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Effect of Phosphorus and Zinc Application on Growth and Yield Attributes of Pearl millet (*Pennisetum glaucum* L.) under Rainfed Condition

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Abstract
A field experiment was carried out during *Kharif* season 2012 at the Agricultural Farm of Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur to study the effect of phosphorus and zinc application on growth, yield attributes and yield of pearl millet. On experimental data basis significant improvements were recorded in growth attributes as plant height, number of tillers per plant and dry matter accumulation and yield attributes as pod length, grain and straw yield and harvest index of pearl millet. Phosphorus and zinc level significantly increased the plant height, the maximum plant height (73.83, 165.27, 167.93 and 170.33 cm) was recorded due to application of 30 kg phosphorus and 20 zinc kg ha^{-1} at 25, 50, 75 DAS and at maturity stage. The maximum (2066.67 & 4443.23 kg ha^{-1}) grain and straw yield recorded with application of 30 kg phosphorus and 20 kg zinc ha^{-1} while minimum (1599.33 &3256.67 kg ha^{-1}) were recorded in control, respectively. The application dose of 30 kg phosphorus and 20 zinc kg ha^{-1} treatment have shown 15%, 6% and 23 % increase in grain yield over 10 kg phosphorus and 20 zinc kg ha^{-1}, 20 kg phosphorus and 20 zinc kg ha^{-1} and control, respectively.

Keywords: Pearl millet, Growth, Yield, Phosphorus and Zinc

1. Introduction

Pearl millet is the most widely cultivated cereal in India after rice and wheat. It is grown on more than 9.3 m ha with current grain production of 9.5 m tones and productivity of 1044 kg ha^{-1}. The major pearl millet growing states are Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana which account for more than 90% of pearl millet acreage in country (Yadav, 2011) [23]. It is a dual purpose crop, its grain is used for human consumption and its fodder as cattle feed. Mineral fertilization is one of the most important ways for qualitative and quantitative improving crop yield and its quality can be improved by adequate soil and crop management practices (Pathak *et al.*, 2012) [16]. Phosphorus (P) is a second leading limiting factor after nitrogen for plant growth and productivity on 40% of the world's arable soil (Vance, 2001) [21]. It plays key roles in many plant processes such as energy metabolism, the synthesis of nucleic acids and membranes, photosynthesis, respiration, nitrogen fixation and enzyme regulation (Raghothama, 1999) [17]. Adequate phosphorus nutrition enhances many aspects of plant growth development including flowering, fruiting, root growth and yield components of different crops. P uptake in plants is often constrained by the very low solubility of P in the soil. In agricultural systems, phosphorus in the harvested crops is removed from the system, resulting in P deprived soils if no P is supplemented as fertilizer. Zinc is a divalent cation exhibiting important role in mankind health and functioning the various physiological and metabolic functions of plant (Alam *et al.*, 2010; Alloway, 2008; Marschner, 1995) [1, 3, 11]. Zinc is essential element for crop production and growth development of plant (Ali *et al.*, 2008; Graham *et al.*, 2000) [2, 5]. Phosphorus and zinc interaction affects the availability and utilization of both the nutrients and imbalance of any in soil matrix affects the dynamics (Nayak and Gupta, 1995) [14]. Since zinc and phosphorus interaction may take place in soil as well as in the plants modifying the nutrition of plant, therefore it is imperative to understand their fate in the system for efficient management of these nutrients.

2. Material and methods

The present investigation entitled "Effect of phosphorus and zinc application on quality, growth and yield attributes of pearl millet (*Pennisetum galaucum* L.) Under rainfed condition" was carried out during *kharif* season of 2012 at the Agronomy farm of Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur, which is situated in *Vindhyan* region of district Mirzapur (25º 10' latitude, 82º 37' longitude and altitude of 427 meters above mean sea level). *Vindhyan* soil comes under rainfed and invariably poor fertility status. This region comes under Agro-Climatic Zone III A (semi-arid eastern plain zone).

