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FEASIBILITY AND ECONOMIC VIABILITY OF INTERCROPPING IN FCV TOBACCO UNDER IRRIGATED ALFISOLS IN ANDHRA PRADESH

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Field experiment was conducted in tobacco based intercropping system at ICAR-CTRI RS, Jeelugumilli, Andhra Pradesh during Rabi season 2005-06 and 2006-2007 in Alfisols under irrigated upland ecosystem The results revealed that tobacco green leaf yield with the intercrops tested was significantly higher than sole tobacco except with radish. Total productivity of tobacco with different intercrops was rather improved as compared to sole tobacco. Garlic and coriander intercrops had complementary effect on base crop tobacco and the cured leaf yield of tobacco with garlic and coriander was higher by 217 (9.36) and 162 kg/ha (6.99%) respectively, as compared to that of sole tobacco (2318 kg/ha). Though there were significant differences in tobacco lamina quality characters due to different intercrops all the values were within the acceptable range. The intercropping system tobacco + amaranthus recorded maximum net returns of Rs 1,26,788/ha and benefit: cost ratio of 1.48 and there was 51.94% percent increase of net returns over sole tobacco. The other remunerative intercropping systems were tobacco + garlic followed by tobacco + fenugreek and tobacco + radish with a net returns of Rs 1,25,658, Rs 1,16,583 and Rs 1,14,700 and benefit: cost ratio of 1.46, 1.43 and 1.43, respectively. All the tobacco based intercropping systems showed net returns of >Rs 1,03,918 and benefit: cost ratio of >1.39 while sole tobacco recorded lower values of net returns (Rs 83,448) and B: C ratio (1.36). It can be concluded that component crops *viz.*, amaranthus, spinach, fenugreek, coriander, carrot, onion, garlic and radish can be grown successfully without much competition to tobacco in between two paired rows of tobacco. Thus, in the long run the farmers in irrigated Alfisols under Northern Light Soils in East and West Godavari (dt) of AP and Khammam (dt) of Telangana may choose a system that gives maximum net returns as per the prevailing market demand taking into consideration the incidence of insect pests and diseases as well as soil health.

Key words : Intercropping, irrigated alfisols, economic viability,

INTRODUCTION

Tobacco is an important commercial crop which is traded for its quality leaves and quoted as golden leaf in the world market (Singh *et al.*, 1998). It contains several alkaloids including nicotine, which can be used in a variety of ways including medical and agricultural pest management. It can be grown under wide range of climatic and soil conditions which play a crucial role in Indian economy in general and Andhra Pradesh in particular. This crop is a remunerative *rabi* cash crop of irrigated uplands of East Godavari, West Godavari districts of Andhra Pradesh and Khammam district of Telangana. It is cultivated with wider spacing (100 X 60 cm) under irrigated conditions (17,776 ha with a production of 39.54 million kg of semi flavourful leaf per annum) in NLS area (Tobacco Board, 2016-17). During the initial period of tobacco growth the crop canopy is less, allowing sufficient sunlight to reach the soil surface between the rows which facilitates growing short duration intercrops in between the rows of tobacco.

The arable land is one of the precious and scarce resources. So, among the options to increase productivity from unit land area, increasing the cropping intensity and efficient utilization of available resources seems a more feasible proposition rather than increasing area under cultivation. Intercropping is one of the viable agronomic practices for stepping up the productivity of a system from a unit area during the cropping period. The productivity of a cropping system is not only governed by the inputs applied to the crop but also by the harmony between the crops grown in association or in sequence. Hence, there is a need to bring in sustainability both in productivity and in the economy of the Indian farmers. Now-a-days with improved crop management practices and availability of high yielding, short duration, photo and thermo insensitive varieties of different crops there is ample scope for developing tobacco based cropping systems. As there is plasticity of response of these varieties to different populations and planting patterns, in addition to the full yield of the base crop tobacco, some additional yield from the intercrop also can be obtained. Yield increase due to complimentary crops, improvement of soil fertility, maximum utilization of labour over a period of time and minimal damage caused by weeds, insect pests and diseases are the possible benefits of intercropping (Willey,1979). The intercropping in paired-row planting helps to maintain full population of main crop and harness the maximum yield advantage in intercropping system (Sarkar and Chakraborty, 1999). Since growth pattern of component crops differ, the nutrient and moisture depletion patterns occur at varying soil depths which is an important factor for efficient use of growth resources and increase in yield of each crop. It is possible to introduce and include the short duration varieties in the intercropping to scale up the economic status of tobacco growers in this tract of AP. The present study was taken up with a view to explore the feasibility of growing compatible and remunerative intercrops having less competition with the base crop FCV tobacco cv. Kanchan for enhancing the productivity per unit area thereby increasing the profitability of the tobacco farming community as a whole under irrigated Alfisols (popularly known as Northern Light Soils) conditions.

