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Influence of Organic Manures and Zinc on Growth, Yield and Economics 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

An experiment was carried out in the field to ascertain the "Influence of organic manures and zinc on growth, yield and economics of Pearl millet (*Pennisetum glaucum* L.)" during Zaid 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology, and Sciences Prayagraj (U.P) (*Pennisetum glaucum* L.). The results showed that treatment 6 [Vermicompost (2.6 t/ha) + Zinc (15 kg/ha)] significantly increased plant height (169.2 cm), dry weight (94.90 g), ear head length (26.4 cm), maximum number of grains/ear head (2046), grain weight/ear head (23.4 g), test weight (9.21 g), grain yield (3.90 t/ha), stover yield (8.20 t/ha), and harvest index (32.24%). In comparison to other treatments, treatment 6 [Vermicompost (2.6 t/ha) + Zinc (15 t/ha)] also had the highest total returns (91919 INR/ha), highest net returns (64269 INR/ha), and highest benefit cost ratio (2.32).

Keywords: Pearl millet; vermicompost; zinc; growth; yield; economics.

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1. INTRODUCTION

Pearl millet grains have a high nutritional content and are used for human consumption. For farmers with limited resources, forage and stove are essential secondary products that can be used as fuel and animal feed. In the world's arid and semi-arid areas, pearl millet, a tropical cereal and one of the most drought-resistant crops, is widely cultivated. Pearl millet is one of the main cereals that is highly tolerant of heat, drought, saline, and acid soils. It is also simple to produce in arid areas where rainfall is insufficient for maize or even sorghum. India contributes 42% of global output and more than half of the world's pearl millet production**.**

The most commonly cultivated millet crop, known scientifically as pearl millet (*Pennisetum glaucum* L.), plays a significant role in world agriculture. India produces the most pearl millet, accounting for 9.4 percent of global production. Grain is used as verdant fodder in addition to being consumed as human food. Pearl millet was grown on a 7.34 million hectares (ha) region in India, producing 10.86 million tonnes at a productivity of 1436 kg/ha. In Uttar Pradesh, pearl millet was grown on 0.91 million hectares of land, producing 2.01 million tonnes and yielding 2221 kilogrammes per hectare, accounting for 11.99% of all arable land and 18.54% of pearl millet output in India [1]. When compared to other cereals, pearl millet may be an alternative crop that offers significant physiological benefits due to its resistance to drought, low soil fertility, high salinity, and high temperature tolerance. Pearl millet has a mechanism for escaping drought, allowing it to thrive in areas with prolonged dry spells. In contrast to using nutrients singly or in combination, balanced fertilisation has positive effects on various aspects of the growth, development, and biological yield of the crop.

One of the most significant biodegradable manures is farmyard manure. By accelerating the respiratory process, boosting cell permeability, or acting on hormones that control growth, FYM appears to directly affect crop output. A thorough understanding of the pattern of nutrient release from organic sources is necessary to prevent nutrient stress because under organic management, nutrient release and crop demand synchrony are very much needed. Therefore, effective nutrient management practices must be developed and put into practice for organic production to succeed as well as to raise output and product quality while also enhancing soil health. FYM maintains both the health of the soil and the crop's productivity because it includes 0.5% N, 0.2% P, and 0.5% K. It primarily contributes to the enhancement of biological activity, physical-chemical characteristics, and soil fertility [2].

Vermicompost is the end result of an organic refuse decomposition process that uses earthworms to create high-quality compost that is primarily made of worm cast and decayed organic matter [3]. Vermicomposting assists in transforming domestic waste, animal manure, and agricultural waste into extremely nutrient-dense fertilisers for plants and soil [4]. Vermicompost has 3% N, 1% P, and 1.5% K content. It protects soil health, prevents environmental pollution, and enhances soil structure and water-holding ability. It increases nutrient solubility, changes soil salinity, solidity, and pH, and promotes the activity of microorganisms that enable plants to obtain macro- and micronutrients through organic processes. Additionally, the current increase in the cost of chemical fertilisers has forced Indian farmers to use unbalanced nutrition for their crops, resulting in lower agricultural yields.

