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RESEARCH ARTICLE :

Studies on economic evaluation and nutrient uptake of Bt and non Bt cotton cultivars as influenced by varied plant densities and nitrogen levels

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SUMMARY : A field experiment was conducted during 2015-16 and 2016-17 at Agricultural Research Institute, Rajendranagar,Hyderabad to assess the performance of two cotton cultivars Bt (MRC 7201 BGII) and non-Bt (WGCV-48) in response to plant densities (P_1: 18,518 plants ha^{-1}, P_2: 55,555 plants ha^{-1} and P_3:1,48,148 plants ha^{-1}) and nitrogen fertilization (120, 150 and 180 kg N ha^{-1}).During 2015 and 2016, among the two cultivars (V_1: MRC 7201 BG II, V_2: WGCV-48), MRC 7201 BG II cultivarseed cotton yield (3497, 2866 kg ha^{-1}), gross returns (1,36,396 and 1,14,629 Rs. ha^{-1}), net returns (87226, 65514 Rs. ha^{-1}) and B:C ratio (2.9, 2.5) over V_2: WGCV-48 cultivar. Among the plant densities,the highest gross returns (1,29,427 and 1,09,045 Rs. ha^{-1}),net returns (88,146 and 68,208 Rs. ha^{-1}) and B: C ratio (3.1 and 2.7) were observed with P_2: 60 cm x30 cm (55,555 plants ha^{-1}) and was followed byP_3: 45 cm x15 cm (1,48,148 plants ha^{-1}) and P_1: 90 cm x60 cm (18,518 plants ha^{-1}). Effect of nitrogen levels did not exert any influence on gross returns, net returns and B: C ratio. In 2015 and 2016, maximum totalnitrogen uptake (kg ha^{-1}) as observed in MRC 7201 BGII cultivar at square initiation (7.1, 7.0 kg ha^{-1}), flower initiation (55.5, 34.5kg ha^{-1}), boll development (104.2, 112.5kg ha^{-1}) and first picking (161.3, 124.7kg ha^{-1}) and significantly superior to WGCV-48 cultivar.Among the plant densities, the highest nitrogen uptake was observed in P_3: 45 cm x 15 cm (1,48,148 plants ha^{-1}) at square initiation (13.5, 13.4 kg ha^{-1}), flower initiation (80.3, 46.4 kg ha^{-1}), boll development (146.0, 154.8 kg ha^{-1}) and first picking (190.5, 181.2 kg ha^{-1}) and significantly superior to P_2: 60 cm x 30 cm (55,555 plants ha^{-1}) and P_1: 90 cm x 60 cm (18,518 plants ha^{-1}).

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BACKGROUND AND OBJECTIVES

Cotton is a natural part of everyday life which serves the mankind from the cradle to the grave. Cotton plays a key role in socio-economic and political affairs of the world (Kairon *et al.*, 2004). Its production, processing and trade generate revenue and sustain livelihoods in many countries. It is the world's leading source of natural textile fibre and fifth largest oilseeds crop which covers 40% of the global textile need (APTMA, 2012) and 3.3% of edible oil (FAS, 2014), respectively. Cotton is the most important commercial and premier cash crop of India. It plays a prominent role in farming and industrial economy of the country. With the introduction of Bt cotton hybrids, there has been a significant change in the cotton cultivation scenario of India. Now, around 40 per cent area under cotton is occupied by Bt cotton hybrids. However, the average production is very low when compared to world's average. This is mainly because 70 per cent of cotton area is under rainfed condition.

Cotton (*Gossypium hirsutum* L.) crop assumes a place of special significance in Indian economy. India is the only country in the world which grows four types of cultivated species of cotton. During the last decade, a decline in seed cotton yield was observed due to severe incidence of boll worms which resulted in decrease in cotton area. However, after the introduction of Bt cotton which resists the boll worm attack in 2002, the technology has been widely accepted by Indians and the area under cotton increased to 11.64 million ha with a production of 33.4 million bales with productivity of 489 kg ha^{-1} in 2012-13 (Anonymous, 2013). Now 90 per cent of cotton area was occupied by Bt cotton. By adopting appropriate agronomic practices cotton yield per unit area can be improved. Management decisions like variety selection, planting date, plant density, and nitrogen management have a profound effect on the development and final outcome of the crop.

