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Effect of increased level of fertilizers on *Bt* cotton and green fodder yield under cotton + legume fodder intercropping system of western zone of Tamil Nadu

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Abstract
A Field experiment was conducted during *Kharif* 2015-16 and 2016-17 at Krishi Vigyan Kendra, Veterinary College and Research Institute campus, Namakkal, Tamil Nadu to assess the performance of increased level of fertilizers on yield of *Bt* cotton and green fodder yield under intercropping situation as part of Ph.D., research programme. Cotton yield was significantly higher (2029 and 1507 kg ha^{-1}) in the *Bt* cotton + moth bean intercropping system during both years experimentation and lower was recorded under *Bt* cotton + fodder cowpea intercropping system. Application of 150% RDF resulted that the significantly higher cotton yield of 1991 kg ha^{-1} and 1474 kg ha^{-1} during 2015-2016 and 2016-2017, respectively. But, intercropping of fodder cowpea with *Bt* cotton had higher seed cotton equivalent yield and net returns with application of 150% recommended dose of fertilizers. Fodder cowpea with application of 150% RDF produced higher green fodder yield 17407 and 14431 kg ha^{-1} during first and second year respectively. Lower fodder yield was recorded under *Bt* cotton + pillipesera with 100% RDF application and it recorded 2788 kg ha^{-1} and 1112 kg ha^{-1} during 2015-2016 and 2016-2017, respectively.

Keywords: Bt cotton, Intercropping, seed cotton equivalent yield, green fodder yield

Introduction
Intercropping *Bt* cotton with annual leguminous fodder is one of the way to increase green fodder yield and improve soil fertility status without yield reduction of cotton. most of the legumes in India are grown as intercrops with cereals and evidences showed that the micro organisms involving in N fixation might provide a route of N transfer to the intercropped components (He *et al*. 2003) [7]. Under low yielding situation, such nitrogen was transferred to base crop especially non-leguminous crop is significant due to N supply to the associated crop is improved at later stage of crop growth (Rao and Mathuva 2000) [11]. Intercrops like Fodder cowpea, moth bean, horse crop, pillipesara are short duration legumes grown in western zone of Tamil Nadu. Cotton (*Gossypium hirsutum* L.), on the other hand is an important cash crop for farmers in the smallholder sector that represents 80% of national production and it provides 85 per cent raw material to the textile industry besides earning foreign exchange by exporting raw materials among agricultural products. India ranks first in cultivated area (12.19 million hectares) and second in production (345 lakh bales) and productivity (481.2 kg ha^{-1}) amongst all the cotton producing countries in the world. *Bt* cotton hybrids are slightly more responsive to nitrogen application and have a higher content of nitrogen than non-*Bt* cotton suggesting that they may have a greater nitrogen uptake and metabolism than non-*Bt* cotton (Showalter *et al.,* 2009) [12]. Intercropping is a modern agronomic technique and is considered to be an effective and potential mean of increasing crop production per unit area and time (Ahmad and Anwar 2001) [1]. Fodder cowpea, Desmanthus, Lucerne, Stylo, Siratro Horsegram, Mothbean, Pillipesera are some of the promising legumes for semi-arid areas and nodulate freely in soil and tolerant to drought and poor soil fertility, having a combining ability in intercropping systems. Long term production of cotton in the same field leads to lower production even with the large amount of externally applied fertilizers. Legumes when intercropped with cereals showed consistently reduced nitrogen fixation indicating that they are less benefit to the cereals (Nambiar *et al*., 1983) [9]. Ahmad and Rao (1982) [2] also reported the close conformity with their findings in the response of maize intercropped with soybean to nitrogen fertilization

was similar to that of sole cropped maize. Although very few studies have been conducted on association of legume with cotton intercropping. Based on this background the study was undertaken in order to develop a compatible, short duration legume fodder to cotton facilitating legume fodder intercropping system without affecting the productivity of cotton at large scale which makes the system more feasible, productive and economical.

Materials and methods

Location and soil characteristics of experimental site

A field experiments were conducted at, Krishi Vigyan Kendra farm, Veterinary College and Research Institute Campus, Namakkal, situated in the North Western Agro climatic Zone of Tamil Nadu and the experimental site is geographically located at 11°15'N latitude, 78 16' E longitudes and an altitude of 216 m above mean sea level.

During the cropping season of *kharif* 2015-16, the crop received 544 mm of rainfall in 17 rainy days. The mean maximum and minimum temperature recorded were 33.17 ^{0}C and 22.70^{0}C, respectively. The mean maximum and minimum relative humidity were 84.77 per cent and 49.83 per cent at 0722 hrs and 1422 hrs, respectively. The mean evaporation prevailed during the cropping period was 3.72 mm and the average wind velocity was 3.77 km hr^{-1}. During the cropping season of *Kharif* 2016-17, the crop received 140 mm of rainfall in 17 rainy days. The mean maximum and minimum temperature recorded were 34.37^{0}C and 22.91 ^{0}C, respectively. The mean maximum and minimum relative humidity were 75.97 per cent and 38.36per cent at 0722 hrs. and 1422 hrs., respectively. The mean evaporation prevailed during the cropping period was 5.02 mm and the average wind velocity was 5.11 km hr^{-1}.

