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Feasibility of crop intensification through inter-cropping of legumes in FCV tobacco

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Abstract
A field experiment on feasibility of crop intensification through inter-cropping of legumes in FCV tobacco was carried out at All India Network Project on Tobacco, Zonal Agricultural and Horticultural Research Station (ZAHRS), Navile, Shivamogga during *kharif* of 2021. The experiment was laid out in RCBD with eleven treatments involving five legumes *viz.,* green gram, black gram, cowpea, field bean and groundnut as intercrops with FCV tobacco in alternate rows and their sole crops for comparison. Experiment was replicated four times. The results revealed that, FCV tobacco + Groundnut recorded significantly higher plant height at harvest (84.6 cm), number of leaves per plant before first picking (16.7), leaf area of X and L position leaves (992.5 and 722.1 cm^2, respectively), cumulative number of leaves harvested per plant (22.2) and cured leaf yield (1771 kg ha^{-1}) of FCV tobacco as compared to sole FCV tobacco. The yield was 13.9 percent higher as compared to sole FCV tobacco. Also, the higher values of intercrop indices were observed in FCV tobacco + Groundnut with 2124 kg ha^{-1} tobacco equivalent yield, 1.62 land equivalent ratio and ₹ 1,47,472 monetary advantage index there by achieved higher B: C (2.36) compared to sole FCV tobacco. However, highest area time equivalent ratio (1.51) was observed in FCV tobacco + Black gram followed by FCV tobacco + Green gram (1.47) and FCV tobacco + Groundnut (1.43).

Keywords: FCV tobacco, legumes, inter-cropping, growth, yield

Introduction
Tobacco (*Nicotiana tabacum* L.) is one of the important commercial crops in the world which is traded for its quality leaves and considered as the golden leaf in the world market. It is a drought tolerant, hardy and short duration crop which can be grown on soils where other crops cannot be cultivated profitably. In India, this crop is grown in an area of 0.45 million ha (0.27% of the net cultivated area) producing 750 million kg of tobacco leaf. (Anon., 2022) [1].
FCV tobacco is one of the commercial crops grown in southern transition zone of Karnataka. The crop is grown during *kharif* season as rainfed crop in about one lakh ha each year in the light soil area, popularly known as Karnataka Light Soils (KLS). Tobacco being a wide spread crop, it is planted at a distance of 90 cm between rows and 60 cm between two plants. However, due to initial slow growth and wide spacing, the inter row spacing could be utilized by growing short duration legumes as intercrops to get more benefit and productivity per unit area without any negative effect on growth, yield and quality of FCV tobacco (Janardhan *et al.*,1990) [13].
During the initial period of tobacco growth, the crop canopy is less. This allows sufficient sunlight to reach the soil surface between the rows which facilitates growing short duration intercrops in between the rows of tobacco. Legumes *viz*., green gram, black gram, cowpea, field bean, groundnut *etc.* are a key functional group and are highly valued for the agroecological services they provide. The intercropped legume systems reduce inter-specific competition by enhancing complementarity/facilitation processes thereby improving the exploitation of resources, which in turn reflected in the increase in plant production corresponding to greater efficiency of the agroecosystem (Duchene *et al*., 2017) [5].

Material and Methods
The field experiment was carried out at All India Network Project (Tobacco), Zonal Agricultural and Horticultural Research Station, Navile, Shivamogga during *kharif* season of the year 2021. The location was situated at 13º 58' N latitude, 75º 34' E longitude with an altitude of 650 m above the mean sea level.

The study site located at Southern Transition Zone (Zone 7) of Karnataka. The soil of the experiment plot was sandy loam, low in available nitrogen (252.32 hg ha^{-1}), high in available phosphorus (77.08 kg ha^{-1}) and medium in available potassium (135.72 kg ha^{-1}) and slightly acidic (5.59) in reaction, which is suitable for raising FCV tobacco and intercrops. The experiment consisted of 11 treatments arranged in randomized complete block design with four replications involving five legumes *viz.,* green gram, black gram, cowpea, field bean and groundnut as intercrops with FCV tobacco in alternate rows and their sole crops for comparison following skip row inter-cropping.

Sowing of nursery beds was carried out on 27th April 2021. In the main field, after the land preparation, farm yard manure at the rate of 12.5 t per ha was applied two weeks before transplanting. The field was uniformly levelled and ridges were formed using a ridger. Healthy, pencil thick, 10 to 15 cm long, hardened, 65 days old tobacco seedlings were uprooted from the nursery beds and planting was carried out on 24th July, 2021 at a spacing of 90 × 60 cm at a rate of one seedling per hill. Intercrops were also sown along with tobacco. The legumes *viz.,* green gram, black gram and ground nut were dibbled with a row spacing of 30 cm × 10 cm, cowpea with a spacing of 45 cm × 10 cm and field bean with a spacing of 45 cm × 15 cm between the rows of FCV tobacco (90 cm). Legumes were sown by skipping the rows.

