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Effect of Intercropping with Minor Millets on Growth, Yield and Economics of Irrigated Cotton

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Abstract : Field experiment was conducted at Agricultural college and Research institute (TNAU), Madurai under summer irrigated condition during March to August (2023) to identify the suitable minor millets in cotton based intercropping system. The experiment was carried out in a randomized block design and replicated thrice. The treatments consisted of intercropping cotton under normal spacing at 1:1 ratio with barnyard millet (T_1), foxtail millet (T_2), finger millet (T_3), 2:2 ratio under paired row system with barnyard millet (T_4), foxtail millet (T_5), finger millet (T_6), 1:3 replacement series under normal spacing with barnyard millet (T_7), foxtail millet (T_8), finger millet (T_9) and cotton sole cropping as control (T_{10}). The results revealed that all the intercropping systems in additive series at 1:1 and 2: 2 ratio under paired row planting produced comparable seed cotton yield with sole cotton and significantly higher yield than replacement series at 1:3 ratio. Among the intercrops, barnyard millet performed well under all the intercropping systems. The total seed cotton equivalent yield was higher in cotton + barnyard millet at 2:2 ratio under paired row system of 3061 kg/ha which was comparable with cotton + barnyard millet at 1:1 ratio under normal spacing. The higher gross income (₹183630/ha), net income (₹119101/ha) and BCR (2.85) were also observed in cotton + barnyard millet at 1:1 ratio under normal spacing. The study concluded that intercropping of barnyard millet either at 1:1 or 2:2 ratio was found to be most viable intercropping system for attaining higher productivity and also gain more economic benefits in cotton.

Key words: Cotton, economics, equivalent yield, intercropping, growth, minor millets, seed cotton.

Cotton is one of the most commercially cultivating fibre cum cash crop in the world and India as well. Cotton is mostly known for its fibre and oil content, which plays a conspicuous role in national and international economy. The dominance of cotton fabric in textile world led to be cotton termed as “King of Fibre”. In Tamil Nadu, cotton is cultivated in an area of 1.74 lakh hectare with a production of 4.40 lakh bales and productivity of 430 kg lint/ha (Policy Note, Tamil Nadu, 2022-2023). Adoption of a number of production technologies will be required in order to breach the productivity limitations. In recent years, achieving high productivity and promoting sustainability throughout time have become the new trends in agricultural production systems. Intercropping is the most common practice used in agricultural system that have an important role in increasing the productivity, profitability and stability of the yield to improve resource utilization and environmental factors (Gitari *et al.*, 2020). As cotton is a wide spaced crop, the inter-row spaces remain empty for around 50-60 days after sowing can be effectively used to grow intercrops. Intercropping of minor millets with compatible crops will pave the way for augmenting the cropping area under minor millets and also to sustain their productivity. With these background, the present study was framed to study the possibility of intercropping minor millets in cotton.

Field experiment was conducted at Agricultural college and Research institute, (Tamil Nadu Agricultural University), Madurai under summer irrigated season during March to August, 2023 to identify the suitable minor millets in cotton based intercropping system. The experiment was carried out in a randomized

block design and replicated thrice. The treatments consisted of intercropping cotton under normal spacing at 1:1 ratio with barnyard millet (T_1), foxtail millet (T_2), finger millet (T_3), 2:2 ratio under paired row system with barnyard millet (T_4), foxtail millet (T_5), finger millet (T_6), 1:3 replacement series under normal spacing with barnyard millet (T_7), foxtail millet (T_8), finger millet (T_9) and cotton sole cropping as control (T10). The soil of the experimental field was sandy clay loam with available N, P and K status of low (190.0 kg/ha), medium (12.3 kg/ha) and high (287.0 kg/ha) respectively. The crops and varieties used for this study were cotton (SVPR 6), barnyard millet (MDU 1), foxtail millet (CO 7) and finger millet (CO 15). For spacing of 75 × 30 cm was adopted for normal (1:1) and replacement series (1:3) and 90/60 × 30 cm was adopted for paired row planting. The blanket recommended dose of 80: 40: 40 kg of NPK/ha was followed for cotton. No more additional fertilizers were applied to the intercrops. Two hand weeding were done at 20 and 40 Days After Sowing (DAS). The growth and yield attributes were recorded. The seed cotton yield and grain yield of cotton and intercrops were registered. The seed cotton equivalent yield was calculated by dividing unit price of intercrop by that of cotton and economics were also worked out.

