Research Article

Productivity and Water use Efficiency of Summer Pearlmillet (*Pennisetum glaucum* L.) Hybrids as Influenced by Irrigation Scheduling in Eastern Uttar Pradesh Plains

Shubham*, Thomas Abraham, Neha and Preeti choudhary

Department of Agronomy, Department of Agronomy, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh 211 007, India

Abstract

A field experiment was conducted during the *summer* season 2015 at the Crop Research Farm, Department of Agronomy, Allahabad School of Agriculture, SHIATS, Allahabad (U.P.) to conclude the response of *summer* pearlmillet hybrids to irrigation scheduling. The experiment consisted of four irrigation schedules, *i.e*., irrigation applied at 75, application of irrigation at 100 and application of irrigation at 125 mm CPE and crop Critical Growth Stages (Tillering, Ear head emergence and Flowering stage), and three hybrids, *viz*., Proagro 9444, Ganga Kaveri, and Pioneer 86M11 was laid out in split-plot design with three replications. The result revealed that application of irrigation at 100 mm CPE gave significantly maximum 3.04, 19.71 and 23.71% grain yield than irrigation schedule at 75 mm CPE, 125 mm CPE and Critical Growth Stages, respectively. Application of irrigation at 100 mm CPE recorded significantly higher yield 4.07 t/ha. Among the hybrids, increase in grain yield and straw yield was 11.17 and 14.71%, and 4.85 and 5.45% on hybrid Proagro 9444 over Ganga Kaveri and Pioneer 86M11, respectively. However, irrigation schedule at 100 mm CPE with hybrid Proagro 9444 had the highest net return (₹ 51842 ha^{-1}) and B:C ratio (2.81). Besides, irrigation schedule at Critical growth stages with hybrid Proagro 9444 had the highest water use efficiency.

Keywords: Cumulative pan evaporation, economics, hybrids, irrigation schedule, pearlmillet

***Correspondence**
Author: Shubham
Email: shubhamuttam023@gmail.com

Introduction

In India, pearlmillet is popularly known as *Bajra*, and it is the fifth most important cereal crop after rice, wheat, maize and sorghum. Millets have potentiality of contributing to increased food production, both in developing and developed countries (Sahu and Murty, 1975). It has the greatest potential of yield among all the millets. Annual planting area of the country under pearlmillet is 9.5 million hectares producing nearly 10.1 million tonnes of grains with productivity of 10.44 q ha^{-1} (GOI, 2011). The major producing states are Rajasthan (46%), Maharashtra (19%), Gujarat (11%), Uttar Pradesh (8%) and Haryana (6%), (Sonawane et al., 2010). Pearlmillet is used in flat breads (*roti*) or mixed up to 25% with wheat flour for use in yeast breads (Kachhadiya *et al*., 2010).

Patel et al., 1994 opined that for better results, both in terms of growth and yield attributes of pearlmillet, may be achieved with proper scheduling of irrigation. Several methods are available for ascertaining irrigation requirement of summer pearlmillet but climatological approach for scheduling irrigation showed wide acceptance. Parihar et al. (2005) have advocated the use of IW:CPE ratio for different crops.

The major problem of summer cultivation is water, which directly affects the growth and development since it is a basic input for increasing the crop production. Both excess and deficit of water, reduces the crop yield drastically. Water stress during the active crop growth stages results into cessation of growth as it influences the photosynthesis and other physiochemical processes and or death, by desiccation. In summer season the temperature increase to about 42^{o}C or more as a result the water requirement of the crop is more due to increase of evapotranspiration. Moisture stress leads to poor plant stand and reduced leaf area index, which results in poor grain yield and fodder yield as observed in many crops (Javed and Khalid, 2009). Non- judicial water use is also a cause of poor productivity in pearlmillet.

Agricultural productivity cannot be maintained without assured supply of moisture to the plant which is accomplished by irrigation. Irrigation at different critical crop growth stages of pearlmillet is very important and it plays a significant role in increasing the yield. Judicial application of water needs immediate attention and this is possible only by adopting scientific and advanced bases for irrigation water application to the crop. One of the

scientific methodologies is IW:CPE ratios (Irrigation Water and Cumulative Pan Evaporation ratio) approach for scheduling of irrigation.

