Research Article

# Performance of Intercropping On Physiological Characters and Competitiveness of *Bt* Cotton with Leguminous Fodder Under Irrigated Condition

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**Abstract**

Field experiments were conducted during 2015-16 and 2016-17at Krishi Vigyan Kendra, Veterinary College and Research Institute, Namakkal. Treatments comprised of various intercropping systems in the main plot and nutrient management practices in sub plots. The experiments were laid out in split plot design with three replications. Among all the intercrops, *Bt* cotton + moth bean ($C_4$) recorded the higher leaf area index (3.03 and 1.96), (6167 and 5861 kg $ha^{-1}$), crop growth rate (5.92 and 6.08 g $m^{-2}$ $d^{1}$) and relative growth rate (0.0049 and 0.0054 mg $g^{-1}$ $d^{-1}$). Among intercrops, fodder cowpea recorded significantly higher growth attributes like LAI, CGR and RGR as compared to horse gram, moth bean and pillipesera. Competitive functions like relative crowing coefficient (19.70 and 9.53) recorded, significantly superior under *Bt* cotton + moth bean ($C_4$) system. Similarly, Aggressivity (A) values was the highest (+0.77 and +0.79) for *Bt* cotton + moth bean ($C_4$) intercropping system. Among the intercrops, the competitive ratio (CR) was higher in fodder cowpea ($C_2$) with values of 0.34 and 0.60 during first and second year, respectively.

**Keywords:** Intercropping, LAI, CGR, RGR, RCC, Aggressivity, Competitive ratio

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## Introduction

Cotton (*Gossypium spp*.) named as 'white gold' is one of the important commercial fibre crop and its production has higher economical value which plays an important role in the Indian economy, provides 85 per cent raw material to the textile industry. Productivity of cotton in India is low is mainly due to depletion of soil nutrients. Intercropping cotton with leguminous fodder is one of the way to improve fodder production and maintaining soil fertility. Though many researchers had studied the various cropping systems on cotton under different situations, most of the work was carried in arid regions where irrigation is limiting factors. Other hand rainfed cotton cultivation has become challenging of cotton growers, on account of uncertain and erratic distribution of rainfall which creating several problems resulting in unstable production of cotton. To overcome this problem, intercropping has been considered as a suitable system to overcome failure of crops. Suitable management practices like adopting complementary intercrops, timely application of manures and suitable irrigation practices and proper crop management operations are considered lowers the production cost and increase lint yield. *Bt* cotton hybrids are highly responsive to nitrogen application than non-*Bt* cotton suggesting that they may have a greater nitrogen uptake and metabolism than non-*Bt* [1]. However, almost all cotton growers use phosphatic fertilizers to increase the seed cotton yield rather than the use of nitrogen fertilizer and there are some cases where cotton responses to phosphorus has been positive and economical [2]. When cotton is intercropped with legume crops, phosphorus requirement is relatively higher in legumes as compared to non-legumes. The contribution of legume crops such as faba bean, field pea and lab-lab on nitrogen fertility of cotton cropping system might increased the cotton productivity [3]. Short duration legume fodders and tree fodders are potential sources of nutrients during summer, which is useful to livestock to feed with other green fodders as a balanced ration and enhancement of cotton is also possible by intercropping with a short duration legume fodders due to their complementary effect. But very few studies have been conducted on association of legume with cotton intercropping. Based on this background the present study was undertaken in order to develop a compatible, short duration legume fodder with cotton, without affecting the productivity of cotton which makes the system more feasible, productive and economical.

## Materials and Methods

The experiment was conducted at Krishi Vigyan Kendra, Veterinary College and Research Institute campus, Namakkal, to investigate the relative performance and effects of legume forage intercropping system on productivity of *Bt* cotton with different fertilizer levels during 2015-16 and 2016-17. The experimental site geographically located at 11°15' N latitude, 78 16' E longitude and an altitude of 216 m above mean sea level. Prevailing climate of this region is semi arid with hot weather during summer and cold weather during winter season. The mean annual maximum and minimum temperature during cropping period were 33.17º C and 22.70º C, respectively and the crop received 544 mm and 140mm of rainfall in 17 and 11 rainy days respectively during the both years. Soil was sandy clay loam in texture (*Typic* Ustropept) with the available soil N 251.5 and 235.8 kg $ha^{-1}$, available P 9.7 and 10.8 kg $ha^{-1}$, and available K 79.0 and 91.6 kg $ha^{-1}$ during 2015-16 and 2016-17, respectively. The treatment of five intercropping system ($C_1$- cotton alone; $C_2$-cotton + fodder cowpea; $C_3$ - cotton + horse gram; $C_4$-cotton + moth bean; $C_5$- cotton + pillipesara) and three fertilizer levels ($F_1$-100% RDF; $F_2$-125% RDF; $F_3$-150% RDF). Statistical analysis was carried out in split plot design with three replications. Cotton and intercrops were sown at 120 x 60 cm and 30 x 15 cm of spacing, respectively. Intercultural operations and all other cultivation practices with respect to cotton and intercrops were carried out as per the recommendation of [4]. The economic part of cotton *i.e.* cotton kapas was picked in the ten days interval and the yield recorded at each picking. Intercrops were harvested above from the ground level for green fodder purpose at 55 days after sowing. Physiological parameters like LAI, CGR, RGR and light interception rate were recorded at every 30 DAS intervals. Competitive behaviour of the component crops across different intercropping systems was determined in terms of relative crowding coefficient (RCC), aggressivity (A) and competitive ratio (CR). Plot wise data on soil nutrient content and yield etc. was subjected to statistical analysis of variance method as suggested by [5].

