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Effect of plant spacing, growth regulator and nutrient management on yield, quality and economics of *Bt* cotton

S.G. JADHAV*., D.A. CHAVAN, AND Y.M.WAGHMARE
Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani – 431402
**E-mail : sharadjadhav_2994@rediffmail.com*

ABSTRACT : The experiment was laid out in split plot design with 4 plant spacings that is (90 x 60 cm, 120 x 45 cm, 150 x 36 cm and 180 x 30 cm) 2 growth regulator G_1 (Control) and G_2 (NAA and GA_3) and 3 fertilizer levels (100 : 50 : 50, 150 : 75 : 75 and 200 : 100 : 100 NPK kg/ha). Plant spacing 150 x 36 cm with the application of growth regulator NAA and GA_3 (G_2) and higher level of fertilizer *i.e.* 200:100:100 NPK kg/ha recorded significantly more seed cotton yield, ginning per cent , gross monetary returns, net monetary return and benefit : cost ratio during both the years of experiment.

Key words : *Bt* cotton, ginning per cent, growth regulator, plant spacing

Cotton, as is called as "White Gold", is a premier cash crop of most the countries with an enormous potential in sustaining employment generation (both in rural and urban sector). Textile industry is the backbone of industrial economy of India and cotton is the basic raw material of the industry. The industry provides direct employment for nearly 9 lakh workers with indirect employment for several millions. The nutrient supply is the second most important limiting factor in cotton production only after irrigation. It is well established fact that adequate quantities of nutrients are needed for achieving high yields. The nutrient management in cotton is complex phenomenon due to simultaneous production of vegetative and reproductive structure during the active growth phase. Cotton plant being heavy feeder needs proper phosphorus while potassium in deficient soil. Hence, adequate supply of fertilizers and manures is essential to sustain high yields which was reflected in many research investigation carried out by previous scientists. (Raut *et al.*,2005 and Katore *et al.*,2008)

Growth regulating substances are obviously have been used owing to their beneficial effects on growth and maturity of plant and also they influenced the cell division, cell elongation extension. The reason for low yield is mainly due to non adoption of precise location specific production packages. Among various production factors, spacing and fertilization beside climate plays a very significant role. The yield and other yield attributing parameters of cotton vary with the plant densities (Kaur *et al.*, 2010). In cotton growing areas, imbalanced fertilization of cotton crop also affects the vegetative and reproductive growth, thereby causing low productivity. Balanced fertilization is one of the major key factors for enhancing the cotton yields.

Plant population is one of the most important factor for efficient utilization of available sources. There must be optimization of plant population for increase in productions. The determination of optimum plant spacing with fertilizer dose for *Bt* cotton is necessary for maximum utilization of various resources like light, soil moisture and CO_2 to augment crop yield. Efficient cotton production packages from the modern agronomy of cotton explore the avenues for realizing the potential crop yields. Looking towards increase in area of *Bt* cotton, it was felt necessary to conduct experiment to know the effect of plant spacing, growth regulator and nutrient management on yield, quality and economics of *Bt* cotton.

MATERIALS AND METHODS

The field experiment was conducted at the Research Farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif*, 2010-2011 and 2011-2012. The soil of the experimental field was clayey in texture, slightly alkaline in reaction (pH 8.10), medium in organic carbon (0.50 %), low in available nitrogen (162.72 kg/ha) and phosphorus (11.78 kg/ha) and rich in available potash (489 kg/ha). The experiment was laid out in split plot design with 3 replications. consisted of 24 treatment combinations comprising of plant spacings (S_1: 90 x 60 cm, S_2: 120 x 45 cm, S_3: 150 x 36 cm and S_4: 180 x 30 cm) in main plot treatments, two growth regulators (G_1: control and G_2: NAA and GA_3 (@100 ppm at 60 and 75 DAS, respectively) treatment in sub plot treatment and 3 fertilizer levels (F_1: 100 : 50 : 50 NPK kg / ha, F_2:150 : 75 : 75 NPK kg ha/ ha, F_3: 200 : 100 : 100 NPK kg ha/ha) in sub sub plot treatments. Seed of cotton hybrid Bunny *Bt* (NCS 145 *Bt*) was selected for experimental purpose. The cotton was sown by dibbling with 2 seeds/ hill on 16.06.2010 and 24.05.2011 during 2010-2011 and 2011-2012, respectively under irrigated conditions. The growth regulator napthaleneacetic acid and gibberlic acid was spread @100 ppm at 60 and 75 days after sowing, respectively.

The fertilizers were applied as per treatments. Half dose of nitrogen and full dose of phosphorus and potash were applied as basal application at the time of sowing. Top dressing of remaining half dose of nitrogen was given after 30 and 60 days after sowing through urea. The sources of nutrients were urea (46% N), Diammonium phosphate (18% N, 46% P_2O_5) and Muriate of potash (60 % K_2O). All other recommended agronomic practices were followed uniformly. Crop received the rainfall of 1152 mm in 60 rainy days during 2010-2011 and 685 mm in 50 rainy days during 2011-2012.