MATERIALS AND METHODS

The field experiment was conducted for two years during *Rabi* season of 2005-06 and 2006-07 at the ICAR-CTRI Research Station, Jeelugumilli, (17 11' 30" N and 81 07' 50" E at 150 m above mean sea-level), West Godavari district, Andhra Pradesh under semi arid tropical climate in northern light soils (alfisols) under irrigated upland ecosystem. The experimental soil is slightly acidic in reaction (pH 6.0 to 6.6) with low soluble salts (0.16 to 0.20 dS/m), chlorides (23 to 26 ppm) and nitrogen (130 to 138 kg/ha), available potassium (72 to 80 kg/ha) and medium with respect to P (20 to 24 kg/ha) in surface layers. The experiment consisted of 9 treatments arranged in randomized block design with four replications. The treatments include sole tobacco in normal planting and 8 intercrops in between two paired rows of FCV tobacco. The intercrops tested were leafy vegetables (spinach, amaranthus, fenugreek and coriander) for culinary purpose, and other tuber crops *viz.*, carrot, radish, onion and garlic.

The gross plot size was 6 X 6 m (60 plants) and net plot size was 4.0 X 4.8m (32 plants). For intercropping treatments, tobacco was planted in paired rows maintaining a spacing of 60 cm within a pair of tobacco rows and 140 cm between two pairs of tobacco rows. Three rows of intercrops (component crops) were sown between two pairs of tobacco rows. FCV tobacco variety Kanchan was used as the base crop. Healthy tobacco seedlings of 60 days old were planted in the first week of October. Intercrops were also sown/ planted along with tobacco. The sole tobacco and tobacco intercropped with other component crops received 115 kg N + 60 kg P_2O_5 + 120 kg K_2O /ha. The popular and local varieties of intercrops were sown. In intercropping system the component crops received fertilizer proportionate to the plant density as per the recommendations of ANGRAU. Recommended cultural practices were followed for raising the base crop tobacco and different component crops. Rhizosphere soil samples were collected at 45 days after planting between base crop tobacco and inter crop rows and in between the rows of intercrops, and soil enzymes alkaline phosphatase (ig p-nitrophenol/g/soil/h) and dehydrogenase (change in OD at 485 nm) were assessed. Weather parameters including rainfall were almost favourable during both the years and the role of rainfall was negligible as the crop was raised during winter under assured irrigation.

The tobacco crop was topped at 24 leaves at bud stage. Decanol 4% was applied @ 10-15 ml/ plant immediately after topping for preventing sucker growth. The first priming was done 90 days after planting. Mature green leaves were harvested by priming and cured in the barn. The data on tobacco green leaf and cured leaf were recorded and grade index was calculated (Gopalachari, 1984). The cured leaf samples collected from P, X, L and T positions were analysed for chemical quality characters (reducing sugars, nicotine, and chlorides) as per the standard procedures. The data were statistically analysed and results of individual years and pooled analysis were presented. The yield of intercrops was recorded and expressed in kg/ ha. Radish yield was expressed as the number of tubers/ha. The yield of each system was computed and assessed for their relative performance and economic returns were calculated for pooled yield data.

RESULTS AND DISCUSSION

Base crop yield: Various intercrops by and large influenced the growth and development of tobacco in different magnitudes (Table 1). Green leaf yield of tobacco showed significant differences between the treatments during 2005-06 and in pooled data. During the first year, green leaf yield of tobacco with intercrops of spinach, fenugreek, coriander, carrot, onion and garlic were significantly higher than sole tobacco. The green leaf yield of tobacco with intercrops of amaranthus and radish were on a par with sole tobacco. In pooled data also tobacco green leaf yield with all the intercrops was significantly higher than sole tobacco except with radish where it was on a par with sole tobacco. There were no significant differences between the treatments with regard to cured leaf yield and grade index. However, the pooled cured leaf yield of tobacco with garlic and coriander was higher by 217 (9.36) and 162 kg/ ha (6.99%) respectively, as compared to that of sole tobacco. Garlic and coriander intercrops had complementary effect on base crop tobacco as their association improved the cured leaf yield of tobacco. The increase in cured leaf yield of tobacco with garlic intercropping was attributed to the lower canopy structure of garlic as compared to other intercrops. Increased tobacco cured leaf yield with garlic intercropping was also reported by Singh *et al.* (1998), Singh (2010) and Singh *et al.*, (2013). The lowest numerical value of cured leaf and grade index were recorded in tobacco intercropped with radish. Total productivity of tobacco with different intercrops was rather improved as compared to sole tobacco. This might be mainly due to the fact that intercropped plots were given more no. of irrigations at early stages of growth and partly due to the availability of more nutrients from intercrops. The tobacco yields of green leaf, cured leaf and grade index were higher during the first year compared to second year.

