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Multi-tier vegetables intercropping system for higher productivity and economic return in cotton

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ABSTRACT : Vegetable crops having different growth habits and requirements of resources were selected to achieve maximum production per unit area per unit time. The ultra short (coriander and amaranthus), short (radish) and medium duration vegetables (beet root, clusterbean, vegetable cowpea and dolichos) were used in the study. Growth and yield characters and seed cotton yield in the different multi-tier intercropping systems did not vary significantly. The highest seed cotton equivalent yield (43.5 q/ha) was registered with multi-tier system of cotton+radish+amaranthus, where intercrops were planted between cotton rows, which was 99% higher than that in sole cotton (21.9 q/ha). Quality parameters were not affected by the multi-tier intercropping systems. Multi-tier intercropping of radish and amaranthus planted between cotton rows under normal planting method also registered the highest gross return (Rs. 84,908/ha) and net return (Rs. 55,832/ha) and benefit : cost ratio (2.9) and was followed by intercropping of radish+coriander between cotton rows. The results summarized that amongst the different multi-tier intercropping systems tried, planting of radish and amaranthus between normally planted cotton rows registered the highest gross return, net return, benefit : cost ratio and seed cotton equivalent yield.

Key words : Gross return, multi-tier cropping, net return, paired row planting, seed cotton equivalent yield

Cotton, an important crop of commerce and industry, occupies an area of 9.13 million hectares in the country with an estimated production of 270 lakh bales (2006-07). Cotton is relatively longer in duration and its slow growth in the initial stages offers a vast scope for raising intercrops. These intercrops serve as an insurance against the menace of pests and diseases, vagaries of weather and help to increase the net profit. The ultra short (coriander and amaranthus), short (radish) and medium duration vegetables (beet root, clusterbean, vegetable cowpea and dolichos) of different root depth and growth habits were selected. The success of intercropping is mainly dependent on crop compatibility and intercropping will be beneficial when crops of different growth habits are inter-planted. Multi-vegetables intercropping acts as a multi-tier system providing an efficient means of harvesting of solar energy. Moreover, the root system of the component crops is also located at distinct zones so as to explore the soil for moisture and nutrients (Palaniappan, 1985).

MATERIALS AND METHODS

A field trial was conducted during winter season (Aug.-Feb.) of 2004-05 at Central Institute for Cotton Research, Regional Station, Coimbatore. The experimental soil was clay loam in texture, low in available N (230 kg/ha), medium in available P (16.1 kg/ha) and high in available K (893.3 kg/ha) with a pH of 8.6. The experiment was laid out in a randomized block design with three replications. The treatment combinations comprised nine multi-tier cropping systems that included three intercropping systems where intercrops were planted between normally spaced cotton rows (90 x 60 cm) and in other five intercropping systems where intercrops were planted between the paired row of cotton (75-105 x 60 cm) and a control (normally spaced sole cotton). Thus, the following nine multi-tier cropping systems were tested *viz.*, Sole cotton (T_1), Cotton+radish+coriander (normal planting) (T_2), Cotton+radish+amaranthus (normal planting) (T_3), Cotton+coriander+amaranthus (normal planting) (T_4), Cotton+radish+vegetable cowpea+coriander (paired row planting) (T_5), Cotton+radish+clusterbean+amaranthus (paired row planting) (T_6), Cotton+beet root+coriander +amaranthus (paired row planting) (T_7), Cotton+coriander+dolichos+amaranthus (paired row planting) (T_8) and Cotton+radish+dolichos +coriander (paired row planting) (T_9).

The quality parameters *viz.*, ginning percentage, seed index, lint index, 2.5% span length, maturity ratio, uniformity ratio, micronaire strength and fibre elongation were analyzed and fibre quality index was worked out

for the different multi-tier intercropping system. The quality parameters were analysed by using high volume instruments (Statex-Fibrotex). Comparative economics was calculated for the different systems to select the best one. The cotton hybrid, RCH-2, coriander (*Coriandrum sativum* L.) cv. Surabhi, amaranthus (*Amaranthus* sp. L.) cv. Co-5, radish (*Raphanus sativus* L.) cv. Pusa Chetki, beet root (*Beta vulgaris* L.) cv. DDR, clusterbean (*Cyamopsis tetragonoloba* L.) cv. Pusa Navbahar, dolichos (*Lablab purpureus* var. *typicus*) cv. Flora and vegetable cowpea [*Vigna unguiculata* (L.) Walp.] cv. Co 2 were grown in the experiment. The main and intercrops were sown during the first week of September 2004. A uniform NPK fertilizer dose of 90 : 45 : 45 kg/ha was followed for all the treatments. Nitrogen was applied at two equal splits, first at the time of sowing and second on 40 days after sowing (DAS), while entire P and K were applied as basal at the time of sowing. Cotton equivalent yields were worked out by equating prices of component crops yield as suggested by De *et al.* (1978).