RESULTS AND DISCUSION

Effect of plant spacing: Data presented in Table 1 indicated that the seed cotton yield (q/ha) was influenced significantly due to different plant spacings during both the years. Seed cotton yield is the ultimate product and photosynthetes produced in the leaves. Among the different plant spacings, plant spacing of 150 x 36 cm produced the highest seed cotton yield (36.36 q/ha) during pooled data analysis. It was significantly superior over plant spacings 90 x 60 cm, 120 x 45, 180 x 30 cm . Differences were *at par* between the treatments of plant spacings of 120 x 45 and 90 x 60 cm during both the years and in pooled analysis. Plant spaced at 150 x 36 cm had produced more biomass at all growth stages because of better light penetration and higher uptake of major nutrients favoured for increasing photosynthetic efficiency and seed cotton yield. The results are in conformity with those obtained earlier by Raut *et al.,* (2005), Singh *et al.,* (2007), Srinivasulu *et al.,* (2007) and Satyanarayana Rao and Setty (2008)

Perusal of data in Table 1 revealed that the ginning percentage was influenced significantly during 2010-2011. Plant spacing of 150 x 36 cm recorded significantly more ginning percentage as compared to other plant spacing during 2010-20111. It was found that ginning percentage was not influenced significantly during 2011-2012.

The gross monetary returns (152180, 153330, 152760 Rs / ha), net monetary returns (103740, 104390, 104060 Rs / ha) and benefit cost ratio (3.13, 3.12 and 3.12 Rs / ha) were significantly higher in plant spacing of 150 x 36 cm compared to other plant spacings during 2010-2011 and 2011-2012 and in pooled analysis, respectively.

Effect of growth regulator : The data in Table 1 revealed that seed cotton yield (q/ha) was influenced significantly due to growth regulator

Table 1. Yield and ginning per cent of *Bt* cotton as influenced by different treatments

Treatments	Seed cotton yield (q/ha)			Ginning (%)		
	2010-2011	2011-2012	**Mean**	2010-2011	2011-2012	**Mean**
Plant spacings (cm)						
S_1 90 x 60	33.05	33.76	**33.40**	33.77	34.44	**34.10**
S_2 120 x 45	34.36	34.11	**34.23**	33.58	34.48	**34.03**
S_3 150 x 36	36.23	36.51	**36.36**	35.23	35.94	**35.58**
S_4 180 x 30	31.26	31.69	**31.11**	33.45	35.12	**34.28**
S.E. +	0.48	0.57	**0.52**	0.64	0.70	-
C.D. (p=0.05)	1.67	1.97	**1.82**	2.22	NS	-
Growth regulator						
G_1 Control	32.34	32.50	**32.42**	33.55	34.22	**33.88**
G_2 NAA and GA_3	35.11	35.53	**35.18**	34.46	35.26	**34.86**
S.E. +	0.36	0.65	**0.50**	0.25	0.22	-
C.D. (p=0.05)	1.18	2.11	**1.64**	0.80	0.70	-
Fertilizer level (NPK Kg/ha)						
F_1 100:50:50	32.71	32.40	**32.34**	33.43	34.10	**33.76**
F_2 150:75:75	33.51	34.00	**33.75**	34.09	34.82	**34.45**
F_3 200:100:100	34.96	35.65	**35.30**	34.50	35.32	**34.91**
S.E. +	0.35	0.51	**0.43**	0.35	0.35	-
C.D. (p=0.05)	1.01	1.48	**1.24**	NS	NS	-
G x F						
S.E. +	0.50	0.72	**0.61**	0.49	0.48	-
C.D. (p=0.05)	1.43	2.09	**1.76**	NS	NS	-
General Mean	**33.73**	**34.02**	**33.78**	**34.01**	**34.74**	**34.37**

treatment during both the years and in pooled data. Growth regulator treatment G_2 (NAA and GA_3) produced higher seed cotton yield of 35.11, 35.53 and 35.18 q/ha during 2010-2011, 2011-2012 and pooled data, respectively and was found significantly superior to treatment G_1 (controlled). The increased seed cotton yield (q/ha) might be due to better fruiting efficiency, vegetative growth, maximum retention of squares/plant and bigger boll size which ultimately reflected in higher seed cotton yield (q/ha) in growth regulator treatment G_2 (NAA and GA_3).

Perusal of data in Table 1 revealed that the ginning percentage was influenced significantly due to different growth regulator treatment. Growth regulator treatment G_2 (NAA and GA_3) recorded significantly higher values of ginning (%), seed index and lint index compared with controlled treatment during both the years. This might be due to more cell elongation and bigger boll size due to the application of growth regulator GA_3.

The trend of increased seed cotton yield (q/ha) in growth regulator treatment G_2 (NAA and GA_3) was also observed in gross monetary returns (Rs. 147470, Rs. 149120 and Rs. 148300), Net monetary returns (Rs. 98862, Rs. 100001 and Rs. Rs. 99436) and benefit cost ratio (3.01, 3.03 and 3.02) which were significantly higher in growth regulator treatment G_2 (NAA and GA_3) during 2010-2011 and 2011-2012 and in pooled data, respectively. From the results it may be concluded that the growth regulator treatment G_2 (NAA and GA_3) was economically more remunerative than its counter part treatment G_1 (control) (Table 2).

