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Effect of phosphorus with zinc and zinc solubilizer on the physical growth of pearl millet

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Abstract
The physicochemical involvement of Zn in soil-plant systems. Zinc (Zn) is required for the metabolism of plants, enzyme function, and ion transport. Zinc-solubilizing rhizobacteria can convert insoluble zinc to an accessible form and increase Zn bioavailability in soil, which help mitigate Zn deficiency in crops. A field experiment was conducted during *Kharif* season of 2023 at Crop Research Farm Department of Agronomy. The soil was tasted in lab and contain pH range of 7.8, which is almost neutral and contain EC 0.41 (ds/m) of The treatments consisted of 3 levels of Zinc (0 kg/ha, 2.5 kg/ha and 5 kg/ha) with Zinc Solubilizer and 3 level of Phosphorus (20, 40 and 60 kg/ha). The experiment was laid out in a Randomized Block Design with 10 treatments and replication thrice. Application of Phosphorus 40 kg/ha with Zinc 2.5 kg/ha and Zinc Solubilizer (Treatment 5) recorded highest plant height (154.17cm), maximum plant dry weight (91.29 gm) However the highest CGR (42.80 g/m2/ day) and RGR (0.01270 g/g/days) are observed in (Treatment 7) Phosphorus 60 kg/ha+ Zinc 0 kg/ha + Zinc Solubilizer in between 40 to 60 DAS and in between 20 to 40 DAS accordingly.

Keywords: Pearl millet, hybrids, kharif, growth, CGR, RGR

Introduction
Pearl millet Crop is a traditional name for Pearl Millet. It is an edible seed of the Pearl Millet plant species. Pearl millet crop cultivation is done in various varieties and is grown in various colours, such as white, yellow and grey. It is an important crop with many health benefits and is one of the most commercial crops. India is the largest Pearl millet -producing country, followed by the African country, Nigeria.

Pearl millet [*Pennisetum glaucum* L.] is an important crop of rain fed areas of Africa India and Serves as staple food for West Africa. It is the most widely cultivated millet crop, occupying prominent position in global agriculture. India is the largest producer of pearl millets in world occupying about 9.4 million hector area with annual production 10.1million tones with average productivity of 1069 kg/ha. India is largest producer of pearl millets covering about 8.75 million ha of marginal and sub marginal lands primarily in the states of Rajasthan, Gujarat, Haryana, Uttar Pradesh and Maharashtra and ranking 3 rd after rice and wheat in acreage. In addition to its grain consumption as human feed, it is also as green fodder in India. Pearl millet may be an alternative crop that exhibits great advantages in physiological characteristics when compared to other cereals as it is resistant to drought, low soil fertility, high salinity and high temperature tolerance [Singh *et al*., 2019] [23]. Because of it drought escaping mechanism pearl millet can grow in areas that have extended dry periods. The balanced fertilization as shown in positive effects on various aspects of growth development and biological yield of the crop in comparison to nutrient use in single or in combination. In India, pearl millet is the fourth most widely cultivated food crop after rice, wheat and maize. During 2019-20, pearl millet was grown in 7.41 million ha with an average production of 10.3 million tonnes and 1391 kg/ha productivity (3rd advanced estimate from Directorate of Millets Development, 2020).

Phosphorus (P) is an essential nutrient for growth and development of plant. Phosphorus plays a very important role in photosynthesis, respiration, energy storage cell division and other metabolic activities in plantlets and also it is very important for seed germination and root formation for plant growth and development (Hrinathan *et al.* 2016) [28] in plants, zinc plays a

key role as a structural constituent or regulatory co-factor of a wide range of different enzymes in many important biochemical pathways. Zinc deficiency in the plant retards development and maturation of the panicles of grain crops. As in soils and plants, Zn deficiency is also a common nutritional problem in humans, predominantly in developing countries where diets are rich in cereal- based foods and poor in animal products. Enhancing Zn in plant derived food is one of the way to improve human health in developing countries where and when the local population cannot afford food sources from which zinc can be taken up easily in large enough quantities in the human gut. Therefore, present investigation 3 was undertaken on Effect of Phosphorus, Zinc and Zinc solubilizer on Growth, Yield and Economics of Pearl Millet (*Pennisetum glaucum* L.). To increase the availability of zinc for plants. zinc Solubilizer use to solubilize the fixed unavailable zinc into available form and that residue fertilizer can be utilize by succeeding crop. Therefore, an attempt was made to increase the productivity of pearl millet with different residual phosphorous and zinc levels, Kumawat *et al.* [2018] [8].

