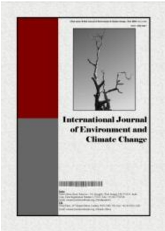


International Journal of Environment and Climate Change

11(10): 38-44, 2021; Article no.IJECC.76093
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Influence of Light Parameters on Photosynthetic Rate of Sorghum Based Intercropping System

S. Divya Dharshini[1], SP. Ramanathan[1*], S. Kokilavani[1] and M. Djanaguiraman[2]

[1]Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India.
[2]Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India.

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/2021/v11i1030490
Editor(s):
(1) Dr. Fang Xiang, University of International and Business Economics, China.
Reviewers:
(1) Mihai Berca, UASVM of Bucharest, Romania.
(2) Sviatoslav Pavlyshyn, Uman National University of Horticulture, Ukraine.
Complete Peer review History: https://www.sdiarticle4.com/review-history/76093

Original Research Article

Received 09 August 2021
Accepted 18 October 2021
Published 22 October 2021

ABSTRACT

Selecting the appropriate row proportion in the intercropping system is required for the effective harnessing of solar radiation. In Semi-arid areas, Sorghum based intercropping is commonly adopted by the farmers for effective utilization of the available resources. The treatments consisted of T_1-Sorghum Sole crop (SS), T_2-2rows of Sorghum+2rows of Cowpea (2S:2C), T_3-2rows of Sorghum+1row of Cowpea (2S:1C), T_4-2rows of Sorghum+2rows of Greengram (2S:2G), T_5-2rows of Sorghum+1rows of Greengram (2S:1G), T_6-2rows of Sorghum+2rows of Lablab (2S:2L), T_7-2rows of Sorghum+1rows of Lablab (2S:1L). The results of the study showed that sorghum under 2:1 pattern had enhanced LAI, Radiation absorption efficiency which resulted in a high photosynthetic rate. The intercrops under 2:2 pattern were suffered from shading of sorghum than 2:1 pattern which affected the photosynthetic rate of intercrops under 2:2 pattern. Hence, planting sorghum under 2:1 pattern with Lablab will be the ideal row ratio to harness maximum sunlight.

Keywords: Sorghum based intercropping system; PPFD; photosynthetic rate; light absorption efficiency.

**Corresponding author: E-mail: sorna_ramu@hotmail.com;*

DEFINITIONS, ACRONYMS, ABBREVIATIONS

DAS : Days After Sowing
PPFD : Photosynthetic Photon Flux Density
PS : Photosynthetic Rate

1. INTRODUCTION

Intercropping Sorghum with legumes is a popular practice in arid and semi arid regions of India. It has emerged as a strategy for efficient utilization of resources. In intercropping, two crops were incorporated in the same unit of land which will partially overlap in the growing period. Both intra-specific and inter-specific competition exists in the intercropping system [1]. The competition for light is one of the common inter-specific above-ground competitions [2]. Light plays a predominant role in determining crop growth and yield. In intercropping, the tall crops alter the amount of light received by the intercrops and in turn, short crops may suffer from shading [3]. The change in irradiance influences crop growth, morphology and negatively affects crop physiology [4,5]. The process of photosynthesis is primarily driven by light. The PAR intensity determines the photosynthetic rate of crops and the photosynthetic rate is strongly interlinked with crop productivity. Change in the light parameters can alter the photosynthetic rate of crops. [6]

The row proportion of intercropping can change the microclimate, especially the light environment. Selecting the optimum row proportion can reduce the mutual shading of adjacent crops and can enhance the crop performance [7]

Hence, no study has been conducted on study of the influence of light parameters, shading on the photosynthetic rate of sorghum legume-based intercropping system. This study will elucidate the effect of light parameters and shading on the photosynthetic rate of the sorghum legume intercropping system and the selection of optimum row proportion to reduce the negative effects of shading.