RESULTS AND DISCUSSION

Effect of Intercropping on Growth and Yield of Cotton

Biometric observations were recorded at 45, 60, 90 and 120 days after sowing (Tables 1 and 2) and at harvest stage. The crop growth characteristics (plant height, number of leaves, nodes, sympodia, squares, bolls), yield attributes and yield of cotton were not significantly affected by different multi-tier cropping systems tried in both the planting methods, namely, normal planting and paired row planting. Cotton crops in the multi-tier cropping systems produced statistically similar growth and yield as compared to that in sole cotton system. The selected components had differential growth habits with varied root and shoot systems. Intercrops *viz.*, vegetable cowpea, dolichos and clusterbean being primarily nodulators, might have contributed to the soil fertility through atmospheric nitrogen fixation and the same might have been effectively utilized by the cotton crop during the peak period of growth. The multi-tier crops *viz.*, coriander was pulled up within 30 DAS, radish harvested at 40 DAS, vegetable cowpea, clusterbean and dolichos attained the peak within 75 DAS and then harvested, and beet root was pulled up at 80 DAS. None of the above vegetable crops competed with the main crop during peak period of growth. This resulted in almost similar seed cotton yield in normal and paired row planting methods. Similar results with the method of planting were reported by Korraddi *et al.* (1991) and Krishnaswamy *et al.* (1995).

Effect of Intercropping on Pest Population

The monoculture has been criticized because of their genetic uniformity resulting in continuous pest susceptibility. Intercropping is one of the important cultural practices in pest management and is based on the principles of reducing insect-pests by increasing diversity of an ecosystem. Pest population was recorded at 60 DAS (Leaf hopper, *Amrasca devastans* Dist.) and whitefly (*Bemisia tabaci* Genn.) and 120 DAS (Leaf hopper, whitefly and bollworms). Significant differences in pest population were not observed in the different cropping systems (Table 2). This may be due to non-occurrence of sufficient pest load during the observation period. Though not much variations observed in pest population during the observation cycles, crops like coriander might have contributed in the ecosystem balancing and support to the natural enemies of pests infesting cotton crops by attracting them through release of green leaf volatiles.

Effect of Intercropping on Cotton Quality Parameters

None of the cotton quality parameters *viz.*, ginning percentage, seed index, lint index, 2.5% span length, maturity ratio, uniformity ratio, micronaire strength, fibre elongation and fibre quality index showed significant differences in the different multi-tier cropping systems (Table 3). The results revealed that the selected intercrops and their genotypes and method of planting did not affect the main crop of cotton, thereby resulting in similar lint qualities in different cropping systems with that in sole cotton.

Table 1. Effect of multi-tier intercropping on growth characters of base crop cotton (45, 60, 90 and 120 DAS)

Multi-tier intercropping system	Days after sowing									
	45		60		90			120		
	Plant height (cm)	Sympodia/ plant	Plant height (cm)	Sympodia/ plant	Plant height (cm)	Sympodia/ plant	Bolls/ plant	Plant height (cm)	Sympodia/ plant	Bolls/ plant
T_1–Sole cotton	56.1	12.7	34.3	7.8	103.4	18.5	16.4	102.6	20.2	37.0
T_2–Cotton+radish+coriander (normal planting)	54.7	11.9	37.4	8.4	97.7	18.1	22.4	96.2	19.7	42.2
T_3–Cotton+radish+amaranthus (normal planting)	53.0	10.8	36.4	7.8	103.0	18.6	15.0	103.2	20.6	33.1
T_4–Cotton+coriander+amaranthus (normal planting)	55.9	10.9	35.8	8.3	100.5	17.6	15.4	104.1	19.4	32.7
T_5–Cotton+radish+vegetable cowpea+coriander (paired row planting)	59.2	12.3	40.7	9.4	98.1	18.5	21.3	97.6	19.7	32.9
T_6–Cotton+radish+clusterbean+amaranthus (paired row planting)	58.8	12.6	39.3	9.4	102.2	18.8	26.8	104.3	20.7	44.9
T_7–Cotton+beet root+coriander+amaranthus (paired row planting)	60.7	12.3	41.6	9.5	109.4	19.0	22.8	106.1	19.9	43.7
T_8–Cotton+coriander+dolichos+amaranthus (paired row planting)	58.4	12.0	38.9	9.1	107.9	17.9	23.0	102.1	20.2	43.4
T_9–Cotton+radish+dolichos+coriander (paired row planting)	60.8	12.5	43.1	9.5	105.6	19.1	25.9	101.8	21.1	45.3
S. Ed	5.5	0.9	3.8	0.7	7.3	1.1	3.1	7.6	1.3	4.3
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS–Non Significant.

