Original Research Article

Studies on Pearl millet-based intercropping system under rainfed condition of Coimbatore district

ABSTRACT

Aim: The aim of the study is to ascertain the response of pearl millet under intercropping system with pulses and their ability to produce higher yield under intercropping conditions.
Study design: The study was carried out in Randomized block design (RBD).
Place and Duration of Study: The field experiment was conducted during *rabi* season of 2023-2024 at Karunya Institute of technology and Sciences, Coimbatore, Tamil Nadu.
Methodology: The experiment was laid out in randomized block design and replicated thrice. It consisted of eleven treatments comprising of pearl millet as main crop and pulses *viz.,*blackgram, greengram, redgram, cowpea and bengalgram as intercrops. Pulses were intercropped with pearl millet in replacement series of 4:1 and 6:1 row proportion.
Results: Significantly higher plant height (186.03cm), dry matter accumulation (7386kg/ha), grain yield (2493 kg/ha) and B:C (2.50) ratio was recorded in pearl millet + blackgram (4:1). Further pearl millet equivalent yield (PMGEY) (2711.1 kg/ha) and Relative Crowding Coefficient (RCC) were higher in pearl millet with blackgram 4:1 ratio and Land Equivalent Ratio (LER) were higher in pearl millet + redgram at a ratio of 4:1.
Conclusion: These results confirmed that, pearl millet + blackgram 4:1 intercropping system may be suggested to get greater net return and B: C ratio.

Keywords*: Pearl millet,Intercropping, PMGEY, LER, RCC and Yield*

1. INTRODUCTION

Pearl millet, known scientifically as *Pennisetum glaucum* L., is an ideal crop to combat water scarcity and ensure food security in regions facing harsh climatic conditions due to its high drought tolerance and resource efficiency (Naorem*et al.,* 2023). It ranks fourth among global food grain crops after rice, wheat, and sorghum (Satyavathi *et al.,* 2021). While it holds a prominent position among millets in terms of cultivation area and production, its cultivation is particularly crucial for dryland agriculture due to its ability to thrive in arid and less fertile conditions, making substantial contributions to a nation's food security.

India is the largest producer of pearl millet in the world with an area of 75.72lakh ha owing to average production of 114.31lakh tons and productivity of 1510 kg/ha (2022-23). In Tamil Nadu it is cultivated in an area of 0.67 lakh ha with the total production of 1.59 lakh tonne and productivity is of 2357 kg/ha (DA and FW, 2023-2024).

The prevalent practice of cultivating pearl millet as a monocrop in arid and semi-arid regions poses significant challenges. The monoculture approach not only increases the risk of diminished production but also strains the land resources (Sharmili *et al.,* 2021). Implementing the practices that promote crop diversification, soil conservation and efficient resource management can help to alleviate the

negative effects of monoculture. These endeavors are crucial for maintaining the long-term resilience of agricultural systems in the face of evolving obstacles (Nandhini *et al*., 2020) Through innovative strategies, we can pave the way for more robust and productive agricultural sector capable of meeting the needs of both present and future generations.

Intercropping stands out as a promising agricultural practice, aimed at enhancing overall productivity by cultivating multiple crops within the same field simultaneously. This approach optimizes the utilization of environmental resources, aiming to maximize the output per unit area over a given period (Manjunath *et al.,* 2018). The fundamental principle of intercropping is to grow two or more crops together allowing them to explore the environment more effectively better than one, ultimately leading to increased yields (Keerthanapriya *et al.,* 2019). The combination of millets and legumes in intercropping systems has garnered attention from agronomists, due to both established and theoretical advantages. Legume-intercropping, have the ability to fix atmospheric nitrogen with the help of rhizobium bacteria, which enhances the qualitative and quantitative traits of crops. This practice contributes to food security and sustainability by improving soil fertility and reducing the need for synthetic fertilizers (Ofori.1987).

To address this current agricultural challenge, a field experiment has been undertaken to assess the efficacy of pearl millet-based intercropping systems with pulses under rainfed conditions.

2.MATERIALS AND METHODS

A field experiment was carried out during the *rabi* season of 2023-2024 to study the performance of pearl millet-based intercropping with pulses under rainfed condition at Karunya Institute of Technology and Sciences, Coimbatore district of Tamil Nadu using randomized block design with eleven treatments. The experiment field is located at 11° N latitude and 77° E longitude, at an altitude of 427 meters above mean sea level and it is situated in the Western agroclimatic zone of Tamil Nadu. The intercropping system treatments are., T_1- pearl millet sole crop, T_2 - pearl millet + blackgram (4:1), T_3 - pearl millet + blackgram (6:1), T_4 - pearl millet + greengram (4:1), T_5 - pearl millet + greengram (6:1), T_6 - pearl millet + redgram (4:1), T_7 - pearl millet + redgram (6:1), T_8 - pearl millet + cowpea (4:1) T_9 - pearl millet + cowpea (6:1), T_{10}- pearl millet + bengalgram (4:1), T_{11}- pearl millet + bengalgram (6:1). The treatments were replicated thrice and sown in replacement series. All intercrops *viz.,*blackgram, greengram, redgram, cowpea and bengalgram were raised separately adjacent to the treatment plots and the yields were recorded to work out indices related to biological, competition and economic efficiency of the intercropping system. The varieties tested in this experiment were pearl millet (CO 10), blackgram (TNAU(Bg) VBN 8), greengran (VBN (Gg) 3), cowpea (CO 2),redgram (CO (Rg) 7) and bengalgram (CO 3).

