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Response of Irrigation and Hydrogel on Growth and Yield of Pearl Millet (*Pennisetum glaucum* L.) under eastern Uttar Pradesh Condition

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ABSTRACT: A trail was carried out at Central Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, (U.P.) during *Zaid*-2020. The soil of experimental site was sandy loam in texture, nearly neutral in soil reaction. The experiment was laid out in split plot design and having nine treatment consisted of Hydrogel *viz.*, H_0 (0 kg/ha), H_1 (2 kg/ha) and H_2 (4 kg/ha) and Irrigation viz., I_1 (2 Irrigation during Emergence and Early Tillering), I_2 (3 Irrigation during Emergence, Early Tillering and Boot stage) and I_3 (4 Irrigation during Emergence, Early Tillering, Boot stage and Grain filling) which are replicated thrice and effect was observed on Manipuri variety of Bajra. The result shown significantly higher effect of irrigation on plant height (182.34 cm), Earhead length (34.05 cm), Total Dry weight (128.33 g), LAI (6.02), Grain yield (1.88 t/ha), Stover yield (4.31 t/ha) and harvest index (30.24 %) were recorded in four irrigation. In case of effect of hydrogel, significantly higher plant height (188.15 cm), Effective tillers (3.09), Earhead length (33.45 cm), Total Dry weight (127.14 g), LAI (6.03), Test weight (12 g), Grain yield (1.98 t/ha), Stover yield (4.44 t/ha) and Harvest index (30.79 %) were recorded with 4 kg/ha hydrogel. Hydrogel can hold 500 times more water than its size, so improper irrigation, improper drainage, and heavy rain may be challenging as it will lead to water logging conditions which will affect growth and development of crop.

Keywords: Hydrogel, Irrigation, Yield, Pearl Millet.

INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.) is one of the most important millet crops for arid and semi-arid conditions. It belongs to the family of Poaceae. This grain is widely grown in Africa and Asia since pre-historic time. It is world's hardiest warm season crop. It grows well in poor soil due to drought escaping characters and it is popular crop for drought prone areas. It is tall tillering annual plant which grows up to 1 meter to 3 meter. Bajra is a coarse grain crops and regarded to be the poor man's staple nourishment and suitable to cultivate in dry lands. It is good source of protein having higher digestibility (12.1%), carbohydrates (69.4%), fats (5%) and minerals (2.3%) (Saini *et al.,* 2020). *Bajra* can also use as valuable animal fodder. It is one of the important crops of China, India, South Eastern Asia, Sudan, Russia & Nigeria.India is the largest producer of bajra, during 2020-21 about 65.15 lakh ha (160.99 lakh acres) area was covered under bajra. The states of Rajasthan 38.42 lakh ha (94.94 lakh acres), Uttar Pradesh 9.20 lakh ha (22.73 lakh acres), Maharashtra 6.14 lakh ha (15.17 lakh acres), Haryana 4.32 lakh ha (10.67 lakh acres), Madhya Pradesh 3.05 lakh ha (7.54 lakh acres), Karnataka 1.45 lakh ha (3.58 lakh acres) and Gujarat 1.81 lakh ha (4.47 lakh acres) are the major growers of bajra in India. According to the 3rd advance estimates for 2019-20 bajra production estimate was 10.31 million tonnes as against 8.66 million tonnes in 2018-19. (Department of Food and Public Distribution 2020-21).

Irrigation is required to replenish soil moisture deficit in the root zone before occurrence of the yield reduction level of plant water deficit. Water deficit in plant develops when transpiration exceeds root water absorption which is dependent primarily on soil moisture status. Optimum scheduling of irrigation therefore should be based on the crop rooting pattern, evapotranspiration rate (ET), available soil moisture in the root zone, allowable soil moisture depletion, effective precipitation and water table depth (Brahma *et al.,* 2007). Improper irrigation scheduling i.e. over watering at shorter interval or imposing soil moisture stress unduly prolonged irrigation interval often leads to reduction in yield. The irrigation scheduling which determines the amount and frequency of irrigation is governed by many complex factors but climate plays a major role. Therefore, it is important to develop irrigation scheduling technique during summer under prevailing climatic conditions (Brevedan *et al.,* 2003; Saini *et al.*, 2018).

Hydrogel is three dimensional, hydrophilic polymer with loosely cross-linked networks capable of imbibing large amounts of water or other biological fluids. When the soil is treated with water hydrogel composite the water volumetric content of the soil increases significantly and when the encircling soil dries, the stored water is released back slowly into the soil. These synthetic polymers crystalline in form and that they are available under several trade names i.e. super absorbent, hydrogel, aquasorb etc. this products shows a swelling potentials of minimum 300 time, often exceeding 500 times its weight in pure water. Swelling ratio increased with the increase in temperature up to 50°C with none adverse effect on the polymer matrix structure (Ashkiani *et al.*, 2013).

