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Response of Pearl Millet to Hydrogel Application and Zinc Fertilization under Semi-arid Conditions of Rajasthan

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Abstract: A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during the *Kharif* 2021 on loamy sand soil. The experiment was laid out in factorial randomized block design with four levels each of hydrogel (control, 2.5 kg ha^{-1}, 5.0 kg ha^{-1} and 7.5 kg ha^{-1}) and zinc sulphate (control, foliar spray of $ZnSO_4$ @ 0.25%, 0.5% and 0.75%). Pearl millet crop grown with 'Pusa Hydrogel' with all application rates yielded higher than control. Yield obtained with application of 5.0 and 7.5 kg ha^{-1} hydrogel was at par with each other and also showed significantly increased earhead length, earhead girth, grain weight per earhead and 1000 grains weight over 2.5 kg ha^{-1} hydrogel and also of control. Results showed that foliar spray of 0.5% $ZnSO_4$ significantly improved yield attributes viz., earhead length, earhead girth, grain weight per earhead and 1000 grains weight and further grain and stover yield of pearl millet over foliar spray of 0.25% $ZnSO_4$ and control. Increasing application rate to 0.75% gave no additional yield advantage. In economics, B:C ratio of 1.75 and 1.78 was recorded with application of 'Pusa Hydrogel' at 5.0 kg ha^{-1} and foliar spray of $ZnSO_4$ at 0.5%, respectively.

Key words: Hydrogel, pearl millet, productivity, yield attributes, zinc fertilization.

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Pearl millet [*Pennisetum glaucum* (L.) R.Br.] known as cattail millet, candle millet, bulrush millet and *Bajra*, is a crop of arid and semi-arid regions of India. It is a C4 crop having high photosynthetic efficiency and survival under adverse climatic conditions and nutritional value of pearl millet is superior to the cereals like rice, wheat, and maize. It is a good source of protein (12.1%), carbohydrates (69.4%), fats (5%), minerals (2.3%) and also a rich source of Ca, K, Mg, Fe, Zn, Mn, riboflavin, thiamine, niacin, lysine and tryptophan (Malik, 2015). Pearl millet cultivation is mainly confined to dry regions of the southern Asia (mainly India). In India, pearl millet is mostly grown in major part of Rajasthan, Gujarat, Haryana, Maharashtra and Uttar Pradesh. In India, pearl millet is being cultivated on 6.93 mha area with 8.61 mt production with an average productivity of 1243 kg ha^{-1} (Anonymous, 2020). The average productivity of pearl millet in the country is far behind to the attainable yield due to moisture and nutritional stress.

For water scarce regions use of super absorbent polymers that can increase water use efficiency and enhance crop productivity is a recent trend. Use of such super absorbent polymer (hydrogel) has great potential to utilize the available water in soil for increasing productivity of crops experiencing moisture stress. The large quantities of water retained by the super absorbing polymer provide extra available water to crops which facilitates better crop growth conditions and more available water in the soil and also reduce irrigation frequencies.

Besides the moisture stress, wide spread and acute deficiency of zinc is another serious problem in arid and semi-arid region (Sahrawat *et al*., 2007; Pratap *et al*., 2008; Kumar *et al*., 2020). The zinc deficiency is more common under water deficient soil conditions due to reduced availability and mobility of zinc in soil. Zinc deficiency reduces not only the grain yield but also the nutritional quality of grain and ultimately nutritional quality of human diet (Cakmak, 2008). Keeping in view of above facts the present research was carried out to study the effect of hydrogel levels and zinc fertilization on productivity and economics of pearl millet.