Till date, there is confusion in the farming community that whether Bt crop needs same plant geometry and nutrient requirement as that of non Bt cotton. Vegetative growth in Bt cotton is restricted due to 100% setting of fruiting bodies on the plant, which requires closer spacing for better yields. Chen *et al*. (2004) specified the need to develop agronomic management practices as there are changes in vegetative and reproductive characteristics of Bt cotton. Lack of knowledge about important agronomical practices could also be another reason. So, there is a need to identify suitable Bt cotton genotype which gives higher, gross returns, net returns with lower cost of cultivation. Keeping this in view the present study was carried out to find the optimum spacing and nitrogen requirement for Bt and non Btcotton under rainfed conditions.

RESOURCES AND METHODS

The investigation was carried out during *Kharif* 2015-16 and 2016-17 at Agricultural Research Institute, Rajendranagar, Hyderabad situated at an altitude of 542.3 m above mean sea level at 17°19' N latitude and 78°23' E longitude. It is in the Southern Telangana agro-climatic zone of Telangana. According to Troll's climatic classification, it falls under semi-arid tropics (SAT). The experiment was laid out in Randomized Block Design with factorial concept and replicated thrice. There were two cultivars *viz*., V_1: MRC 7201 Bt and V_2: WGCV 48 non Bt three plant densities *viz*., P_1: 90 cm x 60 cm (18,518 plants ha^{-1}), P_2: 60 cm X 30 cm (55,555 plants ha^{-1}) and P_3: 45 cm x 15 cm (1, 48,148 plants ha^{-1}) and three nitrogen levels (N_1: 120 kg N ha^{-1}, N_2: 150 kg N ha^{-1} and N_3: 180 kg N ha^{-1}). Cotton crop was sown on July 8, 2015 and July 7, 2016 by dibbling seeds in opened holes with a hand hoe at depth of 4 to 5 cm. Thinning was completed after crop emergence to maintain uniform plant population according to the treatments. Nitrogen was applied as per the treatments (wherever it was required) in the form of urea (46 % N) in four equal splits (20, 40, 60 and 80 days after sowing) to Bt cotton cultivar (MRC 7201). Whereas, for non Bt cotton cultivar (WGCV 48), nitrogen was applied in three equal splits (30, 60 and 90 days after sowing). All other agronomic practices such as irrigation, weeding, plant protection measures and earthling up etc. were kept normal and uniform for all the treatments.Gross monetary returns (GMR) were calculated by multiplying the seed cotton yield and stalk yield with their respective prevailing market price (Perin *et al.*, 1979). Net returns were calculated by subtracting the cost of cultivation from gross returns for each treatment. Benefit cost ratio was calculated by dividing gross returns with cost of cultivation for each treatment.

The plant samples collected for drymatter estimation were utilized for chemical analysis. The dried samples were powdered (100 mesh) together and used for analysis.The total nitrogen content in the plant at square initiation, flowering and boll development and 1st picking were estimated by following micro-kjeldahl method (Piper, 1966).The nutrient uptake (g $plant^{-1}$) by crop at square initiation, flowering and boll development and 1st picking were worked out by multiplying the per cent nutrient content with dry matter of the respective treatments. Total N was calculated for each treatment separately by using the following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{\% of nutrient concentration x Dry matter (kg ha}^{-1}\text{)}}{100}$$

Uptake of N by cotton plant sample were expressed in kg ha^{-1}.

Data on different characters *viz*., growth and yield components and yield, nutrient uptake were subjected to analysis of variance procedures as outlined for Randomized Block Design, factorial concept (Gomez and Gomez, 1984). Statistical significance was tested by F–value at 0.05 level of probability and critical difference was worked out wherever the effects were significant.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Nitrogen uptake (kg ha^{-1}) :

Total nitrogen uptake by plant at square initiation, flower initiation, boll development and first picking stages as influenced by different cultivars, plant densities and nitrogen levels was analysed statistically and presented in Table 1.