The sole tobacco and tobacco intercropped with other component crops received

40 kg N + 30 kg P_2O_5 + 80 kg K_2O per ha in the form of Ammonium sulphate, Diammonium phosphate, Sulphate of potash, respectively. For green gram and black gram and for cowpea, recommended dosage of nitrogen, phosphorus and potassium were applied at the rate of 12.5: 25: 12.5. For field bean and groundnut it was applied at the rate of 25: 50: 25 kg per ha. Fertilizers were applied through Urea, Diammonium phosphate, Sulphate of potash. The varieties used for the experiment were Sahyadri (FCV tobacco), KKM-3 (Green gram), LBG-625 (Black gram), Sahyadri Yukti (Cowpea), HA-4 (Field bean) and GPBD-4 (Groundnut). The crop was raised by following the package of practices recommended by Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga for rainfed condition of Southern Transition Zone (Zone 7).

Harvesting of FCV tobacco was done by priming the leaves which have completed their growth and have turned yellowish green or slightly yellow in colour with spots/ blemish. First priming was done on 22nd September 2021 and subsequent primings were done at 5 to 7 days interval. The entire harvest was completed in seven pickings. Later the harvested tobacco leaves were subjected to curing, conditioning and grading. Green gram, black gram and cowpea were harvested in two pickings for their dried grains. While, groundnut was harvested in a single stretch for its pod and the pods were separated from the haulm. Field bean was harvested four times by picking the green pods for table purpose.

The biometric observations such as plant height, number of leaves per plant, leaf area of X and L leaf, were recorded from selected five plants and subjected to analysis of variance (ANOVA) outlined by Panse and Sukhatme (1967) [15].

Results and Discussion

Plant growth is an influential process and is guided by the complex interaction occurring among soil-plant and weather continuum. Plant growth in one way is expressed with regard to plant height, leaf area and number of leaves counted per plant. Plant height of FCV tobacco was influenced by inter-cropping of legumes (Table 1). Higher values of plant height were observed FCV Tobacco + Groundnut (84.6 cm) which was 8.2 percent more compared to sole FCV tobacco. Increased plant height in tobacco might be due to short and compact stature of groundnut, which did not offer competition to FCV tobacco at any stage of their growth, this gained advantage and consequently resulted in higher growth and development whereas other legumes were quick growing and had early vigour as compared to groundnut. The peak growth stage of tobacco (30-60 DAP) and legumes overlapped except in groundnut (40-45 DAS) which offered less competition for light and nutrients to tobacco and also peak stage increased nodulation which helped nitrogen fixation in soil. This in turn helped in the increase of green leaf and cured leaf yield of FCV tobacco (Gopalachari *et al.,* 1978) [10]. These results are in line with those reported by Chaudhari *et al.* (2013) [4] in groundnut based inter-cropping systems under rainfed condition. Lower plant height was observed in FCV tobacco + Cowpea (72.4 cm) which was 7.3 percent less as compared to sole FCV tobacco. This reduction in height might be due to generation of lot of biomass which lead to suppression of main crop either through interception of light from reaching the soil surface or by inhibiting growth by the release of allelochemicals on the main crop. These results are in line with Awodoyin *et al.* (2021) [2] in Maize-Cowpea cropping system.

Maximum number of leaves per plant was obtained from FCV Tobacco + Groundnut which was 3.7 percent more compared to sole FCV tobacco (Table 1). The possible reason may be nitrogen availability in greater extent to FCV tobacco in presence of groundnut as a component crop. The increase might be also due to better growth and adequate photosynthesis for development of sink. The findings are in agreement with those of Hadiyal *et al.* (2020) [11].

Leaf area of X and L position leaves was more in FCV Tobacco + Groundnut (992.5 and 722.1 cm^2, respectively). This increase was 3.8 and 2.8 percent more as compared to sole FCV tobacco. Higher leaf area in this intercropping system was mainly due to more space available between FCV tobacco and groundnut due to its short stature and less hindrance to the growth of leaves of FCV tobacco in all growth stages. There was also better availability of light, efficient use of resources and favourable inter and intra species competition, which had possible effect on leaf area. The results were evidenced with studies of Mahto *et al.* (2007) [12] and Shwethanjali *et al.* (2018) [18].

