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Effect of Potassium and Zinc on Growth and Yield of Pearl Millet

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ABSTRACT

A field experiment was conducted during *Zaid* 2022, at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (UP). The treatments consist of three levels of potassium and three levels of zinc and one control was used. The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. The results showed that growth parameters viz., plant height (208.6 cm) and dry weight (34.3 g/plant) were recorded significantly higher with the application of 50 kg K/ha and 15 kg Zn/ha and yield attributes viz., ear head length (24.7 cm), number of grains per ear head (2498.3), grain yield (3.93 t/ha), straw yield (7.78 t/ha) and harvest index (50.4 %) were recorded significantly higher with the application of 50 kg K/ha and 15 kg Zn/ha. The maximum gross returns (₹98,250/ha), net returns (₹70,656/ha) and benefit cost ratio (2.56) were gained with the application of 50 kg K/ha and 15 kg Zn/ha.

Keywords Economics, Growth, Pearl millet, Potassium (K), Yield, Zinc (Zn).

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INTRODUCTION

Pearl millet is the most widely cultivated crop occupying a prominent position in global agriculture. It is the fifth most important cereal crop globally after rice, wheat, maize and sorghum. It is used as a staple food for human consumption and fodder for livestock sector. It is critically important for food and nutritional security as it possesses several advantages such as early maturing, drought tolerance, require minimal purchase of inputs and mostly free from biotic and abiotic stresses. It is a good source of energy (360 calories) and carbohydrates (67 g) and also consist of (12 g) protein, (5 g) fat and (2 g) minerals in 100 g of bajra seeds. Due to its excellent nutritional properties, pearl millet is designated as nutri-cereal (Gazette of India, No. 133 dtd 13th April, 2018) for production, consumption, trade and was included in Public Distribution System (PDS).

Pearl millet is being cultivated over 30 million ha world wide, with the major crop area in Africa (>18 million ha) and Asia (>10 million ha). In India, pearl millet is the fourth most widely cultivated food crop after rice, wheat and maize. The production of bajra in 2020-21, was 9.35 million tones from an area of 7.41 million ha with a productivity of 1,391 kg/ha. The major pearl millet growing states are Rajasthan contributes nearly (45%) followed by Uttar Pradesh (19%) (Directorate of Millets Development 2021-22; Project Coordinator Review 2022).

Millets are highly dependent on potassium to complete their life cycle. Potassium is one of the primary nutrients, required for the growth and development of crops. It strengthens the ability of plants to withstand numerous biotic and abiotic stresses. Potassium has a key role in photosynthesis, metabolism of carbohydrate and physiological processes such as root development, water use efficiency, synthesis of protein and amino acids, enzyme activation in plants (Choudhary *et al.* 2014). It is mobile in plant and translocate from the older to younger tissues as and when required. It is accumulated in abundance during the vegetative growth and transforms sugar into starch during grain formation. It plays a major role in activating ~60 enzymes, regulating stomatal function, controlling water relations especially under rainfed crop production, influencing the water balance of the plant system (Mengel and Kirkby 1996).

Micronutrients are essential for improving productivity and quality of crops. Among them, zinc is the most essential for regular healthy growth and reproduction of plants (Marschner 1995). In plants, zinc plays a key role as a structural constitute or regulatory co-factor of wide range of enzymes important for various biochemical pathways. Zinc is the main nutrient in connecting part of some enzymes like alcohol dehydrogenase, carbonic anhydrase and superoxide dismutase (Pedler *et al.* 2000). It is involved in auxin production, also plays a vital role in oxidation process in plant cells. It is used in the formation of chlorophyll and some carbohydrate and also in the conversion of starches to sugar.

MATERIALS AND METHODS

A field trial was conducted during the *Zaid* 2022, at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (UP). The experimental field's soil is neutral and deep, constituting a part of central gangetic alluvium. It had sandy loam texture and contained nitrogen (171.48 kg N/ha), phosphoros (27.6 kg P/ha) and potassium (185.4 kg K/ha). The experiment was set up using Randomized Block Design with ten treatments that were replicated three times viz.,T_1 - 30 kg/ha potassium and 5 kg/ha zinc, T_2 - 30 kg/ha potassium and 10 kg/ha zinc, T_3 - 30 kg/ha potassium and 15 kg/ha zinc, T_4 - 40 kg/ha potassium and 5 kg/ha zinc, T_5 - 40 kg/ha potassium and 10 kg /ha zinc, T_6- 40 kg/ha potassium and 15 kg/ha zinc, T_7 - 50 kg/ha potassium and 5 kg/ha zinc, T_8 - 50 kg/ha potassium and 10 kg/ha zinc, T_9 - 50 kg potassium and 15 kg/ha zinc and T_{10} - control 80-40-0 kg/ha of NPK. The experimental field was thoroughly ploughed, harrowed and brought to fine tilth and 30 plots each of 3.0 m x 3.0 m size were laid out according to layout design. The fertilizers were applied as per treatment combination in the form of urea and SSP entire as basal dose. The seeds of pearl millet (NBH 5863) were sown in lines 45 cm apart at seed rate of 5 kg/ha. Gap filling was done at 8-10 DAS whereas thinning was done at 15 DAS to maintain plant population. The growth parameters such as plant height (cm) and dry weight per plant (g) were recorded at various growth stages was calculated by the methods described by Watson (1947). The ear head length, number of grains per ear head, grain yield, straw yield and harvest index were recorded at the time of harvest and averages were calculated and data was statistically analyzed using ANOVA technique (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect on growth parameters of pearl millet

