Performance of Foxtail millet based Intercropping system for improving the Productivity, Sustainability and Economics in Western Zone of Tamil Nadu Under Irrigated Condition

ABSTRACT

Like other small millets, foxtail millet (*Setaria italica* L.) is also rich in nutrients and as a short duration crop it fits to different cropping systems . Field experiment was carried out at Eastern block farm, Agriculture college and Research Institute, TNAU, Coimbatore, Tamil Nadu during *summer* season to study the performance of Foxtail millet based intercropping system for improving the productivity, sustainability and economics in Western Zone of Tamil Nadu under irrigated condition. The experiment was laid out in Randomized Block Design (RBD) with seven treatments and replicated three times. It comprised of seven treatments *viz.,* T_1 - Foxtail millet (sole crop), T_2 - Foxtail millet + green gram (3:1), T_3 - Foxtail millet + Vegetable cowpea (3:1), T_4 - Foxtail millet + Coriander (3:1), T_5 - Foxtail millet + green gram (4:1), T_6 - Foxtail millet + Vegetable cowpea (4:1), T_7 - Foxtail millet + Coriander (4:1). The results clearly showed that the highest grain and straw yield under intercropping system was obtained when foxtail millet was intercropped with vegetable cowpea it was closely followed by intercropping with green gram. The foxtail millet grain equivalent yield (FMGEY) was computed to be in the range of 2411 to 3873 kg ha^{-1}. The highest values for FMGEY were obtained with vegetable cowpea at two different ratios intercropping, whereas intercropping with green gram (4:1) resulted in lowest FMGEY. Foxtail millet intercropped with vegetable cowpea at 3:1 ratio recorded highest B:C ratio of 2.59. Intercropping index like land equivalent ratio was higher in all intercropping systems except coriander (1.1) at two different ratios, relative crowding coefficient (RCC) was higher in foxtail millet + vegetable cowpea (1.0) at 3:1 ratio and competition index (CI) was higher in foxtail millet + coriander (1.09) at 4:1 ratio.

Keywords: Foxtail millet; Intercropping; Productivity; Sustainability; Economics

Introduction

Millets, often referred to as "Nutri grains," are highly valued for their rich content of micro nutrients, including minerals and B complex vitamins. Small millets, in particular, have garnered attention due to their ability to mature early, achieve higher yields through the C4

plant type mechanism, and thrive in poor soil and low rainfall conditions. These qualities have earned them the reputation of being "climate resilient" crops in Indian agriculture. The cultivation of small millets contributes significantly to the nation's food and fodder security.

Foxtail millet (*Setaria italica*) grains are similar in structure to paddy rice but have an outer husk that requires removal before use. It was domesticated in China over 8000 years ago and has played a significant role in the development of Chinese civilization (Miller et al., 2016) [1]. Foxtail millet remains a staple cereal in arid and semi-arid regions due to its drought tolerance and early maturity, making it suitable for short-term catch cropping. It adapts well to various elevations, soils, and temperatures but cannot withstand waterlogging. In India, small millets are cultivated on an area of 440 million ha. producing 379 million tonnes with the productivity of 789 kg ha^{-1} (India stat. 2023) [2]. In Tamil Nadu, small millets are cultivated on an area of 24.57 million ha producing 30.51 million tonnes with a productivity of 1247 kg ha^{-1}. In Tamil Nadu, foxtail millet is cultivated in an area of 1508 thousand ha. producing 709 thousand tonnes with productivity of 470 kg ha^{-1} (Season and crop report 2021- 2022) [3].

Millets are suitable for arid lands with limited water and higher temperatures. Intercropping, growing multiple crops together, intensifies resource use and yields. Advantages include better resource utilization, weed suppression, yield stability, higher equivalent yields, increased cropping intensity, reduced pest and disease incidence, improved soil health, and sustainable farming. Intercropping in small millets enhances resource efficiency, yields, and sustainability, making it advantageous for agriculture in arid regions. (Maitra *et al*., 2019) [4].

The complementarity among the cultivated species is crucial for achieving higher crop yields in intercropping systems. Particularly, in dryland conditions, intercropping provides a natural insurance against total crop failure, ensuring production sustainability. The combination of foxtail millet with legumes in intercropping further enhances soil fertility and overall system resilience (Maitra *et.al*., 2020) [5].