Effect of fertilizer levels : Data presented in Table 1 observed that every higher level of fertilizer application resulted in significant increase in seed cotton yield over its lower level during both the years and in pooled data also. It may be due to increased availability of nutrients which helped the plant to attain its maximum yield potential. Balanced NPK application encouraged the plant growth which resulted in synthesis of more photosynthates,

Table 2. Economics of *Bt* cotton as influenced by different treatments

Treatment	Gross Return (Rs/ha)			Net Return (Rs/ha)			B:C Ratio		
	2010-2011	2011-2012	**Mean**	2010-2011	2011-2012	**Mean**	2010-2011	2011-2012	**Mean**
Plant spacings (cm)									
S_1 90 x 60	138800	141780	**140290**	91053	93591	**92322**	2.90	2.93	**2.91**
S_2 120 x 45	144330	143260	**143795**	96387	94778	**95582**	2.96	2.94	**2.95**
S_3 150 x 36	152180	153330	**152755**	103740	104390	**10406**	3.13	3.12	**3.12**
S_4 180 x 30	131300	132730	**132015**	83857	84785	**84321**	2.75	2.76	**2.75**
S.E. +	2099	3264	-	2085	3261	-	0.041	0.041	0.041
C.D. (p=0.05)	6357	9886	-	6317	9878	-	0.12	0.12	0.12
Growth regulator									
G_1 Control	135840	136440	**136140**	88656	88756	**88706**	2.86	2.85	**2.85**
G_2 NAA and GA_3	147470	149120	**148295**	98862	100001	**99431**	3.01	3.03	**3.02**
S.E. +	1484	2308	-	14785	2306	-	0.029	0.029	0.029
C.D. (p=0.05)	4495	6991	-	4467	6985	-	0.089	0.087	0.088
Fertilizer level (NPK Kg/ha)									
F_1 100:50:50	137380	135960	**136670**	90952	89001	**89976**	2.84	2.81	**2.91**
F_2 150:75:75	140730	142640	**141685**	92830	94264	**93547**	2.93	2.94	**2.93**
F_3 200:100:100	146850	149720	**148285**	97494	99890	**98692**	3.04	3.07	**2.96**
S.E. +	1477	2136	-	1476	2136	-	0.031	0.047	0.039
C.D. (p=0.05)	4089	5912	-	4085	59163	-	0.087	0.13	0.12
Interaction									
G x F									
S.E. +	2089	3021	-	2088	3021	-	0.044	0.045	0.044
C.D. (p=0.05)	5782	8361	-	5777	8361	-	0.12	0.14	0.13
General mean	**141655**	**142780**	**142217**	**93729**	**94383**	**94056**	**2.93**	**2.94**	**2.93**

sufficient to meet the need of plant more efficiently. Application of fertilizer level 200 : 100 : 100 NPK kg / ha recorded the more functional leaves and greater leaf area/plant which produced more photosynthates and it has reflected in higher seed cotton yield during both the years of experimentation. The yield contributing characters also showed an ascending trend with the increase in dose of fertilizers.

The data in Table 1 revealed that the ginning percentage was not influenced significantly due to different levels of fertilizer. However, numerically ginning percentage (34.50) was observed in fertilizer level F_3 200:100:100 NPK kg/ha during both the years.

The gross monetary returns, net monetary returns and benefit cost ratio influenced significantly due to various fertilizer levels during both the years and in pooled analysis. Application of 200 : 100 : 100 NPK kg/ ha obtained maximum benefit cost ratio during both the years and in pooled analysis.

Interaction : Seed cotton yield (q/ha) was influenced significantly during both the years and pooled analysis (Table 3) .The interaction between growth regulator treatments G_2 (NAA and GA_3) with fertilizer level F_3 200 : 100 : 100 NPK

Table 3. Seed cotton yield (q/ha) as influenced by G x F interaction during pooled analysis

Growth regulators	Fertilizer levels		
	F_1	F_2	F_3
G_1	30.78	32.12	34.72
G_2	34.33	35.39	36.24
SE +	0.61		
C.D. (p=0.05)	1.76		

Table 4. Benefit cost ratio as influenced by G x F interaction in pooled analysis

Growth regulators	Pooled Fertilizer levels		
	F_1	F_2	F_3
G_1	2.76	2.83	2.96
G_2	2.88	3.03	3.14
SE +	0.044		
C.D. (p=0.05)	0.13		

kg/ha which was significantly superior over rest of the treatment combination but was found *at par* with treatment of combination G_2 x F_2 during both the years in pooled analysis. Ginning percentage was not influenced significantly due to interactions of plant spacings, growth regulators and fertilizer levels during both the years.

The gross monetary returns, net monetary returns and benefit cost ratio was influenced by growth regulator with fertilizer levels (Table 4). Interaction between growth regulator treatment G_2 (NAA and GA_3) with fertilizer level F_3(200 : 100 : 100 NPK kg/ha) recorded higher values of gross monetary returns, net monetary returns and benefit cost ratio than other treatment combinations during both the years and pooled data.

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