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Response of Bt cotton to crop geometry and nutrient management under dryland conditions

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Abstract
A field experiment was conducted during 2014-15, 2015-16 and 2016-17 at All India Co-ordinated Research Project for Dryland Agriculture, Vijayapur to study the response of Bt cotton to crop geometry and nutrient management under dryland conditions. The results of three years indicated that growing of Bt. Cotton at 120 cm x 45 cm gave significantly higher kapas yield of 1331 kg ha^{-1} as compared to rest of the crop geometry. Application of 60:30:60 kg N, P_2O_5 and K_2O per ha produced significantly higher kapas yield of 1232 kg ha^{-1} as compared to application of 30:15:15 kg N, P_2O_5 and K_2O per ha (1154 kg ha^{-1}). Interaction effect was also significant. Crop geometry of 120 cm x 45 cm with application of 60:30:60 kg N, P_2O_5 and K_2O per ha produced significantly higher kapas yield of 1433 kg ha^{-1} as compared to rest of the treatments. Similar trend was observed with respect to gross and net returns.

Keywords: Bt cotton, crop geometry, nutrient management, *Gossypium hirsutum* L.

Introduction

Cotton (*Gossypium hirsutum* L.) is an important fibre crop of India and cotton is often called as white gold. Commercial crop extensively grown in India and Karnataka and it is backbone of textile industries mainly because of its lint. India is the only country which cultivates all the four species of cotton with first position in area and second position in production covering the 15 per cent of the global production in three distinct agro-ecological regions *viz.*, irrigated north zone (15.9 per cent of the total cotton cultivated area and 18.5 per cent of the total cotton production). Rainfed central zone (67.7 per cent of total cotton cultivated area and < 60 per cent of total cotton production). Average productivity of cotton in India is 503 kg lint per ha, which is low when compared to the world average of 725 kg lint per ha (Anonymous, 2016) [1]. In Karnataka, cotton occupies an area of 6.12 lakh ha with a production of 18.9 lakh bales of seed cotton with a productivity of 556 kg lint per ha (Anonymous, 2016) [1].

Desi cotton is going out of cultivation due to the low yield in dryland conditions. Many farmers are growing Bt cotton in drylands, they are getting around 10 to 12 q of kapas yield per ha under dryland conditions. They are also expressing that it is profitable. They do not follow any particular crop geometry and application of fertilizer to the crop. There is no recommendation of proper spacing for Bt cotton production under dryland conditions. Supply of nutrients is the major limiting factor in cotton production and the soil in rainfed areas is not only thirsty but also hungry. It is well established fact that sufficient quantity of nutrients at proper time are needed for achieving high yield. The nutrient management in cotton is a complex phenomenon due to simultaneous production of vegetative and reproductive structures during the active growth phase. Cotton plant being a heavy feeder require adequate supply of nutrients to optimize the seed cotton yield, quality and net profit in cotton production (Aladakatti *et al.*, 2011) [2]. Improper crop geometry affect the cotton production, under the close spacing it creates the competition between the plants for nutrients, moisture and water. Higher spacing creates the low plant population so need to optimize the crop geometry for higher production of Bt. cotton in dryland area.

Material and Methods

A field experiment was conducted during 2014-15, 2015-16 and 2016-17 at All India Co-ordinated Research Project for Dryland Agriculture, Vijayapura (Karnataka). The experiment was laid out in Split plot design with four main plots and four sub-plots.

The studies included four Crop geometry as main plot (M_1: 90 cm x 45 cm, M_2: 90 cm x 60 cm, M_3: 120 cm x 45 cm and M_4: 120 cm x 60 cm) and four Nutrient Managements as sub plot (S_1: 30:15:15 kg ha^{-1} NPK, S_2: 45:22.5:22.5 kg ha^{-1} NPK, S_3: 60:30:30 kg ha^{-1} NPK and S_4: 75:37.5:37.5 kg ha^{-1} NPK). Bt cotton variety Ajeet-155 was selected for the study with seed rate of 2.5 kg ha^{-1}. The soil of the experimental site is clay in texture with available nitrogen (179 kg/ha), phosphorus (21 kg ha^{-1}), potassium (361 kg ha^{-1}), organic carbon content (0.42), soil pH (8.4) and sowing was done by dibbling.

Weeds were controlled through one hoeing at 30 days after sowing and one manual weeding. The recommended rate of fertilizers was applied for Cotton at sowing as per the respective treatments. The remaining cultivation practices were followed as per the package of practice of UAS, Dharwad. Five randomly selected plants from 20 sites in each treatment were harvested. Standard procedures were used to measure the yield attributes and yield parameters of Cotton. Variables were analyzed and split plot design test was carried out for analyzed mean square errors using Web Based Agricultural Statistics software Package (WASP 2.0). Significance and non-significance difference between treatments was derived through procedure provides for split plot design. Correlation studies among the yield components of Cotton was done using XLSTAT package.

