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Effect of High Density Planting and Weed Management Practices on Productivity and Economic Analysis of Bt Cotton

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A B S T R A C T

An experiment was conducted during *kharif*, 2015 at College farm, College of Agriculture, Rajendranagar, Hyderabad, with four planting densities 55,555 plants ha^{-1}, 1,11,111 plants ha^{-1} normal planting, 1,11,111 plants ha^{-1} paired row planting, 1,48,148 plants ha^{-1} and 4 weed management practices (pendimethalin 1.0 kg ha^{-1} as PE fb pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60, DAS, early PoE application of pyrithiobac sodium 62.5 g ha^{-1} + quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS, PE application of pendimethalin 1.0 kg ha^{-1} fb HW at 20 and 45 DAS and unweeded control. Research results revealed that, based on economic analysis plant density of 1,11,111 plants ha^{-1} (60 cm x 15 cm) produced significantly more kapas yield (3134 kg ha^{-1}), net returns and B:C ratio (Rs. 67,212 ha^{-1} and 2.24). Among the weed management practices, all three weed management practices recorded comparable kapas yield of 3119, 3018 and 3058 kg ha^{-1} respectively. But early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1} + quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS recorded higher net returns and B:C ratio (Rs.64,527 and 2.32).

Introduction

Cotton (*Gossypium hirsutum* L.) the king of fiber, is one of the momentous and an important cash crop exercising profound influence on economics and social affairs of the world.

Average productivity of cotton in India is 503 kg/ha which is low as compared to world average of 733 kg/ha. Almost 95 per cent Indian cotton farmers are using the genetically modified Bt cotton. However, this Bt period also registered a marked increase in the instability in production (Narala and Reddy, 2011) as the cost of cotton production is escalating due to increased labour demand, increased labour costs, increased seed costs, and increased costs for cotton picking and nutrient requirements.

The high density planting system (HDPS) is now being conceived as an alternate production system having a potential for improving productivity and profitability (Pradeep kumar *et al.*, 2017), increasing efficiency, reducing input costs and minimising risks associated with India's cotton production system.

Optimum cotton yield and quality for high-density planting cotton requires good weed control throughout the growing season. Cotton being a wide spaced and long duration crop suffers from heavy weed competition during the early stages of crop growth. Critical period of crop weed competition is 60 to 70 days from sowing, which may cause yield loss from 40 to 85 per cent depending upon the nature and intensity of weeds. Most often due to incessant rains during *kharif* season; hand weeding and intercultivation (IC) become difficult in cotton. Further, labours being scarce and costly, growers are forced to fall back on chemicals for weed control. Therefore, farmers are need of selective post emergence broad spectrum herbicide/herbicide mixtures. HDPS will provide a soil canopy in about 30 days as compared to 60-75 days for conventional row widths, which will shade out weeds and reduce their competitiveness as lower weed density under high density planting system was recorded with pre emergence application of pendimethalin 1 kg ha^{-1}+one inter cultivation+one hand weeding+1 post emergence spray of tank mixed pyrithiobac sodium 75 g ha^{-1} and quizalofop ethyl 50 g ha^{-1} (Venugopalan *et al.,* 2013).

So vigilant production and economic strategies are important for cotton growing farmers due to expanding cost of cultivation and stagnating productivity. Keeping these points in view an effort was made to find out the optimum plant density with suitable weed management practice.

Materials and Methods

An experiment was conducted during *kharif*, 2015 at College farm, College of Agriculture, Rajendranagar, Hyderabad (The farm is geographically situated an altitude of 542.6 m above mean sea level on 18' 50^{o} N latitude and 77.53^{o} E longitude). The soil of the experimental field was sandy loam in texture, low in available N (250 kg ha^{-1}), medium in phosphorus (21.68 kg P_2O_5 ha^{-1}) and high in potassium (685.6 kg K_2O ha^{-1}). The treatments comprised of four planting densities 55,555 plants ha^{-1} (D_1), 1,11,111 plants ha^{-1} (D_2) normal planting, 1,11,111 plants ha^{-1} (D_3) paired row planting, 1,48,148 plants ha^{-1} (D_4) and weed management practices (pendimethalin 1.0 kg ha^{-1} as pre emergence fb pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60, DAS (W_1), pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS as early post emergence fb glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS (W_2), pendimethalin 1.0 kg ha^{-1} as pre emergence fb HW at 20 and 45 DAS (W_3) and unweeded control (W_4) in randomized block design (factorial), replicated thrice.. Net return or profit was calculated by subtracting cost of cultivation from the gross returns. Price used for harvest products was minimum support price during the experimental period. The benefit: cost ratio was calculated by dividing the gross returns with cost of cultivation.