Soil was sandy clay loam in texture (*Typic* Ustropept). The nutrient status of soil at the initial stage of experiment field was low in available nitrogen (251.5 kg ha^{-1}), low in phosphorus (9.7 kg ha^{-1}) and low in available potassium (79.0 kg ha^{-1}) and soil pH was 7.4. The experiment was laid out in split plot design with five main plots (C1-Cotton; C2-Cotton+Fodder Cowpea; C3- Cotton+ Horse gram; C4-Cotton+Moth bean; C5-Cotton+Pillipesara) and three subplots (F1-100% RDF (120:60:60 kg NPK ha-1); F2-125% RDF (150:75:75 kg NPK ha-1); F3-150% RDF (180:90:90 kg NPK ha-1). The treatments were replicated thrice. The cotton hybrid MRC 7918 was used as a test cultivar and four legume forage crops *viz*., Fodder cowpea (*Vigna ungiculata* L.) *var*. CO(FC)-8, Horsegram (*Macrotyloma uniflorum* L.) *var*. Paiyur-2, Mothbean (*Vigna aconitifolia* Jacq.) *var*. TMV(mb)-1 and Pillipesera (*Vigna trilobata*) *var*. Andhra local used as intercrops. Nitrogen applied in three equal splits at basal, 45 DAS and 65 DAS; P_2O_5 applied full dose as basal and 50% of K at basal, remaining half of the K at 45 DAS. The selected field was ploughed twice with cultivator. Field plots were marked and ridges and furrows were formed at 60 cm apart. The gross plot size of 6.0 m x 5.4 m and the net plot size of 4.8 m x 4.8 m were marked and irrigation channels were formed at 45cm width. Rectification of individual plots was carried out manually. Well decomposed FYM at 12.5 t ha^{-1} was applied uniformly at the time of land preparation. The viable, good quality, bold and delinted seeds were treated with Thiram 2 g kg^{-1} of seeds after the fungicide treated seeds are treated with *Trichoderma viride* @ 4g kg^{-1} of seed for better germination and better stand in the field. Cotton seeds were dibbled with two seeds hill^{-1} in 3 cm depth under 120 cm x 60 cm spacing. Intercrops were sown with 3-5 seeds hill^{-1} under 30 cm x 15 cm spacing. The field was irrigated immediately after sowing and life irrigation was given on 3rd day after sowing. Based on the weather condition especially rainfall prevalence, subsequent irrigations was carried out as per the recommendation of CPG,(2012)[5]. Gap filling was done on seventh day after sowing. For intercrops gap filling and thinning were carried out on tenth day after sowing. Pre-emergence herbicide pedimethalin @ 3.3 l. ha^{-1} was sprayed on third day after sowing. One hand weeding on 20 DAS was carried out in all the treatments. The economic part of cotton *i.e.* cotton kapas was picked in the ten days interval and the yield recorded at each picking. Totally four picking were done and carried out in the morning hours upto 11 a.m. Intercrops were harvested above from the ground level for green fodder purpose at 55 days after sowing. Intercrops of fodder cowpea, horsegram, mothbean and pillipesera were harvested separately from its individual plot and weighed and the yield was recorded as kg ha^{-1}. The data recorded to cotton, forage intercrops and weeds during the field investigation, on various parameters were subjected to statistical analysis of variance method as suggested by Gomez and Gomez (2010) [6]. Wherever the treatment differences were found significant, the critical differences were worked out at 5 per cent probability level and the values were furnished. Treatment differences that were not significant are denoted as 'NS'.

Results and Discussion

Seed cotton yield

Both the legume fodder intercropping system and nutrient levels had significant influence on the seed cotton yield. *Bt* cotton + moth bean (C_4) fodder intercropping system recorded significantly higher seed cotton yield during both years (2029 kg ha^{-1} and 1507 kg ha^{-1}) followed by *Bt* cotton + horse gram (C_3) with 1909 kg ha^{-1} and 1422 kg ha^{-1} during 2015-2016 and 2016-2017, respectively. *Bt* cotton + fodder cowpea (C_2) intercropping system recorded significantly lower seed cotton yield of 1674 kg ha^{-1} and 1228 kg ha^{-1} during the first and second years of the experimentation respectively. Among the fertilizer levels application of 150% RDF (F_3) registered significantly higher seed cotton yield in both the years of experimentation (1991 kg ha^{-1} and 1474 kg ha^{-1}) and it was followed by the application of 125% RDF (F_2). Application of 100% RDF (F_1) recorded the lowest seed cotton yield. This might be due to the application of enhanced fertilizer, which increased, the growth, DMP, number of fruiting points, number of bolls and ultimately the yield. This agrees with the findings of Ram Prakash and Mangal Prasad (2000) [10]. The increase in nitrogen uptake in the plant with the incremental addition of nitrogen might be due to cumulative effect of drymatter accumulation and increased seed cotton yield. Present results are in conformity with the earlier findings of Anupdas *et al.* (2006) [3] and Sisodia and Khamparia (2007) [13].