## Results and Discussion

### *Effect on physiological parameters*

*Leaf area index (LAI)*

Among the different legume fodder intercropping systems, cotton + mothbean ($C_4$) intercropping system registered the highest LAI values of 1.27 and 3.03 at 90 and 120 DAS were recorded during the first year of study. With respect to fertilizer levels application of 150% RDF ($F_3$) had significantly higher LAI of 2.89 and 1.97 at 120 DAS during first and second years of study.

*Crop growth rate (CGR)*

Fodder intercropping system with *Bt* cotton showed significantly increased trend of CGR at all the stages of crop growth. *Bt* cotton + moth bean ($C_4$) recorded the increased CGR at all the stages of crop growth with the values, 7.36 and 6.19 at 60-90 DAS, 5.92 and 6.08 at 90-120 DAS in the first and second years of the study, respectively. Application of 150% RDF ($F_3$) registered significantly more CGR values of 6.76 and 5.77 at 60-90 DAS, and 5.49 and 5.63 at 90-120 DAS during both the years of the study.

*Relative growth rate (RGR)*

*Bt* cotton grown under the intercropping system of *Bt* cotton + mothbean ($C_4$) recorded higher relative growth rate of 0.0049 mg $g^{-1}$ $d^{-1}$ during 2015-2016 and it was 0.0056 mg $g^{-1}$ $d^{-1}$ during 2016-2017.

Effect on crop growth rate of cotton was pronounced only from 45 DAS. CGR values, after 45 days was increased in intercropping system might be attributed to the fact, that availability of nutrients through higher fertilizer levels at critical stages and also nutrients received from root nodules of legume crops after 55 DAS might increased the leaf production of cotton. CGR and RGR values increased with enhanced nitrogen application. This was accordance with findings of [6].

### *Competitive behaviour of the component crops*

*Relative crowding coefficient (RCC)*

Relative crowding coefficient is an important competitive function and each intercrop has its own RCC. If the product of RCC of the two species is equal, less or greater than one it means that the intercropping system has no advantage, disadvantage or advantage, respectively. it is calculated by the following formula.

$$Kab = \frac{Yab}{Yaa - Yab} - \frac{Zba}{Zab}$$

Where, Yab = Intercrop yield of crop 'a'; Yaa = Pure stand yield of crop 'a'; Zba and Zab are sown proportions of crop 'a' and 'b' in an intercropping system

The highest value of RCC was obtained under *Bt* cotton + mothbean intercropping (19.70), followed by *Bt* cotton + fodder cowpea (9.30). This inferred that the *Bt* cotton + moth bean intercropping system preferred over rest of other intercropping and also showed the dominance of other intercrops over horsegram and pillipesera. Similar results also reported by [7].

**Table 1** Effect of legume fodder intercropping systems and fertilizer levels on LAI, CGR (g $m^{-2}$ $d^{1}$) and RGR (mg $g^{-1}$ $d^{-1}$) of *Bt* cotton at different growth stages