The soil was sandy loam, acidic (pH 5.6), low in initial organic carbon (0.29%), available N (188.2 kg/ha) and P_2O_5 (9.66 kg/ha) and medium in available K_2O (186.4 kg/ha), with EC 0.44 dS/m. The experiment comprising 10 treatment with different combinations of phosphorus levels (10, 20 and 30 kg P_2O_5/ha) and zinc levels (10, 20 and 30 kg Zn/ha) and control as without application of phosphorus and zinc was laid out in randomized block design with thrice replications. Pearlmillet *cultivar* Kaveri Super Boss – A recommended variety for cultivation in *Kharif* season matures in 80-85 days. The fertilizer N and K was uniformly applied @ 80 and 30 kg ha^{-1} respectively. Half of the recommended dose of nitrogen and full of potassium were applied at the time of sowing. Remaining half dose of N was applied one month after sowing. The phosphorus and zinc was applied as per treatments at the time of sowing. The source of phosphorus and zinc was single super phosphate (SSP) and Zink Sulphate. All the agronomic practices except those under study were kept normal and uniform for all the treatments. The data gathered in each observation were statistically analyzed using analysis of variance technique and significant differences among treatments mean were tested using least significant difference (LSD) test at 5% probability (Panse and Sukhatme 1985) [15].

3. Result and Discussion

Growth attributes

Plant height (cm): The growth attributes are significantly influenced by phosphorus and zinc application. The data on plant height as influenced by phosphorus and zinc level recorded at 25, 50, and 75 days after sowing (DAS) and at harvest are presented in Table-1. Result of the experiment revealed that plant height at 25, 50, 75 and at harvest varied significantly due to different levels of phosphorus and zinc. Maximum plant height at all the growth stages was recorded in the treatment where 30 kg phosphorus was applied in combination with 20 kg zinc ha^{-1}, however lowest was recorded in control. The plant height varied from 59 to 73.83, 140.43 to 165.27, 154.8 to 167.93 and 154.73 to 170.33 cm at 25, 50, 75 DAS and at harvest, respectively. This could be attributed to effective utilization of nutrients through the extensive root system developed by crop plants under adequate P application (Jain and Dahama, 2006) [7]. Zinc plays a pivotal role in regulating the auxin concentration in plant and nitrogen metabolism and might have improved these growth attributes. In dry land areas Zn application increases root absorption of minerals, these results are consistent with Falah (2002), Kuchaki (1997) and these results are in close conformity with those of Dashadi *et al.* (2013) [4] and Kumawat *et al*. (2015) [10].

Number of tillers: The number of tillers significantly increased with the application of phosphorus and zinc at all the growth stages, it varied from 1.5 to 3.0, 1.6 to 3.0, 1.8 to 2.3 and 1.9 to 2.3 at 25, 50, 75 DAS and at harvest. At 25 and 50 DAS maximum 3.0 numbers of tillers were recorded in treatment 10 kg P_2O_5 ha^{-1} + 30 kg zinc ha^{-1} and minimum number of tiller $plant^{-1}$ was found in control. It showed that, increase in number of tiller $plant^{-1}$ could be assigned due to application of phosphorus and zinc thereby increase in soil micro-organism and also due to better moisture and nutrient availability. Singh and Ram (2001) [19] also found similar results.

