RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume 59 Issue 4: 550-554 (April 2025)

Crop Geometry and Intercropping of Legume and Oilseed in Irrigated Pearlmillet

K. Nagarajan[1], S. Sanbagavalli[1], C. Jayanthi[1], GA. Dheebakaran[2], A. Senthil[3]

10.18805/IJARe.A-5967

ABSTRACT

Background: Pearlmillet is conventionally cultivated by farmers either broadcasting or uniform row spacing of 45 cm where it is difficult to accommodate an intercrop. Modified planting pattern provides additional space for intercrop component as well as harvest better solar energy in the system.

Methods: The field experiment was conducted in Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during *Kharif* (July-October) of 2019. The experiment was laid out in split plot design and were replicated thrice. Different crop geometry *viz.* 45 × 15 cm, 60 × 15 cm, 30/60 × 15 cm and 30/90 × 15 cm were adopted in main plots, whereas intercropping [S_1- Greengram, S_2- Sesame and S_3- No intercrop] were allotted in subplots.

Result: Pearlmillet grown under paired row sowing 30/90 × 15 cm recorded higher growth attributes and yield parameters. Grain and stover yields was also recorded higher in the above-mentioned crop geometry. In intercropping system higher growth and yield parameters was observed in sole crop treatment and it was on par with greengram intercropping system. Pearlmillet grown under paired row sowing 30/90 × 15 cm (M_4) + greengram (S_1) recorded higher equivalent yield.

Key words: Crop geometry, Greengram, Intercropping, Paired row method, Sesame.

INTRODUCTION

Pearl millet is an important coarse grain cereal generally grown as rainfed crop on marginal lands under low input management conditions (Kiroriwal and Yadav, 2013). It is adapted to drought and poor soil fertility, but responds well to good management and higher fertility levels (Sagar *et al.*, 2018). It is a dual-purpose crop; its grain is used for human consumption and its stalk is used for cattle fodder. Crop geometry refers to the shape of space available for individual plants. Crop geometry is altered by changing inter and intra row spacing. Optimum crop geometry is one of the important factors for higher productivity achieved by effective utilization of available resources and also harvesting more solar radiation for better photosynthate formation.

Limited availability of land resources and declining soil fertility, escalated the concerns regarding agriculture production to sustain the demands of ever-increasing population. To increase and sustain agriculture productivity we have to look for the ways of utilizing available resources more effectively. This can be achieved by intercropping, which is an effective practice to augment the total productivity per unit area per unit time by growing more than single crop in the same field by altering the crop geometry. Pearlmillet is conventionally cultivated by farmers either broadcasting or uniform row spacing of 45 cm where it is difficult to accommodate an intercrop. Modified planting pattern provides additional space for intercrop component as well as harvest better solar energy in the system. The objectives were to study the growth and yield of pearlmillet by altering crop geometry and intercropping system.

[1]Department of Agronomy, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.
[2]Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India.
[3]Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India.

Corresponding Author: K. Nagarajan, Department of Agronomy, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India. Email: nkgj07@gmail.com

How to cite this article: Nagarajan, K., Sanbagavalli, S., Jayanthi, C., Dheebakaran, G. and Senthil, A. (2025). Crop Geometry and Intercropping of Legume and Oilseed in Irrigated Pearlmillet. Indian Journal of Agricultural Research. 59(4): 550-554. doi:10.18805/IJARe.A-5967.

Submitted: 29-01-2022 **Accepted:** 11-04-2023 **Online:** 25-05-2023

MATERIALS AND METHODS

Site description

The field experiment was conducted in field No. 37F at Eastern Block Farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore during *Kharif* season (July-October) of 2019. The experimental field was located in the Western Agro Climatic Zone of Tamil Nadu at 11.01701 N latitude, 76.93504 E longitude and at an altitude of 438 m above MSL. The soil sample was drawn randomly from 0-15 cm depth of the field before sowing and analysed for physico-chemical properties were provided in Table 1. The experimental plot was slightly alkaline in nature with low soluble salts and a medium range of organic carbon content. Initial nutrient status of the experimental field was low in

available nitrogen (228 kg ha^{-1}), medium in available phosphorus (16.3 kg ha^{-1}) and high in available potassium (630 kg ha^{-1}). The water source used for irrigation was slightly alkaline (pH 8) with high soluble salts (EC 5.7 dS m^{-1}).