From the results, as presented in Table 2 it was noticed that intercropping of legumes significantly increased the tobacco green leaf and cured leaf yield. Among different intercropping systems, FCV tobacco + Groundnut recorded higher green leaf and cured leaf yield (13795 and 1771 kg ha^{-1}) over other intercropping systems followed by FCV tobacco + Green gram (13070 and 1683 kg ha^{-1}). The increase in green leaf and cured leaf yield was 26.3 and 13.9 percent in FCV tobacco intercropped with groundnut as compared to sole FCV tobacco. As nitrogen is one of the essential components for crop growth and development, inclusion of groundnut as an intercrop enhanced soil nitrogen. It is important source of N fertility through symbiotic biological nitrogen fixation (BNF) as it is capable of fixing 150-200 kg N per ha which is more

as compared to other legumes *viz.*, green gram (19-54 kg N per ha), black gram (16-79 kg N per ha), cowpea (14-35 kg N per ha) and field bean (23-7 kg N per ha) (Gogoi *et al.*, 2018) [9]. Groundnut not only added nitrogen into the soil but increased soil organic matter, improved soil porosity, soil structure and tilth.

Further, the green leaf yield and cured leaf yield of the crop depends on photosynthetic ability of plants and that can be analyzed through different growth parameters of tobacco as influenced by intercropping of different legumes in FCV tobacco. The increased yield is attributed to remarkable improvement in yield attributing characters.

The increased productivity or yield advantage provided by inter-cropping is attributed to better use of resources by crops grown in mixtures, as compared to the same species grown in sole stands (Frank and Anthony, 2007) [7].

Effect of inter-cropping on different biological indices of plant was studied by several scientists. Inclusion of groundnut as intercrop with FCV tobacco gave significantly higher value of TEY than sole planting of the component crops. The increase in TEY was 36.59 percent with groundnut as intercrop as compared to sole FCV tobacco (Table 2). Groundnut is a higher yield potential crop, short duration and less competitive than other legumes so intercropping FCV tobacco with groundnut gave higher value of TEY compared to other intercropping systems. TEY was significantly low in FCV Tobacco + Cowpea due to more competition for resources with the base crop and less yield as a result of lot of biomass generation by cowpea which led to suppression of main crop.

Tobacco equivalent yield is also under the influence of land equivalent ratio (LER) and area time equivalent ratio (ATER) which is indicators of feasibility of any cropping system in which two crops are cultivated together under space and time dimension. Here, in the present study also the feasibility of different FCV tobacco-based intercrop is indicated by utilising these indicators.

Intercropping advantage in terms of land equivalent ratio indicated that LER values were greater than one in all the intercropping systems which shows their yield advantage over sole cropping due to better utilization of environmental resources for growth. LER was significantly low in FCV tobacco + Cowpea and high in FCV Tobacco + Groundnut inter-cropping system. This is due to yield advantage offered by inter-cropping in case of groundnut based inter-cropping system whereas inter-cropping cowpea did not offer much to the system. All the intercrops possessed different nature of growth, plant height and canopy structure and days to maturity. Inter-cropping of groundnut in FCV tobacco gave extra yield advantage of 62 percent. Therefore, these crops differed in yield potential and competitive ability. Similarly, Chen *et al.* (2014) [3] also reported that inter-cropping systems had higher LER than the sole cropping.

Inter-cropping is also followed under the time dimension. Area time equivalent ratio provides a more realistic comparison of yield advantage of intercropping over that of sole cropping because of variation in time taken by component crops in different intercropping systems. However, crop production is a function of both crop duration (time) and land area. The data regarding the area time equivalent ratio are presented in Table 4.7. In all the inter-cropping systems, the ATER values were less than LER values indicating the over estimation of resources utilization in the later. Inter-cropping advantage in terms of ATER was found in FCV tobacco + Black gram (1.51) and was lowest in FCV tobacco + Field bean which indicates not only the efficient use of land but also efficient use of time. Similar results have been reported by Hulihalli (1987) [12], Dutta and Bandhyopadhyay (2006) [6], Singh and Ahlawat (2011) [19] and Chaudhari *et al.* (2013) [4].

The ultimate interest of developed technology over existing lies in economic viability by utilizing the available resources. In inter-cropping system this could be indicated in a better way by monetary advantage. All inter-cropping systems possessed positive values and showed a definite yield advantage irrespective of different component crops when compared to the sole cropping of FCV tobacco. MAI values were high in FCV Tobacco + Groundnut intercropping system and lowest in FCV Tobacco + Cowpea. Higher MAI might be due to higher yield levels of both the crops and higher market price of the component crop. Similar results were reported by Dutta and Bandhyopadhyay (2006) [6] in Groundnut + Pigeonpea.

Effect of different inter-cropping systems on economics

By adopting diverse crops in the field at a time, the income earned by farmers can be increased and thus, risk can be minimised. FCV tobacco intercropped with groundnut recorded significantly higher net returns and B: C (Table 3). It was due to better yield and market price of groundnut. The next best intercropping system was FCV tobacco intercropped with green gram and black gram. The increase in net return was 17.9, 19.6 and 34.1 percent when FCV tobacco was intercropped with green gram, black gram and groundnut as compared to sole FCV tobacco. These findings are in conformity with Gargi *et al.* (1997) [8] and Shankar and Devaiah (2002) [17] where, significantly higher net returns and B: C ratio were recorded in mulberry and legume inter-cropping system compared to sole mulberry.

