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Morpho-Physiological parameters and fiber qualities of *Bt* cotton hybrids as influenced by foliar application of plant growth regulators and macronutrients

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ABSTRACT

A field experiment was conducted at Agricultural College Farm, Bapatla, during *Kharif* 2013-14 and 2014-15 to study the influence of plant growth regulators and nutrients on growth parameters and quality of *Bt* cotton. Significant differences were observed among the parameters studied during two years. Morphological parameters of cotton such as plant height, and physiological parameters *viz.*, leaf area, and total dry matter production at various stages of crop growth were greatly influenced by foliar application of NPK with NAA@ 30 ppm and GA_3@ 30 ppm. The fiber quality parameters (Ginning percentage, Span length 2.5 %, Bundle strength and Micronaire value) were significantly influenced by the use of nutrients and growth regulators. Spraying of GA_3 @30ppm in combination with KNO_3 @ 2 % recorded highest ginning percentage (37.74 and 38.39 %) , higher 2.5 % span length values (35.08 and 35.84 mm) in 2013 and 2014 respectively. GA_3 @ 30ppm in combination with urea @2%+ DAP @ 2%+ KNO_3 @ 2% (T_{14}) recorded highest mean bundle strength (25.41 g/tex) in 2013 and GA_3@30ppm in combination with KNO_3@ 2% recorded highest mean bundle strength (25.56 g/tex) 2014 .Higher seed cotton yield of 2470 kg ha^{-1} in 2013 and 2916.7 kg ha^{-1} in 2014 was obtained in cotton receiving GA_3 @ 30ppm in combination with KNO_3 @ 2 % (T_{13}).

Key words : *Bt Cotton hybrids, Growth regulators, Growth, Macro nutrients, quality and yield*

Cotton, the "white gold or the king of fibres" is one of the most important cash and commercial crop in India and in the world. India is the second largest producer of cotton in the world next to China. Among various production constraints, unbalanced and inadequate nutrition to cotton crop is considered to be one of the important factors. The transgenic cotton cultivars have a higher nutrient demand during the boll filling period (between flowering and maturity) due to their higher boll retention rate and larger boll load at early growth stage because of better insect control over non *Bt* counterparts. During flowering and boll maturity stages nutrients are translocated from leaves to bolls.

One of the important physiological disorders which reduce the seed cotton yield is boll shedding. To get maximum yield in cotton, it is essential to retain more bolls per plant. Hence, improved package of technologies are absolutely necessary to sustain productivity of *Bt* cotton, which is occupied by 90% of area in India. To overcome yield barriers and to increase the productivity, an attempt was made to study the present investigation on Morpho-Physiological parameters and fiber qualities of *Bt* cotton hybrids as influenced by foliar application of plant growth regulators and macronutrients.

MATERIAL AND METODS

The experiment was conducted at Agricultural College Farm, Bapatla during *Kharif* 2013-14 and 2014-15 to study the influence of plant growth regulators (NAA and GA_3) and nutrients (Urea @ 2 %, DAP @ 2%, KNO_3 @ 2%) on *Bt* cotton for enhancing the productivity. The experiment was conducted in field No. 23 of Northern block , Agricultural College Farm, Bapatla located 15° 54' N latitude and 80°30' E longitude at an altitude of 5.49 meters above the mean sea level . The mean maximum and minimum temperatures of 32.6 ^{0}C and 22.6 ^{0}C during 2013, and 28.7 ^{0}C and 23.3 ^{0}C during 2014, respectively, recorded during cropping period, and relative humidity 84.6 per cent and 76.9 per cent, during 2013 and 2014, respectively. The soil of experimental site was clay loam in texture, slightly alkaline in reaction, medium in organic carbon, low in available nitrogen, medium in available phosphorus and high in available potassium. All the micronutrients were sufficient in the soil with values above their critical limits. The experiment was laid out in Split plot design with three replications. The treatments were plant growth regulatorS (NAA@ 30 ppm and GA_3 @ 30 ppm) and foliar nutrition Urea @ 2 %, DAP @ 2%, KNO_3 @ 2 % were sprayed alone and in combinations at peak squaring, peak flowering, peak boll formation and peak boll developmental stages. The seeds were sown adopting a spacing of 105 x 60 cm and recommended dose of N, P, and K 150-60-60 kg N, P_2O_5, K_2O ha^{-1} was applied uniformly to all the plots. Full dose of P and K were applied as basal at the time of sowing. The N was applied in split application *i.e.,* 50 % N at the time of sowing, 25 % applied at earthing up and other 25 % at 45 days after sowing. Plant protection measures were taken as and when necessary. Observations on plant growth, yield and quality parameters were recorded. Soil and plant samples were analyzed as per the procedures.