| Treatments | 2015-2016 | | | | | | 2016-2017 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LAI | | CGR | | RGR | | LAI | | CGR | | RGR | |
| | 90 DAS | 120 DAS | 60-90 DAS | 90-120 DAS | 60-90 DAS | 90-120 DAS | 90 DAS | 120 DAS | 60-90 DAS | 90-120 DAS | 60-90 DAS | 90-120 DAS |
| **Fodder intercropping systems** | | | | | | | | | | | | |
| $C_1$ | 1.10 | 2.66 | 6.57 | 5.43 | 0.0089 | 0.0048 | 0.97 | 1.58 | 6.10 | 5.48 | 0.0089 | 0.0050 |
| $C_2$ | 1.01 | 2.76 | 5.19 | 4.24 | 0.0085 | 0.0046 | 0.90 | 1.73 | 4.40 | 4.29 | 0.0084 | 0.0052 |
| $C_3$ | 1.03 | 2.81 | 6.62 | 5.02 | 0.0090 | 0.0044 | 0.88 | 1.52 | 5.51 | 5.19 | 0.0086 | 0.0051 |
| $C_4$ | 1.27 | 3.03 | 7.36 | 5.92 | 0.0095 | 0.0049 | 0.98 | 1.96 | 6.19 | 6.08 | 0.0087 | 0.0056 |
| $C_5$ | 1.07 | 3.61 | 6.34 | 5.05 | 0.0089 | 0.0046 | 0.91 | 1.50 | 5.35 | 5.69 | 0.0084 | 0.0054 |
| SEd | 0.03 | 0.09 | 0.20 | 0.16 | 0.0003 | 0.0002 | 0.02 | 0.04 | 0.17 | 0.17 | 0.003 | 0.0002 |
| CD (P=0.05) | 0.06 | 0.20 | 0.47 | 0.33 | 0.0007 | 0.0004 | 0.06 | 0.10 | 0.39 | 0.39 | 0.006 | 0.004 |
| **Fertilizer levels** | | | | | | | | | | | | |
| $F_1$ | 1.02 | 2.65 | 6.05 | 4.92 | 0.0085 | 0.0047 | 0.87 | 1.38 | 5.12 | 4.92 | 0.0088 | 0.0053 |
| $F_2$ | 1.12 | 2.78 | 6.44 | 4.98 | 0.0083 | 0.0045 | 0.92 | 1.62 | 5.63 | 5.47 | 0.0086 | 0.0051 |
| $F_3$ | 1.15 | 2.89 | 6.76 | 5.49 | 0.0101 | 0.0047 | 0.99 | 1.97 | 5.77 | 5.63 | 0.0084 | 0.0053 |
| SEd | 0.02 | 0.09 | 0.27 | 0.22 | 0.0003 | 0.0002 | 0.02 | 0.03 | 0.24 | 0.22 | 0.002 | 0.0002 |
| CD (P=0.05) | 0.04 | 0.18 | 0.57 | 0.46 | 0.0006 | 0.0004 | 0.04 | 0.06 | 0.51 | 0.45 | 0.005 | 0.0004 |
| Interaction | S | S | NS | NS | NS | NS | S | S | NS | NS | NS | NS |

**Table 2** Effect on competitive functions under legume fodder intercropping systems and fertilizer levels of *Bt* cotton

| Treatments | 2015-2016 | | | | 2016-2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | RCC | CR | Aggressivity Intercrops | Aggressivity *Bt* cotton | RCC | CR | Aggressivity Intercrops | Aggressivity *Bt* cotton |
| **Fodder intercropping systems** | | | | | | | | |
| $C_1$ | - | - | - | - | - | | - | |
| $C_2$ | 9.30 | 0.34 | +0.59 | -0.59 | 8.10 | 0.60 | -0.58 | +0.58 |
| $C_3$ | 8.40 | 0.30 | +0.72 | -0.72 | 4.67 | 0.23 | -0.75 | +0.75 |
| $C_4$ | 19.70 | 0.31 | +0.77 | -0.77 | 9.53 | 0.46 | -0.79 | +0.79 |
| $C_5$ | 3.70 | 0.29 | +0.64 | -0.64 | 2.73 | 0.27 | -0.71 | +0.71 |
| **Fertilizer levels** | | | | | | | | |
| $F_1$ | 8.00 | 0.312 | -0.66 | +0.66 | 3.43 | 0.28 | -0.69 | +0.69 |
| $F_2$ | 8.20 | 0.307 | -0.68 | +0.68 | 9.59 | 0.29 | -0.71 | +0.71 |
| $F_3$ | 8.40 | 0.315 | -0.71 | +0.71 | 5.76 | 0.60 | -0.72 | +0.72 |

*Aggressivity (A)*

Experimental results revealed that all the fodder intercrops indicated dominant behaviour over the base cotton crop. Aggressivity values was the highest (+0.77 and +0.79) for *Bt* cotton + moth bean ($C_4$) followed by *Bt* cotton + horse gram ($C_3$) (+0.72 and +0.75) and *Bt* cotton + pillipesera ($C_5$) (+0.67 and 0.71) compared to the minimum *Bt* cotton + fodder cowpea ($C_2$) (+0.59 and +0.58) during the first and second year study. Aggressivity was calculated by the following formula,

$$Aab = \frac{Yab}{Yaa \times Zab} - \frac{Zba}{Ybb \times Zba}$$

Various experimental studies also showed the dominant effect of cowpea and mashbean when grown in association with other crops having a positive (+) aggressivity values [8].

*Competitive ratio (CR)*

Among the fodder intercropping systems and fertilizer levels, the intercrops *viz*., fodder cowpea, horse gram, moth bean, pillipesera were more competitive than *Bt* cotton when grown in association with each other. competitive ratio was higher in fodder cowpea ($C_2$) (0.34 and 0.60 during first and second year) Competitive ratio was calculated by the following formula,

$$CRa = \frac{Yab}{Yaa \times Zab} \div \frac{Zba}{Ybb \times Zba}$$

Competitive ratio (CR) is another way to know the degree with which one crop competes with the intercrop. Higher CR values for intercrops than the base cotton crop indicated that all intercrops like fodder cowpea, horse gram, moth bean, pillipesera, were more competitive than cotton when grown in association with each other.

## Conclusion

Considering the biological and economical performance of cotton with intercrops and three fertilizer levels, *Bt* cotton + moth bean intercropping system with application of 150% RDF is an ideal combination which farmers can adopt in their fields due to this treatment registered higher cotton yield and net returns.

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