2. MATERIALS AND METHODS

The field experiment was carried on Field No.37 Eastern Block of Tamil Nadu Agricultural University during Summer 2021. Geographically, the site is located at 11.0° N, 76.9°E falls under the western zone of Tamil Nadu with an annual rainfall of 673 mm. The experiment was laid out in Randomized Block Design. The soil of the experimental field was heavy black clay soil with EC 0.13. The treatments of the study were T_1-Sorghum Sole crop (SS), T_2-2rows of Sorghum+2rows of Cowpea (2S:2C), T_3-2rows of Sorghum+1row of Cowpea (2S:1C), T_4-2rows of Sorghum+2rows of Greengram (2S:2G), T_5-2rows of Sorghum+1rows of Greengram (2S:1G), T_6-2rows of Sorghum+2rows of Lablab (2S:2L), T_7-2rows of Sorghum+1rows of Lablab (2S:1L). The experiment was laid out in Randomized Block Design and the treatments were replicated thrice. The intercropping system was laid in addictive series.

2.1 Sowing

The base crop is sorghum (*Sorghum bicolor*) and intercrops viz., Cowpea, Greengram, Lablab were sown. The crop management practices were done as per recommendation. The plant density maintained in sole sorghum (T_1) was 16 plants m^{-2}, whereas in the 2:1 (T_3, T_5, T_7) and 2:2 (T_2, T_4, T_6) pattern were 20 plants m^{-2} and 22 plants m^{-2} respectively. The seeds were sown by hand in the sides of ridges at depth of 5cm. For 2:1 row proportion, the paired row of sorghum was sown with the spacing of 30cm followed by pulses row at 30cm apart from sorghum rows. For 2:2 row proportion, the paired row of sorghum was sown with the spacing of 30cm followed by pulses row at 15 cm apart from sorghum. The second row of pulses was sown 30 cm apart from the first pulse line.

2.2 Experimental Measurements

2.2.1 Leaf area index

LAI is an effective method to evaluate the light absorption and photosynthetic rate of crops [8]. The LAI of sorghum and intercrops were measured at 30, 45, 60 DAS using the following equation

$$\mathrm{LAI} = \frac{\text{Leaf Area}}{\text{Ground Area}}$$

2.2.2 PAR measurement

The amount of PAR falling on the canopy was measured using Line Quantum sensor EMCON Line quantum sensor. It measured PAR in terms of PPFD. The PAR was measured at the top (I_0) and bottom (I) of the canopy [9]. The readings were taken at 30, 45, 60 DAS between 1000h - 1400 h IST only during bright sunshine hours.

2.2.3 Photosynthetic rate

The photosynthetic rate of component crops was measured using LI-6400 portable Photosynthetic system (PPS) at 30, 45, and 60 DAS only during bright sunshine hours.

2.2.4 Light absorption efficiency

The amount of light absorbed by the sorghum was calculated by using the following formula [10]

$$\mathrm{LAE}(\%) = \frac{\text{Light at top of canopy} - \text{Light at bottom of canopy}}{\text{Light at top of canopy}} \times 100$$

3. RESULTS AND DISCUSSION

3.1 Leaf Area Index

There was a significant difference in the LAI of sorghum under different planting patterns (Fig. 1). The sorghum in T_1 registered the lowest LAI whereas the LAI of sorghum under T_7 was the highest at 30, 45, and 60 DAS. This was due to the change in crop geometry in the sole and intercropping systems. These results were agreed well with the findings of [11]. The increase in LAI under 2:1 pattern was due to the favorable condition created by intercrops [12]. The high plant density under 2:2 pattern exhibited competition between component crops for resources that reduced the LAI.