To maintain crop output while safeguarding soil health and the environment, it is urgent to maximise nutrient recycling at this crucial juncture [5]. There is evidence that applying organic manures like FYM and vermicompost can enhance soil's porosity, reduce bulk density, and increase its capacity to hold the most water [6].

In many agricultural regions, the total Zn concentration is adequate, but the available Zn concentration is low due to varying soil and climatic conditions. One of the first micronutrients whose importance for plant development was proven was zinc. Additionally, zinc aids in the production of protein and nucleic acids, phosphorus, and nitrogen, as well as the development of seeds. Since many proteins require zinc as either a structural component or a reaction site, it is a crucial element for terrestrial living [7].

Stunting (reduced height), interveinal chlorosis (yellowing of the foliage between the veins), bronzing of chlorotic leaves, small and abnormally shaped leaves, and/or stunting and rosetting of leaves are all effects of its deficiency in plants [8]. Lack of zinc in the plant prevents cereal crops' panicles from developing and maturing [9]. Grain yields can be decreased by up to 80% when there is a zinc deficiency, and there are also signs of lower zinc levels in the grain.

Zn is applied to deficient soil, usually in the form of ZnSO4, at rates that typically range from 5 to 25 kg Zn/ha, to correct Zn deficiency and prevent yield losses in crop plants. Higher rates are associated with crops sensitive to Zn deficiency, alkaline or calcareous soil, and broadcasting rather than banding. Soil Zn application rates differ based on the crop species, soil characteristics, and method of application. To increase the Zn content of cereals, it is important to develop Zn-rich cultivars or use Zn fertilisers [10]. Zinc is essential for photosynthesis, the metabolism of nitrogen, and the control of auxin levels in plants [11].

Keeping these points in view, the present investigation entitled ‘‘Influence of organic manures and Zinc on Growth and Yield of pearl millet (*Pennisetum glaucum* L.)”.

2. MATERIALS AND METHODS

The trial was carried out at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, during the Zaid season of 2022. (U.P). The field's neutral, deep soil is a portion of the central Gangetic alluvium. The soil in the experimental area had a sandy loam texture, a pH of 7.8 that was almost neutral, a low level of organic carbon (0.62%), and high availability of nitrogen (225 kg/ha), phosphorus (38 kg/ha), potassium (240.7 kg/ha), and zinc (2.32 mg/kg). Three organic manures, namely FYM at 16 t/ha, vermicompost at 2.6 t/ha, and goat manure at 2.6 t/ha, are combined with various amounts of zinc in the treatment. Nine treatments, each repeated three times, were used in the trial. The treatment combinations are T1- FYM (16 t/ha) + Zinc (5 kg/ha), T2 - FYM (16 t/ha) + Zinc (10 kg/ha), T3 - FYM(16 t/ha) + Zinc (15 kg/ha), T4 - Vermicompost (2.6 t/ha) + Zinc (5 kg/ha), T5 - Vermicompost (2.6 t/ha) + Zinc (10 kg/ha), T6 - Vermicompost (2.6 t/ha) + Zinc (15 kg/ha), T7 - Goat manure (2.6 t/ha) + Zinc (5 kg/ha), T8 - Goat manure (2.6 t/ha) + Zinc (10 kg/ha) , T9- Goat manure (2.6 t/ha) + Zinc (15 kg/ha). A statistical analysis using the analysis of variance technique was performed on data collected on various crop aspects, including growth, yield attributes, and yield [12].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

The results showed that treatment 6 [Vermicompost (2.6 t/ha) + Zinc (15 kg/ha)] significantly and significantly increased plant height (169.2 centimetres). But quantitatively speaking, treatment 5 [vermicompost (2.6 t/ha) + zinc (10 kg/ha)] was comparable to treatment 6 [vermicompost (2.6 t/ha) + zinc (15 kg/ha) (Table 1). The application of vermicompost (2.6 t/ha) resulted in significantly higher plant height, which is possibly explained by the vermicompost's presence of easily available plant nutrients and growth-promoting compounds. Mohammadi et al. has obtained similar findings [13]. Additionally, greater plant height with zinc application (15 kg/ha) may be a result of zinc's significant involvement in the elongation of shoots and roots due to auxin hormone activation in plants. Arshad et al. found results that were comparable [14].

