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Determining the Effect of Potassium and Zinc on Growth and Yield of Pearl Millet (*Pennisetum glaucum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted in Crop Research Farm (CRF) in Department of Agronomy during *Zaid* season 2023-24 on Pearl millet crop**.** The treatment consisted of Potassium (30, 40 and 50 Kg/ha) and Zinc (15, 20 and 25 kg/ha) and a control. The experiment was laid out with a Randomize Block Design (RBD) with ten treatments which are replicated thrice as T_1 Potassium 30 kg/ha + Zinc 15 kg/ha, T_2 Potassium 30 kg/ha + Zinc 20 kg/ha, T_3 Potassium 30 kg/ha + Zinc 25 kg/ha T_4 Potassium 40 kg/ha + Zinc 15 kg/ha, T_5 Potassium 40 kg/ha + Zinc 20 kg/ha, T_6 Potassium 40 kg/ha + Zinc 25 kg/ha, T_7 Potassium 50 kg/ha + Zinc 15 kg/ha, T_8 Potassium 50 kg/ha + Zinc 20 kg/ha, T_9 Potassium 50 kg/ha + Zinc 25 kg/ha and a T_{10} Control. The soil of experiment plot was

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sandy loamy in texture, nearly neutral in soil reaction (pH 6.8), low in organic carbon (0.46%), available N (225.42 kg/ha), available P_2O_5 (38.2 kg/ha) and available K_2O (240.7 kg/ha). Application of Potassium 50 kg/ha + Zinc 25 kg/ha was recorded with the results which revealed that significantly highest growth attributes of Pearl millet at 80 DAS viz., Plant height (203.24 cm), dry weight (144.17 g), Ear head length (30.23 cm), grains/head (1848.78) and yield attributes such as Grain yield (4530.43 kg/ha), Stover yield (7246.59 kg/ha).

Keywords: Nitrogen; pearl millet; phosphorus; potassium; zinc.

1. INTRODUCTION

"Pearl millet is commonly known in India as Bajra or Bajri also known as 'cattail' and 'bullrush millet'. It is originated from tropical western Africa. It belongs to the family Gramineae (Poaceae). The cultivated species are *Pennisetum glaucum* L. (2n=14) used for grain and *Pennisetum purpureum* (2n=28) used for green and dry fodder. Pearl millet 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 a good source of energy (360 calories) and carbohydrates (67 g) and consist of 12 g protein, 5 g fat and 2 g minerals in 100 gm of bajra seeds" [1]. It is considered as poor man's food. It is critically important for food and nutritional security as it possess several advantages such as early maturing, drought tolerance, require minimal purchase of inputs and is mostly free from biotic and abiotic stresses. "Pearl millet (*Pennisetum glaucum* L.) is most widely grown as staple food by small and marginal farmers in Asia and Africa. It is a C4 plant having high photosynthetic efficiency, more dry matter productivity and survives under adverse agro-climatic conditions with lesser inputs and more economic returns. The crop is critically important for food and nutritional security of humans and animals in arid and semi-arid regions as Pearl millet is early maturing, drought tolerant, and has inherent ability to endure high temperatures up to 42°C during reproductive phase enabling it for cultivation in adverse conditions, thus making it a climate resilient crop" [2]. "Due to its excellent nutritional properties, pearl millet is designated as nutri-cereal for production, consumption, trade and was included in Public Distribution System" (PDS). (Gazette of India, No.133 dtd 13th April, 2018).

"Potassium is one of the primary nutrients required for the growth and development of plants. It improves both yield and quality of agricultural produce and enhances the plant resistance to various biotic and abiotic stresses. It majorly functions in the photosynthesis, metabolism of carbohydrate and physiological processes such as root development, water use efficiency, synthesis of protein and amino acids, enzyme activation" [3].

"Micronutrients are important for maintaining soil health and also increasing productivity of crops. These are needed in very small amounts" [2]. Zinc is especially 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 a wide range of different enzymes in many important biochemical pathways.