Growth and yield attributes of cotton

The influence of growth and yield attributes of cotton due to intercropping are presented in the Table 1. The results revealed that significant different on growth and yield attributes were observed except monopodia and boll weight. The sole cotton (T_{10}) recorded the maximum plant height, LAI and DMP (128.2 cm, 3.65 and 4767 kg/ha) when compared with the other intercropping system. The reduction in the plant height, LAI and DMP in intercropping system were mainly due to the more plants per unit area and also for competition of resources. Aladakatti *et al.,* (2011) reported the similar results in sorghum and sunflower intercropped with cotton, Singh *et al.*, (2014) in *Bt* cotton + fodder bajra and Sathishkumar *et al.*, (2021) in cotton + sorghum intercropping system. Significantly maximum number of bolls (22.26) and sympodial branches/plant (15.86) were was observed on sole cotton (T_{10}) which was followed by cotton + foxtail millet at 1:3 ratio under replacement series (T_8). Association of higher number of sympodial branches and bolls with sole cotton than intercropping as reported by Singh *et al.*, (2014) and Jayakumar and Surendran (2017) are in accordance with the result of present investigation.

Seed cotton yield of cotton

The results clearly indicated that all the intercropping systems in additive series at 1:1 and 2:2 ratio under paired row planting produced comparable seed cotton yield with sole cotton and significantly higher yield than replacement series at 1:3 ratio (Table 2). The reduction in the SCY due to intercropping of millets under additive series was attributed to fast growing and tillering nature of millets which was influenced by posing competition for all growth resources as reported by Singh *et al,* (2014). Moreover, comparable yield of sole *Bt* cotton and cotton under intercropping was also registered by Veeraputhiran and Sankaranarayanan (2022). In addition, there was severe yield reduction was noticed under intercropping of minor millets with cotton at 1:3 ratio under replacement series. Intercropping of barnyard millet, finger millet and foxtail millet with cotton under replacement series at 1:3 ratio reduced the SCY by 44.5, 43.1 and 43.6 per cent, respectively. Similar reduction in seed cotton yield by cotton intercropped with sorghum was reported by Aasim *et al.*, (2008) and Sathishkumar *et al.*, (2021), Singh *et al.,* (2014) are in conformity with the present study. The yield reduction under replacement series was also due to 50 per cent reduction in cotton

population and also severe competition of three rows of intercrops.

Yield of intercrops

Performance of intercrops can be altered with different intercropping system like additive or replacement series with cotton. Different intercrops showed significant effect on grain yield of intercrops (Table 2). Higher grain yield of intercrops under 1:1 and 2:2 ratio was due to lesser competition between cotton and intercrops, due to the higher dry matter production, leaf area index and populations. Among the intercrops, barnyard millet was found to be better under all the intercropping systems *viz.*, 1:1, 2:2 and 1:3 ratios. The highest grain yield of intercrops was registered under cotton + barnyard millet with 1:3 replacement series of 1502 kg/ha which was comparable with that of finger millet under 1:3 ratio (1427 kg/ha). The higher yield of all the intercropping systems was due to high tillering capacity, higher DMP with increased number of grains and test weight which were reflected in increased yield. The differential response of intercropping of fodder maize and fodder bajra with *Bt* cotton was documented by Singh *et al.* (2014). Similar higher yield under additive series and replacement series was also reported by Panda *et al.,* (2020) and Kumar *et al.,* (2021).

Seed cotton equivalent yield

Table 1. Influence of intercropping minor millets with cotton on growth and yield attributes of cotton

TREATMENTS	Plant height (cm) at harvest	LAI on 90 DAS	DMP on 90 DAS	Monopodial branches/ plant	Sympodial branches/ plant	Bolls/ plant	Boll weight (g)
T_1 -Cotton + Barnyard millet (1:1)	87.2	3.02	3620	1.85	12. 95	20.07	3.91
T_2-Cotton + Foxtail millet (1:1)	94.9	3.21	4011	1.89	13.90	20.25	4.01
T_3 -Cotton + Finger millet (1:1)	94.6	3.04	3825	1.94	13.89	20.19	3.92
T_4 -Cotton + Barnyard millet (2:2)	125.3	3.23	3962	1.95	12.98	20.30	3.96
T_5 -Cotton + Foxtail millet (2:2)	108.5	3.42	4285	2.09	13.97	20.41	4.03
T_6 -Cotton + Finger millet (2:2)	102.7	3.24	4027	1.98	13.95	20.32	4.01
T_7 -Cotton + Barnyard millet (1:3)	110.3	3.43	2016	1.99	14.87	21.80	4.05
T_8 -Cotton + Foxtail millet (1:3)	118.3	3.62	2113	2.13	14.95	22.06	4.08
T_9 -Cotton + Finger millet (1:3)	117.5	3.61	2095	2.11	14.90	21.95	4.06
T_{10} -Sole cotton	128.2	3.65	4767	2.14	15.86	22.26	4.08
S.Ed	3.02	0.081	95.1	0.16 2	0.417	0.593	0.112
CD (P=0.05)	6.47	0.174	203.5	NS	0.893	1.269	NS

Table 2. Influence of intercropping minor millets with cotton on yield of cotton and minor millets

