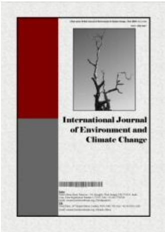

International Journal of Environment and Climate Change

12(11): 893-898, 2022; Article no.IJECC.90080
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Microclimate Modification on Growth and Yield of Pearl Millet

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i1131055

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/90080

Original Research Article

Received 22 May 2022
Accepted 27 July 2022
Published 29 July 2022

ABSTRACT

Field experiment was conducted at Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore during the summer 2022 to study the effect of microclimate modification on growth and yield of pearl millet (CO 10). Experiment was laid in Factorized Random Block Design (FRBD) with three factors *viz*., three levels of land configurations, two levels of mulching and two levels of water stress conditions. Totally 12 treatment combinations that replicated thrice. The results revealed that the paired row with intercropping approach produced the best growth parameters, such as plant height, leaf area index, dry matter accumulation and yield followed by paired row sowing and normal sowing due to higher solar radiation interception and utilization. In terms of irrigation level, maximum growth and yield parameters were observed with 0.75 IW/CPE ratio as compared to 0.5 IW/CPE due to lesser canopy temperature. In respect of mulch treatments, the mulched plots under both the levels of irrigation and at different land configurations had higher DMP and yield by reducing soil moisture stress, lowering the canopy temperature and higher PAR use efficiency It is concluded that the microclimatic alterations through changes in land configuration, irrigation and mulch application showed an effective adaptive strategy to mitigate adverse weather susceptibility and climatic risks in field crops.

Keywords: Irrigation; land configuration; microclimate; mulching; yield.

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1. INTRODUCTION

Agriculture is still prime sector of employment and economy of India. Unpredictability and variations in the climate have the most impact on agriculture. It has become increasingly vulnerable to climatic threats as a result of significant variability in recent years, as well as an increase in the frequency and intensity of extreme weather incidents [1]. These climate variability will likely to reduce crop production, by modifying the crop microclimate it can be made more favourable for sustaining the yield and productivity [2]. To alleviate the adverse impacts of climate change, earlier studies suggested that appropriate land configurations, optimal irrigation requirements and mulching to conserve soil moisture under water stress during the summer season.

Pearl millet is primarily suitable for semiarid climates due to its efficient use of soil moisture and higher level of heat tolerance than sorghum and maize. Enhancement of agricultural production could be achieved by better management options are required to utilise the available resources. This can be accomplished by intercropping, which is a beneficial method for enhancing overall production per unit area of land per unit time by growing more than one crop in the same field while modifying crop geometry. The microclimate can also be modified by intercropping practices to minimize intensity of light, air temperature, desiccating wind, and other environmental factors. Pearl millet growth, yield and nutrient uptake were significantly higher in modified planting patterns such as ridge and furrow, paired row and paired rows + intercrop, than in the uniform row system.

Water shortage is creating a barrier to food production for the arid and semi-arid countries. As a result, water-saving methods that have the potential to increase water production in water-stressed areas. Mulching is an efficient method of controlling the crop-growing environment have positive benefits on soil-water conservation, reduces evapotranspiration by decreasing evaporation, maintenance of canopy temperature at the grain-filling stage which save the crop from the terminal heat effects [3]. Irrigation scheduling based on pan evaporation data is expected to increase agricultural yield by at least 15-20 per cent. In this context, a field experiment was conducted at Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore during the summer 2022 to study the effect of microclimate modification on growth and yield of pearl millet (CO 10) and the results are presented in this paper.

2. MATERIALS AND METHODS

Present study was conducted as field experiment during summer season (Feb. – May 2022) in the eastern block farm, Tamil Nadu Agricultural University (TNAU), Coimbatore. The experiment was laid out in Factorized Random Block Design (FRBD). Experiment was laid in Factorized Random Block Design (FRBD) with three factors *viz*., three levels of land configurations, two levels of mulching and two levels of irrigation conditions. The three levels of land configurations are normal row sowing (L_1), Paired row sowing (L_2) and Paired row sowing with green gram intercropping (L_3), two levels of mulching are with mulching (M_1) and without mulching ($M_{2)}$ and two levels of irrigation are IW/CPE - 0.75 (I_1) and IW/CPE - 0.5 (I_2). The daily pan evaporation data were computed using open pan evaporimeter located at the TNAU meteorological observatory. A fixed depth of 50 mm irrigation water was applied as surface flooding to each treatment based on IW/CPE ratio of 0.5 and 0.75 and the quantity of irrigation was controlled by 7.5 cm head Parshall flume. Crop was fertilized as per TNAU's blanket recommendation 75:30:30 N, P_2O_5, K_2O kgha^{-1}. The statistical analysis of data was done using analysis of variance (ANOVA) technique for Factorized Random Block Design at 0.05 probability level.

