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Assessment of Annual Leguminous Forage Varieties in Cotton Intercropping: Evaluating Green Fodder Yield and Dry Matter Production

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Abstract

Intercropping is an 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). Legume intercrops are included in cropping system due to their ability to reduce soil erosion, improving land productivity through soil amelioration, suppress weeds and fix nitrogen. Intercropping cotton is significant because of higher profit and stabilized yield advantage, especially under adverse climatic conditions (Aladakatti *et al*., 2011). In this aspect, intercropping of short duration legumes in cotton has no adverse effect on cotton performance but an additional yield of legume makes the system more profitable. Rochester *et al*. (2001) studied the contribution of legume crops such as faba bean (*Vicia faba*), field pea (*Pisum sativaum*) and lab-lab (*Lablab purpureus*) on nitrogen fertility of cotton cropping system. The present study was undertaken in order to develop a compatible, short duration legume fodder and to assess the feasibility of different annual legume fodders for higher green fodder production. The field experiments were conducted in Krishi Vigyan Kendra, Veterinary College and Research Institute Campus, Namakkal, under irrigated condition, during July-August of 2021-22 and 2022-23. Experimental procedures were adopted to analyze the effects of various fertilizer levels on green fodder yield of various leguminous fodder crops *viz.*, fodder cowpea (*var*. CO (FC)-8), mothbean (*var*. TMV (mb)-1), horse gram (*var*. Paiyur-2) and pillipesera. The results indicated that green fodder yield recorded at harvest stage (55 Days After Sowing (DAS)) was influenced by various fertilizer levels of *Bt* cotton. With respect to green fodder yield fodder cowpea (17407 and 14431 kg ha^{-1}), horse gram (4439 and 4662 kg ha^{-1}), moth bean (10041 and 10010 kg ha^{-1}) and pillipesera (3066 and 2720 kg ha^{-1}) recorded higher yield with application of 150% RDF and it was followed by 125% RDF and 100 RDF during first- and second -

year study. Similarly, application of 150% RDF (F_3) recorded more dry matter production (DMP) value, for all leguminous fodder crops during first (184.8, 305.6 and 452.7 kg ha^{-1}) and second year study (169.9, 291.2, 450.2 kg ha^{-1}) at all growth stages *viz*., 20, 40 DAS and at harvest stage, respectively.

Keywords: Leguminous fodder, Green fodder yield, Dry matter production, Recommended Dose of Fertilizer (RDF)

Introduction

Cotton provides 85 per cent raw material to the textile industry and its higher economic value enables it to enjoy a predominant position in the Indian economy. It is usually grown at wider inter row spacing and the growth is quite slow upto 60 days, hence intercropping cotton is significant because of stabilized yield advantage, especially under adverse climatic conditions (Aladakatti *et al*., 2011). Intercropping is a modern agronomic technique and is considered to be an effective and potential means of increasing crop production per unit area and per unit time (Ahmad and Anwar 2001). Cereal-legume intercropping is very common in the continents of Asia, Africa and South America (Layek *et al*., 2018). Intercropping of short duration legumes in cotton has no adverse effect on cotton yield but an additional yield of legume makes the system more profitable. Intercropping systems are helpful to avoid reliance on a single crop and results in a variety of products of a different nature such as forages, fruits,oil and pulses (Iqbal *et al*., 2018a). Increase in plant diversity in an intercropping system, is suggested as a pathway towards more resilient and sustainable cropping systems (Kamalongo *et al*., 2020). Legume intercrops are included in cropping system due to their ability to reduce soil erosion, improve land productivity through soil amelioration, suppress weeds and fix nitrogen. Leguminous fodder crops *viz*., fodder cowpea, desmanthus, lucerne, stylo, siratro, horsegram, mothbean, pillipesera are some of the promising legumes, due to their complementary effect and have least smothering effect, which would favour for succeeding crop. When legumes are intercropped with cereal forages, soil fertility is also improved (Iqbal *et al*., 2018b). Sorghum-cowpea and Sorghum-cluster bean intercropping in a 2:1 row proportion resulted in the highest fresh and dry biomass than other spatial arrangements (Iqbal 2018c). Based on this background, the present study was undertaken with objectives of, identifying and assessing the feasibility of different legume fodder intercrops for higher fodder production.

Material and Methods

The field experiments were conducted to investigate the relative performance and effects of legume forage intercropping system on productivity of *Bt* cotton and green fodder yield of annual intercrops *viz.*, fodder cowpea, moth bean, horse gram and pillipesera. The field experiments were conducted in field No.362, Krishi Vigyan Kendra farm, Veterinary College and Research Institute Campus, Namakkal, during winter irrigated season (July-August) of 2021-22 and 2022-23 which is situated in the north western agro climatic zone of Tamil Nadu.