Table 2. Effect of multi-tier intercropping on pest population, yield characters and yield of base crop cotton

Multi-tier intercropping system	Days after sowing								
	60		120			At harvest			
	Jassids/ leaf	Whiteflies/ leaf	Jassids/ leaf	Whiteflies/ leaf	Bollworm infested (%)	Bursted bolls/plant	Boll weight (g)	Single plant yield (g)	Seed cotton yield (q/ha)
T_1–Sole cotton	0.80	0.76	1.26	1.03	5.64	26.0	5.2	116.0	21.90
T_2–Cotton+radish+coriander (normal planting)	0.80	0.73	1.06	1.00	5.48	29.5	5.4	127.9	23.49
T_3–Cotton+radish+amaranthus (normal planting)	0.83	0.70	1.26	1.16	5.48	30.5	5.4	132.8	24.69
T_4–Cotton+coriander+amaranthus (normal planting)	0.80	0.66	0.76	1.13	4.23	25.9	5.2	114.2	21.40
T_5–Cotton+radish+vegetable cowpea+coriander (paired row planting)	0.63	0.73	1.03	1.33	5.25	22.5	5.4	112.0	20.70
T_6–Cotton+radish+clusterbean+amaranthus (paired row planting)	1.00	0.63	1.10	1.00	5.41	30.0	5.3	132.6	24.54
T_7–Cotton+beet root+coriander+amaranthus (paired row planting)	0.60	0.60	1.06	0.90	3.31	28.2	5.5	129.0	23.50
T_8–Cotton+coriander+dolichos+amaranthus (paired row planting)	0.77	0.70	1.10	1.03	7.18	26.9	5.6	124.9	23.30
T_9–Cotton+radish+dolichos+coriander (paired row planting)	0.83	0.56	0.87	1.10	5.10	27.3	5.3	12.0	22.38
S. Ed	0.03	0.03	0.03	0.02	2.00	3.1	0.3	12.3	1.50
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS–Non Significant.

Table 3. Effect of multi-tier intercropping on quality parameters of base crop cotton

Multi-tier intercropping system	2.5% span length (mm)	Maturity ratio	Uniformity ratio (%)	Micronaire (µg/inch)	Strength (g/tex)	Fibre elongation (%)	Seed index (g)	Lint index	Ginning percentage	FQI
T_1–Sole cotton	30.00	0.76	47.7	4.0	22.0	5.3	10.6	5.5	34.1	330
T_2–Cotton+radish+coriander (normal planting)	28.80	0.75	47.0	3.9	21.2	5.1	10.4	5.3	33.7	310
T_3–Cotton+radish+amaranthus (normal planting)	30.70	0.78	47.5	4.1	21.1	5.4	10.7	5.5	34.1	320
T_4–Cotton+coriander+amaranthus (normal planting)	30.60	0.75	47.9	3.9	22.2	5.2	10.5	5.4	34.0	344
T_5–Cotton+radish+vegetable cowpea+coriander (paired row planting)	29.80	0.75	47.2	3.9	21.8	5.3	10.4	5.4	34.2	329
T_6–Cotton+radish+clusterbean+amaranthus (paired row planting)	30.80	0.75	47.8	3.9	22.8	5.2	10.9	5.5	33.6	356
T_7–Cotton+beet root+coriander+amaranthus (paired row planting)	30.00	0.75	46.8	3.8	20.8	5.1	10.8	5.5	33.6	320
T_8–Cotton+coriander+dolichos+amaranthus (paired row planting)	29.10	0.75	47.1	3.9	22.0	5.1	9.98	5.2	34.4	324
T_9–Cotton+radish+dolichos+coriander (paired row planting)	31.10	0.76	48.1	4.0	22.1	5.3	11.1	5.8	34.5	344
S. Ed	0.8	0.02	0.6	0.2	0.5	0.2	0.3	0.2	0.6	19.4
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS–Non Significant.