3.1.2 Plant dry weight (g)

The findings showed that treatment 6 [vermicompost (2.6 t/ha) + zinc (15 kg/ha)] substantially increased plant dry weight (94.90 g). Vermicompost (2.6 t/ha) plus zinc (10 kg/ha) in treatment 5 was significantly comparable to vermicompost (2.6 t/ha) plus zinc (15 kg/ha) in treatment 6 (Table 1). Vermicompost application resulted in a significant rise in plant dry weight (2.6 t/ha), which may be attributable to the material being broken down by interactions between earthworms and microorganisms in a haemophilic process to produce organic soil amendments with low CN ratios. similar findings were also reported by Prajapati et al. [15]. Additionally, the fact that plant dry weight rose after zinc (15 kg/ha) application could be attributed to zinc's role in auxin metabolism, which leads to an increase in biomass as a whole. The same conclusions were reached by Sai and Debbarma [7].

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

The data showed that there was no discernible change between any of the treatments between 60 and 80 DAS. However, treatment 6 [vermicompost (2.6 t/ha) plus zinc (15 kg/ha)] showed the highest crop growth rate (68.20 g/m2/day) (Table 1).

3.1.4 Relative growth rate (g/g/day)

The data showed that treatment 1 [FYM (16 t/ha) + Zinc (5 kg/ha)] had a substantially higher Relative Growth Rate (0.0339 g/g/day) over the course of 60–80 DAS. Treatment-1 [FYM (16 t/ha) + Zinc (5 kg/ha)] was found to be significantly equivalent to Treatment-2 [FYM (16 t/ha) + Zinc (10 kg/ha)] and Treatment-3 [FYM (16 t/ha) + Zinc (15 kg/ha)] (Table 1). The application of FYM (16t/ha) resulted in a substantial and higher relative growth rate, which may be attributable to the soil's gradual mineralization, nutrient availability, and increased moisture-holding capacity. Singh et al. also found outcomes that were comparable [16].

3.2 Yield Attributes

3.2.1 Ear head length (cm)

Treatment 6 with [Vermicompost (2.6 t/ha) + Zinc (15 kg/ha)], which was considerably better than the other treatments, had a significant and higher ear head length (26.4 cm). However, it was discovered that treatment-5, which combined vermicompost (2.6 t/ha) and zinc (10 kg/ha), was numerically equivalent to treatment-6, which combined vermicompost (2.6 t/ha) and zinc (15 kg/ha) (Table 2). The substantial and greater ear head length among cultivars with the application of vermicompost (2.6 t/ha) may have been caused by better photosynthate partitioning from source to sink, according to Divya et al. [17].

3.2.2 Number of grains/ear head

According to the data, treatment 6 [Vermicompost (2.6 t/ha) + Zinc (15 kg/ha)] recorded a considerably higher number of grains/ear head. (2046). Vermicompost (2.6 t/ha) plus Zinc (10 kg/ha) was found to be numerically equivalent to treatment 6 (2.6 t/ha plus Zinc 15 kg/ha), though (Table 2). Due to the synergistic effect of integrating organic and inorganic sources, which resulted in better nutrient uptake and accelerated photosynthetic rate, adequate biomass production, and a significant increase in the number of grains/ear head, vermicompost application (2.6t/ha) has demonstrated positive outcome. Akhil and Umesha had similar outcomes [18]. Additionally, a significantly higher number of grains per ear head could be explained by the application of zinc (15 kg/ha), which is known to play a crucial role in a variety of physiological and metabolic processes, including the synthesis of tryptophane and the production of growth hormones (auxins) like IAA. Reddy and colleagues discovered comparable results [19].