RESULTS AND DISCUSSION

Growth parameters

The data on different growth parameters were presented in Table 1. Among the tested cotton hybrids, Bhaskara recorded significantly higher plant height, leaf area and total dry matter production compared to Bunny BGII during both the years of study. Spraying of GA_3 @ 30 ppm+ urea @ 2%+ DAP @ 2%+ KNO_3 @ 2% recorded highest mean plant height of 142.87 cm in 2013 and 146.75 cm in 2014 compared to other foliar treatments and control. GA_3 treated plants might have consequently increased GA_3 biosynthesis which has a role in cell division and expansion and hence internodal elongation was observed . Gillani *et al.*(2015) reported that plant height was effected significantly by the application of growth regulators (NAA @ 1%) and nutrients (N,P and K).

Among the cotton hybrids, there was 10.89 and 10.41 percent increase leaf area in Bhasakara hybrid than Bunny BG II in 2013 and 2014 respectively at 105 DAS. Spraying of GA @30ppm in combination with DAP @ 2 % recorded higher leaf area (10384 and 10750 cm^2 $plant^{-1}$) in 2013 and 2014 respectively at 105 DAS. Total dry matter production and supply of required photosynthates for the developing bolls largely depends on leaf area. These results are in agreement with the findings of Gillani *et al.* (2015), Saravanan *et al*. (2013)

Spraying of plant nutrients and plant growth regulators significantly increased the total dry matter of two hybrids during both the years *i.e* 2013 and 2014. Among the tested cotton hybrids, Bhaskara recorded significantly higher total dry matter (600.3, 606.25 g $plant^{-1}$) compared to Bunny BGII (503.91, 514.27 g $plant^{-1}$) in 2013 and 2014 respectively . Spraying of GA_3 @ 30ppm alone and in combination with urea @2%, DAP@2%, KNO_3@2% recorded higher mean total dry matter per plant in both the years. However, spraying of GA@30ppm in combination with urea @2%+ DAP@2%+ KNO_3@2% recorded highest total dry matter (571.65 g $plant^{-1}$ and 579.05 g $plant^{-1}$) in 2013 and 2014 respectively at 135 DAS.

Such increase in total plant drymatter due to foliar spray of plant nutrients and hormones is attributed to increase in number of branches with maximum leaf area. Similar results were reported and opined by Saravanan (2013) ,Ayyadurai and Manickasundaram (2014) and Sanghravikiran *et al*. (2012).

QUALITY PARAMETERS AND YIELD

The data on quality parameters viz., Ginning percentage (%) 2.5 %Span length (mm), Bundle strength (g tex^{-1}) and seed cotton yield (kg/ ha), are presented in Table 2. There was significant difference between treatments pertaining to quality parameters.

Results clearly indicated that ginning percentage did not vary significantly among the treatments. Spray of urea @ 2%, DAP @ 2%, KNO_3 @ 2% individually and in combination (urea @ 2% + DAP @ 2% + KNO_3 @ 2%) but these treatments improved the ginning percentage 2.8, 4.1, 4.23 and 6.5 per cent respectively over no spray treatment. However, response to combination spray was more than individual spray at different stages of crop growth. Spraying of GA @30ppm alone and in combination with urea @ 2%, DAP @ 2%, KNO_3 @ 2% and urea @ 2%+ DAP @ 2%+ KNO_3 @ 2% recorded insignificant variability with regard to mean ginning percentage in both the years. However, spraying of GA_3 @ 30ppm in combination with KNO_3 @ 2 % recorded highest ginning percentage (37.74 and 38.39 %) in 2013 and 2014 respectively.

Table.1 . Growth parameters of Bt cotton as influenced by plant growth regulators and nutrients