Hydrogel application reduces micronutrients from leached out the water tables and increase water consumption efficiency and it is also reducing the amount of fertilization, since the nutrient leaching is prohibited by decreasing runoff. And, hydrogels which contain fertilizers and have controlled water release in order that the dose of the fertilizer is adjustable in time. The nutrient is available for the plant over a extend period of time rather than a rapid availability that ammonium phosphate, ammonium nitrate or potassium chloride. This leads to increase yield in crop by providing better water availability and nutrient for crop (Bedi and Sohrab 2004) and (Saini *et al.*, 2020). Keeping this in view, study was taken to know the suitable irrigation and hydrogel level for study area.

MATERIALS AND METHODS

The experiment was conducted during the *Zaid* season of 2020 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Science (SHUATS), Prayagraj (Allahabad) (U.P.). The Crop Research Farm is situated at 25.57° N latitude, 87.19° E longitude and at an altitude of 98m above mean sea level. The experiment was laid out in split plot design, replicated thrice. The treatment comprised of 3 Irrigation interval based on crop growth stages, (during Emergence, Early Tillering, Boot stage and Grain filling) and noted as I_1 (2 Irrigation during Emergence and Early Tillering), I_2 (3 Irrigation during Emergence, Early Tillering and Boot stage) and I_3 (4 Irrigation during Emergence, Early Tillering, Boot stage and Grain filling) assigned as main plot. Each main plot was further divided into 3 sub plots, i.e. Hydrogel levels H_0 (0 kg/ha Hydrogel), H_1 (2 kg/ha Hydrogel), H_2 (4 kg/ha Hydrogel) through surface application andthe possible combination is presented in Table 1 with details of pearl millet crop. During the growing season, the mean weekly maximum and minimum temperature, relative humidity and rainfall were 36.60°C, 24.90°C, 76.40 %, 48.48 % and 4.72 mm respectively. Pearl millet was sown at a spacing of 40 × 10 cm using seed rate of 6-8 kg ha^{-1}. The field was uniformly irrigated before one day of sowing and further irrigated based on treatment. The RDF i.e Nitrogen (60 kg/ha) was applied through urea and DAP in two equal splits, first as basal and remaining dose at 45 DAS (days after sowing), whereas full dose of P_2O_5 (40 kg/ha) and full dose of K_2O (40 kg/ha) were applied through DAP and MOP. Hydrogels were applied in each plots according to the treatments before sowing of seed along with fertilizers during first split as basal. Observations on growth parameters, yield attributes and yield of pearl millet, was recorded and their significance was tested by the variance ratio (F-value) at 5% level (Gomez and Gomez, 1984). Relative economics was calculated as per the prevailing market prices of the inputs and produced during *Zaid* season.

Table 1: Treatment combinations.

Treatments	Treatment Combination
H_0I_1	0 kg/ha of Hydrogel with 2 irrigation (6 DAS and 27 DAS)
H_0I_2	0 kg/ha of Hydrogel with 3 irrigation (6 DAS, 27 DAS and 47 DAS)
H_0I_3	0 kg/ha of Hydrogel with 4 irrigation (6 DAS, 27 DAS, 47 DAS and 62 DAS)
H_1I_1	2 kg/ha of Hydrogel with 2 irrigation (6 DAS and 27 DAS)
H_1I_2	2 kg/ha of Hydrogel with 3 irrigation (6 DAS, 27 DAS and 47 DAS)
H_1I_3	2 kg/ha of Hydrogel with 4 irrigation (6 DAS, 27 DAS, 47 DAS and 62 DAS)
H_2I_1	4 kg/ha of Hydrogel with 2 irrigation (6 DAS and 27 DAS)
H_2I_2	4 kg/ha of Hydrogel with 3 irrigation (6 DAS, 27 DAS and 47 DAS)
H_2I_3	4 kg/ha of Hydrogel with 4 irrigation (6 DAS, 27 DAS, 47 DAS and 62 DAS)

Note: Emergence–6 DAS, Early tillering-27 DAS, Boot stage-47 DAS, Grain filling-62 DAS

RESULT AND DISCUSSION

A. Growth parameter

Growth parameters of pearl millet, *viz.* plant height (cm), Dry weight (g), Leaf Area Index (LAI) varied due to different irrigation interval and hydrogel level are presented in Table 2. The treatment receiving 4 irrigation (I_3) resulted in higher plant height (182.34 cm), Dry weight (128.33 g) and Leaf Area Index (LAI) (6.02). In the above treatment, I_3 was recorded significantly higher plant height (cm), Dry weight (g) and Leaf Area Index (LAI) while Crop Growth Rate (CGR) (g/m^2/day) and Relative Growth Rate (RGR) (g/g/day) was found statistically similar. While increasing dose of Hydrogel (H_2) also contributed significantly higher plant height (188.15 cm), Dry weight (127.14 g) and Leaf Area Index (LAI) (6.03). Optimum crop resulted from higher nutrient availability due to the effect of irrigation at important phases, adding hydrogel improves water holding capacity of soil which ultimately improves growth and Dry matter production of plants (Saini *et al.*, 2018).