2. MATERIALS AND METHODS

This experiment was laid out during the *Zaid* season of 2023-24 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). [4]. The crop research farm is situated at 25^0 39" 42" N latitude, 81^0 67" 56" E longitude and at an altitude of 98 m above mean sea level. The experiment was layout in Randomized Block Design (RBD) with ten treatment and three replicated. The treatment details are as follows T_1 Potassium 30 kg/ha + Zinc 15 kg/ha, T_2 Potassium 30 kg/ha + Zinc 20 kg/ha, T_3 Potassium 30 kg/ha + Zinc 25 kg/ha T_4 Potassium 40 kg/ha + Zinc 15 kg/ha, T_5 Potassium 40 kg/ha + Zinc 20 kg/ha, T_6 Potassium 40 kg/ha + Zinc 25 kg/ha, T_7 Potassium 50 kg/ha + Zinc 15 kg/ha, T_8 Potassium 50 kg/ha + Zinc 20 kg/ha, T_9 Potassium 50 kg/ha + Zinc 25 kg/ha and a T_{10} Control. The observations were recorded for plant height (cm), plant dry weight (g), Crop growth rate (g/m^2/day), Relative growth rate (g/g/day), Ear head length (cm), Number of grains/heads, Test weight (g), grain yield (kg/ha), Stover yield (kg/ha).

3. RESULTS AND DISCUSSION

3.1 Growth Parameter

3.1.1 Plant height (cm)

At 80 DAS maximum plant height of (203.24 cm) was recorded with treatment 9 (Potassium 50 kg/ha along with Zinc 25 kg/ha), whereas treatment 7 and 8 (Potassium 50 kg/ha along with Zinc 15 kg/ha and Potassium 50 kg/ha along with Zinc 20 kg/ha) were statistically at par with treatment 9 (Potassium 50 kg/ha along with Zinc 25 kg/ha).

The significant increase in the plant height of Pearl millet can be attributed to the application of varying levels of Potassium and Zinc. Potassium, being a vital component of all amino acids in plants, plays a crucial role in forming plant proteins. These proteins are essential for the development of plant structures such as cells, membranes, and chlorophyll. Similar findings were observed by Iqbal et al. [5] and Manwar and Mankar [6].

"The enhancement in plant height can also be linked to the role of Zinc as a catalyst or stimulant in various physiological and metabolic processes. Zinc is essential for the synthesis of tryptophan, a protein component necessary for the production of growth hormones, such as Indole Acetic Acid (IAA), an important auxin" [1]. These findings align with those of Reddy et al. [7].

3.1.2 Plant dry weight (g/plant)

At 80 DAS highest plant dry weight (144.17 g) was found in treatment 9 (Potassium 50 kg/ha along with Zinc 25 kg/ha). However, treatment 5, 6, 7 and 8 (Potassium 40 kg/ha along with Zinc 20 kg/ha, Potassium 40 kg/ha along with Zinc 25 kg/ha, Potassium 50 kg/ha along with Zinc 15 kg/ha and Potassium 50 kg/ha along with Zinc 20 kg/ha) were statistically at par with the treatment 9 (Potassium 50 kg/ha along with Zinc 25 kg/ha).

The application of Potassium led to a significant increase in the dry weight of Pearl millet. This could be due to Potassium's ability to create a favorable nutritional environment for plants, supporting its key role in various physiological and biochemical processes critical for plant growth and dry matter accumulation. Additionally, Zinc's contribution as a catalyst and stimulant in numerous physiological and metabolic processes, as well as its role as a metal activator of enzymes, likely promoted increased plant growth and development. These findings are consistent with those of Reddy et al. [7] and Kumar et al. [8].

3.1.3 Crop growth rate (g/m^2/day)

Although, the statistical analysis of CGR during 60 - 80 DAS significant highest CGR value (43.07/m^2/day) was observed in treatment 3 (Potassium 30 kg/ha along with Zinc 25 kg/ha). and accept treatment 9 and 10 (Potassium 50 kg/ha along with Zinc 25 kg/ha and Control) which was not found statistically at par with treatment 3 (Potassium 30 kg/ha along with Zinc 25 kg/ha).