In 2015 and 2016, maximum totalnitrogen uptake (kg ha^{-1}) as observed in MRC 7201 BGII cultivar at square initiation (7.1, 7.0 kg ha^{-1}), flower initiation (55.5, 34.5kg ha^{-1}), boll development (104.2, 112.5kg ha^{-1}) and first picking (161.3, 124.7kg ha^{-1}) and significantly superior to WGCV-48 cultivar at square initiation (6.0, 6.0 kg ha^{-1}), flower initiation (49.3, 28.2kg ha^{-1}), boll development (98.1, 93.8kg ha^{-1}) and first picking (135.3, 104.0kg ha^{-1}), respectively. The reduction in total nitrogen uptake for WGCV-48 cultivar was 16, 14 %; 11, 18 %; 6, 17 % and 16, 17 % over MRC 7201 BGII cultivar during 2015 and 2016, respectively at square initiation, flower initiation, boll development and first picking stages.MRC 7201 BGII cultivar exhibited better yield componentswhich might be due to higher uptake of nutrients by the crop.MRC 7201 BGII recorded significantly higher uptake of nitrogenwhen compared to non Bt WGCV-48cultivar. With the increase in the uptake of nutrients,growth components also increased and has led to the higherdry matter production per plant and its accumulation intodifferent plant parts particularly to the reproductive parts (Manjunatha *et al*., 2010).

Plant densities exerted a significant influence on total nitrogen uptake at square initiation, flower initiation, boll development and first picking stages.In 2015 and 2016, the highest nitrogen uptake was observed in P_3: 45 cm x 15 cm (1,48,148 plants ha^{-1}) at square initiation (13.5, 13.4 kg ha^{-1}), flower initiation (80.3, 46.4 kg ha^{-1}), boll development (146.0, 154.8 kg ha^{-1}) and first picking (190.5, 181.2 kg ha^{-1}) and significantly superior to P_2: 60 cm x 30 cm (55,555 plants ha^{-1}) and P_1: 90 cm x 60 cm (18,518 plants ha^{-1}) which recorded the lowest nitrogen uptake, at square initiation (2.0, 1.6 kg ha^{-1}), flower initiation (28.1, 15.5 kg ha^{-1}), boll development (53.0, 51.9 kg ha^{-1}) and first picking (27.2, 54.0 kg ha^{-1}) stages, respectively. Per cent increase in total nitrogen uptake at first picking stage for P_3 over P_2 and P_1 were 46, 41 % and 70, 70 % during 2015 and 2016, respectively. Nitrogen uptake efficiency increased with increase in planting density due to increasing population per unit area. Similar results were reported by Devraj *et al*. (2011) and Manjunatha *et al*. (2010).The nitrogen uptake was not influenced by the different levels of nitrogen during both the years of study at all the growth stages.Interaction effect of cultivars and plant densities, plant densities and nitrogen levels, nitrogen levels and cultivars, and cultivars, plant densities and nitrogen levels did not exert significant influence on nitrogen uptake at different stages of cotton crop during both the years of investigation.

Seed cotton yield (kg ha^{-1}) :

The highest seed cotton yield (3497 and 2866 kg ha^{-1}) was obtained with MRC 7201 BGIIcultivar (Table 2) and was significantly superior to WGCV-48 cultivar (2560 and 2078 kg ha^{-1}). The rate of increase in seedcotton yield with V_1 was 28 and 27 % during 2015and 2016 over V_2, respectively. Higher seed cotton yield was evidently due to cumulative effect of more number of bolls/plant and boll weight in Bt hybrid than non Bt.The better performance of MRC 7201 BGIIcultivar over WGCV-48 cultivar was ascribed to higher boll numbers plant^{-1} and heavier boll weight and the superior performance of Bt hybrids might be also due to inbuilt resistance to boll worms by Bt gene which in turn might have caused Bt hybrids to move in to reproductive phase early by curtailing vegetative growth and helped to produce higher seed cotton yield (Aruna, 2016).