The observation related to growth parameters were shown in Table 1. The plant height (208.6 cm) and dry weight (34.3 g/plant) were notably higher in T_9 with application of 50 kg/ha potassium and 15 kg/ha zinc. The probable reason for increase in plant height due to the application of potassium and zinc were potassium plays a crucial role in meristematic growth through its effect on the synthesis of phyto-hormones, augmenting cell division and cell expansion and zinc plays a pivotal role in regulating the auxin

Table 1. Effect of potassium and zinc on growth parameters of pearl millet.

Sl. No.	Treatments	Plant height (cm)	Dry weight (g/plant)
1	Potassium 30 kg/ha + Zinc 5 kg/ha	195.2	32.7
2	Potassium 30 kg/ha + Zinc 10 kg/ha	187.6	32.2
3	Potassium 30 kg/ha + Zinc 15 kg/ha	193.6	33.5
4	Potassium 40 kg/ha + Zinc 5 kg/ha	196.6	32.6
5	Potassium 40 kg/ha + Zinc 10 kg/ha	199.4	32.8
6	Potassium 40 kg/ha + Zinc 15 kg/ha	200.8	32.1
7	Potassium 50 kg/ha + Zinc 5 kg/ha	198.4	32.8
8	Potassium 50 kg/ha + Zinc 10 kg/ha	204.6	33.4
9	Potassium 50 kg/ha + Zinc 15 kg/ha	208.6	34.3
10	Control-N:P: K-80:40:0	184.3	31.2
Em(±)		1.89	0.31
CD (5%)		5.64	0.44

concentration in plant and nitrogen metabolism. Both nutrient's functions in the photosynthesis, metabolism of carbohydrates and physiological processes such as root development, water use efficiency, synthesis of protein, amino acids and enzyme activation (Choudhary *et al.* 2014). Zinc is applied especially for regular healthy growth and reproduction of plants (Marschner 1995). Similar results were reported by Yadav *et al.* (2012), Singh *et al.* (2016), Singh *et al.* (2017). The significant increase in plant dry weight at different stages of growth due to application of potassium along with zinc was might be due to crucial role of potassium in meristematic growth through synthesis of phyto-hormones. Similar results were reported by Chauhan *et al.* (2017). Dry weight production and its accumulation in various plant parts depends upon photosynthetic ability of plants which is improved by the application of potassium and zinc. Zinc nutrition is known to increase tillering in pearl millet which perhaps cause a significant increase in dry weight accumulation (Prasad *et al.* 2014).

Effect on yield attributes and yield of Pearl millet

The observation related to yield attributing parameters were shown in Table 2. The ear head length (24.7 cm) and number of grains per ear head (2498.3) were notably higher in T_9 with application of 50 kg/ha potassium and 15 kg/ha zinc. The yield attributes were remarkably improved as higher dose of potassium and zinc stimulates the metabolic activities during reproductive phase of crop growth. Potassium application stimulates the cumulative effect of improvement in yield attributes viz., number of effective tillers per plant, ear head length, number of grains per ear head, thickness Kacha *et al*. (2011). Potassium nutrition improves germination of pollen in the florets which leads to high spikelet fertility. Zinc attributes the beneficial effect on chlorophyll and auxin content which also influence photosynthesis. It has direct role in enzyme activation which may leads to increase in many physiological and molecular activities which improve yield attributing characters. Zinc is used in the formation of chlorophyll and some carbohydrate and in the conversion of starches to sugar. These results are in accordance with Heidari and Jamshid (2010) and Sakarvadi *et al.* (2012). The data showed

Table 2. Effect of potassium and zinc on yield attributes and yield of pearl millet.