Treatments	Plant height (cm)						Leaf area (cm)						Total dry matter production (g plant^{-1})					
	2013			2014			2013			2014			2013			2014		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
T0 (Conrol)	130.50	110.20	120.35	135.40	115.84	125.62	9050.00	8460.00	8755.00	9571.27	8976.00	9273.63	524.00	439.20	481.60	530.30	450.60	490.45
T1(urea@2%)	141.33	120.00	130.67	146.51	124.40	135.46	10010.00	9183.00	9596.50	10510.00	9564.00	10037.00	585.40	498.70	542.05	592.10	510.85	551.48
T2(DAP@2%)	145.87	124.33	135.10	150.29	128.70	139.50	10498.00	9395.00	9946.50	10980.00	9876.00	10428.00	597.50	504.10	550.80	605.60	516.30	560.95
T3(KNO3@2%)	146.10	120.57	133.33	151.79	124.50	138.14	10120.00	9286.00	9703.00	10562.00	9720.00	10141.00	594.70	503.80	549.25	602.40	516.25	559.33
T4(U+D+K)	142.50	122.43	132.47	147.10	127.10	137.10	10254.00	9122.00	9688.00	10650.00	9532.00	10091.00	605.00	501.00	553.00	610.80	513.32	562.06
T5(NAA@30ppm)	144.00	123.00	133.50	148.30	127.30	137.80	9368.00	9320.00	9344.00	10860.00	9764.00	10312.00	587.60	497.30	542.45	592.40	509.96	551.18
T6(T1+T5)	147.63	124.87	136.25	151.80	129.73	140.77	10874.00	9635.00	10254.50	11160.00	10107.00	10633.50	611.20	509.50	560.35	616.20	520.34	568.27
T7(T2+T5)	148.30	125.00	136.65	152.10	130.17	141.13	10886.00	9689.00	10287.50	11162.00	10132.00	10647.00	617.10	506.00	561.55	621.20	517.22	569.21
T8(T3+T5)	150.53	125.90	138.22	155.20	131.13	143.17	10828.00	9479.00	10153.50	11103.00	9913.00	10508.00	605.80	513.80	559.80	612.20	521.18	566.69
T9(T4+T5)	149.10	124.50	136.80	153.20	129.20	141.20	10892.00	9672.00	10282.00	11190.00	10124.00	10657.00	614.30	516.10	565.20	619.90	523.82	571.86
T10(GA@30ppm)	146.90	123.80	135.35	150.90	128.20	139.55	10467.00	9378.00	9922.50	10910.00	9865.00	10387.50	584.00	502.60	543.30	589.60	514.86	552.23
T11(t1+t10)	152.00	125.43	138.72	156.80	130.90	143.85	10893.00	9786.00	10339.50	11235.00	10212.00	10723.50	619.40	508.40	563.90	621.50	518.90	570.20
T12(T2+T10)	151.57	131.00	141.28	154.10	135.10	144.60	10950.00	9710.00	10330.00	11290.00	10178.00	10734.00	622.50	520.80	571.65	629.00	529.10	579.05
T13(T3+T10)	154.20	127.30	140.75	159.20	132.83	146.02	10868.00	9494.00	10181.00	11153.00	9945.00	10549.00	614.00	519.00	566.50	620.40	526.10	573.25
T14(T4+T10)	153.73	132.00	142.87	157.30	136.20	146.75	10915.00	9854.00	10384.50	11250.00	10250.00	10750.00	621.00	518.40	569.70	628.60	525.30	576.95
Mean	146.95	124.02		151.33	128.75		10458.20	9430.87		10905.75	9877.20		600.23	503.91		606.15	514.27	

	2013			2014			2013			2014			2013			2014		
	Sem±	CD(p=0.05)	CV(%)	Sem±	CD(p=0.05)	CV(%)	Sem±	CD(p=0.05)	CV(%)	Sem±	CD(p=0.05)	CV(%)	Sem±	CD(p=0.05)	CV(%)	Sem±	CD(p=0.05)	CV(%)
Varieties (V)	0.95	5.77	4.69	1.39	8.44	2.06	83.05	505.37	5.59	78.85	479.80	5.09	5.52	33.57	6.71	5.19	31.57	6.21
Spraying of growth regulators and nutrients (T)	2.91	8.24	5.26	2.13	6.05	4.70	125.59	355.81	3.09	119.06	337.29	2.81	11.29	31.97	5.01	6.74	19.08	2.94
T at the same V	4.11	11.65		3.02	8.55		177.62	503.19		168.37	477.00		15.96	45.21		9.53	26.99	
V at the same or different T	4.08	12.28		3.23			190.64	657.74		180.77	623.96		16.38	52.44		10.56	38.21	

Table 2. Quality parameters and yield of Bt cotton as influenced by plant growth regulators and nutrients.