3.2.3 Grain weight/ear head (g)

Treatment 6 with (Vermicompost 2.6 t/ha + Zinc 15 kg/ha) had a significantly higher grain weight/ear head (23.4 g), making it notably better than the other treatments. Nevertheless, it was discovered that treatment-5 (vermicompost 2.6 t/ha + zinc 10 kg/ha) was numerically equivalent to treatment-6 (vermicompost 2.6 t/ha + zinc 15 kg/ha) (Table 2). With the addition of vermicompost (2.6t/ha), grain weight/ear head rose noticeably. This led to a larger photosynthesis site and the diversion of photosynthate towards sink (ear and grain). The increased supply of all the necessary nutrients provided by vermicompost, according to Togas et al., may also be responsible for the favourable impact on yield characteristics [20].

3.2.4 Test weight (g)

The treatment-6 experiment with [vermicompost (2.6 t/ha + zinc (15 kg/ha)] had the greatest test weight (9.21 gm). However, there was no discernible change between the treatments (Table 2).

3.2.5 Grain yield (t/ha)

Treatment 6 with [Vermicompost (2.6 t/ha) + Zinc (15 kg/ha)], which was considerably better than the other treatments, showed a significant and higher grain yield (3.90 t/ha). However, it was discovered that Treatment-5, which combined vermicompost (2.6 t/ha) and zinc (10 kg/ha), was numerically equivalent to Treatment-6 (vermicompost 2.6 t/ha + zinc 15 kg/ha) (Table 2). The significant increase in grain yield (2.6 t/ha) that resulted from the application of vermicompost may have been caused by the provision of sufficient amounts and proportionately balanced amounts of plant nutrients as well as by the creation of a congenial environment in the root rhizosphere. Another potential explanation for the higher productivity found by Nikhitha et al. could be the enhanced physical, chemical, and biological characteristics of the soil brought about by the application of vermicompost [6]. Additionally, a significantly higher grain yield was observed with the application of zinc (15 kg/ha). This could be attributed to improved individual plant performance, increased nutrient availability due

Table 1. Influence of Organic manures and zinc on growth parameters of pearl millet

S No	Treatments	Plant height (cm)	Plant dry weight (g)	CGR (g/m^2/day)	RGR (g/g/day)
1.	FYM 16 t/ha + zinc 5 kg/ha	153.7	81.92	66.55	0.0339
2.	FYM 16 t/ha + zinc 10 kg/ha	155.6	84.23	67.10	0.0330
3.	FYM 16 t/ha + zinc 15 kg/ha	158.9	85.22	67.10	0.0324
4.	*Vermicompost* 2.6 t/ha + zinc 5 kg/ha	163.3	92.08	67.76	0.0295
5.	*Vermicompost* 2.6 t/ha + zinc 10 kg/ha	167.4	93.72	67.65	0.0291
6.	*Vermicompost* 2.6 t/ha + zinc 15 kg/ha	169.2	94.90	68.20	0.0283
7.	Goat manure 2.6 t/ha + zinc 5 kg/ha	156.8	86.53	66.55	0.0314
8.	Goat manure 2.6 t/ha + zinc 10 kg/ha	160.6	88.31	67.10	0.0309
9.	Goat manure 2.6 t/ha + zinc 15 kg/ha	161.1	89.87	66.00	0.0295
	F-test	S	S	NS	S
	Sem (±)	1.15	0.48	1.20	0.001
	CD at 5%	3.46	1.44	-	0.002

