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Studies on the nutrient management of *Bt* cotton based legume intercropping system

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Abstract: Field studies were conducted during 2010 and 2011 at Punjab Agricultural University, Regional Research Station, Faridkot to evaluate the impact of different planting methods and nutrient management strategies in *Bt* cotton. The experiment comprised of 3 planting methods {*i.e* T_1: conventional sole cotton (67.5 x 75cm);T_2: paired row cotton planting (67.5:135cm) and T_3: paired row cotton planting + mungbean as an intercrop }in main plots and 4 nutrient management practices {*i.e* N_1:75 kg N and 50 kg MOP/ha+DAP @1.5%+K@0.5 %; N_2 : N_1 + $MgSo_4$@50 kg /ha as basal soil application + $MgSO_4$@0.5 % + Boron @ 0.15 %; N_3 : 94 kg N and 62.5 kg MOP/ha +DAP @1.5 %+ K@0.5% and N_4 : N_3 + $MgSO_4$ @0.5 % + Boron @ 0.15 %} in sub plots of randomized block design (factorial) was laid out with 3 replications. Paired row cotton along with intercropped mungbean recorded 18.9 per cent significantly higher seed cotton yield (3534 kg/ha) as compared to conventional sole cotton (2971kg/ha) though it was *at par* with paired row cotton planting (3334kg/ha). Among nutrient management practices , highest seed cotton yield of 3558 kg/ha was observed in N_4 {94 kg N and 62.5 kg MOP/ha + DAP @1.5 % + K @ 0.5 %+$MgSO_4$@ 0.5 % + Boron as solubor (0.15 %) followed by N_3 (3494kg/ha), N_2 (3157kg/ha) and lowest under N_1 (2911 kg/ha).

Key words : *Bt* cotton, fertilizer use efficiency, intercrop, paired row planting, seed cotton yield

Cotton (*Gossypium hirsutum* L.), also known as “White Gold”, is one of the most important commercial cash crops of semi arid Indian region. In Punjab, *Bt* cotton is presently covering 94 per cent of total cotton acreage (Kranthi, 2012). Besides improvement in yield, *Bt* cotton has lowered the bollworm incidence and reduced environmental pollution with limited use of insecticides by about 50 per cent (Karihaloo and Kumar, 2009). Cotton cultivation in semi arid regions of country is considered as most risky crop as its yield is very sensitive to weather parameters like rain and temperature. Intercropping *Bt* cotton with short duration legumes offer good scope for increasing the productivity besides improvement in soil fertility. Cotton based intercropping systems may also gain popularity for more tangible reasons like risky cultivation due to continuous increasing sucking pests problem in *Bt* cotton, price instability, market uncertainty, increasing cost of inputs besides meeting domestic requirements of protein rich pulses for improving family health. Intercropping in paired rows of cotton has also been found to be more advantageous than crop grown in alternate rows. Moreover, different cotton based intercropping systems have been reported to increase farm income by 30-40 per cent though magnitude of such agro economic advantages depends upon the type of intercrop .Conventional method of planting cotton in closely spaced single rows does not permit convenient intercropping. Paired row cotton plantation in widely spaced strips not only gives equivalent or better seed cotton yield (SCY) comparable with conventional plantation but also facilitates intercropping. Moreover, due to yield stability and better returns/unit area even under adverse conditions, intercropping of short duration legumes in cotton is gaining emphasis (Gadade *et al.,* 2006). Therefore, field studies were conducted on *Bt* cotton for finding suitable planting method and nutrient management practices for maximizing the productivity and profitability under semi-arid conditions of north western India.

MATERIALS AND METHODS

The field studies were conducted during *kharif* 2010 and 2011 at Punjab Agricultural University, Regional Research Station, Faridkot ($30^0$40'N and $74^0$44'E), a typical representative of semi-arid conditions of north western India primarily occupying south western zone (Zone IV) in Punjab. The soil of the experimental plot was typically alluvial with loamy texture, slightly alkaline (pH 8.5), normal EC (0.58 mmhos/cm), medium in OC (0.45%) and N, high in available P (24.75 kg P_2O_5/ha) but very high in available K (675 kg K_2O/ha). The experiment comprised of 3 planting methods {*i.e* T_1: Conventional sole cotton (67.5 x 75cm);T_2: Paired row cotton planting (67.5:135cm) and T_3: Paired row cotton planting + mungbean as an intercrop }in main plots and four nutrient management practices {*i.e* N_1 : 75 kg N and 50 kg MOP/ha + DAP @1.5 % + K@ 0.5 %; N_2 : N_1 + $MgSo_4$ @50 kg /ha as basal soil application + $MgSO_4$ @0.5 % + Boron as solubor @ 0.15 % [Twice during flowering to boll development stages] ; N_3 : 94 kg N and 62.5 kg MOP/ha + DAP @1.5 %+ K @0.5 %, and N_4 : N_3 + $MgSO_4$@0.5 % + Boron as solubor @ 0.15 % [Twice during flowering to boll development stages] } in sub plots of randomized block design, replicated thrice . The *Bt* hybrid MRC7017 was sown during first fortnight of May by dibbling method and 2-3 seeds/hill were sown and later on thinned to one seedling /hill at 30DAS. Sowing was performed by keeping 8 rows for sole and 6 rows for paired row cotton plots. However, paired row cotton plots having intercropping treatment had two rows of mungbean (Cv.SML 668) after every 2 rows of cotton. Uniform plant stand as that of conventional sole cotton was maintained in all the paired row treatments by adjusting to closer intra row spacing. In this intercropping experiment plant population of base crop was kept constant while the planting geometry was altered. Nitrogen, MOP and $MgSO_4$ @50 kg /ha were applied through soil while all other nutrients were supplied through foliar sprays. Total amount of rainfall received was 432.8 and 606.4 mm for the year 2010 and 2011, respectively. Number of rainy days (41) were higher during 2011 as compared to only 34 days during 2010. All other production and protection measures were applied. Data on growth and yield attributing characters were recorded from 5 randomly selected plants in each treatment plot. SCY was recorded from whole plot. The data were pooled and analyzed statistically. Since, the interaction effects among the planting methods and nutrient management practices were found to be non significant, hence, only main effects have been used to discus the results.