Climate and weather

During winter irrigated cropping season of 2021-2022, the crop received 544 mm of rainfall in 17 rainy days. The mean maximum and minimum temperature recorded were 33.17 ºC and 22.70 ºC, respectively. During the cropping season of 2022-23, the crop received 140 mm of rainfall in 17 rainy days. The mean maximum and minimum temperature recorded were 34.37 ºC and 22.91 ºC,

respectively. The mean solar radiation received during the cropping period was 14.72 and 16.84 MJ $m^{-2}day^{-1}$ during the year 2021-22 and 2022-23, respectively.

Soil characteristics and season

The results of Physieo-chemical properties of soil revealed that the 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}). The cotton crop was raised as winter irrigated crop during winter irrigated (July-August) season of 2021-22 and 2022-23. Total duration of the cotton crop was 150-160 days. Intercrops were sown on 17.08.2021 and 22.08.2022 and the fodder intercrops were harvested at 55-60 DAS as green fodder.

Crop and variety

The cotton hybrid MRC 7918 was used as test cultivar. Fodder cowpea variety CO (FC)-8, HORSE gram variety Paiyur-2, moth bean variety TMV (mb)-1 and pillipesera variety: local are used as an intercrops for the study.

Experimental details, design and layout

The field experiments were laid out in split plot design with gross plot size of 36.0m^2 (6.0 m x 6.0 m). Main plot was allotted with *Bt* cotton as base crop and four intercrops namely, fodder cowpea, horsegram, mothbean, and pillipesera. Forage legume crops were intercropped with cotton in the pattern of 1:3 row ratio of intercropping. Sub plot was designed with three levels of fertilizer doses *viz*., F_1-100% (Recommended Dose of Fertilizer) @(120:60:60 kg NPK ha^{-1}), F_2-125% RDF (@ 150:75:75 kg NPK ha^{-1}) and F_3-150% RDF @(180:90:90 Kg NPK ha^{-1}).

Treatments

Main plot : Base crop with intercrops

C_1	:	Cotton alone
C_2	:	Cotton + Fodder cowpea (*Vigna ungiculata* L.)
C_3	:	Cotton + Horsegram (*Macrotyloma uniflorum* L.)
C_4	:	Cotton + Mothbean (*Vigna aconitifolia* Jacq.)
C_5	:	Cotton + Pillipesara (*Phaseolus trilobata*)

Sub plot : Fertilizer levels

F_1	:	100% RDF (120:60:60 kg NPK ha^{1})
F_2	:	125% RDF (150: 75:75 kg NPK ha^{1})
F_3	:	150 % RDF (180:90:90 kg NPK ha^{-1})

- N applied in three equal splits at basal, 45 DAS and 65 DAS.
- P_2O_5 applied full dose as basal.
- 50% of K at basal, remaining half of the K at 45 DAS.

Crop management

The selected field was ploughed twice and the gross plot size of 6.0 m x 6.0 m and the net plot size of 3.6 m x 4.8 m were marked and irrigation channels were formed at 45 cm width. Rectification of

individual plots was carried out manually. Well decomposed FYM @ 12.5 t ha^{-1} was applied uniformly at the time of land preparation.

The recommended dose of 120:60:60 kg NPK ha^{-1} (100% RDF) was applied uniformly to the sub plot as a treatment (F_1) in the form of inorganic fertilizers such as urea (46% of N), single super phosphate (16% of P_2O_5) and muriate of potash (60% of K_2O) to supply of nitrogen, phosphorous and potassium, respectively. The fertilizer doses of 125% RDF and 150% RDF were applied to the sub plot (F_2) and sub plot (F_3) as 150:75:75 kg NPK ha^{-1} and 180:90:90 kg NPK ha^{-1}, respectively. 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.

Green fodder yield

Intercrops of fodder cowpea, horse gram, moth bean and pillipesera were harvested on 60 DAS in all the treatment plots and harvesting was carried out on the same day, weighed individually and yield was recorded, expressed in kg ha^{-1}.

Dry matter production (DMP)

Dry matter production of *Bt* cotton was calculated at 30, 60, 90, 120 DAS and at harvest stages of the plant. The results of DMP on leguminous fodder recorded were influenced by various fertilizer levels at 20, 40 DAS and at harvest stage of plant growth. Five plants from the sampling row were selected at each plot and the plants were uprooted, shade dried for two days and then oven dried at 70 °C for three days. Oven dried plants were weighed and the crop dry matter production was computed and expressed in kg ha^{-1}.