Results and Discussion

Effect of plant densities on yield

The main and interaction effect of plant densities and weed management practices showed significant influence on yield and economics of Bt cotton (Tables 1 and 2). Plant density of 1,11,111 plants ha^{-1} normal planting (60 cm×15 cm) recorded higher kapas yield and was superior over rest of the plant densities *viz*.1,11,111 plants ha^{-1} paired row planting (60 cm×15 cm), 1, 48,148 plants ha^{-1} (45 cm×15 cm) and 55,555 plants ha^{-1} (60 cm×30 cm). In turn plant densities of 1, 48,148 plants ha^{-1} and 55,555 plants ha^{-1} were on par with each other. Although more plant height, crop drymatter and reduced LAI per plant (Table 1) was noticed with 55,555

plants ha^{-1} (60 cm×30 cm) at wider spacing, but the increased yield in 1, 11,111 plants ha^{-1} normal planting was due to more number of bolls m^{-2}, boll weight over rest of the densities. Yield increase of 30.31 %, 29.57 % and 17.20 % was observed when plant density was increased to 1,11,111 plants ha^{-1} normal planting from plant density of 55,555 plants ha^{-1}, 1,48,148 plants ha^{-1} and 1,11,111 plants ha^{-1} paired row planting respectively. Even though, the boll number, boll weight and seed cotton yield $plant^{-1}$ was significantly higher with wider spacing (Pradeep kumar*et al.*, 2017), it could not compensate for the loss in number of plants ha^{-1} and number of bolls m^{-2}, thus recorded lower seed cotton yield ha^{-1} when compared to high density planting.

Effect of weed management practices on yield

Higher kapas yield was recorded with pendimethalin (PE) 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS and was comparable with pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS and early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS and were significantly superior over unweeded control treatment.

The yield reduction of 70.34% was observed from unweeded control treatment. Further, timely and effective control of weeds through herbicides coupled with cultural methods which resulted in better availability of soil moisture and nutrients (Prabhu *et al.*, 2012). Interaction effect of plant densities and weed management practices did not show any significant influence on seed cotton yield and economics in Bt cotton.

Effect of plant densities on economics

Plant densities exerted significant influence on monetary returns of Bt cotton cultivation (Table 2). Significantly higher cost of cultivation was noticed with 1,48,148 plants ha^{-1} (45 cm×15 cm) and was followed by 1, 11,111 plants ha^{-1} (60 cm×15 cm) normal planting and 1,11,111 plants ha^{-1} (60 cm × 15 cm) paired row planting. The lowest cost of cultivation was recorded with 55,555 plants ha^{-1} (60 cm ×30 cm).

This reduced cost of cultivation was might be due to reduced seed cost towards purchase of seed. However more gross returns was achieved with 1,11,111 plants ha^{-1} (60 cm×15 cm) normal planting followed by plant density of 1,11,111 plants ha^{-1} (60 cm×15 cm) paired row planting, 1,48,148 plants ha^{-1} (45 cm×15 cm) and 55,555 plants ha^{-1} (60 cm×30 cm) respectively. This increased gross returns was might be due to more kapas yield per unit area. This was reflected as significantly higher net returns with 1, 11,111 plants ha^{-1} normal planting over rest of the plant densities. This was followed by 1,11,111 plants ha^{-1} paired row planting and 55,555 plants ha^{-1}, in turn these two recorded on par net returns. Even though more gross returns were recorded, reduced net returns were obtained with plant density of 1, 48,148 plants ha^{-1}. This reduced net returns were might be due to increased cost of cultivation and reduced kapas yield per unit area at higher plant densities.

Economic analysis showed that, higher B:C ratio was noticed with 1,11,111 plants ha^{-1} normal planting followed by 55,555 plants ha^{-1}, 1,11,111 plants ha^{-1} paired row planting and 1,48,148 plants ha^{-1} treatment.