RESULTS AND DISCUSSION

Growth and yield parameters: The results presented in the Table 1 revealed significant differences among planting methods for SCY, bolls /plant, lint as well as seed yield and biomass. Paired row cotton along with mungbean as an intercrop (T_3) gave significantly higher seed cotton yield (3534 kg/ha) owing to significantly better bolls/plant as compared to conventional sole cotton (2971 kg/ha) though was *at par* with paired row cotton (3334 kg/ha) without intercrop (T_2).The increase in SCY, in case of T_2 and T_3 over conventional sole crop (T_1) was 12.2 and 18.9 per cent, respectively. Alteration of plant geometry in paired row treatments resulted in creating congenial environment for various resources like light interception, aeration, nutrients and soil moisture etc, which has reflected in improved SCY over conventional planting. The improvement of SCY in T_3 might be also due to beneficial effects of the intercrop in the soil profile by fixation of atmospheric nitrogen as well as soil incorporation of mungbean biomass after picking of pods. On an average, with or without incorporation of residue into the soil, mungbean can fix upto 74 kg and 112 kg N/ha, respectively (Shah *et al.,* 2003). The results in present studies are also in accordance with Shah *et al.,* (2002) that 2:1 geometry of cotton mungbean produced statistically similar yield to that recorded from the sole cotton. Shah *et al.,* (2002), Khan and Khaliq (2004) reported reduction in the SCY to a significant extent for cotton + mungbean intercropping systems, though, additional production obtained from intercrops compensated more than the losses in cotton production. In the present investigations, the yield differences within the paired row treatments *i.e* T_2 and T_3 were not statistically significant.

Among planting methods, highest lint yield of 1196.2 kg/ha was recorded with T_3 followed by T_2 (1108.5kg/ha) with least value under conventional cotton planting (999.8 kg/ha). The lint yield in case of T_2 and T_3 was higher by 10.8 and 19.6 per cent, respectively over the conventional cotton. A similar trend was also recorded for seed yield (Table 1). However, seed yield (2338.3 kg/ha) under paired row planting system with intercrop (T_3) was significantly higher than sole cotton planting (1971.9 kg/ha).Ginning outturn (GOT %) was significantly affected by planting methods with statistically least value under T_2 (33.2%) but among nutrient management practices, N_2 and N_3 recorded significantly higher GOT than N_1.Planting methods failed to produce any significant effect on plant height, boll weight, monopods and sympods/plant. Biomass accumulation was significantly improved under paired row planting (111.3-112 q/ha) over that of conventional sole cotton (94.6q/ha).Among the nutrient management practices, non significant effects were observed for seed cotton yield and yield contributing characters except for sympods/plant which improved significantly from 27.0 (N_1) to 33.4 (N_4) with increase in level of nutrition. There was a gradual improvement in sympods/plant from 27.0 to 29.3, 31.1 and 33.4 with increasing nutrition for N_1, N_2, N_3 and N_4, respectively. However, highest SCY of 3558kg/ha was recorded in N4 {N_3 + $MgSO_4$ @0.5 per cent + Boron @ 0.15 per cent followed by N_3 (3494kg/ha), N_2 (3157kg/ha) and least under N_1 (2911kg/ha).