Intercrops yield: Among the green leafy vegetables (Table 2), amaranthus performed well and produced relatively higher yields (4706 kg/ha) followed by spinach (4342 kg/ha). Among the tuber crops, radish produced on an average 22539 tubers/ha. Among other tuber crops, carrot recorded higher yields followed by onion and garlic. The yields of different intercrops grown with tobacco were relatively lower as compared to their potential yield as sole crops. The reduction in the yields of intercrops may be attributed to their reduced plant population rather than depression effects expected on account of competition between base crop and intercrop components. Competition among base crop and intercrop components for solar radiation, nutrients and moisture might have also contributed to some extent. However, the intercrops performed well and the yields of intercrops were relatively higher during the second year. Beneficial effects of intercropping have also been reported by Singh *et al.*, (1998), Singh, (2010) and Singh *et al.*, (2013).

Tobacco leaf chemical quality: Tobacco is one of the few crops cultivated for its quality leaves having good taste, aroma and balanced chemical quality parameters. Nicotine, reducing sugars and chlorides in leaf are important quality parameters influenced by different intercrops (Table 3). In general, mean nicotine concentration increased from P to T position, while mean reducing sugars increased from P to L position and thereafter decreased in T position. The increase in nicotine content from P to T position is due to the fact that the nicotine is synthesized in the roots and its rate of synthesis is accelerated after the plants are topped. Nicotine is concentrated in the remaining tissues after the tobacco is topped and de-suckered. Thus, the degree of nicotine accumulation is directly related to the duration the leaves remain on the plants after topping. As the FCV tobacco in irrigated Alfisols is topped and complete sucker control is practiced, top leaves at the tip of the plant remain for a longer period on the plant and leading to an increase in the nicotine concentration from P to T position (with increase in stalk position) (Collins and Hawks, 1993, Krishna Reddy *et al.*, 2009).

Table1: Yield of tobacco as influenced by tobacco based intercropping in irrigated Alfisols (NLS)

Treatments	Green leaf yield (kg/ha)			Cured leaf yield (kg/ha)			Grade index (kg/ha)		
	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled	2005-06	2006-07	Pooled
Tobacco + Spinach/ Palak	20182	15269	17726	2575	2125	2350	1590	1248	1419
Tobacco + Amaranthus	18799	14169	16480	2590	2145	2368	1546	1212	1379
Tobacco + Fenugreek (Menthi)	19502	14639	17071	2675	2105	2440	1546	1205	1376
Tobacco + Coriander	19760	14753	17256	2725	2135	2480	1616	1256	1436
(for culinary purpose)									
Tobacco + Carrot	19187	14455	16821	2579	2129	2354	1554	1221	1387
Tobacco + Radish	18052	13551	15801	2525	2085	2305	1535	1207	1371
Tobacco + Onion	19334	14448	16891	2700	2220	2460	1585	1234	1409
Tobacco + Garlic	19757	14721	17239	2775	2275	2525	1609	1252	1431
Sole tobacco	17495	13346	15420	2540	2095	2318	1649	1297	1473
SEm ±		535	512	370	68.84	72.43	50	44.86	42.59
31									
CD (P=0.05)		1562	NS	1026	NS	NS	NS	NS	NS
NS									
Seasons									
2005-06			19119			2632			1581
2006-07			14372			2168			1237
SEm ±			111			16			8
CD (P=0.05)			383			55			28

Table 2: Yield of intercrops as influenced by tobacco based inter ropping in irrigated Alfisols

Treatments	Yield (kg/ha)		
	2005-06	2006-07	Pooled
Tobacco + Spinach/ palak	3959	4724	4342
Tobacco + Amaranthus	5274	4137	4706
Tobacco + Fenugreek (Menthi)	2520	3267	3787
Tobacco + Coriander (for culinary purpose	3253	3157	3205
Tobacco + Carrot	3250	4050	3650
Tobacco + Radish	22020*	23058*	22539*
Tobacco + Onion	3478	3633	3556
Tobacco+ Garlic	6525	2289	2407
Sole tobacco (cured leaf yield)	2540	2095	2318