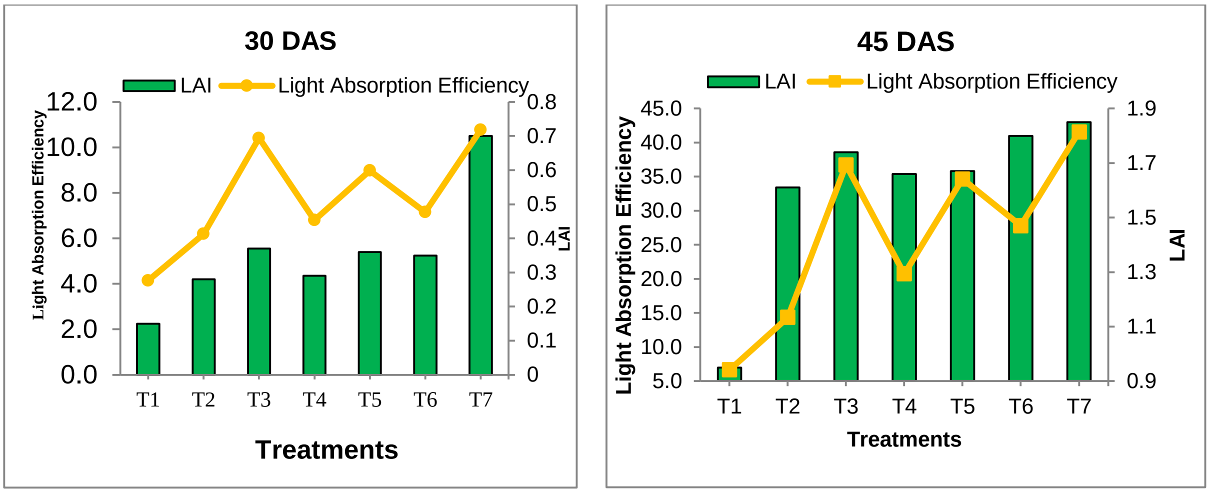
3.2 Light Absorption Efficiency

There was a significant difference in the amount of light absorbed by the sorghum under different planting patterns (Fig. 1). The sorghum under T_7 absorbed a good amount of light than other treatments at 30, 45, and 60 DAS whereas T_1 absorbed comparatively less amount light. The higher LAI under T_7 allowed high absorption of light compared to other treatments. The lowest LAI under T_1 resulted in poor radiation absorption.

3.3 Photosynthetic Rate

3.3.1 Sorghum

The results showed that the photosynthetic rate of sorghum was highly dependent on the amount of light absorbed by the canopy. The regression analysis between light absorption and photosynthetic rate of sorghum showed that the relationship was significant and positive (Fig. 2) at 30 (*P= 0.001*), 45 (*P=0.0001*), and 60 DAS (*P=0.001*). Similar results were observed by [13]. The maximum LAI of sorghum in T_7 resulted in enhanced light absorption that resulted in a high photosynthetic rate at 30, 45, and 60 DAS [14]. The photosynthetic rate of sorghum under T_7 was 31%, 21% and 27% higher than sole sorghum at 30, 45, 60 DAS respectively.



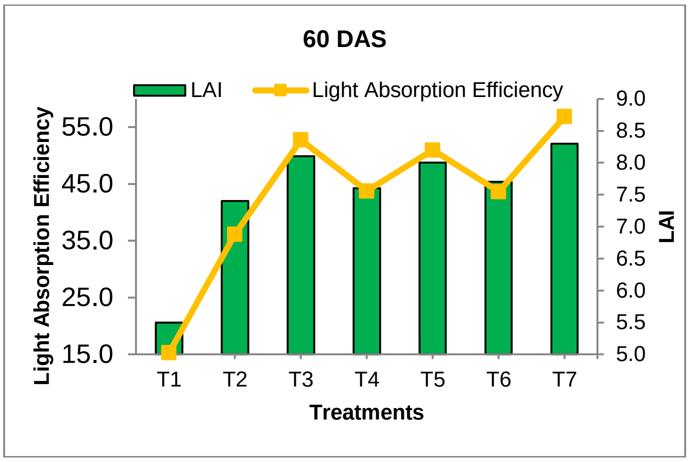


Fig. 1. Leaf area index and light absorption efficiency of sorghum under different treatments