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

S. No.	Treatment combinations	Ear head length (cm)	No. of Grains/ear head	Grain weight/ear head (g)	Test weight (g)	Grain yield(t/ha)	Stover yield(t/ha)	Harvest index (%)
1.	FYM 16 t/ha + zinc 5 kg/ha	24.3	1860	19.8	6.88	3.27	7.19	31.30
2.	FYM 16 t/ha + zinc 10 kg/ha	24.8	1876	20.1	7.43	3.36	7.58	30.70
3.	FYM 16 t/ha + zinc 15 kg/ha	24.9	1934	20.6	7.65	3.42	7.67	30.86
4.	*Vermicompost* 2.6 t/ha +zinc 5 kg/ha	25.6	1942	22.9	7.82	3.65	7.89	31.65
5.	*Vermicompost* 2.6 t/ha +zinc 10 kg/ha	26.1	1996	22.9	8.88	3.78	8.10	31.83
6.	*Vermicompost* 2.6 t/ha +zinc 15 kg/ha	26.4	2046	23.4	9.21	3.90	8.20	32.24
7.	Goat manure 2.6 t/ha + zinc 5 kg/ha	25.2	1881	21.9	7.37	3.47	7.60	31.36
8.	Goat manure 2.6 t/ha + zinc 10 kg/ha	25.6	1930	21.4	8.20	3.50	7.76	31.13
9.	Goat manure 2.6 t/ha + zinc 15kg/ha	25.4	1965	22.4	7.67	3.66	8.13	31.04
	F test	S	S	S	NS	S	S	NS
	SEm (±)	0.19	18.17	0.51	0.52	0.42	0.93	0.43
	CD at 5%	0.55	54.49	1.51	--	1.25	2.80	—

Table 3. Influence of organic manures and zinc on economics of pearl millet

S. No	Treatments	Total cost of cultivation (INR/ha)	Gross Returns (INR/ha)	Net Returns (INR/ha)	B:C ratio
1	FYM 16 t/ha + zinc 5 kg/ha	29450	77282	47832	1.62
2	FYM 16 t/ha + zinc 10 kg/ha	29950	79393	49443	1.65
3	FYM 16 t/ha + zinc 15 kg/ha	30450	80947	50497	1.66
4	*Vermicompost* 2.6 t/ha + zinc 5 kg/ha	26650	86232	59582	2.24
5	*Vermicompost* 2.6 t/ha + zinc 10 kg/ha	27150	89147	61997	2.28
6	*Vermicompost* 2.6 t/ha + zinc 15 kg/ha	27650	91919	64269	2.32
7	Goat manure 2.6 t/ha + zinc 5 kg/ha	27950	91898	53948	1.93
8	Goat manure 2.6 t/ha + zinc 10 kg/ha	28450	82835	54385	1.91
9	Goat manure 2.6 t/ha + zinc 15 kg/ha	28950	86463	57513	1.99

to an increase in the rate at which organic matter is decomposing, or higher photosynthesis efficiency. These observations are consistent with those of Arshad et al. [14].

3.2.6 Stover yield (t/ha)

Using vermicompost (2.6 t/ha) and zinc (15 kg/ha), treatment 6 produced the highest stover yield (8.20 t/ha), according to the statistics. However, treatment 5 [vermicompost (2.6 t/ha) + zinc (10 kg/ha)] and treatment 6 [vermicompost (2.6 t/ha) + zinc (15 kg/ha)] were significantly equivalent (Table 2). With the application of vermicompost, a significant and higher stover yield of (2.6t/ha) was observed. This increase in stover yield may be attributed to the primary nutrients' prolonged availability and uptake, as well as the addition of zinc, which improved the assimilatory surface and increased photosynthate, protein synthesis, and growth hormone production. These observations are consistent with those of Reddy et al. [21].

3.2.7 Harvest index (%)

The results showed that treatment 6 [vermicompost (2.6 t/ha) + zinc (15 kg/ha)] had the highest harvest index (32.24%). There were no discernible differences between the therapies (Table 2).

3.2.8 Economics

The outcome revealed Treatment 6 [Vermicompost (2.6 t/ha) + Zinc (15 kg/ha)] had the greatest benefit cost ratio (2.32) and the highest gross return (91,919.00 INR/ha), net return (64,269.00 INR/ha), of all the treatments (Table 3). Zinc (15 kg/ha) application resulted in higher net returns, gross returns, and benefit cost ratios, which may have improved the crop's growth and development, made it more vigorous, enhanced grain filling, and ultimately increased the yield of pearl millet while maintaining economics by maximising the net return and B:C ratio. These outcomes are consistent with what Shalini et al. reported seeing [22].

4. CONCLUSION

Based on the above findings it can be concluded that combination of Vermicompost 2.6 t/ha along with Zinc 15 kg/ha (treatment 6) was observed highest grain yield and benefit cost ratio.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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