Fertilizer use efficiency (FUE): Significant improvement in FUE was recorded only for planting methods while among nutrient management practices, the effects were not statistically significant. This might be due to the fact that soil test reports of the experimental site indicated high P and very high K in the available

Table 1. Effect of different treatments on growth parameters, yield attributes and fertilizer use efficiency

Treatments	Seed cotton yield (q/ha)	Bolls/ plant	Boll weight (g)	Final height (cm)	Lint yield (kg/ha)	Seed yield (kg/ha)	GOT (%)	FUE (kg SCY/kg of fertilizer applied)
Planting methods								
T_1: Conventional sole cotton (67.5 x 75cm)	2971	49.0	4.9	153.7	999.8	1971.9	33.6	6.35
T_2: Paired row cotton planting (67.5:135cm)	3334	55.4	5.1	148.0	1108.5	2225.8	33.2	7.13
T_3: T_2+mungbean as an intercrop	3534	58.1	5.2	152.2	1196.2	2338.3	33.8	7.56
SEm ±	164.7	2.7	0.1	1.7	56.8	108.4	0.2	0.4
P=0.05	445	4.25	NS	NS	150.6	295.6	0.3	0.95
Nutrient management practices								
N_1	2911	52.8	4.9	150.5	967.6	1943.5	33.2	6.22
N_2	3157	53.4	5.0	151.1	1066.0	2091.5	33.7	6.75
N_3	3494	55.1	5.2	155.6	1180.2	2313.9	33.7	7.47
N_4	3558	55.4	5.3	148.0	1192.2	2365.7	33.5	7.61
SEm ±	151.2	0.6	0.1	1.6	52.9	98.4	0.1	0.3
P=0.05	NS	NS	NS	NS	173.9	NS	0.4	NS

Table 2. Effect of different treatments on the monetary parameters

Treatments	Cost of cultivation (Rs/ha)	Gross returns (RS/ha)	Net returns (Rs/ha)	B:C ratio (kg/ha)	Mungbean yield (kg/ha)	Seed cotton yield (kg/ha)	Cotton equivalent with intercrop	Net returns (Rs/ha)
Planting methods								
T_1: Conventional sole cotton (67.5 x 75cm)	24759	118870	94110	3.78	-	2971	2971	94110
T_2: Paired row cotton planting (67.5:135cm)	25665	133375	107709	4.16	-	3334	3334	107709
T_3: T_2+ mungbean as an intercrop	27606	168432	140826	5.08	676 (Rs.27040)	3534	3534+676=4210	140826+ 27040 = 167866
P=0.05	1114	17828	16714	0.45		445	-	-
Nutrient management practices								
N_1	25087	125912	100824	4.00	-	2911	-	100824
N_2	25703	135970	110266	4.25	-	3157	-	110266
N_3	26545	148432	121886	4.53	-	3494	-	121886
N_4	26705	150589	123884	4.57	-	3558	-	123884
P=0.05	NS	NS	NS	NS	-	NS	-	-

Market rate prevalent @ 4000/q of mungbean and seed cotton has been considered for monetary calculations

form, which could be the reason for non significant effects observed among nutritional treatments. FUE was highest under paired row cotton planting+ mungbean (7.56) followed by T_2 (7.13) with least value (6.35) under conventional sole cotton (Table 1).

Monetary parameters: The data on various monetary parameters indicated significant effects only for planting methods whereas nutritional management practices could not differ statistically (Table 2). Cost of cultivation was significantly highest in case of T_3 (₹27606/ha) as compared to other planting methods. This was primarily due to more expenditure incurred on labour deployed for 3 periodic pickings of mature mungbean pods and later incorporation of legume residue in the soil. However, significantly highest net returns of 140826/ha were also recorded for T_3 followed by T_2 (107709) with least value for T_1 (94110).Though, there was an increasing trend for net returns as well as B:C ratio, with increasing nutrient treatments from N_1 to N_4, but statistically differences were not significant. In our studies, highest B:C ratio was recorded with T_3 (5.08) owing to significant improvement in net returns as compared to T_2 (4.16) followed by T_1(3.78). A cotton equivalent yield of 4210kg/ha indicated an income of 167866/ha as net returns .Therefore , net returns in cotton intercropped with mungbean legume were increased by 73756 and 60157/ha as compared to T_1 and T_2, respectively (Table 2). Shah *et al.,* (2002) also reported cotton and mungbean intercropping (2:1 row arrangement) as the most compatible system which resulted in producing combined higher yield by 18.7 per cent (4465kg/ha) than monoculture cotton.

Intercrop yield: In the present studies, a mungbean yield of 676 kg/ha has been obtained from paired row cotton with intercropped legume. Therefore, data revealed feasibility of short duration mungbean varieties as an intercrop in *Bt* cotton besides other legume benefits such as soil enrichment in terms of atmospheric N fixation and addition of organic matter, finally leading to improvement in soil fertility indices. At this yield level, mungbean can not only fetch an additional income of 27040/ha but can also help to meet domestic pulse requirement for maintaining good health of the farmer families. Shah *et al.,* (2002) also reported a mungbean yield of 950 and 740 kg/ha in intercropping pattern (cotton: mung bean) of 1:1 and 2:1, respectively. It may be concluded that better productivity as well as higher profitability in an intercropping system could be achieved by manipulating planting ratio of intercrops in such a way that recessive component like mungbean should thrive without affecting the seed cotton yield *i.e* dominant associate of the system.

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