Materials and Methods

A field experiment was conducted at Agronomy farm of S.K.N. College of Agriculture, Jobner (Rajasthan) during *Kharif*, 2021. The soil of experimental field was loamy sand in texture, alkaline in reaction (pH 8.3), low in organic carbon (0.19%) and available nitrogen (126 kg ha^{-1}), medium in available phosphorus (19.23 kg ha^{-1}) and potassium content (150 kg ha^{-1}). The experiment was laid out in factorial randomized block design comprising 16 treatment combinations viz., four levels of hydrogel (control, 2.5 kg ha^{-1}, 5.0 kg ha^{-1} and 7.5 kg ha^{-1}) and four levels of zinc sulphate (control, foliar spray of $ZnSO_4$ @ 0.25%, 0.50% and 0.75%) which were replicated thrice. The pearl millet cv. MPMH-17 @ 4 kg ha^{-1} was sown at the spacing of 45 cm row to row and 10 cm plant to plant. 'Pusa Hydrogel' was applied in respective plots as band placement. Available granules of 'Pusa Hydrogel' were mixed with approximately 10 times the quantity of the farm soil. The mixture was applied uniformly in the rows with the help of plough at below the depth of seed. Zinc was sprayed as per treatment and applied through zinc sulphate ($ZnSO_4.7H_2O$ 21% Zn). The foliar spray was done at flowering initiation as per treatments. Statistical analysis of the data was carried out using standard analysis of variance (Snedecor and Cochran 1980). The benefit cost ratio was calculated by dividing net returns with cost of cultivation.

Results and Discussion

Effect of hydrogel

Application of hydrogel significantly influenced the yield attributes viz., earhead length, earhead girth, grain weight per earhead and 1000 grains weight of pearl millet (Table 1). Its application at 5.0 kg ha^{-1} significantly improved earhead length by 8.62 and 11.62% over the application of 2.5 kg ha^{-1} and the control. Earhead girth improved by 10.04 and 11.64% over the application of hydrogel 2.5 kg ha^{-1} and the control. Grain weight per earhead improved by 10.55 and 12.20% and 1000 grains weight by 7.79 and 9.59% over the application of hydrogel 2.5 kg ha^{-1} and the control, respectively.

Application of hydrogel 5.0 kg ha^{-1} also recorded significantly higher grain yield 2573 kg ha^{-1} and stover yield 5938 kg ha^{-1} over the application of hydrogel 2.5 kg ha^{-1} and control which were at par with hydrogel 7.5 kg ha^{-1}. The application of hydrogel 5.0 kg ha^{-1} increased grain yield to the extent of 13.64 and 33.04%, respectively over the application of hydrogel 2.5 kg ha^{-1} and control (Table 1). Super absorbent polymer stored water and nutrient are released slowly as required by plant to improve growth under limited water supply (Yazdani *et al*., 2007). The increase in the crop yield parameters and crop yield might be due to the fact that hydrogel application increased the availability of water in root zone at early stage of crop. Hydrogels when hydrated transformed themselves into water-laden gel 'chunks' and these gel chunks acted as local water reservoirs which perhaps helped in initial establishment of crop and resulted in better crop growth. Similar results of incorporating superabsorbent polymer into the soil on yield have been reported by Ray *et al.* (2021). The improvements in yield attributes with the application of hydrogel might be due to the favourable effect on growth through adequate

Table 1. Effect of Pusa Hydrogel and zinc fertilization on yield attributes and yield of pearl millet

Treatment	Earhead length (cm)	Earhead girth (cm)	Grain weight earhead^{-1} (g)	1000-grain weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Hydrogel levels						
Control	19.74	6.71	12.18	6.08	1934	4607
2.5 kg ha^{-1}	21.67	7.47	13.27	6.67	2264	5286
5.0 kg ha^{-1}	23.54	8.22	14.67	7.19	2573	5938
7.5 kg ha^{-1}	24.19	8.34	14.89	7.31	2646	6009
SEm±	0.53	0.15	0.31	0.13	58	115
CD (P=0.05)	1.54	0.45	0.89	0.37	169	332
Zinc fertilization						
Control	19.44	6.82	12.14	6.09	2005	4763
0.25%	21.88	7.54	13.36	6.70	2318	5395
0.50%	23.85	8.14	14.66	7.20	2524	5832
0.75%	23.98	8.25	14.85	7.27	2571	5850
SEm±	0.53	0.15	0.31	0.13	58	115
CD (P=0.05)	1.54	0.45	0.89	0.37	169	332

supply of moisture, leading to greater nutrient uptake, efficient partitioning of metabolites and adequate accumulation and translocation of photosynthates resulted in improved yield attributes (Saini *et al.,* 2020 and Yadav *et al*., 2020).