Microclimatic parameters such as canopy temperature, soil temperature and soil moisture was monitored at fortnightly interval during 10.00 and 14.00 hours. A digital soil thermometer (Model KUSAM MECO-936) with a probe inserted at 15 cm depth of soil to record soil temperature (°C). A digital soil moisture instrument (Model HH2 Delta Theta probe ML2x) was used to measure the soil moisture and expressed in percentage. The canopy temperature (°C) was measured using an infrared thermometer (Foopro, Raytek, USA). The angle of the infrared thermometer for the measurement was set to 45° horizontally and the results were recorded. Photosynthetically Active Radiation (PAR) was measured at fortnightly interval between 1130 hrs and 1200 hrs using an EMCON Line quantum sensor by placing it along the planting rows. The light interception was calculated using the following formula and expressed in percentage.

$$\text{PAR interception (\%)} = \frac{\text{PAR (I)} - \text{PAR (T)} - \text{PAR (R)}}{\text{PAR (I)}} \times 100$$

Where, PAR (I) = Total PAR incoming above the canopy (W m^{-2}),
PAR (T)= PAR transmitted to ground (W m^{-2})
PAR (R)= PAR reflected from the canopy (W m^{-2})

3. RESULTS AND DISCUSSION

Microclimate modification on the canopy temperature, PAR and their impact on the Dry Mater Production (DMP) and grain yield are presented here and discussed. The canopy temperature and PAR of flowering stage (60 DAS) alone presented here while the other stages (30, 45 and 75 DAS) had very similar trend.

3.1 Microclimate Modification and Canopy Temperature

Effect of microclimate modification on the Canopy Temperature (CT) during 10.00 and 14.00 hours at flowering stage (60 DAS) were depicted in the Fig. 1. The canopy temperature was ranged between 29.3°C and 32.2°C during 10.00 hours, whereas it was between 33°C and 35.7°C during 14 hours. Among the land configuration, maximum CT was observed in paired row followed by the normal planting and least in paired row with intercropping. The mulch applied treatments had significantly lesser canopy temperature than the without mulch applied plots. Between the irrigation levels, the 0.75 IW/CPE had significantly lesser CT than 0.5 IW/CPE treatments. Due to appropriate moisture availability under 100 mm CPE irrigation regime, the canopy temperature was much lower while inadequate moisture condition under 150 mm CPE irrigation regime, the canopy temperature was higher [4]. The application of irrigation and preserving moisture through mulching reduced the canopy temperature compared to bare soil and moisture stressed plants. Similarly intercropping in paired row reduced the canopy temperature.

3.2 Microclimate Modification and Light Interception (LI)

Effect of microclimate modification on the Light Interception (LI) at different stages were presented in the Fig. 2. The light interception was ranged between 58.8 to 69.5 percent at panicle initiation stage whereas it was between 76.2 to 87.5 percent at flowering stage and between 67.4 to 80.2 percent at milking stage. Among the land configuration, maximum light interception was observed in paired row with intercropping followed paired row planting and least in normal row planting. Maximum interception was observed during the flowering stage with maximum foliage cover by the crop canopy. Even though sole cropping had a high PAR interception rate, the pearl millet in an intercropping system pattern would have converted the PAR more effectively to biomass [5]. Better crop growth and canopy expansion were encouraged by appropriate irrigation at 0.75 IW/CPE, which intercepted more PAR than canopy grown with insufficient irrigation at 0.5 IW/CPE. Crop growth was reduced by water stress, which significantly reduced intercepted PAR [6]. In rice straw residue plots, PAR interception was observed as higher in wheat crop [7].