Keeping an eye on the above aspects the present study entitled "Effect of Phosphorus, Zinc and Zinc solubilizer on growth of Pearlmillet." was carried out at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences. Prayagraj during 2023 Kharif Season.

Materials and Methods

Experimental sites and soil

The experiment was conducted during the Kharif season 2023 at the Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higgin bottom University of Agriculture, Technology and Sciences, Prayagraj, U P. The Crop Research Farm is located at 250 24' 42"N latitude, 810 50' 56" E longitude and 98 m altitude from the sea level. This area is situated on the right side of the river Yamuna and by the opposite side of Prayagraj, Rewa Road about 5 km away from Prayagrajcity.

The soil been collected from the experimental site was tasted in laboratory and the results are been observed

Organic carbon (%)	0.35%
Available Nitrogen	243 kg/ha
Available Phosphorus	20.10 kg/ha
Available Potassium	105.00kg/ha
Soil pH	7.8
EC	0.41(ds/m)

Formulations used for the experiment

Three level of Phosphorus and Zinc with Zinc Solubilizer is being used in the particular experiment. The Phosphorus (20 to 60 kg per ha) and Zinc (0 to 5 kg per ha) with Zinc solubilizer, Phosphorus, Zinc and Zinc Solubilizer (20:0,20:2.5, 20:5,40:0, 40:2.5, 40:5, 60:0, 60:2.5,60:5) and control trail was separately maintained. The experiment was laid out in Randomized Block Design in three replication.

The pearl millets were sown by maintaining 45 cm X 15 cm spacing in a plot area of 9 m2. The soil was treated with basal dose of urea and MOP (according to RDF) during field preparation. The seeds were treated with zinc Solubilizer before sowing at the rate 10 ml per 1kg of seed. And the dose of zinc and phosphorus was applied according to the treatment combinations. The 10 treatments was laid in the formulation as followed (T_1) Phosphorus 20 kg/ha + Zinc 0 kg/ha + Zinc Solubilizer, (T_2) Phosphorus 20 kg/ha+Zinc 2.5 kg/ha + Zinc Solubilizer, (T_3) Phosphorus 20 kg/ha+Zinc 5 kg/ha + Zinc Solubilizer, (T_4) Phosphorus 40 kg/ha+Zinc 0 kg/ha + Zinc Solubilizer, (T_5) Phosphorus 40 kg/ha+Zinc 2.5 kg/ha + Zinc Solubilizer. (T_6) Phosphorus 40 kg/ha+Zinc 5 kg/ha + Zinc Solubilizer, (T_7) Phosphorus 60 kg/ha+Zinc 0 kg/ha + Zinc Solubilizer, (T_8) Phosphorus 60 kg/ha+Zinc 2.5 kg/ha + Zinc Solubilizer, (T_9) Phosphorus 60 kg/ha+Zinc 5 kg/ha + Zinc Solubilizer, (T_{10}) Control (N: P: K -80: 40: 40 kg/ha) each treatment was carried out in three plots, total 30 plots. The irrigation time, frequency, and quantity were identical among treatments once after sowing, and then every 20 days interval.

Physiological determination

At 15 DAS 5 plants from each plot are tagged randomly for determining the physiological parameters. At 20 DAS the plant height was measured by scale and recorded, the measurement was taken at 20 days interval at 20 Days interval 5 plants rather than tagged plant are been collected from the field and dried well in open air and the samples are put into the Hot air oven for 24 hour. Then the sample are weighted in wing balance. That's how the data of dry weight is recorded.