Economic benefits like net returns and B:C ratio was calculated according to market price of each crop. The effectiveness and sustainability of the systems are evaluated using a different index. These indexes are often calculated using the information gathered using conventional survey techniques.

Grain equivalent yield is used to convert the yield of different crops to one unit Lal and Ray. (1976). proposed economic of crop by converting grain in terms of gross return for valid comparison as GEY. The pearl millet equivalent yield of the intercropping system was calculated by the following formula and expressed in kg ha^{-1}.

$$\text{GEY (kg ha}^{-1}) = \frac{\text{Yield of intercrop (yi)} \times \text{Price of intercrop (pi)}}{\text{Price of base crop (Pp)}}$$

LER (Land Equivalent Ratio) was worked out by using the formula suggested byWilley. (1979). It is actually the proportionate land area required under pure stand of crop species to yield the same produce as obtained under an intercropping at the same management level.

$$\text{LER} = \frac{\text{Yab}}{\text{Yaa}} + \frac{\text{Yba}}{\text{Ybb}}$$

Where, Yab is the yield of “a” crop grown in association with “b” crop and Yba is the yield of “b” crop grown in association with “a” crop. Yaa and Ybb represent the yields of “a” and “b” crops grown in pure stand respectively. The value of LER greater than one (1.0) indicates the advantages of the intercropping system.

Relative crowding coefficient (RCC) indicates whether a crop, when grown in mixed population, has produced more or less yield than expected in pure stand (De Wit, 1979). The value of RCC greater than one indicates the advantages of the intercropping system.

$$\text{RCC} = \frac{\text{Yab} \times \text{Zab}}{(\text{Yaa} - \text{Yab}) \times \text{Zab}}$$

Where,Zab and Zba are the sown proportion of crop “a” and “b” in intercropping condition.

3. RESULTS AND DISCUSSION

3.1. GROWTH AND YIELD OF PEARL MILLET BASED INTERCROPPING SYSTEM

3.1.1. Growth attributes

Intercropping had a significant impact on growth factors such as plant height and dry matter production. Pearl millet + blackgram at 4:1 ratio, the recorded the maximum plant height which was followed by pearl millet intercropped withgreengram in the same ratio (Table 1). This was because blackgram, being a short-duration and early maturing crop, competed less for resources like sunlight, water, and nutrients compared to crops like cowpea. This reduced competition allowed the pearl millet plants to grow better and yield more.[12] Similar results were also reported by (Somu *et al.,* 2020).

The dry matter production was significantly higher in pearl millet sole crop (T_1) followed by pearl millet + blackgram at 4:1 row ratio (Table 1). Sole pearl millet exhibits greater dry matter production per plant when compared to intercropping system. This might due to reduced competition for space, solar radiation and nutrients. Which resulted in enhanced vegetative growth and overall

higher dry matter accumulation per plant.[13] Theseresults were similar to the findings of (Shiyal*et al.,* 2023).

3.1.2. Grain Yield

Pearl millet sole crop registered the maximum grain yield and stover yield (2583 kg/haand 5126 kg/ha) followed, bypearl millet + blackgram at 4:1 ratio (2493 kg/haand 4815 kg/ha of stover yield)(Table 1). It could be due to the presence of a greater number of plant population than the intercropping system.[13] The results are similar with the findings of(Suman*et al.,* 2021).

3.2. COMPETITIVE INDICES

3.2.1 Grain equivalent yield

The pearl millet grain equivalent yield (GEY) was estimated to compare various intercropping arrangements (Table 2). Among the various intercropping system pearl millet + blackgram at a ratio 4:1 produced the higher pearl millet grain equivalent yield (2711.1 kg/ha) and was closely followed by pearl millet + greengram (4:1) and pearl millet + redgram (4:1) row ratio. This might be due to better utilization of resources and complimentary interactions between component crops as well as extra yield and high market price of blackgram andgreengram. [14] Thesefindings are in similar with the results of(Kaushik and Sharma, 2017).