*No of radish tubers

Table 3: Chemical quality characters nicotine, reducing sugars and chlorides as influenced by tobacco based intercropping in irrigated Alfisols (Pooled)

Treatments	Nicotine (%)				Reducing sugars				Chlorides (%)			
	P	X	L	T	P	X	L	T	P	X	L	T
Tobacco + Spinach/ palak	1.81	2.12	2.50	2.73	9.29	11.80	12.64	9.26	0.49	0.58	0.59	0.62
Tobacco + Amaranthus	1.84	2.14	2.51	2.74	9.10	11.48	12.49	9.08	0.48	0.55	0.60	0.63
Tobacco + Fenugreek (Menthi)	1.88	2.29	2.73	2.91	9.36	11.78	12.57	9.30	0.47	0.55	0.58	0.64
Tobacco + Coriander	1.84	2.16	2.53	2.78	9.01	11.48	12.38	9.02	0.52	0.53	0.55	0.60
Tobacco + Carrot	1.73	2.12	2.42	2.68	9.38	11.83	12.64	9.32	0.51	0.55	0.55	0.62
Tobacco + Radish	1.69	2.04	2.34	2.58	9.63	12.12	12.92	9.67	0.47	0.55	0.56	0.64
Tobacco + Onion	1.97	2.34	2.78	3.07	8.96	11.32	12.40	8.93	0.48	0.50	0.54	0.60
Tobacco + Garlic	2.04	2.41	2.78	3.09	8.80	11.11	12.72	8.83	0.53	0.49	0.54	0.58
Sole tobacco	1.69	2.03	2.31	2.55	10.01	12.46	13.20	9.91	0.42	0.53	0.57	0.58
SEm ±	0.10	0.11	0.10	0.12	0.51	0.56	0.58	0.48	0.09	0.09	0.10	0.11
CD (P=0.05)	0.28	0.30	0.28	0.33	1.41	1.55	1.60	1.33	NS	NS	NS	NS
Seasons												
2005-06	1.96	2.32	2.69	2.93	8.99	10.02	11.23	7.93	0.52	0.57	0.58	0.60
2006-07	1.70	2.04	2.40	2.65	9.57	13.40	14.09	10.58	0.45	0.50	0.54	0.62
SEm ±	0.03	0.04	0.03	0.04	0.14	0.16	0.17	0.14	0.03	0.03	0.03	0.03
CD (P=0.05)	0.10	0.14	0.10	0.14	0.14	0.55	0.58	0.48	NS	NS	NS	NS

Higher values of nicotine in tobacco leaf lamina in P, X, L and T positions were recorded with intercrop of garlic followed by onion, fenugreek and amaranthus. Sole tobacco recorded the lowest values of nicotine as compared to tobacco intercropped with other crops. Higher values of reducing sugars were recorded in sole tobacco followed by tobacco intercropped with radish, carrot and fenugreek. Higher values of nicotine are always associated with lower values of reducing sugars. Chlorides are well within the acceptable limits of good quality (<1.5%). Though there were significant differences in lamina quality characters of intercropped tobacco, all the values were within the acceptable range. These results are in conformity with the findings of Krishna Reddy *et al.*, (2009) and Kasturi Krishna *et al.*, (2016).

Rhizosphere enzyme activity: The rhizosphere enzyme activities of alkaline phosphatase (µg p-nitrophenol/ g soil/h) and dehydrogenase (Change in OD at 485 nm) were found to be higher in fenugreek + tobacco and carrot + tobacco where as low values were observed in spinach + tobacco (Table 4). A significant correlation was noticed between the depletion of organic P and phosphatase activity in the rhizosphere soil of wheat and clover. The dehydrogenase (DHA) is one such enzyme which reflects the total range of oxidative activity of soil microflora and imparts good knowledge about the soil fertility status. It is known to oxidize soil organic matter (SOM) by transferring protons and electrons from substrates to acceptors. These processes form part of respiration pathways of soil microbes and depend on the type of soil and soil air-water conditions (Kandeler *et al.*, 1996 and Sengupta *et al.*, 2016).