In view of the aforestated facts, the present field experiment was carried out to study the response of summer pearlmillet (*Pennisetum glaucum* L.) hybrids to irrigation scheduling, at the Crop Research Farm, Department of Agronomy, Allahabad School of Agriculture, Faculty of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad during the *Summer* season of 2015.

Materials and Methods

The field trial was conducted during *Summer* season 2015 at Crop Research Farm, Department of Agronomy, Allahabad School of Agriculture, SHIATS, Allahabad (U. P.) which is located at 25^0 24' 42" N latitude, 81^0 50' 56" E longitude and 98 m altitude above the mean sea level. The soil was sandy loam in texture having 7.80 pH, 0.37% organic carbon, available P_2O_5 and K_2O of 9.0 and 302.0 kg ha^{-1}, respectively.

The experiment consisted of four irrigation schedules *i.e*., irrigation at 75, 100 and 125 mm CPE and crop Critical Growth Stages (Tillering, Ear head emergence and Flowering stage), and three hybrids *viz*. Proagro 9444, Ganga Kaveri, and Pioneer 86M11 was laid out in split-plot design with three replications. The field was pre irrigated before planting the field experiment. The plot size 3.0 m × 5.0 m was made with provision of buffer channel of 1.0 m wide between plots as well as replications. The depth of irrigation was fixed 5.0 cm in all treatments and so the crop was irrigated 7, 6 and 5 times at 75, 100 and 125 mm CPE, respectively. The pearlmillet hybrids, *viz*., Proagro 9444, Ganga Kaveri and Pioneer 86M11 were planted on 16^{th} May at planting geometry of 45 cm x 15 cm and harvested on 9^{th} June 2015. Fertilizer dose of 80:45:40 kg N:P:K ha^{-1} was applied to crop. Full dose of P and K and ½ dose Nitrogen were applied at sowing and remaining Nitrogen was top dressed at maximum tillering stage.

The growth attributes like plant height, number of tiller and dry weight were recorded of crop on randomly selected five hills from each treatments. The plant population, grain yield, straw yield were also recorded on basis of 1 m^2 area of the plot. The field water use efficiency (WUE) was estimated by dividing grain yield with total applied of water. The economics parameters like gross returns, net returns and benefit: cost ratio (B:C ratio) were calculated on the basis of prevailing prices of grain and straw.

Results and Discussion

Growth and yield attributes

Among the irrigation schedule CGS (Critical growth stages) had significant the highest value (33.83 g m^{-2} day^{-1}) of Crop Growth Rate (**Table 1**) which was 8.95% higher than lowest CGR (31.05 g m^{-2} day^{-1}) observed in irrigation (125 mm CPE). Among the hybrids, Ganga Kaveri recorded maximum value (32.88 g m^{-2} day^{-1}) of CGR though non significant. The increase soil moisture content due to irrigation helped the plants to absorb greater amount of water and nutrients from the soil which in turn accelerated CGR (Mondal et al., 2012).

Irrigation I_2 (100 mm CPE) had significant and highest number of tillers $hill^{-1}$ (2.84). However, irrigation I_1 (75 mm CPE) was statistically at par with I_2. Among the hybrids, Proagro 9444 produced significant and highest number of tillers (2.95). The higher IW:CPE ratio promoted sufficient moisture surrounding the root zone, thereby reducing moisture stress. This may have enabled better vegetative growth leading to higher number of productive tillers $hill^{-1}$ (Kachhadiya et al., 2010). These results corroborate the findings of Vyas et al. (1994).