Total dry matter accumulation (g plant-1): It was clearly indicate that significant variations observed on dry matter accumulation due to the application of phosphorus and zinc treatments. At 25 DAS maximum dry matter accumulation of 2.22 g $plant^{-1}$ was recorded with 20 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1}, however, at 50 and 75 DAS (30.00 and 79.20 g plant-1, respectively) it was recorded with 30 kg P_2O_5 ha^{-1} + 30 kg zinc ha^{-1}. The dry matter accumulation in pearl millet at harvest varied from 69.47 to 95.50 g plant-1. Maximum dry matter accumulation at harvest (95.50 g $plant^{-1}$) was recorded in 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1}, which have shown an increase of 27% and 11 % over control and 10 kg P_2O_5 ha^{-1} + 10 kg zinc ha^{-1}, respectively. Minimum dry matter accumulation was recorded in control at all the growth stages. The dry matter accumulation in 20 kg P_2O_5 ha^{-1} + 30 kg zinc $ha^{-1}$and 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1} treatment were at par at maturity. Application of phosphorus up to 30 kg ha^{-1} significantly increased the dry matter yield over 10 and 20 kg P application. This may be ascribed to improvement in the status of available P and Zn of soil and its better absorption by the plants. The increased availability of P and Zn increased the dry matter accumulation as growth attributing characters which reflected in higher yield of pearl millet. Similar results were reported by Falah (2002) and Dashadi *et al.* (2013) [4].

Yield attributes

Ear length (cm): The yield attributes and yield of pearl millet were significantly influenced by phosphorus and zinc application (table-1). The ear length of pearl millet varied from 21.33 to 26.44 cm, minimum being in the treatment 10 kg P_2O_5 ha^{-1} + 10 kg zinc ha^{-1}. The highest length of ear (26.44 cm) was recorded in 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1} which have shown 16 % increase over control. All the treatments except 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1} were statistically at par with control. The following yield attributing characters were recorded under application of phosphorus and zinc @ 15 and 10 kg ha^{-1} and it was significantly higher over control. Similar finding was observed by Jakhar *et al (2005)* [24].

Grain yield (kg ha^{-1}): The maximum grain yield (2066.67 kg ha^{-1}) was recorded in the treatment 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1} followed by 30 kg P_2O_5 ha^{-1} + 10 kg zinc ha^{-1} which treatments was statistically at par, however, minimum (1599.33 kg ha-1) was recorded in control. The treatment 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1} have shown 15, 6 and 23 % increase over 10 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1}, 20 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1} and control, respectively. The treatments 10 kg P_2O_5 ha^{-1} + 30 kg zinc ha^{-1} and 20 kg P_2O_5 ha^{-1} + 10 kg zinc ha^{-1}, were found statistically at par, also treatments 20 kg P_2O_5 ha^{-1} + 30 kg zinc ha^{-1} and 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1} had similar relation. Similar finding also were reported by Nath *et al*. (2008) [13] and Ajwain and Mehta *et al*. (2010) [12] reported that the increase in the yield components might be connected with the release of essential nutrient elements.

Stover yield (kg ha^{-1}): The stover yield varied significantly between 3256.67 to 4443.23 kg ha^{-1} due to application of phosphorus and zinc. Maximum stover yield recorded with the treatment 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1}, it was significantly superior over all the rest of treatments. Lowest value of stover yield was recorded in control. Among various nutrients, phosphorus and zinc play a crucial role in pearl millet production. The significant increase in grain and stover yield of pearl millet was largely a function of improved growth and the consequent increase in different yield attributes as mentioned above. This favourable effect might be owing to the fact that P is well known for its role as 'Energy currency' and plays a key role in development and energy transformation in various vitally important metabolic processes in the plant. Similer results were accorded by Vyas & Choudhary (2000) [22], Sammauria & Yadav (2008) [18], Hamza & Sadanandan (2005) [6] and and Jakhar *et al*. (2013) [8].

Harvest index (%): The data pertaining to harvest index as influenced by the application of phosphorus and zinc. Maximum (33.69) and minimum (31.74%) harvest index was reported in 10 kg P_2O_5 ha^{-1} + 30 kg zinc ha^{-1} and 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1}, respectively. Lower harvest index in 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1} reflects that the photosynthetic in this treatment might be utilized for increasing the vegetative growth than producing economic yield. This may be ascribed to improvement in the status of available P of soil and its better absorption by the plants. The increased availability of P increased the growth and yield attributing characters which reflected in higher yield of pearl millet. Similar residual effects were also reported by Jat and Shaktawat (2003) [9]. The beneficial effect of Zn application could be attributed to improved fertility status of the experimental field in terms of available Zn was reported by Sammauria & Yadav (2008) [18].