On the basis of dry weight the Crop Groth Rate (CGR) s been collected by using the formula -Crop Growth Rate = (W2−W1) / S (t2-t1) Here,

W1=dry weight per unit area at time t1
W2=dry weight per unit area at time
t1=days to first sampling
t2 = days to second sampling
S= Spacing

Same way the Relative Growth Rate (RGR) also been calculated by using the formula

$$\text{RGR (g/g/day)} = \frac{\ln W_2 - \ln W_1}{(t_2 - t_1)}$$

Where,

ln W1 = natural log of initial(t1) dry weight(g)of b plant
ln W2 = natural log of dry weight(g) of the plants after a certain interval of time
t1 = initial time (days)
t2 = time period after a certain interval

Statistical analysis

All data were analyzed using the MS Excel software, and the results were expressed as the arithmetic mean value (±) standard deviation. The differences in the means were compared by the ANOVA. P <.05 was considered as statistically significant.

Result and Discussion

The maximum plant height was recorded with the application of Phosphorus 40 kg/ha with Zinc 2.5 kg/ha and Zinc Solubilizer (128.63 and 154.17 cm) at 60 DAS and at physiological maturity stages, respectively, followed by the application of Phosphorus 20 kg/ha with Zinc 0 kg/ha and Zinc Solubilizer (126.05, 150.94 cm) 60 DAS and at physiological maturity over rest of treatments.

The highest total dry weight of plant was recorded application of Phosphorus 40 kg/ha with Zinc 2.5 kg/ha and Zinc Solubilizer (61.28, and 91.29 g) at 60 DAS and at physiological maturity, respectively, followed by application of Phosphorus 20 kg/ha with Zinc 0 kg/ha and Zinc Solubilizer at 60 DAS and at

physiological maturity over rest of treatments including control. In case of Crop Growth Rate parameter the highest growth is recorded with in 40 to 60 DAS, with the application of Phosphorus 20 kg/ha with Zinc 5 kg/ha and Zinc solubilizer (42.80 g/ m2 / day) followed by Phosphorus 20 kg/ha with Zinc 0 kg/ha and Zinc Solubilizer (41.75 g/m2/ day) over the rest of treatments. Relative Growth is found significantly higher in between 15 to 30 DAS with the application of Phosphorus 60 kg/ha with Zinc 0 kg/ha and Zinc Solubilizer (0.1270 g/g/ day) in compare to other treatments.

Influence of Phosphorus with Zinc and zinc solubilizer on growth attributes of Pearl millet

At 80 DAS					
S. No.	**Treatments**	**Plant height (cm)**	**Dry matter (g/plant)**	**CGR (g/m^2/day) 60-80 DAS**	**RGR (g/g/day) 60-80 DAS**
1.	Phosphorus 20 kg/ha + Zn 0 kg/ha + Zn Solubilizer	150.94	89.05	32.22	0.0262
2.	Phosphorus 20 kg/ha + Zn 2.5 kg/ha + Zn Solubilizer	146.83	86.63	32.08	0.0270
3.	Phosphorus 20 kg/ha + Zn 5 kg/ha + Zn Solubilizer	150.72	88.92	32.28	0.0263
4.	Phosphorus 40 kg/ha + Zn 0 kg/ha + Zn Solubilizer	148.76	87.77	32.01	0.0265
5.	Phosphorus 40 kg/ha + Zn 2.5 kg/ha + Zn Solubilizer	154.17	91.29	33.34	0.0265
6.	Phosphorus 40 kg/ha + Zn 5 kg/ha + Zn Solubilizer	150.38	88.72	32.71	0.0268
7.	Phosphorus 60 kg/ha + Zn 0 kg/ha + Zn Solubilizer	147.81	87.20	31.40	0.0261
8.	Phosphorus 60 kg/ha + Zn 2.5 kg/ha + Zn Solubilizer	148.12	87.39	31.78	0.0264
9.	Phosphorus 60 kg/ha + Zn 5 kg/ha + Zn Solubilizer	149.06	87.94	31.84	0.0262
10.	Control (N: P:K -80: 40: 40 kg/ha)	148.55	87.64	31.91	0.0246
	F-Test	S	S	S	NS
	Sem (±)	1.16	0.91	0.385	0.000338
	CD (P=0.05)	3.44	1.93	0.810	_

Conclusion

It is concluded that application Phosphorus 40 kg/h along with Zinc 2.5 kg/ha and Zinc Solubilizer (Treatment 5) recorded higher growth.

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