Irrigation schedule had significant difference on the ear length. Irrigation I_2 (100 mm CPE) was recorded significantly higher value (29.85 cm) of ear length which was 7.37% higher than lowest value (27.80 cm) observed in I_0 (CGS). Among the hybrids, Proagro 9444 was significantly superior to other hybrids with the value of 29.47 cm of ear length of pearlmillet and it was 5.71% higher than the lowest ear length (27.88 cm), which was registered in Pioneer 86M11. The probable reason for increased length of ear might be due to inherent genetic ability, suitability and adaptability of which have resulted in to higher rate of photosynthesis as well as higher translocation of photosynthates from various plant organs to the development of ear length (Kumar *et al.*, 2015). These results are in conformity with those reported by Parihar et al. (2005) and Kalyani et al. (2012).

Irrigation had significant difference on the number of grains ear^{-1} of pearlmillet. Irrigation I_2 (100 mm CPE) recorded maximum number of grains ear^{-1} (2395.52), which was 17.02% higher than the lowest value (2047.04) observed in irrigation I_0 (CGS). However, irrigation I_1 (75 mm CPE) was found to be statistically on a par with I_2. Among the hybrids, hybrid H_1 (Proagro 9444) was significantly superior to other hybrids with the maximum number of grains ear^{-1} 2318.69 of pearlmillet and it was 9.21% higher than the lowest number of grains, which was registered in Pioneer 86M11. Continuous and favourable moisture supply helps in nutrient uptake by the crop (Patel et al., 2007). Similar results were reported by Kavita and Wahab (2000).

Table 1 Effect of different irrigation schedule and hybrids on growth, yield attributes, grain and straw yields and water use efficiency of pearlmillet in *summer* season

Treatment	Crop growth rate (g m^{-2} day^{-1})	Number of tillers $hill^{-1}$	Number of grains ear^{-1}	Ear length (cm)	Test weigh t (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Water use efficiency (kg ha^{-1} mm)
Irrigation schedule	33.83	2.53	2047.04	27.80	8.58	3.29	6.91	16.46
Critical growth stages								
75 mm CPE	33.49	2.64	2348.92	28.95	10.28	3.95	7.39	11.27
100 mm CPE	32.29	2.84	2395.52	29.85	10.29	4.07	7.34	13.56
125 mm CPE	31.05	2.42	2083.30	28.35	8.94	3.40	6.80	13.62
SEd±	0.80	0.10	37.17	0.25	0.25	0.23	0.10	0.90
CD (P=0.05)	1.95	0.25	90.96	0.61	0.62	0.55	0.23	2.20
CV (%)	5.16	8.44	3.33	1.85	5.62	13.01	2.78	13.88
Hybrids	32.63	2.95	2318.69	29.47	10.93	3.98	7.35	15.08
Proagro9444								
Ganga Kaveri	32.88	2.52	2214.25	28.86	9.17	3.58	7.01	13.33
Pioneer 86M11	32.49	2.36	2123.14	27.88	8.47	3.47	6.97	12.77
SEd±	0.28	0.13	24.04	0.21	0.44	0.11	0.13	0.48
CD (P=0.05)	NS	0.27	50.96	0.44	0.94	0.24	0.27	1.01
CV (%)	2.14	12.21	6.89	1.77	11.44	7.56	4.44	8.49

CPE: Cumulative Pan Evaporation, NS: Non significant

Irrigation had significant difference on test weight of pearlmillet. Irrigation I_2 (100 mm CPE) registered maximum value (10.29 g) of test weight which was 19.93% higher than lowest test weight (8.58 g) recorded in irrigation I_0 (CGS). However, Irrigation I_1 (75 mm CPE) was found statistically to be on a par with I_2 (100 mm CPE). Hybrids had significant influence on test weight of pearlmillet and the highest value (10.93 g) was observed in Proagro 9444 and it was 29.04% higher than lowest test weight (8.47 g), which was observed in Pioneer 86M11. The test weight may have improved with increase in irrigation of summer pearlmillet. Water is an essential component and acts as a carrier of food for the crop plants. Thus, water accelerates the process of photosynthesis, ultimately resulting into accumulation of more photosynthates, which might have helped in increasing the size and weight of the grains resulting higher test weight (Kachhadiya et al., 2010). These results corroborate the findings of Vyas *et al*. (1994).