Material and Methods

The experiment was conducted at Eastern Block Farm, Tamil Nadu Agriculture University, Coimbatore, Tamil Nadu. The experiment was laid out in randomized block design with seven treatments and replication thrice. The treatments comprised T_1 [Foxtail millet (sole crop)], T_2 [Foxtail millet + Green gram (3:1)], T_3 [Foxtail millet + Vegetable Cowpea (3:1)], T_4 [Foxtail millet + Coriander (3:1)], T_5 [Foxtail millet + Green gram (4:1)],

T_6 [Foxtail millet + Vegetable Cowpea (4:1)], T_7 [Foxtail millet + Coriander (4:1)] intercropping under replacement series and all the intercrops viz., green gram, vegetable cowpea, and coriander were raised separately in adjacent to the treatment plots for observation purpose. The yields were recorded to work out the intercropping assessment indices like Foxtail Millet Grain Equivalent Yield (FMGEY) , Land Equivalent Ratio (LER) (Mead and Willey, 1980) [6], Relative Crowding Coefficient (RCC) (De Wit, 1960) [7] and Competition Index (CI) (Donald, 1963) [8] as per the standard formulae. Correspondingly grain and straw yield of foxtail millet was also recorded in all the treatments. The

Treatments	At harvest stage	Land	Relative	Competition

intercropping system was also evaluated on the basis of different economical parameters *viz.*, gross returns (Rs ha^{-1}), net returns (Rs ha^{-1}) and B: C ratio.

Results and Discussion

Growth and yield attributes of foxtail millet

The effect of growth and yield on foxtail millet as influenced by inter crops. Even through the results were significant, plant height of foxtail millet was found to be higher at all stages under the treatment, foxtail millet + vegetable cowpea at 4:1 ratio (120.7 cm at harvest) followed by foxtail millet + vegetable cowpea at 3:1 ratio (114.2 cm at harvest), foxtail millet + green gram (110.4 cm at harvest) at 4:1 ratio. (Table 1). Among the various intercrops, foxtail millet + vegetable cowpea at 4:1 ratio produced higher dry matter production (6223.5 kg ha^{-1}) followed by foxtail millet + vegetable cowpea at 4:1 ratio (5938.5 kg ha^{-1}) , foxtail millet + green gram (4:1) at harvest (Table 1). Similar results found in finger millet with cowpea by Ramamohan Reddy *et.al*., (2021) [9].

The yield attributes of foxtail millet like no of tillers plant $^{-1}$ and 1000 grain weight found to be increased when intercropped with vegetable cowpea at different ratios followed by green gram at different ratios at harvest (Table 1). Sharmili and Manoharan *et.al*., (2018) [10] reported that yield attributes of little millet like no of tillers plant $^{-1}$ and 1000 grain weight is increased when intercropped with pulses (Black gram and green gram) at 8:2 ratio, respectively and it was on par with sole crop of little millet.

Table 1. Growth and yield attributes of foxtail millet, RCC, LER, CI as influenced by different intercropping systems.

*Data not statistically analysed

	Plant height (cm)	Dry matter production (Kg ha^{-1})	No of tillers $plant^{-1}$	1000 grain weight (g)			
T_1 - Foxtail millet (Sole crop)	106.8	5285.42	4.9	3.1	-	-	-
T_2 - Foxtail millet + Green gram (3:1)	112.4	5328.49	5.2	3.2	1.1	0.6	0.12
T_3 - Foxtail millet + Vegetable cowpea (3:1)	114.2	5938.54	5.4	3.6	1.1	1.0	0.07
T_4 - Foxtail millet + Coriander (3:1)	102.8	4584.58	4.2	2.88	1.0	0.4	0.16
T_5 - Foxtail millet + Green gram (4:1)	110.4	5648.87	5.2	3.4	1.1	0.4	0.10
T_6 - Foxtail millet + Vegetable cowpea (4:1)	120.7	6223.54	5.6	3.9	1.1	0.7	0.07
T_7 - Foxtail millet + Coriander (4:1)	105.4	5068.08	4.6	2.91	1.0	0.3	0.14
Mean	96.6	4759.69	4.39	2.87			
S.Ed	5.56	290.5	0.27	0.18			
CD (5%)	15.3	801.9	0.74	0.49			

Assessment of Intercropping Indices

Land equivalent ratio (LER)

All the intercropping system having a LER of more than one indicating that these intercropping system gives a yield advantage except coriander. (Table 1). This results were similar to findings of Sharmili and Parasuraman *et.al.* (2018) [11].