Table 1: Effect of phosphorus and Zinc application on growth, yield attributes and yield of pearl millet.

Treatments	Plant height (cm)				number of tiller plant^{-1}				Total dry matter accumulation (g plant^{-1})				Ear length (cm)	Grain yield (kg ha-1)	Straw yield (kg ha^{-1})	Harvest index (%)
	25 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest				
T_1- 0 kg P_2O_5 + 0 kg Zn ha^{-1}	59.00	140.43	154.80	154.73	1.5	1.6	1.8	1.9	1.24	19.06	52.33	69.47	22.33	1599.33	3256.67	32.94
T_2- 10 kg P_2O_5 + 10 kg Zn ha^{-1}	61.73	148.47	157.07	161.73	1.8	1.8	2.1	2.1	1.98	24.97	69.57	85.17	21.33	1670.00	3357.33	33.22
T_3- 10 kg P_2O_5 + 20 kg Zn ha^{-1}	66.27	153.33	158.47	164.47	1.9	1.9	2.0	2.1	2.08	25.77	73.53	86.13	23.17	1747.33	3511.67	33.23
T_4- 10 kg P_2O_5 + 30 kg Zn ha^{-1}	67.07	154.53	160.23	162.40	3.0	3.0	2.1	2.3	2.19	26.62	78.47	86.88	22.67	1835.33	3611.22	33.69
T_5-20 kg P_2O_5 + 10 kg Zn ha^{-1}	67.93	160.50	163.07	165.60	2.0	2.2	2.1	2.2	2.11	25.05	71.83	85.22	23.13	1858.00	3896.67	32.29
T_6-20 kg P_2O_5 + 20 kg Zn ha^{-1}	68.53	163.40	165.80	168.00	1.9	2.0	2.2	2.1	2.22	25.67	76.50	89.53	22.67	1929.33	3985.53	32.52
T_7-20 kg P_2O_5 + 30 kg Zn ha^{-1}	67.80	162.13	162.67	169.00	2.0	2.1	2.1	2.2	2.16	26.33	79.13	95.20	23.67	2010.00	4051.10	33.16
T_8-30 kg P_2O_5 + 10 kg Zn ha^{-1}	70.13	162.80	165.87	166.93	1.9	1.7	2.1	2.3	1.93	26.70	72.07	89.15	23.17	2050.00	4184.44	32.88
T_9-30 kg P_2O_5 + 20 kg Zn ha^{-1}	73.83	165.27	167.93	170.33	1.9	1.8	2.0	2.2	2.13	29.33	77.60	95.50	26.44	2066.67	4443.32	31.74
T_{10}-30 kg P_2O_5 + 30 kg Zn ha^{-1}	71.10	160.67	162.40	164.40	1.7	1.7	2.3	2.0	2.13	30.00	79.20	92.43	24.33	2010.00	4214.00	32.29
S.Em.±	3.05	5.83	6.35	6.47	0.321	0.328	0.089	0.102	1.506	0.368	0.760	0.758	0.672	11.25	44.34	-
CD (p=0.05)	9.06	17.33	18.87	19.25	0.95	0.97	0.26	0.30	4.474	1.094	2.260	2.252	1.998	33.45	131.74	-

4. Conclusion

On the basis of the findings of the present investigation, it can be concluded that the levels of phosphorus (30 kg ha^{-1}) and zinc (20 kg ha^{-1}) was found most suitable levels of phosphorus and zinc, among all the levels of phosphorus and zinc under rain fed condition. The treatment 30 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1} have shown 15%, 6% and 23 % increase in grain yield over 10 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1}, 20 kg P_2O_5 ha^{-1} + 20 kg zinc ha^{-1} and control, respectively.

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