Significantly higher seed cotton yield (3319 and 2726 kg ha^{-1}) was obtained in P_2: 60 cm x 30 cm (55,555 plants ha^{-1}) over P_3: 45 cm x15 cm (1,48,148 plants ha^{-1}) and P_1: 90 cm x60 cm (18,518 plants ha^{-1}), while P_3 (2954 and 2381 kg ha^{-1}) and P_1(2738 and 2309 kg ha^{-1}) are comparable and at par with each other. The per cent increase of seedcotton yield in $P_2$11, 13 % and 17,15 % during 2015 and 2016 over P_3 and P_1, respectively. The ultimate seed cotton yield is the manifestation of yield contributing characters. These yield attributing characters

Table 1 : Nitrogen uptake (kg ha^{-1}) of cotton at different growth stages as influenced by cultivars, plant densities and nitrogen levels

Treatments	Square initiation		Flower initiation		Boll development		1st picking	
	2015	2016	2015	2016	2015	2016	2015	2016
Factor 1 (Cultivars)								
V_1 (MRC 7201 BGII)	7.1	7.0	55.5	34.5	104.2	112.5	161.3	124.7
V_2 (WGCV-48)	6.0	6.0	49.3	28.2	98.1	93.8	135.3	104.0
S.E.±	0.21	0.32	1.94	1.75	2.06	5.39	5.94	5.10
C.D. (P=0.05)	0.60	0.91	5.56	5.03	5.93	15.48	17.07	14.66
Factor 2 (Plant densities)								
P_1 (90 cm x 60 cm)	2.0	1.6	28.1	15.5	53.0	51.9	57.2	54.0
P_2 (60 cm x 30 cm)	4.2	4.6	48.8	32.1	104.4	102.7	135.9	107.8
P_3 (45 cm x 15 cm)	13.5	13.4	80.3	46.4	146.0	154.8	190.5	181.2
S.E.±	0.26	0.39	2.37	2.14	2.53	6.60	7.27	6.25
C.D. (P=0.05)	0.74	1.11	6.82	6.16	7.26	18.96	20.91	17.95
Factor 3 (Nitrogen levels)								
N_1 (120 kg N ha^{-1})	6.2	6.2	50.2	31.2	96.8	93.5	143.0	112.1
N_2 (150 kg N ha^{-1})	6.7	6.5	52.3	31.8	102.1	102.4	146.9	115.1
N_3 (180 kg N ha^{-1})	6.8	7.0	54.8	31.0	104.5	113.5	155.0	115.8
S.E.±	0.26	0.39	2.37	2.14	2.53	6.60	7.27	6.25
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

NS=Non-significant

Table 2 : Seed cotton yield (kg ha^{-1}), gross returns, net returns and B:C ratio of cotton as influenced by cultivars, plant densities and nitrogen levels

Treatments	Seed cotton yield (kg ha^{-1})		Cost of cultivation (Rs. ha^{-1})		Gross returns (Rs. ha^{-1})		Net returns (Rs. ha^{-1})		B:C ratio	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Factor 1 (Cultivars)										
V_1 (MRC 7201 BGII)	3497	2866	49,170	49,114	1,36,396	1,14,629	87,226	65,514	2.9	2.5
V_2 (WGCV-48)	2510	2078	37,022	36,226	97,882	83,136	60,860	46,910	2.6	2.2
S.E.±	74	49	-	-	-	-	-	-	-	-
C.D. (P=0.05)	214	141	-	-	-	-	-	-	-	-
Factor 2 (Plant densities)										
P_1 (90 cm x 60 cm)	2738	2309	37,651	37,170	1,06,780	92,356	69,128	55,186	2.8	2.5
P_2 (60 cm x 30 cm)	3319	2726	41,281	40,837	1,29,427	1,09,045	88,146	68,208	3.1	2.7
P_3 (45 cm x 15 cm)	2954	2381	50,355	50,003	1,15,210	95,246	64,855	45,243	2.3	1.9
S.E.±	91	60	-	-	-	-	-	-	-	-
C.D. (P=0.05)	261	173	-	-	-	-	-	-	-	-
Factor 3 (Nitrogen levels)										
N_1 (120 kg N ha^{-1})	2946	2383	42,717	42,291	1,14,909	95,322	72,191	53,031	2.7	2.3
N_2 (150 kg N ha^{-1})	2962	2528	43,099	42,673	1,15,530	1,01,106	72,431	58,432	2.7	2.4
N_3 (180 kg N ha^{-1})	3102	2505	43,471	43,045	1,20,979	1,00,219	77,508	57,174	2.8	2.4
S.E.±	91	60	-	-	-	-	-	-	-	-
C.D. (P=0.05)	NS	NS	-	-	-	-	-	-	-	-