Table 1: Effect of inter-cropping of legumes on plant height, number of leaves counted on the plant at harvest, leaf area at X and L position and cumulative number of leaves harvested per plant of FCV tobacco

Treatment	Plant height at harvest (cm)	Number of leaves counted on the plant at first picking	Leaf area of X position leaves (cm^2)	Leaf area of L position leaves (cm^2)	Cumulative number of leaves harvested per plant
FCV Tobacco + Green gram	82.3	16.3	976.32	718.34	21.2
FCV Tobacco + Black gram	81.2	16.3	963.21	715.29	20.3
FCV Tobacco + Cowpea	72.4	13.5	650.42	552.34	18.2
FCV Tobacco + Field bean	76.5	14.8	852.32	685.22	19.3
FCV Tobacco + Groundnut	84.6	16.7	992.57	722.14	22.2
Sole FCV Tobacco	78.1	16.1	955.44	702.19	20.3
S.Em±	0.52	0.12	12.5	5.0	0.3
CD at 5%	1.55	0.38	37.67	15.07	0.9

Table 2: Effect of intercropping of legumes in FCV tobacco on main crop yield, intercrop yield, tobacco equivalent yield, land equivalent ratio, area time equivalent ratio and monetary advantage index

Treatment	Green leaf yield (kg ha^{-1})	Cured leaf yield (kg ha^{-1})	Legume yield (kg ha^{-1})	Tobacco equivalent yield (kg ha^{-1})	LER	ATER	MAI (₹)
FCV Tobacco + Green gram	13070	1683	251	1821	1.55	1.47	116275
FCV Tobacco + Black gram	12030	1675	297	1842	1.55	1.51	117868
FCV Tobacco + Cowpea	7789	1146	344	1252	1.27	1.24	51746
FCV Tobacco + Field bean	10550	1422	1451*	1663	1.40	1.18	86529
FCV Tobacco + Groundnut	13795	1771	1141*	2124	1.62	1.43	147472
Sole FCV Tobacco	11139	1555	-	1555	-	-	-
Sole Green gram	-	-	536	293	-	-	-
Sole Black gram	-	-	645	361	-	-	-
Sole Cowpea	-	-	743	227	-	-	-
Sole Field bean	-	-	3206*	534	-	-	-
Sole Groundnut	-	-	2468*	762	-	-	-
SEm±	915.90	77.45	-	49	0.03	0.02	3652
CD at 5%	2760.85	233.48	-	146	0.1	0.06	11254

Table 3: Economics as influenced by FCV tobacco-legume based intercropping system

Treatment	Cost of cultivation (₹ ha^{-1})			Gross return (₹ ha^{-1})			Net return (₹ ha^{-1})			B:C
	FCV tobacco	Legumes	Total	FCV tobacco	Legumes	Total	FCV tobacco	Legumes	Total	
FCV Tobacco + Green gram	134674	16098	150772	302940	24743	327683	168266	8646	176912	2.17
FCV Tobacco + Black gram	134674	16049	150723	301500	29969	331469	166826	13920	180746	2.19
FCV Tobacco + Cowpea	134674	13132	147806	206280	37088	243368	71606	23955	95561	1.64
FCV Tobacco + Field bean	134674	20351	155025	255960	43533	299493	121286	23182	144468	1.93
FCV Tobacco + Groundnut	134674	26899	161573	318780	63399	382179	184106	36500	220606	2.36
Sole FCV Tobacco	134674	-	134674	279900	-	279900	145226	-	145226	2.07
Sole Green gram	-	45435	45435	-	62816	62816	-	17380	17380	1.38
Sole Black gram	-	45337	45337	-	64917	64917	-	19580	19580	1.43
Sole Cowpea	-	38665	38665	-	60785	60785	-	22121	22121	1.57
Sole Field bean	-	51542	51542	-	96180	96180	-	44638	44638	1.86
Sole Groundnut	-	72504	66504	-	137097	137097	-	70593	70593	1.89
SEm±	-	-	-	-	-	10408	-	-	5773	0.1
CD at 5%	-	-	-	-	-	31374	-	-	17403	0.3

Conclusion

From this study it can be concluded that intercropping of groundnut in FCV tobacco offered less competition to the main crop in terms of availability of space for FCV tobacco due to groundnut's short stature and less hindrance to the growth of FCV tobacco in all growth stages. This helped in increased plant height, number of leaves per plant, leaf area and yield of FCV tobacco. There was also better availability of light, efficient use of resources and favourable inter and intra species competition, which had possible effect on growth and development.

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