Results and Discussion

Green fodder yield of fodder cowpea

When legume fodder was intercropped with *Bt* cotton, the 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. It was followed by *Bt* cotton + fodder cowpea with 125% RDF (C_2F_2) application with values of 12953 and 12544 kg ha^{-1} during first and second year, respectively. The lower green fodder yield was produced under the treatment of *Bt* cotton + fodder cowpea along with the application of 100% RDF (C_1F_1) with 12690 kg ha^{-1} during first year and 9865 kg ha^{-1} during second year at 55 DAS. The increase in seed cotton yield equivalent was due to higher additional fodder yield from fodder cowpea intercrop. This finding is in agreement with Chellaiah and Gopalaswamy (2000)

Green fodder yield of horse gram

Horse gram along with application of 150% RDF (C_3F_3) recorded higher green fodder yield of 4439 kg ha^{-1} at 55 DAS during 2021-22 and 4662 kg ha^{-1} during 2022-23. It was followed by application of 125% RDF (F_2) which recorded the yield of 3899 kg ha^{-1} and 3874 kg ha^{-1} during first and second year, respectively. The lesser green fodder yield (3627 kg ha^{-1} and 3121 kg ha^{-1}) was noted under *Bt* cotton + horse gram with 100% RDF treatment (C_3F_1) during 2021-22 and 2022-23.

Green fodder yield of moth bean

It was recorded, under *Bt* cotton + moth bean intercropping system along with application of 150% RDF (C_4F_3), the moth bean produced higher green fodder yield of 10041 kg ha^{-1} at 55 DAS and 10010 kg ha^{-1} during the first and second year, respectively. It was followed by *Bt* cotton + moth bean with application of 125% RDF (C_4F_2) during 2021-22 and 2022-23. *Bt* cotton + moth bean with application of 100% RDF (C_4F_1) registered lower fodder yield of 9228 kg ha^{-1} and 5631 kg ha^{-1} at 55 DAS, during the first and second year, respectively.

Green fodder yield of pillipesera

Fertilizer levels had significant effect on green fodder yield of pillipesera. *Bt* cotton + pillipesera with application of 150% recommended dose of fertilizer (C_5F_3) had significantly produced higher yield (3066 and 2720 kg ha^{-1}) at 55 DAS during first and second years of the study, followed by application of 125% RDF (C_5F_2). The lower fodder yield was recorded under *Bt* cotton + pillipesera with 100% RDF application (C_5F_1) and it was recorded 2788 kg ha^{-1} and 1112 kg ha^{-1} during 2021-22 and 2022-23, respectively.

Dry matter production (DMP) of legume fodder

Among various legume fodder intercrops, fodder cowpea (C_2) recorded more DMP of 204.2, 455.7 and 713 kg ha^{-1} at 20, 40 DAS and at harvest stage, respectively during 2021-2022, and it was produced as 193.0, 444.7 and 709.2 kg ha^{-1} at 20, 40 DAS and at harvest stage, respectively, during 2022-2023. With respect to fertilizer levels, application of 150% RDF (F_3) recorded more DMP value for all leguminous fodder crops during first (184.8, 305.6 and 452.7 kg ha^{-1}) and second year study (169.9, 291.2 and 450.2 kg ha^{-1}) at 20, 40 DAS and at harvest stage, respectively. The lesser DMP was registered under 100% RDF (F_1) treatment during both years of study.

Dry matter production of fodder cowpea

During 2021-2022, fodder cowpea (C_2) registered more DMP under the treatment 150% RDF (F_3) with values of 234.5, 488.0 and 812.4 kg ha^{-1} at 20, 40 DAS and at harvest stage, respectively. The same trend was observed during 2022-2023 and the DMP recorded was 220.8, 476.7 and 765.8 kg ha^{-1} at 20, 40 DAS and at harvest stage, respectively. It was on par with the application of 125% RDF (F_2) with values of 193.0 kg ha^{-1} at 20 DAS, 445.0 kg ha^{-1} at 40 DAS and 682 kg ha^{-1} at harvest stage, during first year study. The lower value of DMP was recorded under the application of 100% RDF (F_1) in both years of study.

Dry matter production of horse gram

Increased DMP was resulted during 2021-2022 under the application of 150% RDF (F_3) recorded with values of 173.5, 223.5 and 275 kg ha^{-1} at 20, 40 DAS and at harvest stage, respectively. It was followed by application of 125% RDF (F_2) at all growth stages and the observed value was 156.9, 207.4 and 242.0 kg ha^{-1} at 20 DAS, 40 DAS and at harvest stage respectively. During second year, the recorded DMP was higher under 150% RDF (F_3) with DMP of 154.5, 208.5 and 239.4 kg ha^{-1} at 20 DAS, 40 DAS and at harvest stage, respectively.