Grain and straw yield

Irrigation had significant influence on grain yield (t ha^{-1}) of pearlmillet. Irrigation I_2 (100 mm CPE), recorded significantly higher value (4.07 t ha^{-1}) of grain yield, which was 23.71% higher than lowest grain yield (3.29 t ha^{-1}) observed in I_0 (Critical Growth Stages). However, Irrigation I_1 (75 mm CPE) was found to be on a par to I_2 (100 mm CPE). Among the hybrids treatment H_1 (Proagro 9444), recorded significantly higher value (3.98 t ha^{-1}) and it was found 14.69% higher than lowest grain yield (3.47 t ha^{-1}) observed in H_3 (Pioneer 86M11). The increase in seed yield might be due to increase in irrigation frequency and consumptive use because of increased ratio. Thus, there was progressive increase in seed yield due to favourable soil moisture condition and better availability of soil moisture at higher frequency of irrigation throughout the crop growth period, which remarkably stimulated yield attributes and finally seed yield (Kumar et al., 2015).

Irrigation showed significant difference on straw yield of pearlmillet. Irrigation I_1 (75 mm CPE), recorded significantly higher value (7.39 t ha^{-1}) of straw yield, which was 8.68% higher than lowest straw yield (6.80 t ha^{-1}) observed in I_3 (125 mm CPE). However, Irrigation I_2 (100 mm CPE) was found statistically to be on a par with I_1 (75 mm CPE). Among the hybrids treatment H_1 (Proagro 9444), recorded significantly higher value of 7.35 t ha^{-1} and it was found 5.45% higher than the lowest straw yield of 6.97 t ha^{-1} observed in H_3 (Pioneer 86M11). Availability of optimum soil moisture throughout the life cycle of the crop with 75 mm CPE, where more number of irrigations were given might have favoured the cell division, cell elongation, cell turgidity, better opening of stomata, transport of nutrients and finally increasing the partitioning of photosynthates to sink resulting in better growth potential (Tomar, 2001). The another probable reason was the superiority of Proagro 9444 over other hybrids might be due to more

assimilatory surface leading to higher dry matter production (Kalyani, 2012). Similar observations were also reported by Bhansali and Bhandari (2004).

Water use efficiency

Irrigation showed significant difference on WUE of pearlmillet. Irrigation I_0 (CGS) recorded significant and highest WUE (16.46 kg ha^{-1} mm), which was 46.05% higher than lowest WUE (11.27 kg ha^{-1} mm) as observed in I_1 (75 mm CPE). Among the hybrids, hybrid H_1 (Proagro 9444) was significantly superior to other hybrids with the highest WUE (15.08 kg ha^{-1} mm) of pearlmillet and it was 18.09% higher than the lowest WUE, which was registered in Pioneer 86M11. In higher moisture regimes more moisture is used for evaporation rather than for production, thereby reducing the water use efficiency by (Kumar et al., 2015). However, there was increased the WUE when less quantity of water was applied. This phenomenon was also observed by Prajapati et al. (2007) and Patel *et al*. (2005).

Conclusion

It may be concluded that amongst the irrigation schedule [100 mm CPE (Six irrigation)] in combination with hybrid Proagro 9444 has been found to be the best for obtaining the highest grain yield (4.25 t ha^{-1}) and benefit cost ratio (2.81) in Pearlmillet. Since the findings are based on the research done in one season, it may be repeated for confirmation.

References

[1] Bhansali, A.K., Bhandari, M.M., 2004. New cluster bean variety for arid and semiarid tract of the country. National symposium on arid legumes for sustainable agriculture and trade, held during 5-7 November 2001, at University of Agricultural Sciences, Bangalore, Karnataka 131 p.

[2] GOI. 2011. Economic survey. Govt. of India, New Delhi.

[3] Javed, A.T., Khalid, U., 2009. Regulated deficit irrigation scheduling of maize crop. Sarhad Journal of Agriculture 25(3): 441–50.

[4] Kachhadiya, S.P., Chovatia, P.K., Jadav, K.V., Tarpara, V.D., 2010. Growth and yield attributes of summer pearlmillet (Pennisetum glaucum L.) as influenced by irrigation, mulches and antitranspirant. International Journal of Plant Science 5 (2): 463-467.

