Influence of rainfall and land configuration on pearl millet grown under irrigated conditions with saline water

Abstract

Field experiment was conducted in Eastern Block Farm of Tamil Nadu Agricultural University, Coimbatore to evalute the effect of land configuration and rainfall on growth and yield of pearl millet under irrigated conditions with saline water. The study was carried out in split plot design with three main plots (flatbed (M_1), ridges and furrows (M_2) and raised bed paired row planting (M_3)) and four subplot treatments (direct sowing (S_1), 10 Day Old Seedlings (DOS) (S_2), 15 DOS (modified dapog) (S_3) and 20 DOS (S_4)) which was replicated thrice. Water availability is acritical factor in deciding the length of the growing period while water quality significantly influencescrop growth and yield.Consequently, rainfall received during the growing period affects plant height, Leaf Area Index(LAI), effective tillers and yield. The cumulative rainfall received 208 mm in 22 days and with 10 rainy days during the cropgrowth period.During, 40 to 60 Days After Sowing/Planting (DAS/P) the crop received higher rainfall and wascorrelatingwith the Crop Growth Rate during this period. Among main plot treatments, ridges and furrows (M_2) recorded higher plant height (173 cm), effective tillers (2.6) and Dry Matter Production (DMP) (9222 kg ha^{-1}) at harvest.Grain and stover yieldswere also higher in ridges and furrows (M_2) (3315 and 6124, respectively) which was statistically on par with raised bed paired row planting (M_3) (3314 and 6125, respectively).

Keywords: Raised bed sowing, ridges and furrows, salinity, rainfall, Crop Growth Rate

Introduction

Pearl millet (*Pennisetum glaucum*) is the most extensively cultivated millet. Its resilience to harsh growing conditions, such as drought, poor soil fertility, and high temperature, allows it to thrive in regions where other cereal crops like maize (*Zea mays*) or wheat (*Triticum aestivum*) would fail. The majority of pearl millet production is concentrated in developing countries, which account for over 95% of global production and acreage (Basavaraj *et al.*, 2010). India stands as one of the top millet producers globally, with pearl millet contributing to approximately two-thirds of the nation's total millet output (Singh *et al,* 2022). The area, production and productivity of India, in 2022-2023 accounts for about 6.84 million hectares, 9.7 million tonnes, 1430 kg ha^{-1}. Rajasthan accounts for 44 % of pearl millet produced in India (India stat, 2023).

Generally, crop growth and development depend on many factors such as the type of soil, irrigation water properties, seeds, and climatic factors like temperature, relative humidity etc. In those factors, irrigation is essential in maintaining yields, mainly in arid regions (Nascimento, 2020). Water is essential for plant growth and development by transporting vitamins, nutrients and other necessary elements from the soil to the plant (Patel *et al.*,2022). Irrigation management as well as irrigation water quality are equally important for successful crop production (Malash*et al.*, 2005). The main parameters to assess water quality include pH, Electrical Conductivity (EC) and Total Dissolved Salts (TDS). High-quality water can improve seedling growth and yields, whereas poor water quality can slow the growth rates and reduce yields (Chin, 1976).

India is facing a serious problem of shortage of natural assets particularly, water (Gorde, 2013). Due to this, the use of saline water for irrigation is increasing (Prashanthi *et al.*, 2020) where salts are dissolved in water (Bauder *et al.*, 2007). Guy (2013), stated that irrigation water with excess salinity than the threshold of the crop then yield reduction occurs.As salinity increases the osmotic potential of root zoneincreases, reducing the water availability to plants (Stewart, 2020). To improve the growth and yield of the crop and reduce the effect of salinity on crop, there is a need to improve agronomic practices in the field (Prashanthi *et al.*, 2020).

Hence, a study was formulated to study the influence of rainfall and land configuration on pearl millet grown under irrigated conditions with saline water.