3.2.2 Land Equivalent Ratio

Among the intercropping systems, pearl millet + redgram(4:1) intercropping system had the maximum land equivalent ratio(1.21), and it was closely followed by pearl millet + blackgramat 4:1 row ratioof (1.13) (Table 2.). It has been reported in the earlier studies that greater value of LER indicated greater biologicalefficiency of crops grown in association and wasprobably due to temporal and spatial complementaryeffect and thereby giving corresponding yieldadvantages.[16] Similar findings were reported by (Sharmili *et al.,* 2023).

3.2.3 Relative Crowding Coefficient

Pearl millet + blackgram at 4:1 ratio recorded higher RCC value of 6.92 compared to other intercropping systems. The RCC value greater than unity in this intercropping system denotes the advantage of intercropping (Table 2).This row proportion was found to be more competitive in terms of input resource use efficiency and to additionally indicate yield advantage.[17] Theseresults were similar to the findings of (Kumar *et al.,* 2018).

3.3 ECONOMICS OF INTERCROPPING

Pearl millet + blackgram 4:1 combination recorded higher gross returns, net returns and B:C ratio than other treatment studied (Rs.1,40,385/ha, Rs.84,204/ha and 2.50 respectively). It was followed by pearl millet + greengram 4:1 (Rs.1,36,891/ha, Rs. 80,960/haand 2.44) and pearl millet + redgram 4:1 (Rs.1,36,710/ha, Rs. 80,469/ha and 2.43). Intercropping was always beneficial and recorded higher B: C with respect to pearl millet sole crop. This may be attributed due to higher grain yield and good market price. [18] The results align withthe findings of were similar to (Kumar *et al.,* 2020)

4. CONCLUSION

Based on the findings, it can be concluded that intercropping pearl millet with blackgram at a ratio of 4:1 resulted in higher productivity and per unit area compared to other intercropping methods. Hence, for rainfed conditions, it is recommended to adopt the pearl millet + blackgram intercropping system at a 4:1 ratio in order to achieve increased productivity and net income. Alternatively, another suggested intercropping system is pearl millet + greengram, pearl millet + redgram at a ratio of 4:1 row ratio.

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Table 1. Effect of intercropping on growth, yield and economics

	Treatments	Plant height (cm)	Dry matter production (kg/ha)	Pearl millet (kg ha^{-1})		Yield of intercrops (kg/ha)	Net income (Rs. /ha)	B: C ratio
				Grain	Stover			
T_1	Pearl millet sole crop	181.82	7935	2583	5126	-	78625	2.41
T_2	Pearl millet + Blackgram (4:1)	186.03	7386	2493	4815	156.0	84204	2.50
T_3	Pearl millet + Blackgram (6:1)	171.63	7231	2197	4987	69.4	63551	2.13
T_4	Pearl millet + Greengram (4:1)	185.18	7207	2469	4730	134.2	80690	2.44
T_5	Pearl millet + Greengram (6:1)	169.30	7112	2192	4893	87.4	63987	2.14
T_6	Pearl millet + Redgram (4:1)	184.45	7164	2252	4798	297.1	80469	2.43
T_7	Pearl millet + Redgram (6:1)	170.48	7206	2231	4875	169.5	71250	2.27
T_8	Pearl millet + Cowpea (4:1)	153.55	6158	1847	4169	233.1	46758	1.82
T_9	Pearl millet + Cowpea (6:1)	160.45	6602	2013	4526	165.2	53525	1.95
T_{10}	Pearl millet + Bengalgram (4:1)	159.26	6389	2141	4082	156.6	66351	2.16
T_{11}	Pearl millet + Bengalgram (6:1)	160.14	6128	2023	4046	120.8	57815	2.01
	SE(d)	10.66	516	203	349			
	CD (P=0.05)	22.23	1077	424	728			

Table 2. Effect of intercropping on various competitive assessments

Treatments		Grain equivalent yield (kg/ha)	Land Equivalent Ratio (LER)*	Relative Crowding Coefficient (RCC)*
T_2	Pearl millet + Blackgram (4:1)	2711	1.13	6.92
T_3	Pearl millet + Blackgram (6:1)	2294	0.92	0.94
T_4	Pearl millet + Greengram (4:1)	2643	1.09	5.41
T_5	Pearl millet + Greengram (6:1)	2305	0.93	0.93
T_6	Pearl millet + Redgram (4:1)	2638	1.21	1.70
T_7	Pearl millet + Redgram (6:1)	2451	1.05	1.05
T_8	Pearl millet + Cowpea (4:1)	1986	0.96	0.60
T_9	Pearl millet + Cowpea (6:1)	2112	0.94	0.50
T_{10}	Pearl millet + Bengalgram (4:1)	2390	0.99	1.20
T_{11}	Pearl millet + Bengalgram (6:1)	2215	0.91	0.60
	SE (d)	210		
	CD (5%)	441		

*Data not statistically not analyzed.