[5] Kachhadiya, S.P., Chovatia, P.K., Jadav, K.V., Tarpara, V.D., 2010. Growth and yield attributes of summer pearlmillet (Pennisetum glaucum L.) as influenced by irrigation, mulches and antitranspirant. International Journal of Plant Science. 5 (2): 463-467.

[6] Kalyani, D.L., 2012. Performance of clusterbean [Cyamopsis tetragonploba (L.) Taub.] genotypes under varied time of sowing. Legume Res. 35: 154-158.

[7] Kavita, R., Wahab, K., 2000. Effect of irrigation and mulching practices on growth parameters and yield of greengram. Madras Agric. J. 88: 359-360.

[8] Kumar, M., Patel, H.K., Patel, C.N., Umale, A.A., Patel, J.J. 2015. Varietal response of summer clusterbean (Cymopsis tetragonoloba L.) to different irrigation scheduling (IW:CPE ratios) under middle Gujarat conditions. Eco. Env. & Cons. 21: 159-163.

[9] Mondal, C., Bandopadhyay, P., Alipatra, A., Banerjee, H., 2012. Performance of summer mungbean [Vigna radiata (L.) Wilezek] under different irrigation regimes and boron levels. Journal of Food Legumes 25(1): 37-40.

[10] Parihar, C.M., Kaushik, M.K. and Palsaniya, D.R. 2005. Effect of varieties, plant density and phosphorus levels on growth and yield of clusterbean (Cyamopsis tetragonoloba L.). Annals of Agril. Res. 26(1): 5-7.

[11] Parihar, C.M., Kaushik, M.K., Palsaniya, D.R., 2005. Effect of varieties, plant density and phosphorus levels on growth and yield of clusterbean (Cyamopsis tetragonoloba L.). Annals of Agril. Res. 26(1): 5-7.

[12] Patel, I.C., Patel, B.S., Patel, M.M., Patel, A.G., Tikka, S.B.S., 2005. Effect of varieties, levels of irrigation and dates of sowing on yield and monetory return of summer cowpea under North Gujarat condition. Indian J. Pulse Res. 18(2): 217-218.

[13] Patel, M.M., Patel, I.C., Patel, P.H., Patel, B.S., 2007. Effect of irrigation scheduling and fertilizer doses on growth and yield attributing characters and water expense efficiency of summer clusterbean [Cyamopsis tetragonploba (L.) Taub.]. GAU Res. J. 32: 15-18.

[14] Patel, P.T., Meisheri, T.G. and Mehta, H.M. 1994. Scheduling irrigation to summer pearlmillet using pan evaporation. GAU Res. J. 19: 1-4.

[15] Prajapati, M.N., Patel, J.J., Gedia, K.M., 2007. Influence of different irrigation schedules and growth regulators on summer greengram (Vigna radiata L.). Agronomy Digest (7): 23-24.
[16] Sahu, G., Murty, K.S., 1975. Influence of nitrogen on dry matter production, nitrogen uptake and yield in high yielding cultivars. Indian Journal of Plant Physiology 15: 115-120.
[17] Sonawane, P.D., Wadile, S.C., Girase, P.P., Chitodkar, S.S., Sonawane, D.A., 2010. Response of summer pearlmillet (Pennisetum glaucum L.) to depth and time of irrigation scheduling. International Journal of Agricultural Sciences 6(1): 283-285.
[18] Tomar, S.S., 2001. Response of frenchbean (Phaseolus vulgaris) to irrigation schedule and phosphorus level in vertisols. Indian Journal of Agronomy 46: 496-499.
[19] Vyas, S.H., Patel, J.C., Patel, B.S., Khanpara, V.D., 1994. Influence of irrigation and N, P fertilization on yield consumptive use of water, water use efficiency and nutrient uptake by summer pearlmillet. Gujarat Agric. Univ. J. 19(2): 113-116.

Publication History
Received 30th May 2018
Revised 04th July 2018
Accepted 08th July 2018
Online 30th July 2018