NS=Non-significant

were significantly affected by differentplant populations.Even though, the boll number, boll weight and seed cotton yield plant^{-1} were significantly higher with wider spacing, 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. Higher plant density at closer spacing recorded significantly higher seed cotton yield than lower plant density at wider spacing due to significantly more number of bolls m^{-2} and higher plant stand ha^{-1} (Kalaichelvi, 2008; Krishnaveni *et al.*, 2010; Manjunatha *et al.*, 2010 and Brar *et al*., 2013). The seed cotton yield was not influenced by the nitrogen levels during both the years of study. Reddy and Kumar (2010); Bhalerao and Gaikwad (2010) and Aruna (2016) also recorded insignificant influence of fertilizers on seed cotton yield.

Economics :

The economic indicators such as cost of cultivation (Rs. ha^{-1}), gross return (Rs. ha^{-1}), net return (Rs. ha^{-1}) and B: C ratio was worked out and these indicators were analyzed statistically and presented in the Table 2. Gross returns, net returns and B:C ratio decreased with WGCV-48 cultivar compared to MRC 7201 BGII cultivarin both the years of study as that of seed cotton yield. During 2015 and 2016, highest gross returns (1,36,396 and 1,14,629 Rs. ha^{-1}) and net returns (87,226 and 65,514 Rs. ha^{-1}) was recorded in MRC 7201 BGII cultivar followed by WGCV-48 cultivar. The highest B: C ratio (2.9 and 2.5) was obtained in MRC 7201 BGII cultivar followed by WGCV-48 cultivar (2.6 and 2.2). This is because of higher seed cotton yield and harvest index obtained with MRC 7201 BGII cultivar when compared with WGCV-48 cultivar. Similar results were reported by Manjunatha *et al*. (2010); Gangaiah *et al*. (2013) and Aruna (2016).

Gross returns, net returns and B:C ratio decreased consistently with decrease in plant density during both the years of study as that of seed cotton yield. In 2015 and 2016, the highest gross returns (1,29,427 and 1,09,045 Rs. ha^{-1}) were observed with P_2: 60 cm x30 cm (55,555 plants ha^{-1}) and was followed by P_3: 45 cm x 15 cm (1,48,148 plants ha^{-1}) and P_1: 90 cm x60 cm (18,518 plants ha^{-1}) while, highest net returns (88,146 and 68,208 Rs. ha^{-1}) were observed with P_2: 60 cm x30 cm (55,555 plants ha^{-1}) and followed by P_1: 90 cm x60 cm (18,518 plants ha^{-1}) and P_3: 45 cm x 15 cm (1,48,148 plants ha^{-1}). The highest B: C ratio (3.1 and 2.7) was observed with P_2followed by P_1 and P_3 in turn,P_3(2.3 and 1.9) obtained the lowest B:C ratio.

Effect of nitrogen levels did not exert any influence on gross returns, net returns and B: C ratio.Interaction effect of cultivars and plant densities, plant densities and nitrogen levels, nitrogen levels and cultivars, cultivars, plant densities and nitrogen levels did not exert any influence on gross returns, net returns and B:C ratio of cotton crop during both years of study.

Conclusion :

In conclusion, during 2015 and 2016, among the two cultivars (V_1: MRC 7201 BG II, V_2: WGCV-48), MRC 7201 BG II cultivar showed higher totalnitrogen uptake (kg ha^{-1}), seed cotton yield (kg ha^{-1}),gross returns, net returns and B:C ratioover V_2: WGCV-48 cultivar. Among the plant densities, the highest nitrogen uptake was observed in P_3: 45 cm x 15 cm (1,48,148 plants ha^{-1}) and P_2: 60 cm x30 cm (55,555 plants ha^{-1}) was recorded higher gross returns, net returns and B:C ratio. Nitrogen levels did not show any significant influence.

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