Results and Discussion

Effect of crop geometry

In this study, crop geometry significantly influenced the kapas yield over three years. Among the different geometry, 120cm x 45cm gave significantly higher kapas yield of 1331 kg ha^{-1} than other crop geometry 120cm x 60cm (1246 kg ha^{-1}), 90cm x 60 cm (1137 kg ha^{-1}) and 90cm x 45cm (1066 kg ha^{-1}). Increase in kapas yield might be due to less competition for light, nutrient and moisture under 120 cm x 45 cm compared to closer spacing (90cm x 45cm and 90cm x 60cm) which resulted into better growth and more translocation of photosynthesis towards sink. Less number of plants per ha under 120cm x60cm over 120cm x 45cm resulted in lower kapas yield.Similar results were also reported by Ogola *et al*., (2006) [12]. Singh *et al*., (2007) [14], Reddy and Gopinath (2008) [13] and Kumar *et al*., (2010) [10].

For any new production technology most important thing as farmer's point of view is economics of technology. In the present investigation among different crop geometry, 120cm x 45 cm crop geometry resulted in significantly higher gross and net returns (67208 Rs ha^{-1} and 41314 Rs ha^{-1}, respectively) as compared to 120 cm x 60 cm (62641 Rs ha^{-1} and 36410 Rs ha^{-1}, respectively), 90cm x 45cm (53825 Rs ha^{-1} and Rs. 28195 Rs ha^{-1}, respectively), 90 cm x 60 cm (53825 Rs ha^{-1} and 28195 Rs ha^{-1}, respectively). Higher gross and net returns is due to higher yield and yield parameters. The results are in conformity with the study of Singh *et al*. (2007) [14] and Waghmare *et al*. (2018) [15].

Effect of different nutrient management

Nutrient is one of the most important growth and yield limiting factor. Among the different nutrients, management of macronutrients like Nitrogen, Phosphorus and Potassium is very important for achieving higher productivity of cotton under dry land condition because most of the soil in dryland areas is not only thirsty but also hungry and cotton is heavy feeder of nutrients. In this investigation, nutrient levels differ significantly with respect to kapas yield. Application of 60:30:60 kg NPK per ha produced significantly higher kapas yield of 1232 kg ha^{-1} than application of 30:15:15 kg NPK per ha (1154 kg ha^{-1}) and application of 45:22.5:22.5 kg NPK per ha (1181 kg ha^{-1}), but it was on par with the 75:37.5:37.5 kg NPK per ha (1213 kg ha^{-1}). Increase in yield may be attributed to higher number of bolls per plant and boll weight per plant. These results are in accordance with the findings of Kumbhar *et al*. (2008) [9], Ayissaa and Kebedeb (2011) [3], Giri *et al* (2008) [5] and Katore *et al*. (2005) [8].

Gross and net returns were also significantly influenced by different nutrient levels. Among different levels, aapplication of 60:30:60 kg NPK per ha recorded higher gross and net returns (62199 Rs ha^{-1} and 35935 Rs ha^{-1}, respectively) as compared to application of 30:15:15 kg NPK per ha (58299 Rs ha^{-1} and 33444 Rs ha^{-1}), 45:22.5:22.5 kg NPK per ha (57419 Rs ha^{-1} and 34060 Rs ha^{-1}, respectively) and 75:37.5:37.5 kg per ha (60974 Rs ha^{-1} and 34005 Rs ha^{-1}, respectively). But, gross returns were on par with the application of 75:37.5:37.5 kg NPK per ha (60974 Rs ha^{-1}).

Effect of crop geometry and different nutrient management

Interaction of crop geometry and different nutrient levels was significant. Crop geometry of 120 cm x 45 cm with application of 60:30:60 kg NPK per ha produced significantly higher kapas yield, gross and net returns (1433 kg ha^{-1}, 70037 Rs ha^{-1} and 46115 Rs ha^{-1}, respectively) than other interactions. Similar results were also reported by Hussain *et al*. (2000) [7], Hoogar and Gidnavar, (1997) [6], Clawson *et al*. (2006) [4], Giri *et al*. (2008) [5] and Munir *et al*. (2015) [11].

Table 1: Kapas yield kg ha^{-1}as influenced by crop geometry and nutrient management

Treatments	2014-15	2015-16	2016-17	Pooled
Crop geometry				
90 cm x 45 cm	1007	624	1567	1066
90 cm x 60 cm	1171	633	1607	1137
120 cm x 45 cm	1544	764	1684	1331
120 cm x 60 cm	1337	770	1632	1246
S.Em ±	9	18	17	15
CD (0.05%)	32	62	52	48
Nutrient Management ($N:P_2O_5$: K_2O kg ha^{-1})				
30:15:15	1161	748	1554	1154
45:22.5:22.5	1215	711	1617	1181
60:30:30	1382	682	1633	1232
75:37.5:37.5	1319	669	1652	1213
S.Em ±	11	15	17	15
CD (0.05%)	33	44	42	40

Table 2: Interaction effect of crop geometry and nutrient management on kapas yield (Pooled)