Experimental details

The experiment was designed in split plot design and with three replications. In main plots crop geometry with 4 levels [M_1- Pearlmillet in 45 × 15 cm, M_2- Pearlmillet in 60 × 15 cm, M_3- Pearlmillet in paired row sowing 30/60 × 15 cm and M_4- Pearlmillet in paired row sowing 30/90 × 15 cm] and intercropping in 3 levels [S_1- Greengram, S_2- Sesame and S_3- No intercrop] were allotted in subplots. Pearlmillet (CO 10) was used as maincrop and greengram (CO (Gg) 8) and sesame (TMV 7) were chosen as intercrops. Pearlmillet (CO 10) was composite of five elite inbred (PT 6029, PT 6033, PT 6034, PT 6039) with the duration of 85 to 90 days. It suites well under both irrigation and rainfed conditions. It is resistant to downy mildew and has high protein content (12.07%). The greengram variety CO (Gg) 8 has synchronized maturity and indeterminate type with plant height of 35 to 55 cm. The average yield is 900 kg ha^{-1} under rainfed condition and 1050 kg ha^{-1} under irrigated condition. The duration is 55 to 60 days. It is suitable for single or mechanical harvest and moderately resistant to Mungbean Yellow Mosaic Virus and stem necrosis. It is moderately resistant to sucking pests like aphids and stem fly.Sesame variety TMV 7 is an erect, intermediate type with duration of 80 to 85 days. The average yield is 850 kg ha^{-1} and 920 kg ha^{-1} in rainfed and irrigated respectively. The seed colour is brown and it consists of 50 per cent oil content.

Crop management

Initially, rills were formed based on different treatments and pearlmillet was sown and intercrops were sown in between the pearlmillet. The recommended dose of fertilizer is 70:35:35 NPK kg ha^{-1}. Entire dose of phosphorus (SSP- 219 kg ha^{-1}) and potassium (MOP- 58.3 kg ha^{-1}) were applied as basal and nitrogen (Urea-152 kg ha^{-1}) was applied in three splits 25%, 50% and 25% at basal, 15 and 30 DAS, respectively. Weeding was done by using hand hoe. The first weeding was done on 13 DAS and next weeding was done on 25 DAS. Immediately after sowing irrigation was given and subsequent irrigations were given based on weather conditions prevailed during crop period and physical appearance of the crop. Based on the duration, crops were harvested at different dates.

Observations

Five plants were randomly selected from the net plot area of each treatment and tagged for recording growth and yield attributes throughout the crop growing period. The mean values of each plot were recorded. In pearlmillet growth attributes *viz.,* plant height, leaf area index, drymatter production and crop growth rate was observed. Yield parameters *viz.,* number of earheads per hill, earhead length, earhead width, test weight (g), grain yield, stover yield was observed. Yield of the intercrops was converted to pearlmillet grain equivalent yield based on the price of economic parts of different crops involved in the experiment and expressed in kg ha^{-1}.

Pearlmillet grain equivalent yield =

$$\frac{\text{Yield of intercrop} \times \text{Price of intercrop}}{\text{Price of pearlmillet}}$$

Results and Discussion

Growth parameters

Crop geometry and intercropping did not influence the plant height of pearlmillet; Leaf area index of a canopy was important for predicting crop growth (Yin *et al.*, 2003). Crop geometry showed significant influence of crop (Table 2). Pearlmillet grown under paired row sowing 30/90 × 15 cm (M_4) recorded maximum LAI (3.3) and it was on par with pearlmillet grown under paired row sowing 30/60 × 15 cm (M_3) with LAI of 2.9. The orientation and angle of leaves was created to adjust at paired row sowing which in turns minimise the overlapping of leaves mutual shading resulted in greater leaf development which could increase the leaf area index. Similar results were obtained by Satheeshkumar *et al.* (2011). Intercropping system produces significant difference on LAI at all the stages of the crop. No intercrop (S_3) treatment recorded higher LAI at all the stages of crop. This might be due to adequate availability of essential resources like water, nutrients and incoming sunlight without competition from intercrops (Triveni, 2016).

Yield attributes

In pearlmillet, number of earheads per hill was one of the factors considerably influencing the yield of crop (Table 3). Among the different crop geometries, there was no significant difference in number of earheads per hill but numerically pearlmillet grown under paired row sowing 30/90 × 15 cm (M_4) recorded higher number of earheads (1.4). Number of earheads were significantly influenced by different intercropping system. No intercrop (S_3) noticed higher number of earheads and was on par with treatment greengram as intercrop (S_1). This might be due to the better development of complementary relationship with greengram and adequate availability of water and nutrients under sole pearlmillet (Yadav *et al.*, 2015).