Sl. No.	Treatments	Ear head length (cm)	No. of grains/ear	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1	Potassium 30 kg/ha + Zinc 5 kg/ha	21.8	2022.6	2.8	6.6	41.6
2	Potassium 30 kg/ha + Zinc 10 kg/ha	22.1	2038.6	2.94	6.8	42.9
3	Potassium 30 kg/ha + Zinc 15 kg/ha	23.7	2444.3	3.39	7.2	46.7
4	Potassium 40 kg/ha + Zinc 5 kg/ha	23.7	2338.0	3.33	7.1	46
5	Potassium 40 kg/ha + Zinc 10 kg/ha	23.3	2309.6	3.47	7.3	47.3
6	Potassium 40 kg/ha + Zinc 15 kg/ha	20.4	1936.6	2.9	6.7	42.5
7	Potassium 50 kg/ha + Zinc 5 kg/ha	24.0	2415	3.5	7.42	47.5
8	Potassium 50 kg/ha + Zinc 10 kg/ha	24.3	2460.3	3.6	7.48	47.6
9	Potassium 50 kg/ha + Zinc 15 kg/ha	24.7	2498.3	3.93	7.78	50.4
10	Control-N:P: K-80:40:0	22.0	1940.3	2.46	6.2	39.7
	SEm (±)	0.74	140.23	0.25	0.26	1.9
	CD (5%)	2.22	416.660	0.76	0.79	5.8

significantly highest grain yield (3.93 t/ha), Stover yield (7.78 t/ha) and harvest index (50.4 %) was found with application of 50 kg/ha potassium and 15 kg/ha zinc whereas treatment 5, 7 and 8 found to be statistically at par with treatment 9. Potassium application resulted in the root development, which promoted growth and development of the plant leading to higher photosynthetic activity which in turn results in better development of yield attributes and finally higher seed yield. It transforms sugar into starch in the grain filling process. It is a third major plant nutrient because of the large amount in which it is absorbed by plants and its significant place for the production of high yield. The increase in yield might due to zinc in biosynthesis indole acetic acid especially due to its role initiation of primordial reproductive parts promoting photosynthesis towards them Ganapathy and Savalgi (2006). It has direct role in enzyme activation which may leads to increase in many physiological and molecular activities which improve yield attributes and finally higher grain yield. Zinc plays an important role in crop growth, involving in photosynthesis processes, respiration and other biochemical and physiological activates and thus their importance in achieving higher yield Zeidan *et al.* (2010). The probable reason for recording maximum stover yield with application of potassium and zinc recorded significantly higher stover yield, this might be attributed to better growth in terms of early growth of seedling, plant height, dry matter accumulation, increases the photosynthetic efficiency and greater accumulation of photosynthates in vegetative parts results in superior vegetative growth and hence the stover yield increases. The probable reason for recording maximum stover yield with application of potassium is development of strong cell walls and therefore stiffer straw.

Effect on economics on pearl millet

The observation related to economics were shown in Table 3. The maximum gross return (₹98,250/ha), net return (₹70,656/ha) and benefit cost ratio (2.56) was recorded in T_9 with application of potassium 50 kg/ha and zinc 15 kg/ha, while the lowest gross return (₹60,000/ha), net return (₹34,258/ha) and benefit cost ratio (1.33) was recorded in control T_{10} this could be due to the manifestation of higher grain and straw yields.

Table 3. Effect of potassium and zinc on economics of pearl millet.

Sl. No.	Treatments	Gross return (₹/ha)	Net return (₹/ha)	B : C ratio
1	Potassium 30 kg/ha + Zinc 5 kg/ha	70,000	43,427	1.63
2	Potassium 30 kg/ha + Zinc 10 kg/ha	72,500	45,577	1.69
3	Potassium 30 kg/ha + Zinc 15 kg/ha	84,750	57,477	2.10
4	Potassium 40 kg/ha + Zinc 5 kg/ha	82,500	55,767	2.08
5	Potassium 40 kg/ha + Zinc 10 kg/ha	86,750	59,667	2.20
6	Potassium 40 kg/ha + Zinc 15 kg/ha	72,500	45,067	1.64
7	Potassium 50 kg/ha + Zinc 5 kg/ha	87,500	60,606	2.25
8	Potassium 50 kg/ha + Zinc 10 kg/ha	90,000	62,756	2.30
9	Potassium 50 kg/ha + Zinc 15 kg/ha	98,250	70,656	2.56
10	Control-N:P: K-80:40:0	60,000	34,258	1.33

*Economics not subjected to data analysis.

CONCLUSION

It was concluded that cultivation of pearl millet during *Zaid* season with the application of potassium 50 kg/ha along with zinc 15 kg/ha was found to be more desirable in term of growth, yield attributing characters, yield and economics when compared with other treatments.

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