Dry matter production of moth bean

Moth bean (C_4) produced higher DMP with application of 150% RDF (F_3) treatment with values of 210.6 kg ha^{-1} at 20 DAS, 355.6 kg ha^{-1} at 40 DAS and 528.1 kg ha^{-1} at harvest stage during the first-year study. The same trend (201.8, 337.0, 485.5 kg ha^{-1} at DAS, 40 DAS and at harvest stage, respectively) was observed during 2022-2023. Application of 100% RDF (F_1) registered the minimum value of DMP as 172.4, 282.0 and 445.4 kg ha^{-1} at 20 DAS,40 DAS and at harvest stage, respectively during first year and 169.6, 284.0 and 402.4 kg ha^{-1} at 20 DAS, 40 DAS and at harvest stage, respectively during second year.

Dry matter production of pillipesera

With respect to fertilizer levels on *Bt* cotton, application of 150% RDF (F_3) recorded significantly more DMP on pillipesera with values of 120.4 kg ha^{-1} at 20 DAS, 155.4 kg ha^{-1} at 40 DAS and 195.3 kg ha^{-1} at harvest stage during 2021-2022. During 2022-2023, higher DMP of 102.5, 142.8 and 152.8 kg ha^{-1} was observed at 20, 40 DAS and at harvest stage, respectively. It was on par with the fertilizer treatment 125% RDF (F_2). The treatment 100% RDF (F_1) recorded lesser DMP at all the stages of both year study. This is confirmity with the earlier findings of Asangla and Gohain (2016), since legumes have low dry matter yield, higher forage yield can obtained from intercropping legumes compared with their sole crops.

Conclusion

In the present study, fodder cowpea significantly recorded higher dry matter production and green fodder yield as compared to other intercrops *viz*., horsegram, mothbean, pillipesera and sole *Bt* cotton. Similarly among the three fertilizer levels, application of 150% RDF produced the higher growth characters and yield of intercrops than 100 per cent RDF. Further it can be concluded from the above study that *Bt* cotton + fodder cowpea combination produced higher green fodder yield and higher net returns than other intercropping systems, primarily because the yield reduction in seed cotton was compensated by the good value of green fodder.

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

Fodder intercropping systems					
Fertilizer levels	**2015-2016**				
	Fodder cowpea	**Horse gram**	**Moth bean**	**Pillipesera**	**Mean**
F_1	12690	3627	9228	2788	**7083**
F_2	12953	3899	9475	3041	**7392**
F_3	17407	4439	10041	3066	**8738**
Mean	**14350**	**3988**	**9581**	**2965**	
Fertilizer levels	**2016-2017**				
	Fodder cowpea	**Horse gram**	**Moth bean**	**Pillipesera**	**Mean**
F_1	9865	3121	5631	1112	**4932**
F_2	12544	3874	7292	1478	**6297**
F_3	14431	4662	10010	2720	**7956**
Mean	**12280**	**3886**	**7644**	**1770**	

Fertilizer levels

F_1 - 100% RDF (120:60:60 kg NPK ha^{-1})
F_2 - 125% RDF (150:75:75 kg NPK ha^{-1})
F_3 - 150% RDF (180:90:90 kg NPK ha^{-1})

Table 2. Effect on DMP (kg ha^{-1}) of legume fodder intercrops as influenced by fertilizer levels of *Bt* cotton

Treatments	2015-2016			2016-2017		
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest
Fodder intercropping systems						
C_1	-	-	-	-	-	-
C_2	204.2	455.7	713.2	193.0	444.7	709.2
C_3	156.3	206.4	242.3	145.3	195.2	242.3
C_4	191.3	312.9	479.4	183.7	306.8	479.4
C_5	101.5	143.1	169.9	93.86	130.6	169.9
SEd	4.2	6.5	8.2	3.9	6.1	8.21
CD (P=0.05)	9.7	15.0	18.9	9.1	14.1	18.9
Fertilizer levels						
F_1	144.6	258.0	139.8	140.2	251.2	139.8
F_2	160.6	275.0	391.1	151.8	265.6	391.1
F_3	184.8	305.6	452.7	169.9	291.2	450.2
SEd	5.9	10.1	14.9	5.6	9.7	14.9
CD (P=0.05)	12.4	21.0	31.1	11.6	20.3	31.1