Treatments	Yield (kg/ha)			
	Seed cotton yield	Grain yield of intercrops	Cotton equivalent yield of intercrops	Total cotton equivalent yield
T_1 -Cotton + Barnyard millet (1:1)	2158	1127	845	3003
T_2 -Cotton + Foxtail millet (1:1)	2175	743	557	2732
T_3 -Cotton + Finger millet (1:1)	2167	932	621	2788
T_4 -Cotton + Barnyard millet (2:2)	2168	1190	893	3061
T_5 -Cotton + Foxtail millet (2:2)	2191	782	587	2778
T_6 -Cotton + Finger millet (2:2)	2183	967	645	2828
T_7 -Cotton + Barnyard millet (1:3)	1242	1502	1031	2273
T_8 -Cotton + Foxtail millet (1:3)	1274	1238	752	2026
T_9 -Cotton + Finger millet (1:3)	1263	1427	874	2137
T_{10} -Sole cotton	2240	0	0	2240
S.Ed	64.4	41.9	29.7	81.7
CD (P=0.05)	137.8	89.8	63.5	174.8

Table 3. Influence of intercropping minor millets with cotton on economic analysis

Treatments	Cost of cultivation (₹ha)	Gross income (₹ ha)	Net income (₹ ha)	B:C Ratio
T_1 -Cotton + Barnyard millet (1:1)	64529	180195	115666	2.79
T_2 -Cotton + Foxtail millet (1:1)	64541	163935	99394	2.54
T_3 -Cotton + Finger millet (1:1)	64181	167300	103119	2.61
T_4 -Cotton + Barnyard millet (2:2)	64529	183630	119101	2.85
T_5 -Cotton + Foxtail millet (2:2)	64541	166650	102109	2.58
T_6 -Cotton + Finger millet (2:2)	64181	169660	105479	2.64
T_7 -Cotton + Barnyard millet (1:3)	60033	142110	82077	2.37
T_8 -Cotton + Foxtail millet (1:3)	58037	132150	74113	2.28
T_9 -Cotton + Finger millet (1:3)	57721	132860	75139	2.30
T_{10} -Sole cotton	60803	134400	73597	2.21

The seed cotton equivalent yield (SCEY) is a measure of total productivity of intercropping system by adding the yield of cotton and also intercrops yield in equivalent to cotton price. In this present study was significantly increased by all the intercropping systems attempted, except finger millet and foxtail millet intercropped with cotton under replacement series (1:3), (Table 2). Among the additive series of intercropping of cotton + millet at 2:2 ratios recorded higher yield advantage than that of 1:1 ratios. The maximum cotton equivalent yield was obtained in cotton + barnyard millet (T_4) at 2:2 ratio under paired row (3061 kg/ha) which was comparable with cotton + barnyard millet at 1:1 ratio under normal spacing (3003 kg/ha) and all effect of both these intercropping system was significantly superior than all other intercropping systems and also sole cotton. The CEY improvement by the above intercropping system was 36.7 and 34.1 per cent, respectively as compared to sole cotton. The highest SCEY under intercropping system than sole cotton was attributed to additional yield harvested by intercrops and prevailing market price of intercrops (Veeraputhiran and Sankaranarayanan, 2022). The higher yield under 2:2 ratio was due to the corresponding higher yield of intercrops. These findings of higher CEY with cotton intercropping with sorghum (Aasim *et al.*, 2008), fodder maize and fodder bajra (Singh *et al.,* 2014), foxtail millet (Siddhaganganmma *et al.,* 2021) are in agreement with the present study.

Economics

The economic analysis indicated that higher cost of cultivation under intercropping of cotton + minor millets at both 1:1 and 2:2 ratio than that of sole cropping was due to cost incurred towards the seed, labours for sowing and harvest, etc., of intercrops. The cost of cultivation was higher under sole cotton and intercropping of minor millets at both 1:1 and 2:2 ratio under additive series than that of 1:3 under replacement series. The highest gross return, net return and BCR of ₹183630/ha, ₹119101/ha and 2.85, respectively were obtained in cotton + barnyard millet (T_4) at 2:2 ratio under paired row. This was closely followed by cotton + barnyard millet (T_1) at 1:1 ratio under normal spacing of ₹ 180195/ha (gross return), ₹115666/ha (net return) and 2.79 (BCR). Higher economic benefits realized under above intercropping systems were due to the resultant additional yield of intercrops (Table 3). Similar results of improvement in economic benefits of intercropping in cotton were reported by Seemasepat and Ahlawat (2010), Sankaranarayanan *et al*, (2012) (cluster bean and coriander) Singh *et al.* (2014) (sorghum and fodder bajra), (blackgram and green gram) and Veeraputhiran and Sankaranarayanan (2022) (clusterbean and onion).

It can be concluded from the study that barnyard millet was the most suitable intercrop in cotton, followed by finger millet. Intercropping of barnyard millet with cotton under both paired row (2:2) and normal spacing (1:1) was found to be the most viable intercropping system for

maximization of yield and also higher economic benefits.

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