Materials and methods

The experiment was conducted at Eastern Block Farm of Department of Agronomy during summer, 2024 at Tamil Nadu Agricultural University, Coimbatore. Pearl millet hybrid COH 10 was used. The experimental site is located in the Western Agro-Climatic Zone of Tamil Nadu, with the co-ordinates of 11°01’00.9” N Latitude, 76° 56’03.9” E Longitude and at an altitude of 426.8 meters above Mean Sea Level. The mean maximum and minimum mean temperature recorded were 34.8°C and 24.8°C, respectively. Wind speed was 5.65 km hr^{-1}. A total rainfall of 208 mm was received during crop growing period in 22 days in 10 rainy days.Relative humidity of 81% at 07.22 hr and 49% at 14.22 hr were documented.Mean sunshine hours and solar radiation were7.0 hr. and 351.6 $Cal/cm^2/day$, respectively. The mean evaporation recorded was 6.5 mm. The data on weather parameters that prevailed during the cropping period (April to June) are presented in Figure 1. The pH and EC of irrigation water were 8.03 (slightly alkaline) and 5.2 (moderately saline), respectively.

In this field study, the split-plot design was replicated thrice. Main plot with three land configurations (M_1- flatbed, M_2- ridges and furrow and M_3- raised bed paired row planting). and subplots with four levels of sowing (S_1-direct sowing, S_2-10 DOS, S_3-15 days old dapog seedlings and S_4-20 DOS) was followed. The dapog nursery bed was prepared by spreading a polythene sheet of 50-60 gauge on top of the raised bed. Perforations of 1-2 mm diameter were made to drain the excess water from the seedbed. Over the plastic sheet, a mixture of soil (35kg), well-decomposed FYM (10 kg) and vermicompost (5 kg) (70:20:10) was thoroughly mixed and was spread to a height of 5 cm and properly levelled for uniform distribution of water. Pre-germinated seeds were broadcasted gently without damaging the radicle. For different establishment methods, line sowing of seeds was done along with transplanting 10, 15 and 20 DOS. Normal spacing of 45 cm × 15 cm and paired row spacing of 60/30 cm × 15 cm were adopted.

Fertilisation, weeding, irrigation and pest management were done uniformly in all the treatment plots to avoid local control. The five plants in each plot were selected randomly. Selected plants were tagged and subsequently used for recording growth and yield parameters by adopting standard procedures. For calculating grain, stover and biological yield, crop from net plots was selected. Data obtained were statistically analysed in R software (CD at P=0.05) to determine the significant difference between the average data of treatments.

Results and Discussion

The establishment parameters of pearl millet in various land configurations were significantly different. Establishment percentage and initial plant population ha^{-1}were observed higherin ridges and furrows (M_2) (87.1 and 129115, respectively) which was significantly on par with paired row raised bed planting (M_3) (81.5 and 120713, respectively). The lower establishment percentage and initial plant population $ha^{-1}$was recorded in flatbed (M_1) (77.6 and 114969, respectively). The results were in conformity with Thakare *et al*., 2019. Higher establishment and population might be due to the raised sowing zone in ridges and furrows (M_2) and raised bed paired row planting (M_3) which reduced the effect of salinity in irrigation water (Jat *et al.*, 2012).

Plant height and chlorophyll content at harvest was not significantly influenced by the land configurations. Higher plant height (cm) (at harvest) wasregistered in ridges and furrows (M_2) (173)while the lowest among treatments was observed in flatbed (M_1) (160.8). Chlorophyll content at harvest was higher in raised bed paired row planting (M_3) (74.0)and lower was recorded in flatbed(M_1) (72.2). The effect of different land configurations was significant on LAI. LAI at harvest was higher in raised bed paired row planting (M_3)(9.89) which was comparable toridges and furrows (M_2) (9.40). The lowest LAI was recorded in flatbed (M_1) (8.52). This might be due to high salt stress in flatbed and a reduced effect of salt was observed in ridges and furrows and raised bed paired row planting (Kang *et al.,* 2010) (Table 1).

CGR was significantly affected by land configuration and rainfall indicating a correlation between the two factors. From 0-20 DAS/P, higher CGR was recorded in ridges and furrows (M_2) (0.004) while the lowest was observed in flatbed (M_1) (0.003). From 20-40 DAS/P, higher CGR was registered in ridges and furrows (M_2) (14.7) and the next best treatment was raised bed paired row planting (M_3) (11). Lowest CGR for this period was found in flatbed (M_1) (8.6). During 40-60 DAS/P, ridges and furrows (M_2) (17.1) recorded higher CGR whereas lowest CGR was observed in flatbed (M_1) (11.1) (Fig. 2). Higher CGR from 40-60 DAS/P, might be attributed to rainfall received in that period. Similar results were obtained byOkorogbona*et al.,*2018, showing that crop irrigated with rainwater performed better than those with groundwater.