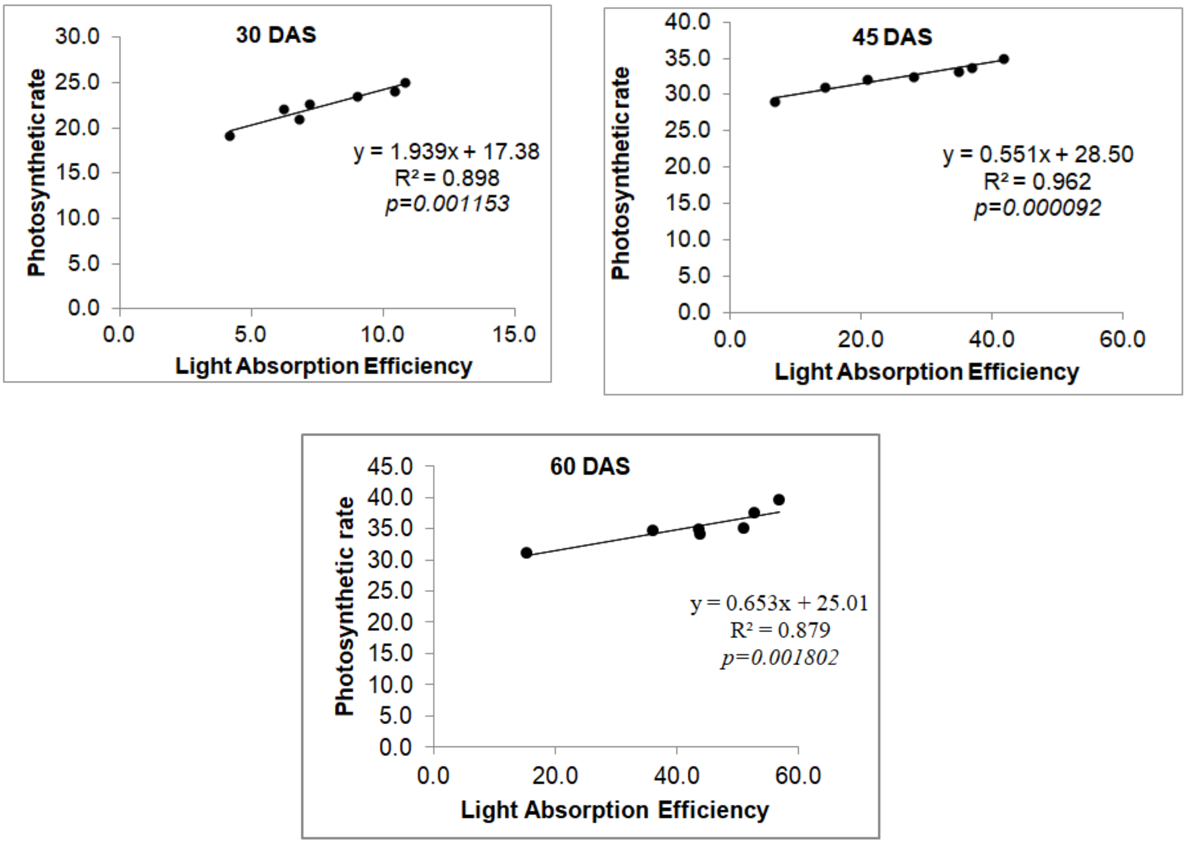


Fig. 2. Regression analysis between photosynthetic rate and radiation absorption efficiency by the sorghum

3.3.2 Intercrops

The photosynthetic rate of intercrops was highly dependent on the amount of PPFD falling on the top of the canopy (Table 1). The shading of sorghum over intercrops altered the amount of PPFD falling on the intercrops which changed the photosynthetic activity [15]. The PPFD falling on the top of intercrops was reduced over days. The prominent shading of sorghum on intercrops at 60 DAS reduced the PPFD and Photosynthetic rate. The shading effect was more on 2:2 pattern than 2:1 pattern which reduced the light intensity and photosynthetic rate of legumes under 2:2 pattern than 2:1 pattern [16].

Table 1. Amount of PPFD on the intercrops and its respective Photosynthetic rate (μ mol $m^{-2}s^{-1}$)

	Cowpea				Green Gram				Lablab			
	2:2 Pattern		2:1 Pattern		2:2 Pattern		2:1 Pattern		2:2 Pattern		2:1 Pattern	
Average	**PPFD**	**PS**	**PPFD**	**PS**	**PPFD**	**PS**	**PPFD**	**PS**	**PPFD**	**PS**	**PPFD**	**PS**
30DAS	1158.3	12.6	1226.7	14.0	1118.3	25.5	1215.7	27.2	1051.3	11.7	1230.0	13.8
45DAS	718.3	41.4	835.0	43.9	815.0	24.9	952.3	25.4	789.3	8.5	904.3	11.1
60DAS	595.3	37.2	655.3	39.5	669.3	19.1	755.0	19.4	529.3	9.3	723.0	6.8