	Ginning percentage (%)						2.5 % span length					
	2013			2014			2013			2014		
	Vl	V2	Mean	Vl	V2	Mean	Vl	V2	Mean	Vl	V2	Mean
T0 (control)	36.42	32.51	34.46	37.50	33.09	35.30	33.12	29.87	31.50	34.47	30.21	32.34
T1(urea@2%)	36.97	33.86	35.42	37.60	33.91	35.76	33.99	30.91	32.45	34.64	31.54	33.09
T2(DAP@2%)	37.14	34.59	35.87	37.70	34.62	36.16	34.56	31.81	33.19	34.76	31.90	33.33
T3(KNO3@2%)	37.27	34.56	35.92	37.90	35.21	36.56	33.96	32.10	33.03	34.88	32.86	33.87
T4(U+D+K)	37.32	36.08	36.70	37.85	36.45	37.15	34.86	32.86	33.86	34.92	33.42	34.17
T5(NAA@30ppm)	36.43	35.87	36.15	37.27	35.86	36.57	34.02	31.23	32.63	34.89	31.90	33.40
T6(T1+T5)	37.19	36.05	36.62	37.92	36.21	37.07	34.65	31.67	33.16	35.19	32.09	33.64
T7(T2+T5)	37.64	36.81	37.23	37.48	37.02	37.25	34.81	32.42	33.62	35.64	32.86	34.25
T8(T3+T5)	37.85	36.28	37.07	38.26	36.88	37.57	34.82	32.56	33.69	35.87	33.21	34.54
T9(T4+T5)	38.15	36.55	37.35	38.20	36.64	37.42	35.00	32.91	33.96	35.88	33.87	34.88
T10(GA@30ppm)	37.57	36.02	36.80	37.59	36.87	37.23	35.24	31.76	33.50	36.34	32.04	34.19
T11(t1+t10)	38.12	36.67	37.40	38.26	36.90	37.58	35.67	33.54	34.61	36.75	34.12	35.44
T12(T2+T10)	38.23	36.62	37.43	38.96	36.62	37.79	35.83	33.58	34.71	36.86	34.64	35.75
T13(T3+T10)	38.67	36.81	37.74	39.50	37.28	38.39	36.33	33.82	35.08	37.12	34.55	35.84
T14(T4+T10)	38.26	36.80	37.53	39.30	37.20	38.25	36.07	33.61	34.84	37.00	34.65	35.83
Mean	37.55	35.74		38.06	36.05		34.86	32.31		35.68	32.91	
	2013			2014			2013			2014		
	Sem±	CD (p=0.05)	CV(%)	Sem±	CD (p=0.05)	CV(%)	Sem±	CD (p=0.05)	CV(%)	Sem±	CD p=0.05)	CV(%)
Varieties (V)	0.36	2.16	6.50	0.25	1.51	4.49	0.345	2.101	6.90	0.292	1.778	5.71
Spraying of growth regulators and nutrients (T)	0.54	1.53	3.62	0.51	1.46	3.40	0.533	1.509	3.89	0.526	1.491	3.76
T at the same V	0.77	2.17		0.73	2.06		0.753	2.134		0.744	2.109	
V at the same or different T	0.82	2.82		0.74	2.38		0.806	2.763		0.776	2.557	

Conti Table 2.a. Quality parameters and yield of Bt cotton as influenced by plant growth regulators and nutrients

	Bundle strength (g tex^{-1})						Kapas yield / ha (kg)					
	2013			2014			2013			2014		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
T0 (control)	24.12	21.67	22.90	24.88	22.09	23.49	2109.50	1666.20	1887.85	2548.30	2096.00	2322.15
T1(urea@2%)	24.78	22.13	23.46	25.18	22.73	23.96	2254.00	1831.00	2042.50	2670.20	2255.10	2462.65
T2(DAP@2%)	24.95	22.94	23.95	25.45	23.37	24.41	2297.00	1999.00	2148.00	2693.60	2232.00	2462.80
T3(KNO3@2%)	25.54	23.14	24.34	25.93	23.80	24.87	2208.00	1915.90	2061.95	2596.90	2298.50	2447.70
T4(U+D+K)	24.93	23.00	23.97	25.42	23.41	24.42	2273.10	1786.10	2029.60	2792.40	2312.40	2552.40
T5(NAA@30ppm)	25.03	22.30	23.67	25.17	22.75	23.96	2306.90	1817.40	2062.15	2895.70	2254.20	2574.95
T6(T1+T5)	25.21	22.78	24.00	25.61	22.97	24.29	2414.00	1984.60	2199.30	2930.70	2543.00	2736.85
T7(T2+T5)	25.28	23.16	24.22	25.87	23.56	24.72	2499.20	2007.00	2253.10	2996.63	2580.30	2788.47
T8(T3+T5)	25.64	23.34	24.49	26.02	23.82	24.92	2481.10	1941.00	2211.05	2995.30	2499.40	2747.35
T9(T4+T5)	25.00	23.17	24.09	25.89	23.80	24.85	2554.00	1991.10	2272.55	3074.60	2523.00	2798.80
T10(GA@30ppm)	24.76	22.99	23.88	25.34	23.26	24.30	2384.60	1886.00	2135.30	2908.50	2265.20	2586.85
T11(t1+t10)	25.13	23.45	24.29	25.83	23.95	24.89	2622.50	2094.30	2358.40	3106.90	2590.00	2848.45
T12(T2+T10)	26.37	23.63	25.00	26.50	24.05	25.28	2788.80	2119.00	2453.90	3184.30	2550.00	2867.15
T13(T3+T10)	26.53	23.60	25.07	26.98	24.13	25.56	2702.00	2239.47	2470.73	3222.50	2610.90	2916.70
T14(T4+T10)	26.41	24.40	25.41	26.40	24.17	25.29	2666.40	2155.40	2410.90	3163.57	2630.30	2896.93
Mean	25.31	23.05	25.76	23.46	2437.41	1948.90	2193.1522	2918.67	2416.02	2667.35		