Zinc fertilization

Results showed that foliar spray of 0.5% $ZnSO_4$ significantly improved yield attributes viz., earhead length, earhead girth, grain weight per earhead and 1000 grain weight of pearl millet over foliar spray of 0.25% $ZnSO_4$ and control. The foliar spray of 0.5% significantly improved earhead length by 9.00 and 9.59% over the spray of 0.25% $ZnSO_4$ and the control, earhead girth by 7.95 and 9.41% over the spray of 0.25% $ZnSO_4$ and the control, grain weight per earhead by 9.73 and 11.15% over the spray of 0.25% $ZnSO_4$ and the control and 1000 grains weight by 7.46 and 8.50%, respectively over the spray of 0.25% $ZnSO_4$ and the control. Results from the data also showed that foliar spray of 0.5% and 0.75% $ZnSO_4$ significantly improved grain yield by 8.8, 25.88 and 10.91, 28.22%, respectively over the spray of 0.25% $ZnSO_4$ and control (Table 1). Foliar applied Zn is easily absorbed and transported through phloem as show by using radio labeled Zn especially in plants grown under low Zn supply (Haslett *et al*., 2001). Higher grain yield with zinc sulphate application might be due to the fact that zinc plays an important role in the biosynthesis of IAA and initiation of primordial for the reproductive part which have favored the metabolic reaction within the plant. These results are closely in conformity with findings of Shekhawat and Kumawat, 2017 and Dambiwal *et al*., 2017.

Economics

Data pertaining to economics of pearl millet cultivation under different levels of hydrogel and Zn fertilization are given in Table 2. Among the hydrogel levels, the application of

Table 2. Effect of 'Pusa Hydrogel' and zinc fertilization on economics of pearl millet

Treatment	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Hydrogel levels			
Control	66862	39451	1.46
2.5 kg ha^{-1}	77970	47654	1.60
5.0 kg ha^{-1}	88096	55741	1.75
7.5 kg ha^{-1}	90815	55602	1.63
SEm±	1910	1193	0.02
CD (P=0.05)	5516	3446	0.07
Zinc fertilization			
Control	70635	38773	1.29
0.25%	79123	48381	1.56
0.50%	86218	55122	1.78
0.75%	87767	56171	1.81
SEm±	1910	1193	0.02
CD (P=0.05)	5516	3446	0.07

Market price of Pusa Hydrogel Rs. 850 kg^{-1}; $ZnSo_4$ Rs. 35 kg^{-1}; pearl millet grain Rs. 22.5 kg^{-1}, pearl millet stover Rs. 5.0 kg^{-1}

hydrogel 5.0 kg ha^{-1} being on par with 7.5 kg hydrogel ha^{-1} fetched significantly higher net return to the tune of Rs. 55741 and Rs. 55602 ha^{-1} and B:C ratio 1.75 and 1.63, respectively over control and 2.5 kg hydrogel ha^{-1}. Similarly, in Zn fertilization, the foliar spray of 0.5% $ZnSO_4$ being on par to 0.75% $ZnSO_4$ fetched significantly higher net return of Rs. 55122 and 56171 ha^{-1} and B:C ratio of 1.78 and 1.81, respectively over control and 2.5 kg hydrogel ha^{-1}. The higher net returns and B:C ratio of pearl millet might have been attributed to higher yield advantages with higher doses of respective treatments.

Conclusion

The application of 'Pusa Hydrogel' 5.0 kg ha^{-1} and foliar application of $ZnSO_4$ 0.5% recorded significantly higher yields and net returns of pearl millet. Thus under rainfed conditions of semi-arid regions, application of hydrogel up to 5.0 kg ha^{-1} with Zn fertilization may be rewarding for higher productivity and profitability of pearl millet.

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