3.1.4 Relative growth rate (g/g/day)

During the growth interval of 60 - 80 DAS interval highest RGR value (0.028 g/g/day) was recorded with treatment 1,2 and 3 (Potassium 30 kg/ha along with Zinc 15 kg/ha, Potassium 30 kg/ha along with Zinc 20 kg/ha, and Potassium 30 kg/ha along with Zinc 25 kg/ha).

3.2 Yield attributes and Yield Parameter

3.2.1 Ear head length (cm)

A significant impact was experiential by the statistical analysis of ear head length. Treatment with Potassium 50 kg/ha along Zinc 25 kg/ha was recorded highest ear head length (30.23). However, treatment 7 and 8 (Potassium 50 kg/ha along with Zinc 15 kg/ha and Potassium 50 kg/ha along with Zinc 20 kg/ha) were found statistically at par with treatment 9 (Potassium 50 kg/ha along with Zinc 25 kg/ha). "The application of NPK fertilizers can be linked to overall improvements in plant growth, as evidenced by increased dry matter accumulation. This improvement may be attributed to better nutrient availability during the flowering stage, which could enhance effective tiller formation and result in longer ear heads. The extension of ear head length can be associated with Zinc's role in physiological and metabolic processes, including the synthesis of tryptophan. Zinc is crucial for the production of growth hormones like Indole Acetic Acid (IAA), which drive plant growth" [9] (Sharma et al., 2008).

3.2.2 Number of grains/ear head

Significant effect was observed by the statistical analysis of number of grains/ear head. Treatment 9 (Potassium 50 kg/ha along with Zinc 25 kg/ha)

Table 1. Influence of potassium and zinc on growth of pearl millet

S.No.	Treatments	Plant height (cm) 80 DAS	Dry weight (g) 80 DAS	CGR (g/m^2/day) 60-80 DAS	RGR (g/g/day) 60-80 DAS
1.	Potassium 30 kg/ha + Zinc 15 kg/ha	176.70	131.93	42.57	0.028
2.	Potassium 30 kg/ha + Zinc 20 kg/ha	177.83	133.17	42.29	0.028
3.	Potassium 30 kg/ha + Zinc 25 kg/ha	181.80	135.87	43.07	0.028
4.	Potassium 40 kg/ha + Zinc 15 kg/ha	185.11	136.74	42.26	0.027
5.	Potassium 40 kg/ha + Zinc 20 kg/ha	187.17	137.93	41.76	0.026
6.	Potassium 40 kg/ha + Zinc 25 kg/ha	191.67	139.82	42.32	0.026
7.	Potassium 50 kg/ha + Zinc 15 kg/ha	195.68	141.90	42.34	0.026
8.	Potassium 50 kg/ha + Zinc 20 kg/ha	198.92	143.10	41.41	0.025
9.	Potassium 50 kg/ha + Zinc 25 kg/ha	203.24	144.17	39.47	0.022
10.	Control (RDF:- 80:40:40 NPK kg/ha)	168.85	118.62	33.42	0.024
	F test SEm±	S	S	S	NS
	CD (P=0.05)	3.70	2.17	1.74	0.0010
		11.01	6.45	5.18	-