Yield attributes and yield were significantly affected by land configurations. Effective tillers were registered higher in ridges and furrows(M_2) and raised bed paired row planting (M_3) (2.6)and lowest in flatbed (M_1) (2.3). Higher grain yield was observed in ridges and furrows (M_2) (3315) and raised bed paired row planting (M_3) (3315) and poor yield was obtained from flatbed (M_1) (2755 and 5054, respectively). Stover yield was recorded high in raised bed paired row planting (M_3) (6125) which was comparable to ridges and furrows (M_2) (6124) and the lowest was observed in flatbed (M_1) (5492)(Table 1).Enhanced performance of ridges and furrows and raised bed paired row planting might be linked to better water management, reduced salt stress and improved soil structure which led to higher plant growth and production (Ming chen*et al.,* 2009).

Initial establishment was higher in 15 and 20 DOS (S_4). Among subplots, higher plant height, LAI, grain yield and stover yield were recorded in direct sowing than in transplanted plots. This might be due to the uninterrupted growth cycle and extended vegetative growth.

Conclusion

It can be concluded that sowing in raised beds such as ridges and furrows and raised bed paired row planting effectively mitigate the salinity effects of irrigation water. These land configurations resulted in higher plant height, and LAI and DMPcompared to flatbed. However, increased rainfall during the crop growing period furtherenhanced CGR.Yield parameters such aseffective tillers were significantly higher in sowing in raised beds than flatbed as the salts accumulate on top of the raised side of the beds. Notably, the grain and stover yield wasincreasedupto 10% in ridges and furrows and raised bed paired row planting over flatbed. These findings show the importance of a raised sowing zone and optimal rainfall in enhancing crop growth and yield under saline water irrigation conditions.

Table 1. Effect of saline irrigation water on establishment percentage at initial plant population (no.) at 10 DAS/P, plant height (cm) (at harvest), chlorophyll content (at harvest), LAI (at harvest), effective tillers (at harvest), grain yield (kg ha^{-1}) and stover yield (kg ha^{-1})

Treatment	Establishment percentage (%)	Initial plant population ha^{-1} (no.)	Plant height (cm) (at harvest)	Chlorophyll content (at harvest)	LAI (at harvest)	Effective tillers(at harvest)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
M_1	77.6	114969	160.8	72.2	8.52	2.3	3005.6	5492.7
M_2	87.1	129115	173.4	72.7	9.40	2.6	3315.1	6124.5
M_3	81.5	120713	172.7	74.0	9.89	2.6	3314.7	6125.0
SEd	**2.2**	**3222**	**5.3**	**2.3**	**0.29**	**0.1**	**75.5**	**191.3**
CD	**6.0**	**8947**	**NS**	**NS**	**0.82**	**0.2**	**209.6**	**531.1**
S_1	81.9	121399	191.8	70.1	9.58	2.5	3430.9	6227.4
S_2	73.1	108367	172.7	68.9	9.73	2.4	3177.0	5891.9
S_3	86.6	128257	155.2	75.1	8.77	2.5	3092.0	5723.5
S_4	86.1	127571	156.2	77.9	9.02	2.6	3147.3	5813.5
SEd	**1.4**	**2048**	**5.1**	**2.4**	**0.25**	**0.1**	**120.3**	**268.1**
CD	**2.9**	**4302**	**10.7**	**5.1**	**0.54**	**NS**	**250.7**	**NS**
Interaction								
M × S								
SEd	**3.0**	**4452**	**9.3**	**4.3**	**0.48**	**0.1**	**194.2**	**445.3**
CD	**6.3**	**9354**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S × M								
SEd	**2.4**	**3547**	**8.8**	**4.2**	**0.44**	**0.1**	**206.6**	**464.3**
CD	**5.0**	**7452**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