Table 4. Economics of multi-tier cropping system in cotton

Systems	Items	Intercrops							Gross return (GR, Rs./ha)			Total net return (Rs./ha)	SCEY (q/ha)	B : C ratio
		Radish	Coriander	Amaranthus	Vegetable cowpea	Clusterbean	Beet root	Dolichos	Intercrop total	Cotton	Total			
T_1	Yield (kg/ha)	-	-	-	-	-	-	-						
	GR (Rs./ha)								-	42705	42705	15855	21.90	1.6
T_2	Yield (kg/ha)	6420	233	-	-	-	-	-						
	GR (Rs./ha)	25680	2796						28476	45805	74281	45397	38.06	2.6
T_3	Yield (kg/ha)	8299	-	1783	-									
	GR (Rs./ha)	33196		3566		-	-	-	36762	48146	84908	55832	43.54	2.9
T_4	Yield (kg/ha)	-	520	2155	-	-	-	-						
	GR (Rs./ha)		6240	4310					10550	41730	52280	23606	26.81	1.8
T_5	Yield (kg/ha)	3384	170	-	283	-	-	-						
	GR (Rs./ha)	13536	2040		1698				17274	40365	57639	27753	29.56	1.9
T_6	Yield (kg/ha)	3472	-	447	-	220	-	-						
	GR (Rs./ha)	13888		894		1760			16542	47853	64395	34833	33.02	2.2
T_7	Yield (kg/ha)	-	196	1097	-	-	1249	-						
	GR (Rs./ha)		2352	2194			8743		13289	45825	59114	29696	30.30	2.0
T_8	Yield (kg/ha)	-	131	1016	-	-	-	282						
	GR (Rs./ha)		1572	2032				3102	6706	45435	52141	22105	26.74	1.7
T_9	Yield (kg/ha)	3342	106	-	-	-	-	207						
	GR (Rs./ha)	13368	1272					2277	16917	43641	60558	30462	31.06	2.0

Price of the produce : Amaranthus Rs. 2/kg, Beet root Rs. 7/kg, Clusterbean Rs. 8/kg, Dolichos Re. 1/kg, Coriander Rs. 12/kg, Veg. cowpea Rs. 6/kg and Radish Rs. 4/kg. SCEY–Seed cotton equivalent yield.

Economics of Multi-tier Cropping System

The highest gross return (Rs. 84,908/ha) was recorded with intercropping of radish and amaranthus between normally planted cotton rows and was followed by planting of radish and coriander between normally spaced cotton rows. Similar results were also observed for net return and benefit : cost ratio (Table 4). Intercropping of radish and amaranthus between normally spaced cotton rows registered the highest net return and benefit : cost ratio of Rs. 55,832/ha and 2.9, respectively. The second highest net return (Rs. 45,397/ha) and benefit : cost ratio (2.6) were calculated in radish and coriander grown between normally planted cotton rows. The results conveyed that combination of short duration crops (radish+amaranthus and radish+coriander) produced higher return without affecting the cotton crop. This may be attributed to differential growth peaks in the selected crops in the intercropping involving radish and amaranthus that coincided with lag phase of the cotton and helped in avoiding competition among the components and main crop.

The multi-tier system offered 4.8 to 21.6 q/ha of higher seed cotton equivalent yield, which is 22 to 99% higher than the sole cotton crop. Higher seed cotton equivalent yield in cotton based multi-tier cropping system was reported by Pothiraj and Srinivasan (1992) and Sharma *et al.* (1997). The highest seed cotton equivalent yield (43.5 q/ha) was calculated with cotton+ radish+amaranthus (normal planting of cotton) system. The multi-tier cropping systems registered the monetary advantage of Rs. 6, 250 to 39,977/ha and were 39 to 252% higher than that in the sole cotton crop.

The introduction of root tuber crops *viz.*, radish and beet root in the various multi-tier systems introduced indicated that these salvaged the risk perturbed by rest of the intercrops like coriander, amaranthus, vegetable cowpea and dolichos, thereby maintaining the yield equivalents and income. Thus, higher yield and profit may be realized with the introduction of root tuber crops since the other multi-tier components *viz.*, coriander, dolichos and amaranthus contributed much less to the overall productivity and net return in the existing intercropping systems. Hence, selection of multi-tier crops for intercropping is highly essential to reduce the risk and to get stabilized yield and economic return.

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