	2013			2014			2013			2014		
	Sem±	CD (P=0.05)	CV (%)	Sem±	CD (P=0.05)	CV (%)	Sem±	CD (P=0.05)	CV (%)	Sem±	CD (P=0.05)	CV (%)
Varieties (V)	0.21	1.27	5.78	0.28	1.73	11.85	46.431	282.53	14.20	53.543	325.80	13.47
Spraying of growth regulators and nutrients (T)	0.39	1.09	3.91	0.40	1.12	8.51	72.356	204.98	8.08	81.164	229.94	7.45
T at the same V	0.55	1.55		0.56	1.59		102.326	289.89		114.783	325.18	
V at the same or different T	0.57	1.85		0.61	2.16		109.217	373.60		123.141	424.56	

Spraying of GA @30ppm in combination with urea @2%, DAP@2%, KNO_3@2% and urea @2%+ DAP@2%+ KNO_3@2% recorded significant variability with regard to mean 2.5 per cent span length over spray of GA @ 30 ppm alone in both the years. However, spraying of GA @30ppm in combination with KNO_3 @ 2 % recorded higher values (35.08 and 35.84 mm) in 2013 and 2014 respectively. Spraying of GA @30ppm alone and in combination with urea @2%, DAP@2%, KNO_3@2% and urea @2%+ DAP@2%+ KNO_3@2% recorded significant variability with regard to mean bundle strength in both the years comapared to control. However, and GA@30ppm in combination with urea @2%+ DAP@2%+ KNO_3 @2% (T_{14}) recorded highest mean bundle strength (25.41 g/tex) in 2013 and GA@30ppm in combination with KNO_3@ 2% recorded highest mean bundle strength (25.56 g/tex) 2014 . Abdallah and Mohamed (2013) showed that, auxin had significant effects on fiber length and fiber fineness.

The results indicated that among all the treatments, application of GA@30ppm in combination with KNO_3@ 2% (T_{13}) recorded significantly higher boll weight (6.14g and 6.51g) over control and remaining treatments during both years of experimentation. This might be due to the reason that when nutrients are applied through foliar spray, the nutrients are supplied directly to where they are required and foliar application may increase the utilization of applied nutrient by enhancing the translocation of nutrients into the boll which increases the number and size of the boll.

The mean seed cotton yield was significantly higher in Bhaskara hybrid compared to Bunny BG II. Bhaskara hybrid recorded 25.06 and 20.80 percent higher mean seed cotton yield compared to Bunny BG II in both the years respectively. This might be due to more sympodial branches, more leaf area, drymatter production, total chlorophyll and more number of bolls and boll weight compared to Bunny BG II. Spraying of GA @30ppm alone and in combination with urea @2%, DAP@2%, KNO_3@2% and urea @2%+ DAP@2%+ KNO_3@2% recorded significant variation with regard to mean seed cotton yield in both the years. Spraying of GA@30ppm in combination with KNO_3 @ 2 % recorded highest mean seed cotton yield of 2470 kg ha^{-1} in 2013 and 2916.7 kg ha^{-1} in 2014 compared to all other treatments. The increase in seed cotton yield was due to increased plant height and LAI which resulted in an increase in photosynthetic activity and dry matter production.These results are in conformity with the report of Rajendran *et al.* (2010) in cotton crop.

CCONCLUSION

In terms of genotypic performance, Bhaskara hybrid showed better performance compared to Bunny BG II. The foliar spray of GA @ 30ppm + KNO_3 @ 2% (T_{13}) at peak squaring, peak flowering, peak boll formation and peak boll developmental stage can be recommended for getting higher dry matter, better assimilate transfer from source to sink and higher yield in *Bt* cotton.

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