight of leaves with phosphorus application. Zinc significantly increased the fresh weight of leaves plant^{-1}. Zinc is essential for water uptake and water relation to the plant, plants absorb water from surrounding and nutrients already dissolve in water and plant taken it, so when plant absorb more nutrients they result in more number of leaves and more fresh weight. Abedin *et al*. (2012) also recorded that varying levels of zinc affected the fresh weight of leaves.

Weight of Bulb Plant^{-1} (g)

Weight of bulb Plant^{-1} had showed significant difference for phosphorus. Phosphorus mainly improves the reproductive growth. More energy is stored in the bulb and they look healthier and stronger. This also may be because of the reason that phosphorus is a significant component of nucleic acids that helps the whole plants to grow and reproduce. Activity of photosynthesis increases with the application of zinc as a result growth of the plant enhanced. By the application of zinc root system of the plant improved and help in maximum absorption of soil moisture and other essential nutrient dissolved in it. As a result plants growth is very good due to which plant produced maximum bulb weight plant$^{-1.}$ Sakarvadia *et al*. (2009) reported the results having resemblance to these results. They found that zinc significantly influenced bulb weight.

Bulb Diameter (cm^2)

Bulb diameter of garlic showed difference for phosphorus because phosphorus helps in reproductive growth and also involved in cell enlargement that results in increase in diameter of the bulb. Phosphorus stimulates growth of root, branches and neck of garlic. High level of phosphorus throughout the growth period of the plant in the root zone is essential for rapid root development and for good utilization of water and other nutrients by the plants that results in increased in diameter of the bulb. Poor root growth is associated with low phosphorus content available to plant. These findings were also justified by Reddy *et al.* (2000), They revealed that phosphorus significantly enhanced the bulb diameter of garlic. Zinc also increased the bulb diameter of garlic. Zinc was also found responsible for larger size of bulb. This fact is due to improved physiological activities like photosynthesis during which food manufactured by the plant and translocated in the bulb that results in larger size of bulb. These results have resemblance with conclusions made by Nasreen *et al* (2007), and they observed that the application of zinc, boron and poultry manure significantly increase the plant height, number of leaves plant^{-1}, number of cloves bulb^{-1},diameter of bulb^{-1},bulb weight and yield ha^{-1}.

Number of Cloves Bulb^{-1}

Number of Cloves Bulb^{-1} significantly influenced by the application of phosphorus. Results were reported by Suthar (2009) that number of cloves is enhanced by phosphorus appliation. Zinc helped in translocation of constituents from one part to the other. Zinc application markedly increased the number of cloves bulb^{-1} and weight of cloves. The improvement in weight and number of cloves might be due to increase in size and weight of bulb under the influence of zinc, might be due to rapid transformation and storage of food material in the bulb which ultimately increased the number of cloves bulb^{-1} and weight of cloves. The improved vegetative growth of plant and yield attributing characters due to zinc application and has also direct relation in improvement of bulb development and increase in bulb yield. These results are in the conformity with the findings of Nasreen *et al.* (2007), and they found that zinc, boron and poultry yard manure application significantly increased the plant height, number of leaves plant^{-1},number of cloves bulb^{-1},diameter of bulb^{-1},bulb weight and yield ha^{-1}.

Average Yield ha^{-1} (kg)

The result regarding to average yield ha^{-1} (kg) of garlic showed significant differences to the application of phosphorus as phosphorus enhance the reproductive phase of plant and phosphorus is highly mobile in plants and when it is deficient it may be translocated from old plant tissue to young actively growing areas. As plant matures, phosphorus is translocated into the reproductive parts of the plant where high energy requirements are needed for the formation of seeds and fruit. Phosphorus deficiencies late in the growing season affect the normal crop maturity. That's why availability of phosphorus helps to increase the yield ha^{-1}. These results are similar to the finding of Reddy *et a*l (2000). Their results showed that treatment with 150 kg nitrogen and 90 kg phosphorus ha^{-1} shown the maximum plant height, bulb diameter and bulb yield. Zinc also showed significant difference for average yield ha^{-1}. The improved vegetative growth of plant and yield attributing characters due to zinc application has also direct relation in improvement of bulb development and increase in bulb yield. These result are in the conformity with the findings of Arshad *et al.* (2007), they found that both nitrogen and zinc significantly affected all the growth parameters. Maximum leaf length, plant height, bulb weight and yield were recorded in the plots fertilized with 100 kg N ha^{-1} and Zn 10 kg ha^{-1}. These results are also justified with Trivedi *et al.* (2005). They found that the yield ha^{-1} of garlic were significantly enhanced by the application of zinc when applied with 2,4-D (3 ppm) as folier spray.

4. CONCLUSIONS

From the obtained results, it is concluded that Phosphorus @ 50 kg ha^{-1} gave best results for days to sprouting, plant height number of leaves plant^{-1}, leaf area, leaf length, fresh weight of leaves, dry weight of leaves, bulb weight, bulb diameter, number of cloves bulb^{-1}, chlorophyll content and average yield, and Zinc @ 4 ppm ha^{-1} gave more plant height, number of leaves plant^{-1}, dry weight of leaves, weight of bulb plant^{-1}, number of cloves bulb^{-1}, chlorophyll content and average yield ha^{-1}.