The earhead length and width was significantly influenced by crop geometry. Among the different crop geometry, the larger earheads were recorded under pearlmillet grown under paired row sowing 30/90 × 15 cm (M_4) which was on par with pearlmillet under paired row sowing 30/60 × 15 cm (M_3) It. may be attributed to better growth and development of plants under less plant density which leads into better source to sink relationship due to availability of balanced and adequate nutrients and better light, space and moisture unlike in narrow spacing (Sharanya *et al.*, 2018). Similar trend was observed in earhead width also. This might be due to less competition between the crops and more interception of sunlight. These findings were in accordance with Dhimmar and Raj (2009). Hooda *et al.*

(2004) also found similar results where pearlmillet nutrient and feeding area per plant as compared to normal spacing. Similar results were obtained by Ansari and Rana (2012) and Singh *et al.* (2019). Baskar and Jagannathan, 2021 reported that all the yield attributing characters were higher under the wider spacing (120 × 60) in cotton. Intercropping system did not influence the earhead length and width of pearlmillet.

Grain yield, stover yield and harvest index (HI)

Crop geometry and intercropping produces significant impact on grain yield of pearlmillet (Table 4). Among the several crop geometries, pearlmillet in paired row sowing 30/90 × 15 cm (M_4) produced maximum yield and was on par with pearlmillet under paired row sowing 30/60 × 15 cm (M_3). This was mainly due to significant increase in yield components *viz*., number of earheads per hill, earhead length, earhead width and thousand grain weight and it was achieved due to better light distribution upto lower leaves, sufficient availability of soil moisture and higher nutrient uptake in paired row system which in turn increased the photosynthetic rate resulted in increased sink size and finally reflected on the crop yield. This result was similar with the findings of Singh and Singh (2001). Among the different intercrops, no intercrop (S_3) produced more pearlmillet yield which was on par with green gram (S_1). Because of competition free environment and greengram seems to be less harmful for pearlmillet. This might be due to its short life span and also their growth peaks were not coincided with each grain yield and stover yield were statistically on

Table 1: Physico-chemical properties of soil.

Particulars	Values	Method of analysis
I. Mechanical properties		
Clay (%)	43.3	Robinson's International pipettemethod
Silt (%)	17.6	
Coarse sand (%)	19.7	
Fine sand (%)	19.4	
Textural class	Sandy clay loam	
II. Physical properties		
Bulk density (g cc^{-1})	1.40	Core sampler method
Particle density (g cc^{-1})	2.28	
Porosity (%)	40	
III. Chemical properties		
pH (1:2.5 Soil to water ratio)	8.1	pH meter
EC (1:2.5 Soil to water ratio) (dS m^{-1})	1.2	Conductivity bridge
Organic carbon (%) Organic matter (%)	0.510.87	Wet digestion method
Available nitrogen (kg ha^{-1})	228	Alkaline permanganate method
Available phosphorus (kg ha^{-1})	16.3	Modified Olsen's extractant method
Available potassium (kg ha^{-1})	630	Neutral normal ammonium acetate extractant, Flame photometry

Table 2: Effect of crop geometry and intercropping on growth parameters of pearlmillet.

Treatments		Plant height (cm)	LAI	DMP (kg ha^{-1})
Main plot: Crop geometry				
M_1 - Pearlmillet in 45 × 15 cm		225.6	2.7	9963
M_2 - Pearlmillet in 60 × 15 cm		222.8	2.7	8480
M_3- Pearlmillet in paired row sowing 30/60 × 15 cm		209.0	2.9	11522
M_4- Pearlmillet in paired row sowing 30/90 × 15 cm		211.0	3.3	11596
SEd.		8.9	0.15	443
CD (P = 0.05)		NS	0.37	1083
Subplot: Intercrops				
S_1- Greengram		215.6	3.0	10440
S_2- Sesame		215.8	2.7	9868
S_3- No intercrop		219.8	3.1	10862
SEd.		5.7	0.08	401
CD (P = 0.05)		NS	0.18	NS
M × S	SEd.	12.9	0.20	790
	CD (P = 0.05)	NS	0.47	NS

par in both pearlmillet + greengram intercropping system and sole pearlmillet. Similar trend was observed in stover yield also. Harvest index did not show significant difference under different crop geometry and intercropping system. However, maximum harvest index of 0.34 observed in pearlmillet in paired row sowing 30/90 × 15 cm (M_4). With regard to intercropping systems, all treatments recorded similar harvest index of 0.33. The treatment interaction found to be non-significant under crop geometry and intercropping systems.