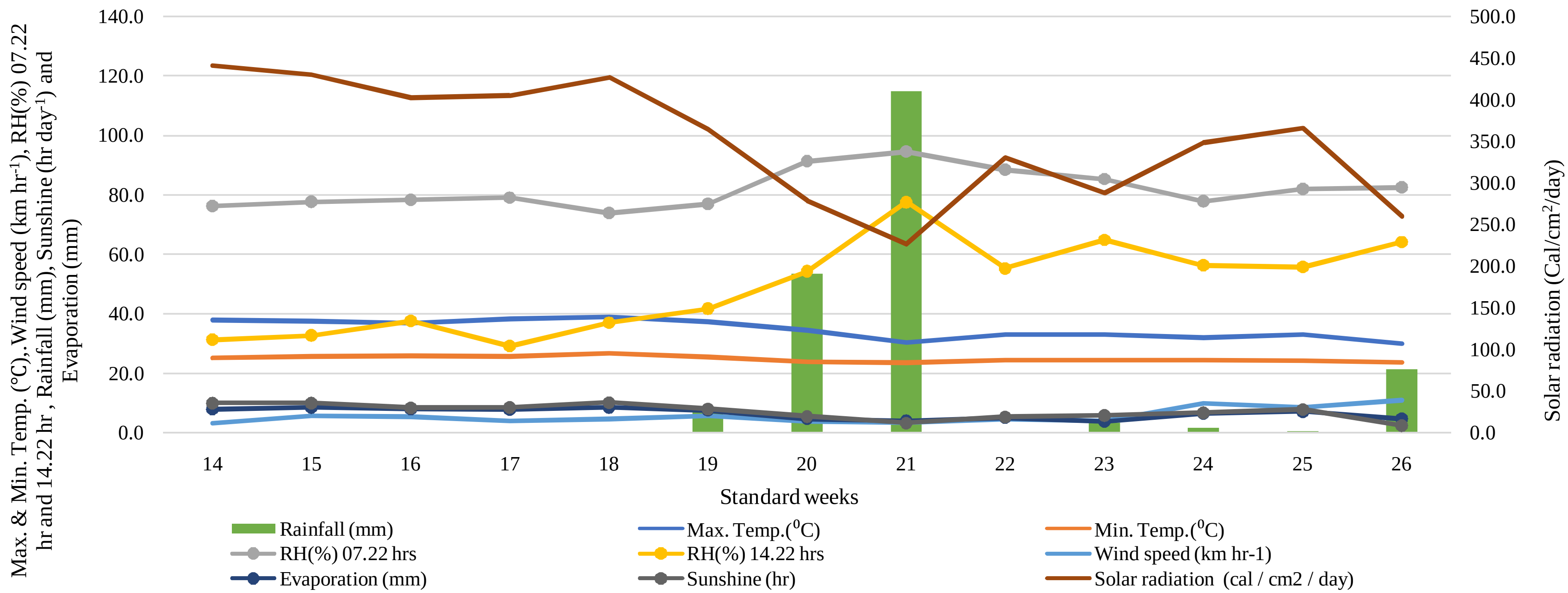

Fig. 1. Weather parameters prevailed during the cropping period of Pearl Millet Hybrid COH 10 during Chithirai pattam, Summer (April- June), 2024

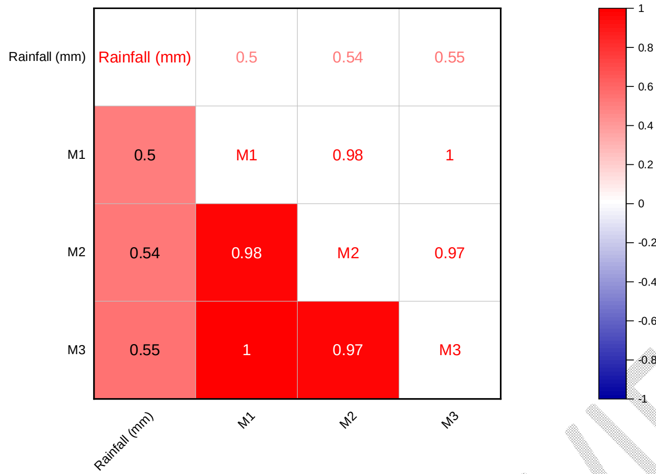

Fig. 2. Correlation between rainfall and CGR in different land configurations (M_1- Flatbed, M_2- Ridges and furrows, M_3- Raised bed paired row planting)

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