Table.1 Plant height, crop dry matter, Leaf area index and yield in Bt cotton under varied plant densities and weed management practices *kharif*, 2015

Treatment **Plant densities (D)**	**Plant height (cm)**	**Crop drymatter (g plant^{-1})**	**Leaf area index**
60 cm×30 cm (55,555)	112	76.99	1.47
60 cm×15 cm (1,11,111)	102	73.99	2.89
60 cm×15 cm (1,11,111 Paired row- 45 cm × 75 cm)	105	64.34	2.74
45 cm×15 cm (1,48,148)	110	54.18	3.55
S. Em±	2.6	3.34	0.02
CD (P=0.05)	NS	9.69	0.10
Weed Management Practices (W)			
Pendimethalin 30% EC 1.0 kg ha^{-1} as PE fb PoE pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 5% EC 50 g ha^{-1} at 20, 40, 60 DAS	109	82.29	3.28
Pyrithiobac sodium 10% EC 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS as early PoE fb glyphosate 71% SG 2.13 kg ha^{-1} at 45 DAS	124	70.97	2.71
Pendimethalin 1.0 kg ha^{-1} as PE fb HW at 20 and 45 DAS	109	75.81	3.18
Unweeded control	86	40.43	1.48
S. Em±	2.6	3.34	0.02
CD (P=0.05)	7.7	9.69	0.10
Interaction (D X W)			
S. Em±	5.3	6.67	0.05

Table.2 Yield, gross returns, net returns and B: C ratio of Bt cotton under varied Plant densities and weed management practices kharif, 2015

Treatment	Yield Kg ha^{-1}	CC ₹ ha^{-1}	Gross returns ₹ ha^{-1}	Net returns ₹ ha^{-1}	B:C ratio
Plant densities (D)					
60 cm×30 cm (55,555)	2184	41182	83009	41828	1.95
60 cm×15 cm (1,11,111)	3134	51886	119097	67212	2.24
60 cm×15 cm (1,11,111 Paired row- 45 cm × 75 cm)	2595	51886	98585	46700	1.87
45 cm×15 cm (1,48,148)	2207	58943	83843	24901	1.39
S. Em±	149.43			5678.51	
CD (P=0.05)	433.69			16480.07	
Weed Management Practices (W)					
Pendimethalin 30% EC 1.0 kg ha^{-1} as PE fb PoE pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 5% EC 50 g ha^{-1} at 20, 40, 60 DAS	3119	56566	118508	61942	2.11
Pyrithiobac sodium 10% EC 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1}at 15 DAS as early PoE fb glyphosate 71% SG 2.13 kg ha^{-1} at 45 DAS	3018	50154	114681	64,527	2.32
Pendimethalin 1.0 kg ha^{-1} as PE fb HW at 20 and 45 DAS	3058	53132	116200	63068	2.22
Unweeded control	925	44042	35145	-8897	0.80
S. Em±	149.43			5678.51	
CD (P=0.05)	433.69			16480.07	
Interaction (D X W)					
S. Em±	298.87			11357.03	
CD (P=0.05)	NS			NS	

The increased B: C ratio was attributed due to higher cotton yield, gross returns and net returns with comparatively lower cost of cultivation. Even though, the lowest yield was obtained from 55,555 plants ha^{-1} (60 cm x 30 cm), the increased B: C ratio was due to reduced cost of cultivation when compared to other densities, where increased cost of cultivation was noticed due to increased population per unit area with reduced yield.

Effect of weed management practices on economics

Weed management practices also showed significant impact on profitability of Bt cotton under different weed management practices. Increased cost of cultivation and gross returns was recorded with sequential PE application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS. This was followed by IWM practice of pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS and sequential early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS. The lowest cost of cultivation and gross returns was recorded with unweeded control treatment. This might be due to effective control of weeds which reflected in less weed population, dry weight of weeds and maximum bolls $plant^{-1}$, higher seed cotton yield and higher gross returns (Madhu *et al.,* 2014).

Even though small reduction in kapas yield was observed with early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS, but significantly higher net returns and B:C ratio were obtained due to reduced cost of cultivation and was followed by pendimethalin 1.0 kg ha^{-1} (PE) fb HW at 20 and 45 DAS and PE application of pendimethalin 1.0 kg ha^{-1} fb PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 20, 40, 60 DAS. Least net returns and B: C ratio was obtained with unweeded control treatment. Interaction was not found significant under varied plant densities and weed management practices on net returns and B: C ratio.

In concluding remarks based on economic analysis, normal planting density of 1,11,111 plants ha^{-1} (60 cm X 15cm) is effective to realise higher kapas yield (3134 kg ha^{-1}) net returns of (Rs 67,212 ha^{-1}) and B:C ratio (2.24 ha^{-1}). Among the weed management practices sequential early PoE tank mix application of pyrithiobac sodium 62.5 g ha^{-1}+quizalofop-p-ethyl 50 g ha^{-1} at 15 DAS fb directed spray of glyphosate ammonium salt 2.13 kg ha^{-1} at 45 DAS was effective to get higher kapas yield (3018 kg ha^{-1}), net returns (Rs.64,527 and 2.32 ha^{-1}) and B:C ratio.

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