3.3 Microclimate Modification and DMP

Effect of microclimate modification on the Dry Matter Production (DMP) at different stages were presented in the Fig. 3. Dry Matter Production was ranged between 550 to 771 $kgha^{-1}$ at panicle initiation stage whereas it was between 2777 to 3764 $kgha^{-1}$ at flowering stage and between 4425 to 6009 $kgha^{-1}$ at milking stage.

Among the land configuration, maximum dry matter production was observed in paired row with intercropping followed normal row planting and least in paired row planting. The enhanced DMP could be attributed to component crops capacity to maximise resource consumption due to a distinct rooting pattern for resource usage, resulting in less competition [8]. Improved growth in terms of dry matter accumulation at different stages was attained with higher IW/CPE of 0.75 coupled with mulching and lower in 0.5 IW/CPE. Least amount of irrigation application, resulting in lower plant height, leaf area, and nutrient uptake, which in turn reduced photosynthetic activity, resulting in lower dry matter production [9].

3.4 Microclimate Modification and Grain Yield

Effect of microclimatic modification on grain yield were furnished in Fig. 3. Across all combination of planting methods, mulching and irrigation

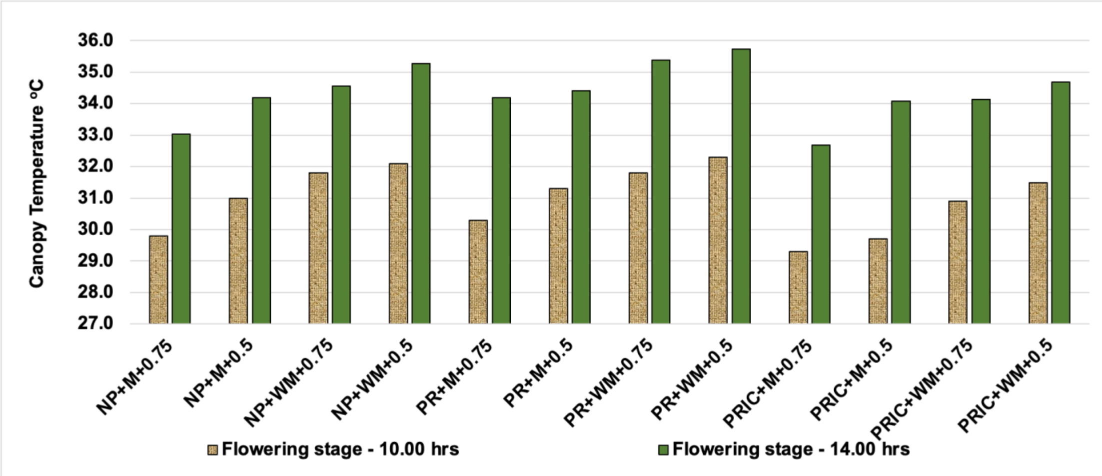

Fig. 1. Influence of canopy temperature on microclimatic modification at flowering stage