Crop geometry	Nutrient management (N, P_2O_5 and K_2O kg ha^{-1})				
	30:15:15	45:22.5:22.5	60:30:30	75:37.5:37.5	Mean
90 cm x 45 cm	1015	1090	1041	1114	1066
90 cm x 60 cm	1090	1109	1204	1145	1137
120 cm x 45 cm	1295	1300	1433	1295	1331
120 cm x 60 cm	1214	1223	1249	1298	1246
Mean	1154	1181	1232	1213	--

For comparing the means of	S.Em±	CD (0.05)
1. Crop geometry (CG)	15	48
2. Nutrient management (NM)	15	40
3. NM at the same level of CG	29	81
4. CG at the same/different levels of NM	29	84

Table 3: Gross returns (Rs ha^{-1}) as influenced by crop geometry and nutrient management

Treatments	2014-15	2015-16	2016-17	Pooled
Crop geometry				
90 cm x 45 cm	50841	31527	79107	53825
90 cm x 60 cm	59131	31971	81153	57419
120 cm x 45 cm	77961	38611	85050	67208
120 cm x 60 cm	67509	38870	81543	62641
S.Em ±	469	902	789	743
CD (0.05%)	1445	2779	2431	2289
Nutrient Management($N:P_2O_5$: K_2O kg ha^{-1})				
30:15:15	58634	37781	78482	58299
45:22.5:22.5	61342	35923	81598	59621
60:30:30	67031	34428	85138	62199
75:37.5:37.5	68434	32848	81640	60974
S.Em ±	573	763	575	643
CD (0.05%)	1589	2114	1593	1783

Table 4: Interaction effect of crop geometry and nutrient management on gross returns (Pooled)

Crop geometry	Nutrient management (N, P_2O_5 and K_2O kg ha^{-1})				
	30:15:15	45:22.5:22.5	60:30:30	75:37.5:37.5	Mean
90 cm x 45 cm	51417	55025	52580	56279	53825
90 cm x 60 cm	55061	56022	60790	57802	57419
120 cm x 45 cm	67011	66380	70037	65403	67208
120 cm x 60 cm	61322	61763	63065	64413	62641
Mean	58299	59621	62199	60974	--

For comparing the means of	S.Em±	CD (0.05)
1. Crop geometry (CG)	743	2289
2. Nutrient management (NM)	643	1783
3. NM at the same level of CG	1287	3566
4. CG at the same/different levels of NM	1339	3839

Table 5: Net returns (Rs ha^{-1}) as influenced by crop geometry and nutrient management

Treatments	2014-15	2015-16	2016-17	pooled
Crop geometry				
90 cm x 45 cm	25210	5897	53477	28195
90 cm x 60 cm	33237	6078	55260	31525
120 cm x 45 cm	52068	12718	59157	41314
120 cm x 60 cm	41278	12638	55312	36410
S.Em ±	469	902	789	743
CD (0.05%)	1445	2779	2431	2289
Nutrient Management ($N:P_2O_5$: K_2O kg/ha)				
30:15:15	33779	12927	53626	33444
45:22.5:22.5	35781	10362	56037	34060
60:30:30	40767	8163	58875	35935
75:37.5:37.5	41464	5879	54671	34005
S.Em ±	573	763	575	643
CD (0.05%)	1589	2114	1594	1646

Table 6: Interaction effect of crop geometry and nutrient management on net returns (Pooled)

Crop geometry	Nutrient management (N,P_2O_5 and K_2O kg ha^{-1})				
	30:15:15	45:22.5:22.5	60:30:30	75:37.5:37.5	Mean
90 cm x 45 cm	26844	29746	26598	29591	28195
90 cm x 60 cm	30225	30480	34545	30851	31525
120 cm x 45 cm	40559	40131	46115	38452	41314
120 cm x 60 cm	36149	35884	36480	37125	36410
Mean	33444	34060	35935	34005	--

For comparing the means of	S.Em±	CD (0.05)
1. Crop geometry (CG)	743	2289
2. Nutrient management (NM)	643	1783
3. NM at the same level of CG	1287	3566
4. CG at the same/different levels of NM	1339	3839

Conclusions

Based on three year results, it may be summarized that nutrient levels differ significantly with respect to kapas yield. Application of 60:30:60 kg NPK per ha produced significantly higher kapas yield of 1232 kg ha^{-1} than application of 30:15:15 kg NPK per ha (1154 kg ha^{-1}) and application of 45:22.5:22.5 kg NPK per ha (1181 kg ha^{-1}). Interaction of crop geometry and different nutrient levels was significant. Crop geometry of 120 cm x 45 cm with application of 60:30:60 kg NPK per ha produced significantly higher kapas yield, gross and net returns (1433 kg ha^{-1}, 70037 Rs ha^{-1} and 46115 Rs ha^{-1}, respectively) as compared to other treatments. Therefore, it is concluded that crop geometry of 120 cm x 45 cm with application of 60:30:60 kg NPK per ha was found suitable for northern dry zone of Karnataka under rainfed condition.

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