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Table 1: Variable doses of phosphorus (SSP) and zinc (zinc sulphate) in different combinations with control

P_0	Control	Zn_0	Control
P_1	30 kg	Zn_1	3 ppm
P_2	50 kg	Zn_2	4 ppm
P_3	70 kg	Zn_3	5 ppm

Table: 2. Mean values of morphological parameters affected by different level of phosphorus

Parameters	P @ 0 kg ha^{-1}	P @ 30 kg ha^{-1}	P @ 50 kg ha^{-1}	P @ 70 kg ha^{-1}	LSD
Plant height (cm)	55.0 c	62.0 b	66.2 a	62.2 b	0.963
No. of leaves plant^{-1}	5.6 c	6.0 b	6.6 a	5.7 c	0.142
Leaf area (cm^2)	64.1c	76.0 b	86.3 a	55.0 d	41.80
Leaves fresh weight (g)	1.8 c	2.1 b	2.7 a	2.0 c	0.143
Bulb Weight (g)	25.0 c	33.0 b	39.0 a	26.3 c	2.203
Bulb diameter (cm^2)	3.8 b	3.8 b	4.1 a	3.7 c	0.140
Number of Cloves Bulb^{-1}	7.7 b	7.5b	8.2 a	7.3 c	0.140
Average yield (kg ha^{-1})	3800 b	4000 b	4300 a	3400 c	243.1

Table 3. Mean values of morphological parameters affected by different level of zinc

Parameters	Zn @ 0 ppmha^{-1}	Zn @ 3 ppmha^{-1}	Zn @ 4 ppmha^{-1}	Zn @ 5 ppmha^{-1}	LSD
Plant height (cm)	59.0 c	61.0 b	65.0 a	61.2 b	0.963
No. of leaves plant^{-1}	5.6 d	5.7 c	6.3 a	6.1 b	0.142
Leaf area (cm^2)	69.0 b	74.4 a	67.3 b	71.0 ab	41.80
Leaves fresh weight (g)	2.0 c	2.5 a	2.1 b	2.0 c	0.143
Bulb Weight (g)	26.0 c	29.7 b	34.3 a	32.2 a	2.203
Bulb diameter (cm^2)	3.9 b	3.6 c	4.2 a	3.7 c	0.140
Number of Cloves Bulb^{-1}	7.3 d	7.5c	8.0 a	7.8 b	0.140
Average yield (kg ha^{-1})	3700 b	3900 a	4000 a	4000 a	243.1

Table: 4. Interactive effect of phosphorus and zinc levels on different morphological parameters.

Parameters	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}	T_{16}	LSD
Plant height (cm)	52.5 f	52.6 f	61.5 bcd	52.9 f	60.5 d	61.8 b-d	63.4 b	62.6 bc	63.4 b	66.8 a	67.5 a	67.4 a	58.1 e	61.3 cd	67.2 a	62.2 bcd	1.9287
No. of leaves	5.20 ef	5.30 ef	5.90 d	5.80 d	5.40 e	5.90 d	6.30 bc	6.20 c	6.30 bc	6.50 b	6.85 a	6.50 b	5.10 f	5.20 f	6.40 bc	5.90 d	0.2924
Leaf area (cm^2)	63.3 fg	75.2 cde	54.7 hi	63.4 fg	69.8 ef	78.6de	72.7 de	82.4 bc	53.5 hi	93.9 a	60.4 gh	53.9 hi	87.5 ab	50.2 i	81.5 bc	82.6 bc	8.3760
Fresh wt. of leaves (g)	1.82 f	2.21 de	1.66 fg	1.59 fg	2.15 e	2.49 b-d	2.21 de	1.83 f	2.52 bc	2.88 a	2.71 ab	2.50 b-d	1.37 g	2.24 c-e	2.15 e	1.85 f	0.2926
Weight of bulb (g)	23.2 f	23.6 f	26.8 ef	25.9ef	28.1e	30.0 de	37.9bc	34.2cd	35.4 bc	37.1bc	42.6a	38.9ab	17.3 g	28.2 e	30.0 de	29.9 de	4.4086
Bulb Diameter (cm^2)	3.7 cd	3.5 de	4.3 a	3.8 bcd	4.3 a	3.3 ef	4.3 a	3.3 ef	3.7 cd	4.4 a	4.4 a	4.0 b	3.8 bc	3.2 f	3.8 bc	3.8 bc	0.2800
No. of Cloves $Bulb^{-1}$	7.2 d	7.3 d	8.3 ab	7.8 c	6.8 c	7.4 d	8.2 b	7.7 c	8.1 b	8.2 b	8.5 a	8.3 ab	7.2 d	7.2 d	7.3 d	7.3 d	0.2960
Yield (kg ha^{-1})	3800 c-e	3700 de	4000 b-d	3700 c-e	3900 b-e	4000 b-d	3800 c-e	4200 a-c	4200 a-c	4400 ab	4500 a	4200 a-d	2800 f	3500 e	3700 c-e	3800 cde	486.41