Economic analysis: Economics of different tobacco based intercropping systems worked out on the basis of input, output and prevailing market prices reveal wide variation in net monetary return as well as benefit: cost ratio (Table 5). The intercropping system tobacco + amaranthus recorded maximum net returns of Rs 1,26,788/ ha and benefit: cost ratio of 1.48 and the percent

Table 4: Effect of intercropping on rhizosphere soil enzymes activity as influenced by tobacco based intercropping in irrigated Alfisols (NLS)

Treatments	Alkaline phosphatase activity (µg p-nitrophenol/ g soil/h)	Dehydrogenase activity (Change in OD at 485 nm)
Spinach/ palak	20.78	0.210
Tobacco + Spinach/ palak	20.78	0.224
Amaranthus	28.26	0.266
Tobacco + Amaranthus	22.86	0.205
Fenugreek (Menthi)	29.73	0.312
Tobacco + Fenugreek (Menthi)	34.34	0.368
Coriander (for culinary purpose	30.43	0.402
Tobacco + Coriander (for culinary purpose	33.47	0.412
Carrot	24.34	0.245
Tobacco + Carrot	35.7	0.298
Radish	28.17	0.241
Tobacco + Radish	24.08	0.206
Carrot	23.54	0.241
Tobacco + Carrot	24.58	0.251
Radish	28.32	0.248
Tobacco + Radish	30.45	0.251

Table 5. Economics as influenced by tobacco based inter cropping in irrigated Alfisols (Based on pooled yield data)

S. No.	Treatments	Yield (kg/ha)		Cost of cultivation(Rs/ha)			Gross returns (Rs /ha)			Net returns (Rs/ha)	B:C ratio
		Tobacco cured leaf	Intercrop	Tobacco	Intercrop	Total	Tobacco	Intercrop	Total		
1.	Tobacco + Spinach/ Palak	2350	4342	230442	36000	266442	317250	65130	382380	115938	1.44
2.	Tobacco + Amaranthus	2368	4706	230982	32500	263482	319680	70590	390270	126788	1.48
3.	Tobacco + Fenugreek	2440	3787	233142	36500	269642	329400	56805	386205	116563	1.43
4.	Tobacco + Coriander	2480	3205	234342	38000	272342	334800	48075	382875	110533	1.41
5.	Tobacco + Carrot	2354	3650	230562	37500	268062	317790	54750	372540	104478	1.39
6.	Tobacco + Radish	2305	22539*	229092	35000	264092	311175	67617	378792	114700	1.43
7.	Tobacco + Onion	2460	3556	233742	30000	263742	332100	35560	367660	103918	1.39
8.	Tobacco + Garlic	2525	2407	235692	39000	275392	340875	60175	401050	125658	1.46
9.	Sole tobacco	2318	—	229482	—-	229482	312930	—	312930	83448	1.36

*no. of tubers

Note ** CLY used for calculating economic returns; curing cost of FCV tobacco above sole crop yield of 2318 kg/ha is Rs 30/kg; sale price/kg of tobacco = Rs 135/kg; sale price/kg of intercrops - spinach = Rs 15; amaranthus = Rs 15; fenugreek = Rs 15; coriander = Rs 15; carrot = Rs 15; onion = Rs 10 and garlic = Rs 25; radish = Rs 3/one tuber;

increase of net returns over sole tobacco was 51.94%. The other remunerative intercropping systems were tobacco + garlic followed by tobacco + fenugreek and tobacco + radish with a net returns of Rs 1,25,658, Rs 1,16,583 and Rs 1,14,700 and benefit: cost ratio of 1.46, 1.43 and 1.43, respectively. These results corroborate with the findings of Singh *et al.*, (1998), Singh *et al.*, (2000), Singh *et al.*, (2013) and Shivayogi *et al.*, 2015. All the tobacco based intercropping systems showed a net returns of >Rs 1,03,918 and benefit: cost ratio of >1.39 while tobacco recorded net returns of Rs 83,448 and B: C ratio of 1.36.

CONCLUSION

It can be concluded that component inter crops *viz.*, amaranthus, spinach, fenugreek, coriander, carrot, onion, garlic and radish can be grown successfully as intercrops in between two paired rows of tobacco without much competition to tobacco with enhanced growth and higher yields thereby providing higher monetary returns to the farmers. Thus, in the long run the farmers in irrigated Alfisols under Northern Light Soils in East and West Godavari (dt) of AP and Khammam (dt) of Telangana may choose a system that gives maximum net returns as per the prevailing market demand taking into consideration the incidence of insect pests and diseases as well as soil health.

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