Seed cotton equivalent yield

Among the intercropping system, *Bt* cotton + fodder cowpea (C_2) recorded significantly the highest seed cotton equivalent yield during both the years (3268 and 2763 kg ha^{-1}) which was followed by *Bt* cotton + moth bean (C_4) with 2882 and 2272 kg ha^{-1} during 2015-2016 and 2016-2017, respectively. *Bt* cotton pure stand (C_1) recorded the lowest seed cotton equivalent yield of 1856 and 1371 kg ha^{-1} during the first and second year of the experimentation, respectively. Among the three fertilizer levels, application of 150% RDF (F_3) recorded significantly the highest seed cotton equivalent yield of 2647

and 2136 kg ha^{-1} during first and second year respectively. Application of 100% RDF (F_1) recorded the lowest seed cotton equivalent yield of 2264 and 1687 kg ha^{-1} during 2015-2016 and 2016-2017 respectively. Similar findings were in accordance with Khargkharate *et al*. (2014) [8], reported that good yields and better prices of soybean influenced to increase the seed cotton equivalent yield in the cotton + soybean intercropping system. This finding is in agreement with Chellaiah and Gopalaswamy (2000) [4].

Table 1: Effect of legume fodder intercropping systems and fertilizer levels on seed cotton yield (kg ha^{-1}) of *Bt* cotton

Fertilizer levels	Fodder intercropping systems											
	2015-2016						2016-2017					
	C_1	C_2	C_3	C_4	C_5	Mean	C_1	C_2	C_3	C_4	C_5	Mean
F_1	1793	1618	1684	1990	1623	1742	1315	1187	1246	1393	1190	1266
F_2	1812	1689	1832	1831	1766	1786	1359	1239	1405	1453	1295	1350
F_3	1964	1715	2210	2266	1800	1991	1440	1258	1613	1677	1380	1474
Mean	1856	1674	1909	2029	1730		1371	1228	1422	1507	1288	
	SEd			CD (P=0.05)				SEd			CD (P=0.05)	
C	39			90				40			92	
F	46			95				41			85	
C at F	92			195				85			181	
F at C	102			212				91			190	

Table 2: Effect of legume fodder intercropping systems and fertilizer levels on seed cotton equivalent yield (kg ha^{-1})

Fertilizer levels	Fodder intercropping systems											
	2015-2016						2016-2017					
	C_1	C_2	C_3	C_4	C_5	Mean	C_1	C_2	C_3	C_4	C_5	Mean
F_1	1793	3028	1942	2810	1747	2264	1315	2420	1496	1956	1246	1687
F_2	1812	3128	2110	2673	1901	2325	1359	2807	1715	2181	1369	1886
F_3	1964	3649	2526	3158	1936	2647	1440	3062	1986	2677	1516	2136
Mean	1856	3268	2193	2881	1862		1371	2763	1732	2272	1377	
	SEd			CD (P=0.05)				SEd		CD (P=0.05)		
C	63			146				50.		116		
F	81			169				64		134		
C at F	161			340				128		271		
F at C	181			377				144		300		

Table 3: Effect on green fodder yield (kg ha^{-1}) of legume fodder intercrops as influenced by fertilizer levels of *Bt* cotton

Fertilizer levels	Fodder intercropping systems											
	2015-2016						2016-2017					
	C_1	C_2	C_3	C_4	C_5	Mean	C_1	C_2	C_3	C_4	C_5	Mean
F_1	-	12690	3627	9228	2788	7083	-	9865	3121	5631	1112	4932
F_2	-	12953	3899	9475	3041	7392	-	12544	3874	7292	1478	6297
F_3	-	17407	4439	10041	3066	8738	-	14431	4662	10010	2720	7956
Mean	-	14350	3988	9581	2965		-	12280	3886	7644	1770	
	SEd			CD (P=0.05)				SEd		CD (P=0.05)		
C	163			375				139		320		
F	129			269				113		235		
C at F	287			618				248		535		
F at C	289			602				252		526		

Green fodder yield

Fodder cowpea with application of 150% RDF (C_2F_3) produced higher green fodder yield (17407 kg ha^{-1}) at 55 DAS during first year, and it was recorded as 14431 kg ha^{-1} during second year study. The lower fodder yield was recorded under *Bt* cotton + pillipesera with 100% RDF application (C_5F_1) and it recorded 2788 kg ha^{-1} and 1112 kg ha^{-1} during 2015-2016 and 2016-2017, respectively. Among the different intercrops, fodder cowpea significantly recorded higher green fodder yield as compared to other intercrops *viz*., horse gram, moth bean and pillipesera and pure stand of cotton. Similarly among the three fertilizer levels, application of 150% RDF produced the higher growth characters and yield of intercrops then 100 per cent RDF.

Conclusion

All the intercropping treatments significantly enhanced the seed cotton equivalent yield as compared to sole *Bt* cotton. Similarly application of 150% RDF treatment recorded significantly greater seed cotton yield as compared to 100% RDF, during both the years of experimentation.

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