Relative crowding coefficient (RCC)

Relative crowding coefficient of all intercropping system were less than one indicating that these intercropping system were disadvantageous except vegetable cowpea at

3:1 ratio is equal to one indicating that these intercropping is no difference in yield than expected. Similar results were reported by Keerthanapriya *et.al.* (2019) [12] (Table 1).

Competition index (CI)

CI value of all intercropping system are advantage especially foxtail millet intercropped with coriander at 3:1 ratio is high advantage (0.16) and foxtail millet intercropped with vegetable cowpea is less advantage (0.07) (Table 1).

Yield and system productivity

The grain yield of foxtail millet was significantly influenced by various intercrops at harvest and the grain yield range from 1735 to 2208 kg ha^{-1} (Table 10). Foxtail millet sole crop recorded the highest grain yield (2208 kg ha^{-1}) followed by foxtail millet + vegetable cowpea , foxtail millet + green gram, foxtail millet + coriander ratio at two different ratios. These results were similar to findings of Himasree *et.al.* (2017) [13]. Basavarajappa *et al.* (2003) [14] found higher yield in sole foxtail millet crops compared to intercropped treatments. The harvest index in different treatments ranged between 0.31 to 0.32.

Economics

The gross return, net return and benefit cost ratio was higher under foxtail millet when intercropped with vegetable cowpea and green gram. Foxtail millet with vegetable cowpea at 3:1 ratio recorded higher gross return (Rs. 1,18,526 ha^{-1}), net return of (Rs. 72,743 ha^{-1}) and benefit cost ratio (2.59) and followed by foxtail millet with vegetable cowpea at 3:1 ratio (Table 2) due to higher yield of vegetable cowpea. The gross return, net return and benefit cost ratio was lower in sole crop of foxtail millet recorded gross return (Rs. 75,954 ha^{-1}), net return of (Rs. 30,571) and benefit cost ratio (1.67). Rahmi Yadav *et.al.* (2010) [15] reported that the gross return, net return and B: C ratio were highest with finger millet + French bean (3:1) intercropping. Manjunath *et al.* (2018) [16] reported that superiority of intercropping pigeon pea + foxtail millet (1:2) as higher net returns and benefit cost ratio were recorded over sole cropping. Similar results found in intercropping of finger millet with vegetables by Ramamoorthy *et.al.* (2004) [17].

Table 2. Yield, Harvest index, Net returns and B: C ratio of different foxtail millet intercropping system

Treatments	Foxtail millet yield (kg ha^{-1})		Harvest index	Yield of intercrops (kg ha^{-1})	Foxtail millet Grain Equivalent yield (FMGEY)	Cost of Cultivation (Rs ha^{-1})	Net income (Rs ha^{-1})	B:C ratio
	Grain yield	Straw yield						
T_1 - Foxtail millet (Sole crop)	2208	4857	0.31	-	-	45,383	30,571	1.67
T_2 - Foxtail millet + Green gram (3:1)	1858	4088	0.31	275	2500	45,583	37,583	1.82
T_3 - Foxtail millet + Vegetable cowpea (3:1)	1998	4168	0.32	1675	3873	45,783	72,743	2.59
T_4 - Foxtail millet + Coriander (3:1)	1735	3897	0.31	1598	2584	45,483	38,331	1.84
T_5 - Foxtail millet + Green gram (4:1)	1925	4104	0.32	221	2441	45,583	35,845	1.79
T_6 - Foxtail millet + Vegetable cowpea (4:1)	2023	4568	0.31	1468	3521	45,783	68,083	2.49
T_7 - Foxtail millet + Coriander (4:1)	1798	3998	0.31	1501	2549	45,483	38,968	1.86

Conclusion

Based on the results of the above experiment, it could be concluded that intercropping of foxtail millet with vegetable cowpea at 3:1 ratio registered higher net return and B: C ratio and sole crop of foxtail millet recorded lower net return and B: C ratio. Foxtail millet with vegetable cowpea at two different ratios intercropping system is more remunerative over sole cropping. Therefore, it is concluded that foxtail millet with vegetable cowpea at two different

ratios of intercropping system was found suitable for Western Zone of Tamil Nadu Under Irrigated Condition due to high yield in vegetable cowpea.

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