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

S.No.	Treatments	Ear head Length (cm)	No. of grains/ ear head	Test weight (g)	Seed yield (Kg/ha)	Stover yield (Kg/ha)
1.	Potassium 30 kg/ha + Zinc 15 kg/ha	22.77	1279.65	5.80	3359.37	6391.84
2.	Potassium 30 kg/ha + Zinc 20 kg/ha	23.21	1308.55	5.93	3490.14	6473.69
3.	Potassium 30 kg/ha + Zinc 25 kg/ha	23.63	1339.06	6.31	3573.38	6585.61
4.	Potassium 40 kg/ha + Zinc 15 kg/ha	24.87	1409.91	6.76	3718.26	6660.26
5.	Potassium 40 kg/ha + Zinc 20 kg/ha	25.28	1516.07	6.94	3854.11	6751.13
6.	Potassium 40 kg/ha + Zinc 25 kg/ha	26.04	1610.44	7.55	3964.08	6958.59
7.	Potassium 50 kg/ha + Zinc 15 kg/ha	28.82	1629.51	7.66	4171.65	7085.82
8.	Potassium 50 kg/ha + Zinc 20 kg/ha	29.04	1715.03	7.92	4340.04	7176.40
9.	Potassium 50 kg/ha + Zinc 25 kg/ha	30.23	1848.75	8.22	4530.43	7246.59
10.	Control (RDF:- 80:40:40 NPK kg/ha)	21.43	1215.07	5.71	3076.06	5689.70
	F test SEm±	S	S	NS	S	S
	CD (P=0.05)	1.17	80.20	0.40	113.02	165.13
		3.48	338.30	1.197	335.81	490.63

recorded significant and highest number of grains/ear head (1848.75). However, treatment 5, 6, 7 and 8 (Potassium 40 kg/ha along with Zinc 20 kg/ha, Potassium 40 kg/ha along with Zinc 25 kg/ha, Potassium 50 kg/ha along with Zinc 15 kg/ha and Potassium 50 kg/ha along with Zinc 20 kg/ha) were statistically at par with the treatment 9 (Potassium 50 kg/ha along with Zinc 25 kg/ha. “Potassium application can be linked to an overall enhancement in plant growth, likely due to improved nutrient availability during the flower primordial initiation stage. This may have contributed to the formation of more effective tillers, ultimately increasing both the number of grains per ear head and ear head length. Zinc also plays a crucial role as a catalyst or stimulant in various physiological and metabolic processes. As a component of certain proteins, Zinc is essential for the production of growth hormones, such as Indole Acetic Acid (IAA)” [7,8,10].

3.2.3 Test weight (g)

The statistical analysis on test weight was found to be non-significant. However, highest test weight (8.22 g) was recorded with treatment 9 (Potassium 50 kg/ha + Zinc 25 kg/ha) and lowest test weight (5.71 g) was recorded in control.

3.2.4 Grain yield (kg/ha)

Increased grain yield was obtained due to Potassium and Zinc and RDF treatment combinations. The highest grain yield (4530.43 kg/ha) was obtained in treatment 9 (Potassium 50 kg/ha along with Zinc 25 kg/ha) whereas, treatment 8 (Potassium 50 kg/ha along with Zinc 20 kg/ha) were statistically at par with treatment 9 (Potassium 50 kg/ha along with Zinc 25 kg/ha). “The application of potassium may contribute to enhanced vegetative growth, potentially due to improved uptake and utilization of other nutrients, supported by a robust root system developed through NPK application. Zinc's function as a catalyst in tryptophan synthesis and its role in promoting plant growth and development could be linked to the observed increase in grain yield” [9,11].

3.2.5 Stover yield (kg/ha)

Application of Potassium and Zinc has significantly impact on stover production of the Pearl millet. At Potassium 50 kg/ha + Zinc 25 kg/ha, the highest stover yield (7246.59 kg/ha) was obtained whereas, treatments 6, 7 and 8 (Potassium 40 kg/ha + Zinc 25 kg/ha, Potassium 50 kg/ha + Zinc 15 kg/ha and Potassium 50 kg/ha + Zinc 20 kg/ha) were obtained statistically at par with the treatment 9 (Potassium 50 kg/ha + Zinc 25 kg/ha). “The application of potassium may enhance vegetative growth, possibly due to its role in improving the uptake and utilization of other nutrients, facilitated by the extensive root system developed under potassium influence. Biological yield is closely related to stover yield. Zinc plays a vital role in the growth and development of tryptophan, an essential amino acid necessary for plant growth” [9,11].

4. CONCLUSION

From the results, it is concluded that application of Potassium 50 kg/ha along with Zinc 25 kg/ha (Treatment 9) in Pearl millet has recorded highest plant height, dry weight, grain yield and stover yield.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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