4. CONCLUSION

The LAI and the photosynthetic rate of intercrops were different under 2:2 pattern and 2:1 pattern. The shading of Sorghum on intercrops altered the PPFD, changed the intercrops' LAI and the photosynthetic activity. The planting proportions significantly affected the LAI and the photosynthetic activity. The maximum LAI of Sorghum under T_7 absorbed the maximum light falling on the canopy which resulted in high photosynthetic rate of Sorghum. The enhanced shading and plant density under 2:2 pattern significantly reduced the performance of intercrops than 2:1 pattern. Thus, above-ground competition for light was maximum under 2:2 pattern which was the contributor for the poor performance of crops than 2:1 pattern. Hence planting sorghum in 2:1 pattern will be an effective practice for harvesting maximum light.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Li L, Zhang L, Zhang F. Crop mixtures and the mechanisms of overyielding; 2013.
2. Yang F, Liao D, Wu X, Gao R, Fan Y, Raza MA, Wang X, Yong T, Liu W, Liu J, Du J. Effect of aboveground and belowground interactions on the intercrop yields in maize-soybean relay intercropping systems. Field Crops Research. 2017;203:16-23.
3. Zhu W, Wenyu Y, Qilin W. Effects of shading in maize/soybean relay-cropping system on the photosynthetic characteristics and yield of soybean.
4. Deng Y, Li C, Shao Q, Ye X, She J. Differential responses of double petal and multi petal jasmine to shading: I. Photosynthetic characteristics and chloroplast ultrastructure. Plant Physiology and Biochemistry. 2012;55:93-102.
5. Contin DR, Soriani HH, Hernandez I, Furriel RP, Munne-Bosch S, Martinez CA. Antioxidant and photoprotective defenses in response to gradual water stress under low and high irradiance in two Malvaceae tree species used for tropical forest restoration. Trees. 2014;28(6):1705-22.
6. Marenco RA, de C. Gonçalves JF, Vieira G. Leaf gas exchange and carbohydrates in tropical trees differing in successional status in two light environments in central Amazonia. Tree Physiology. 2001;21(18):1311-8.
7. Yang F, Huang S, Gao R, Liu W, Yong T, Wang X, Wu X, Yang W. Growth of soybean seedlings in relay strip intercropping systems in relation to light quantity and red: far-red ratio. Field Crops Research. 2014;155:245-53.
8. Sun J, Gao J, Wang Z, Hu S, Zhang F, Bao H, Fan Y. Maize canopy photosynthetic efficiency, plant growth, and yield responses to tillage depth. Agronomy. 2019;9(1):3.
9. Ying SU, Zhang Y, Jiang Y, Kai SO, Juhong GA, Zhang D, Zhang J. Leaf potential productivity at different canopy levels in densely-planted and intermediately-thinned apple orchards. Horticultural Plant Journal. 2016;2(4):181-7.
10. Kubota A, Safina SA, Shebl SM, MOHAMED AE, Ishikawa N, Shimizu K, Abdel-Gawad K, Maruyama S. Evaluation of intercropping system of maize and leguminous crops in the Nile Delta of Egypt. Tropical Agriculture and Development. 2015;59(1):14-9.
11. Karimian K, Ghorbani R, Koochaki AR, Asadi GA. Investigating of radiation absorption and use efficiency in intercropping of wheat and canola. International Journal of Life Sciences. 2015;9(6):61-71.
12. Ginwal DS, Kumar RA, Ram HA, Meena RK, Kumar U. Quality characteristics and nutrient yields of maize and legume forages under changing intercropping row ratios. Indian J. Anim. Sci. 2019;89: 57-62.
13. Mukherjee J, Singh G, Bal SK. Radiation use efficiency and instantaneous photosynthesis at different growth stages of wheat (*Triticum aestivum* L.) in semi arid ecosystem of Central Punjab, India. Journal of Agrometeorology. 2014;16(1):69.
14. Srinivasan V, Kumar P, Long SP. Decreasing, not increasing, leaf area will raise crop yields under global atmospheric change. Global change biology. 2017;23(4):1626-35.
15. Fan Y, Chen J, Cheng Y, Raza MA, Wu X, Wang Z, Liu Q, Wang R, Wang X, Yong T, Liu W. Effect of shading and light recovery on the growth, leaf structure, and photosynthetic performance of soybean in

a maize-soybean relay-strip intercropping system. PloS one. 2018;13(5):e0198159.

16. Baligar VC, Elson MK, He Z, Li Y, Paiva AD, Almeida AA, Ahnert D. Light intensity effects on the growth, physiological and nutritional parameters of tropical perennial legume cover crops. Agronomy. 2020;10(10):1515.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/76093