Pearlmillet grain equivalent yield (PEY) and benefit cost ratio (BCR)

Higher grain equivalent yield was obtained under pearlmillet in paired row sowing 30/90 × 15 cm (M_4). Intercropping system also showed significant difference on pearlmillet grain equivalent yield. The higher equivalent yield was recorded in greengram (S_1). The treatment interaction also made significant effect on pearlmillet grain equivalent yield. Pearlmillet under paired row sowing 30/90 × 15 cm (M_4) + greengram (S_1) recorded higher equivalent yield. Higher yield of pearlmillet and additional advantage of greengram yield due to healthy complementary relationship and good price of greengram might resulted in highest pearlmillet equivalent yield. Similar result was obtained by Rana *et al.* (2006) and Yadav *et al.* (2015). Pearlmillet under paired row sowing 30/90 × 15 cm (M_4) + greengram (S_1) obtained higher benefit cost ratio and it might be due to higher yield of pearlmillet under wider spacing and extra yield obtained from intercrop made the higher advantageous of combination. This results were similar with the outcome of Choudhary (2009) in which intercropping of pearlmillet with greengram

Table 3: Effect of crop geometry and intercropping on yield parameters of pearlmillet.

Treatments		Number of earhead hill^{-1}	Earhead length (cm)	Earhead width (cm)	Test weight (g)
Main plot: Crop geometry					
M_1 - Pearlmillet in 45 × 15 cm		1.3	23.8	2.4	13.4
M_2 - Pearlmillet in 60 × 15 cm		1.3	21.8	2.3	13.5
M_3 - Pearlmillet in paired row sowing 30/60 × 15 cm		1.3	25.6	2.3	14.6
M_4 - Pearlmillet in paired row sowing 30/90 × 15 cm		1.4	27.5	2.8	15.5
SEd		0.06	1.07	0.11	0.64
CD (P = 0.05)		NS	2.61	0.26	1.57
Subplot: Intercrops					
S_1 - Greengram		1.4	24.4	2.4	14.2
S_2 - Sesame		1.3	23.9	2.5	14.1
S_3 - No intercrop		1.3	25.7	2.5	14.6
SEd		0.04	0.72	0.08	0.36
CD (P = 0.05)		0.07	NS	NS	NS
M × S	Sed	0.08	1.59	0.16	0.87
	CD (P = 0.05)	NS	NS	NS	NS

Table 4: Influence of crop geometry and intercropping on yield, HI, PEY and BCR of pearlmillet.

Treatments		Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index	PEY	B.C ratio
Main plot: Crop geometry						
M_1- Pearlmillet in 45 × 15 cm		2910	4599	0.33	3018	1.41
M_2 - Pearlmillet in 60 × 15 cm		2551	4311	0.32	2684	1.26
M_3- Pearlmillet in paired row sowing 30/60 × 15 cm		2957	4716	0.33	3226	1.51
M_4- Pearlmillet in paired row sowing 30/90 × 15 cm		3230	4980	0.34	3678	1.72
SEd.		129	174	0.02	119	*
CD (P = 0.05)		316	427	NS	291	*
Subplot: Intercrops						
S_1- Greengram		2985	4676	0.33	3663	1.64
S_2- Sesame		2615	4385	0.33	2661	1.22
S_3- No intercrop		3135	4893	0.33	3130	1.56
SEd.		87	157	0.01	90	*
CD (P = 0.05)		185	333	NS	190	*
M × S	SEd.	192	310	0.03	189	*
	CD (P = 0.05)	NS	NS	NS	425	*

in 2:2 paired rows was found more profitable than sole pearlmillet. Panjab and Joshi (1980) also obtained more profit in pearlmillet + moth bean (2:2) intercropping system.

CONCLUSION

The present experiment concluded that pearlmillet grown under paired row sowing 30/90 × 15 cm with greengram was found to be more profitable intercropping system under irrigated condition in Western agro climatic zone of Tamilnadu.

Future line of work

Microclimatic condition in different crop geometry and intercropping system. Microbial load *viz.,* bacteria, actinomycetes and fungi in different crop geometry and intercropping system. Allelopathic study in pearlmillet and sesame intercropping system to know the factors reducing the pearlmillet sesame intercropping system.

Conflict of interest

All authors declared that there is no conflict of interest.

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