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Performance of Pearl Millet and Pulses Based Intercropping System under Rainfed Condition

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Authors' contributions

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

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ABSTRACT

A field experiment was conducted during *rabi* season of 2022 at Karunya Institute of Technology and Sciences, Coimbatore to study the performance of different pearl millet-based intercropping with legumes under rainfed condition. Greengram (*Vigna radiata*), cowpea (*Vigna unguiculata*) and redgram (*Cajanus Cajan)* were sown as intercrops in replacement series of 4:1 and 6:1 row ratio. The result of the study indicated that intercropping of blackgram and redgram with pearl millet in 4:1 gave higher total grain yield (25503.0 kg/ha) and stover yield (4927.1 kg/ha) compared to the sole

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cropping of pearl millet under rainfed condition. Other intercropping indices like grain equivalent yield, land equivalent ratio, relative crowding coefficient, competition index and income equivalent ratio were calculated. Intercropping system of pearl millet + blackgram (4:1) recorded the higher net returns (Rs. 81,621/ha) and B:C ratio (2.42).

Keywords: Intercropping; yield; GEY; LER; RCC.

1. INTRODUCTION

"Indian agriculture is dominated by farming. Rainfed agriculture contributes to 42 per cent of the national foodgrain production, mainly through sorghum, millets and pulses. Therefore dryland areas are important for the economy of the country and will continue to be so in future" [1]. "In rainfed areas intensive agriculture in the form of millets intercropping with pulses is an insurance against bad weather and which increase the land equivalent ratio, soil fertility and monetary returns considerably" [2].

In rainfed conditions with low and erratic rainfall, growing crops as a sole crop is considered risky and leads to low productivity. To achieve higher yields in such situations, it is essential to adopt a strategy of intensification and diversification of crops. One viable approach to stabilize production of rainfed crops is through intercropping, which involves growing multiple compatible crop species on the same land simultaneously. Intercropping aims to achieve several objectives, including the production of additional crops, optimization of natural resource utilization, and the stabilization of crop yields to mitigate risks [3]. "Intercropping is an effective practice to augment the total productivity per unit area of the land per unit time by growing more than one crop in the same field, with the prime objective of better utilization of available environmental resources. Research work in rainfed areas has shown that intercropping with better selection of compatible crops and proper nutrient management is a profitable practice to make use of available soil moisture and nutrients more efficiently and per se, improving productivity of dryland crops" [4].

Pearl millet is an important crop cultivated for both human consumption and livestock feed in dryland areas. Its cultivation primarily occurs in rainfed lands with poor and impoverished soils within the semi-arid tropics of Africa and India [5]. "It is an ideal fodder crop, possessing quick growing and high-yielding ability during summer. Intercropping of legumes in pearl millet was found more productive and remunerative" [6]. Pearl millet is often grown as a mono crop without the use of fertilizers. Despite various challenges, pearl millet yields are relatively high and more reliable compared to other tropical dry cereal crops such as sorghum and maize. However, cultivating pearl millet as a sole crop under these conditions is risky and economically unfeasible. Intercropping emerges as the best solution to increase production and productivity by utilizing available resources more effectively, minimizing risks, and bringing stability to rainfed conditions.

"Growing only cereals or cereals as sole crop is not so much remunerative in present scenario of agriculture so to fulfil the diverse demand of consumers and rapid growing population there is an urgent demand for incorporation of the pulses in cereals production system. Intercropping of millets with different pulses has greater scope to utilize the land and other resources to maximum extent. The productivity of the system can be enhanced by judiciously selecting the intercrops which differ in duration and growth in many situations" [7]. Legumes are known as suitable companion in intercropping system and cereal legume combination is widely adopted in intercropping. Cereals are soil exhaustive crops; however, legumes replenish the soil fertility.

"Intercropping of legumes with cereals is a recognized practice for economizing the use of nitrogenous fertilizers and increasing the productivity and profitability per unit area and time. In intercropping system, the competitive effects between main and intercrop depends on the rooting pattern, canopy structure and days to maturity. The intercropping system of cereals + pigeonpea/legumes were tested and found to be profitable systems" [8]. In this context the intercropping systems with Blackgram, cowpea and redgram for higher productivity and soil sustainability were evaluated in this study.

2. MATERIALS AND METHODS

A field experiment was carried out during the *rabi* season 2022 to study the pearl millet-based intercropping with legumes under rainfed

condition at Karunya Institute of Technology and Sciences, Coimbatore district of Tamil Nadu using randomized block design with seven treatments. The intercropping system treatments are., T_1- sole crop of pearl millet, T_2- pearl millet + blackgram (4:1), T_3- pearl millet + blackgram (6:1), T_4- pearl millet + cowpea (4:1), T_5- pearl millet + cowpea (6:1), T_6- pearl millet + cowpea (6:1) and T_7- pearl millet + redgram (6:1). The treatments were replicated thrice and sown in replacement series. All intercrops *viz*., blackgram, cowpea, redgram were raised separately adjacent to the treatment plots and the yields were recorded to work out indices related to biological efficiency of the intercropping system. The varieties tested in this experiment were pearl millet (Co 10), blackgram (VBN 8), cowpea (VBN 3) and redgram (Co (Rg) 7).