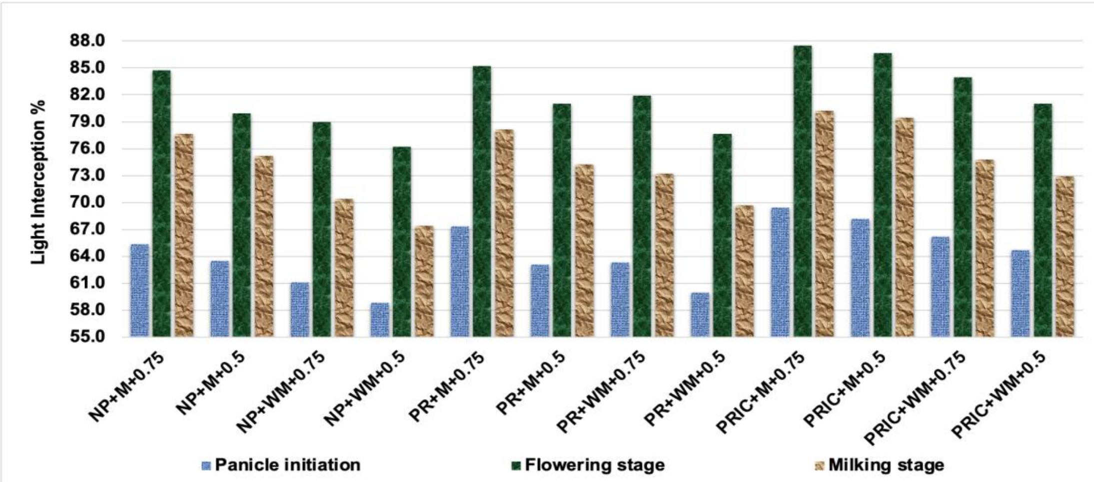

Fig. 2. Effect of light interception on microclimatic modification at different stages

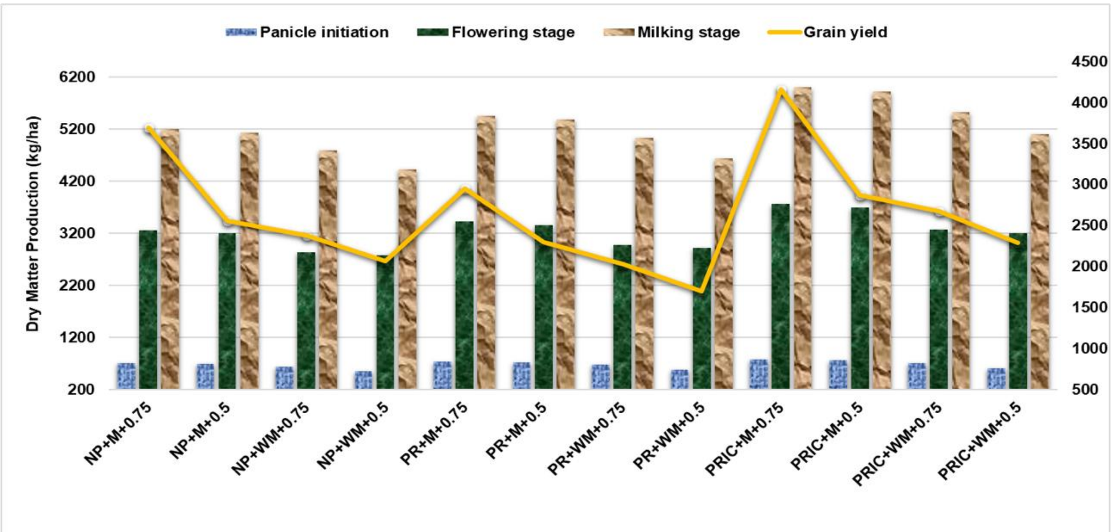

Fig. 3. Effect of dry matter production and grain yield on microclimatic modification

regimes, grain yield ranged from 1700 to 4158 kg ha^{-1}, being the highest in paired row with intercropping followed by normal planting and the lowest in paired row planting. With comparable growth and output, the mulch application showed considerable water-saving potential under water stress conditions in pearl millet compared to without mulching. The increased grain yield in 0.75 IW/CPE was due to increased soil moisture in associate with mulching accelerated the nutrients uptake, which helped the plant to put optimum growth. Poor moisture supplies during the 0.5 IW/CPE ratio decreased the yield attributes and led to a poor yield of grain and stover [10]. Mulched plots produced greater yields and improved crop development, which they attribute to soil moisture conservation and temperature reduction [11].

4. CONCLUSION

The study acknowledged the fact that warming scenarios could adversely influence the growth and performance of pearl millet in both semi-arid and arid agro climatic conditions. Intercropping legumes decrease soil temperature, accelerate foliage and canopy cover of the soil which ensure the favourable growth and yield of pearl millet. This enhance radiation interception and subsequent conversion into biomass. Mulches prevent the water loss from soil evaporation which is very helpful during the summer season. These findings had implications with respect to microclimate modification were paired rows of pearl millet with intercropping by scheduling 0.75 IW/CPE irrigation regime with mulching, creates a favourable environment for the development and yield qualities of summer pearl millet under water stress. It is concluded that the microclimatic alterations through changes in land configuration, irrigation and mulch application showed an effective adaptive strategy to mitigate adverse weather susceptibility and climatic risks in field crops.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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