Yield attributes such as number of effective tillers/plant, Ear head length (cm), test weight (g) exhibited marked variation during the experimental period due to irrigation at different growth stages and hydrogel levels (Table 2). The yield attributing character No. of effective tillers/plant and test weight

(g) showed non-significant result for irrigation practice. Higher Earhead length (cm) was recorded significantly superior under 4 irrigation (I_3) practice, which help to maximum yield. In case of hydrogel level (H_2) increased the No. of effective tillers/plant (3.09) and Earhead length (33.45 cm) significantly over no hydrogel application. Irrigation interval and hydrogel application resulted in higher yield attributes over less irrigation (I_1) and no hydrogel application (H_0). Due to sufficient moisture surrounding root zone promotes vegetative growth and hence length and girth of Earhead increased and also increased test weight with increase in hydrogel level and frequency of irrigation, similar results reported by Sayyari and Ghanbari, (2012) and Saini *et al., (*2018).

B. Yield

Grain and stover yield varied considerably significant due to various irrigation interval and application of 4 irrigation (I_3) recorded up to 18.2% and 9.9% higher grain yield than that of 2 irrigation (I_1) and 3 irrigation (I_2) respectively. Stover yield significantly higher under 4 irrigation ((I_3) (4.31 t/ha). In case of hydrogel, 4 kg/ha hydrogel application recorded significantly higher grain yield which fetched 34.6% more over no hydrogel application. Similar findings recorded in Stover yield due to application of hydrogel 4 kg/ha (4.44 t/ha) produced more biomass significantly over other hydrogel application. Increase in irrigation frequency and hydrogel levels tended in increase consumptive use of water, which provided congenial condition throughout the growth period of the crop more over less moisture stress experienced by crop during their vegetative and reproductive growth period, that too later stages of crop growth resulting in an improvement of growth and yield attributing characters, thereby produced higher grain and dry folder yield was confirmed with the result of Singh, (2012) and Saini *et al.*, (2020).

Table 2: Effect of Hydrogel and Irrigation on Growth attributes of pearl millet.

Treatment	Growth attributes				
	Plant Height (cm.)	**Dry Weight (g/plant)**	**Crop Growth Rate (g/m^2/day) 75-90 DAS**	**Relative Growth Rate (g/g/day) 75-90 DAS**	**Leaf area index**
Irrigation (no.)					
I_1-2 Irrigation	161.41	111.827	58.29	0.025	4.08
I_2-3 Irrigation	169.15	120.878	55.75	0.022	5.09
I_3-4 Irrigation	182.34	128.333	57.39	0.021	6.02
SEd (±)	4.86	1.48	4.39	0.002	0.283
C.D at 5%	7.79	2.372	-	-	0.453
Hydrogel (kg/ha)					
0 kg ha^{-1} Hydrogel	153.49	114.09	56.3	0.024	4.04
2 kg ha^{-1} Hydrogel	171.25	119.81	55.26	0.022	5.11
4 kg ha^{-1} Hydrogel	188.15	127.14	59.88	0.022	6.03
SEd (±)	5.78	2.04	4.94	0.002	0.285
C.D at 5%	12.59	4.446	-	-	0.62

Table 3: Effect of Hydrogel and Irrigation on Yield attributes and yields of pearl millet.

Treatment	Yield attributes and Yield					
	Number of Effective Tillers	**Earhead length (cm.)**	**Test Weight (g)**	**Grain Yield** (t/ha)	**Stover Yield** (t/ha)	**Harvest Index (%)**
Irrigation (no.)						
I_1-2 Irrigation	2.22	29.85	10.8	1.59	4.07	28.02
I_2-3 Irrigation	2.31	30.16	10.72	1.71	4.13	29.11
I_3-4 Irrigation	2.84	34.05	11.41	1.88	4.31	30.24
SEd (±)	0.191	0.32	0.261	0.032	0.042	0.453
C.D at 5%	-	0.514	-	0.052	0.067	0.726
Hydrogel (kg/ha)						
0 kg ha^{-1} Hydrogel	1.82	29.7	10.21	1.47	3.88	27.55
2 kg ha^{-1} Hydrogel	2.47	30.91	10.72	1.72	4.19	29.03
4 kg ha^{-1} Hydrogel	3.09	33.45	12	1.98	4.44	30.79
SEd (±)	0.156	0.526	0.439	0.041	0.041	0.375
C.D at 5%	0.339	1.146	-	0.09	0.09	0.817

7 DAS (Before thinning) 22 DAS

Spraying of neem oil Flowering and grain filling

CONCLUSION

Pearl millet needs a less amount of water as compared to rice or wheat. Application of hydrogel along with irrigation during critical stage of crop in pearl millets provides a better results as compared to only irrigated conditions. Hence for better growth and yield of pearl millet, application of 4 irrigation at different growth stages along with hydrogel 4 kg/ha considerable increased and found beneficial. Hydrogel breaks down to CO_2 and ammonia when comes in contact with sunlight leaving behind zero residue. Application of hydrogel with limited amount of irrigation available with farmers in different part of arid and semi-arid region of India can be helpful by increase yield of crop without any detrimental effect to soil.

FUTURE SCOPE

Further scope for experiment can be carried to see how different level of hydrogel reacts with different amount and sources of nutrient along with irrigation.

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