Economics of crop by converting grain/seed/ fodder in terms of gross return for valid comparison as grain equivalent yield (GEY). Pearl millet equivalent yield (PMGEY) of intercropping system was calculated by the formula:

$$\text{GEY (kg/ha)} = \frac{Yield\ of\ intercrop\ (Yi) \times price\ of\ intercrop\ (Pi)}{price\ of\ base\ crop\ (Pp)}$$

LER (Land Equivalent Ratio) was worked out by using the formula. 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.

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

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 and Zab and Zba are the sown proportion of crop “a” and “b” in intercropping, respectively. The value of LER greater than unity (1.0) indicates the advantages of the intercropping system [9].

Relative crowding coefficient (RCC) indicates whether a crop, when grown in mixed population, has produced more or less yield than expected in pure stand. The value of RCC greater than unity (1.0) also indicates the advantages of the intercropping system.

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

3. RESULTS AND DISCUSSION

3.1 Growth and Yield of Pearl Millet based Intercropping System

Growth attributes like plant height and dry matter production was significantly affected by intercropping. Plant height of pearl millet was found to be higher under the treatment T_2 - maize + blackgram at 4:1 ratio (189.66 cm at harvest) followed by pearl millet + redgram at 4:1 ratio (T_6) (185.46 cm at harvest) (Table 1). Among the various intercrops, pearl millet + redgram at 4:1 ratio (T_6) intercropping system produced higher dry matter production (6800 kg/ha). Similar results were also obtained by Sharmili et al. [10] in little millet based intercropping system with pulses.

Pearl millet sole crop registered the maximum grain yield and stover yield (2503.0 kg/ha and 4927.1 kg/ha) it was statistically on par with pearl millet + blackgram at 4:1 ratio (2485.3 kg/ha grain yield) and (4759.2 kg/ha respectively) (Table 1). The results are also in conformity with findings of Rawat [11].

3.2 Effect of Intercropping on Different 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 intercropping system 4:1 row proportion of pearl millet + blackgram intercropping system produced the higher pearl millet grain equivalent yield (5467.7 kg/ha) and was closely followed by the 4:1 row proportion of pearl millet + redgram intercropping system. These were similar to the findings of Sharmili and Manoharan [12] in little millet based intercropping system and Kaushi and Sharma [13] in wheat intercropping system.

3.2.2 Other intercropping indices

Among the intercropping systems, pearl millet + redgram 4:1 (1.23) intercropping system had the maximum land equivalent ratio, and it was closely followed by pearl millet + blackgram 4:1 (1.16). This increased value of LER was caused by improved intercrop yield, demonstrating the advantages of intercropping pearl millet in a 4:1 ratio. Similarly Sharmili et al. [14] reported significantly higher value of LER (1.46) little millet + pigeon pea (6:1) intercropping system.

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

	Treatments	Plant height (cm)	Dry matter production (kg/ha)	Pearl millet (kg/ha)		Yield of intercrops (kg/ha)	Net income (Rs/ha)	B:C ratio
				Grain	Haulm			
T_1	Pearl millet sole crop	180.20	6925	2503.0	4927.1	-	75964	2.34
T_2	Pearl millet + blackgram (4:1)	189.66	6638	2485.3	4759.2	139.6	81621	2.42
T_3	Pearl millet + blackgram (6:1)	173.66	6480	2171.3	4917.9	57.4	62008	2.08
T_4	Pearl millet + cowpea (4:1)	152.80	5472	1807.8	4121.8	204.6	45035	1.78
T_5	Pearl millet + cowpea (6:1)	158.86	5146	2063.5	4504.8	136.7	56657	1.99
T_6	Pearl millet + redgram (4:1)	185.46	6800	2239.7	4621.8	309.1	78541	2.37
T_7	Pearl millet + redgram (6:1)	169.00	6421	2139.4	4770.0	172.7	68064	2.19
	Sed	12.14	611.70	216.1	310.3			
	CD (P=0.05)	25.36	1277.9	451.5	648.3			

Table 2. Effect of intercropping on various competitive assessments

	Treatments	Grain equivalent yield	Land equivalent ratio	Relative crowding coefficient
T_2	Pearl millet + blackgram (4:1)	5467.7	1.16	1.97
T_3	Pearl millet + blackgram (6:1)	4776.9	0.93	0.61
T_4	Pearl millet + cowpea (4:1)	2892.5	0.95	0.46
T_5	Pearl millet + cowpea (6:1)	3301.6	0.97	0.50
T_6	Pearl millet + redgram (4:1)	5105.3	1.23	1.00
T_7	Pearl millet + redgram (6:1)	4920.6	1.05	0.57
	Sed	354.07		
	CD (P=0.05)	739.68	*	*

**Data not statistically analysed*

Pearl millet + blackgram at 4:1 ratio had higher RCC value of 1.97 compared to other intercropping systems. The combined RCC value greater than unity in this intercropping system denotes the advantage of intercropping (Table 2). Tripathi [15] reported pigeon pea + pearl millet has higher RCC.

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.1,39,178/ha, Rs. 81,621/ha and 2.42, respectively). It was followed by pearl millet + redgram 4:1 (Rs. 1,36,007/ha, Rs. 78541/ha and 2.37, respectively). Intercropping was always beneficial and recorded higher B:C with respect to pearl millet monoculture. Renu et al. [16] observed similar results also reported that intercropping of pearl millet with mungbean recorded the highest net returns and B:C ratio over sole pearl millet.

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 + redgram at a ratio of 4:1.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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