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Yield and Quality of *Bt* Cotton Hybrid NHH 44 (BG II) as Influenced by Moisture Conservation Practices and Fertilizer Levels under Rainfed condition

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ABSTRACT: Crop yield and quality may differ with nutrient management and moisture conservation. Popular public sector *intra hirsutum* cotton hybrid NHH 44 converted in transgenic version is made available to farmers. Hence, it was necessary to optimize the fertilizer requirement for its higher seed cotton yield and better fiber properties. Hence, a field trial was conducted at Cotton Research Station, Nanded (Maharashtra, India) during *kharif* 2019-20 and 2020-21 seasons to study the effect of moisture conservation techniques and fertilizer levels on yield and quality of *Bt* cotton hybrid NHH 44 (BG II) under rainfed condition. The experiment was conducted on vertisol in split plot design with three replications. Moisture conservation practices included in main plot were control *i.e.* M_1 - flat bed; M_2 - opening furrow at 60 DAS; M_3 - application of superabsorbent @ 12.5 kg ha^{-1} and M_4 - broad bed and furrow. The sub plot treatments were consisted with four fertilizer (NPK) levels *viz*., F_1 - 80:40:40 NPK kg ha^{-1}; F_2 - 100:50:50 NPK kg ha^{-1}; F_3 - 120:60:60 NPK kg ha^{-1} and F_4 - 140:70:70 NPK kg ha^{-1}. Sowing on broad bed and furrow and opening of furrow at 60 DAS stage has increased number of picked bolls m^{-2}, seed cotton yield ha^{-1}, lint yield ha^{-1} and oil yield ha^{-1} significantly over control and application of superabsorbent @ 12.5 kg ha^{-1}. The seed cotton yield, lint yield and oil yield were highest in fertilizer level of 140:70:70 NPK kg ha^{-1} however, it was on par with 120:60:60 NPK kg ha^{-1} and both were significantly superior over lower levels. The fiber properties of cotton hybrid NHH 44 BG II remained unaffected due to moisture conservation practices and fertilizer levels except uniformity index which was significantly increased with fertilizer level of 140:70:70 NPK kg ha^{-1} over lowest level of 80:40:40 NPK kg ha^{-1}.

Keywords: Seed cotton yield, fiber quality, bolls m^{-2}, lint yield, oil yield.

INTRODUCTION

India ranks first among the countries that practice rainfed agriculture both in terms of extent and value of production (Sharma, 2011). Rainfed areas in India has major share in production of cereals, legumes, oil seeds and cotton. The share of cotton produced in rainfed region of India is around 65 per cent (Rao *et al.*, 2015). India ranks first in area and second in production of cotton on global level. India shares around 25 per cent in global cotton production. The cotton acreage in India is 129.57 lakh ha with productivity 487 kg lint ha^{-1}. Maharashtra state contributes to 41.84 lakh ha area majority under rainfed condition. Vidarbha and Marathwada region are the traditional cotton growing area in rainfed ecosystem. These areas often experience dry spells during the crop growing period. Vegetative growth and metabolic processes are adversely affected due to moisture stress especially in grand growth stages.

Moisture conservation measures carried *in-situ* increase infiltration by reducing run off and temporarily impounding of water, there by improve soil moisture and resulting nutrient availability. Crop growth and yield depends upon suitable moisture condition and temperature. Proper soil moisture conservation practice not only improves soil moisture also enhances growth, yield and nutrient use efficiency. Many moisture conservation techniques were developed and evaluated, opening of furrow and broad bed and furrow were proved for sustainable yield (Muthamilselvan *et al.*, 2020). Superabsorbent polymers are also suitable materials for adequate water requirement and prevention from water and nutrient loss from rhizosphere soil (Fallahi *et al.*, 2015).

Yield of cotton were improved after availability of GM technology. Thus, it is necessary to supply adequate nutrients as needed by the crop. The optimum requirement of NPK nutrients for achieving the maximum yield of *Bt* cotton varies from location to location in consideration with soil moisture, temperature, cropping pattern followed by crop cultivars. Additional nutrient conditions improve crop growth and development as well as yield of cotton (Ambika *et al.*, 2017; Pragathi Kumari *et al.*, 2019). The popular public sector *intra hirsutum* cotton hybrid NHH 44 was converted in BG II version and made available to farmers of Maharashtra. Thus, it was necessary to study the optimum fertilizer level for the hybrid. Hence, a field trial was conducted to study the effect of moisture conservation practices and fertilizer levels on yield and quality of *Bt* cotton hybrid NHH 44 (BG II) under rainfed condition.

MATERIALS AND METHODS

A field trial was conducted at Cotton Research Station, Nanded during 2019-20 and 2020-21 seasons. The site of experiment was clay loam with slightly alkaline pH of 8.10. The available nitrogen was in the range of low (148.74 kg ha^{-1}), P_2O_5 was medium (11.92 kg ha^{-1}) and K_2O was high (403.18 kg ha^{-1}).

The experiment was laid out in split plot design with three replications. The gross and net plot sizes were 32.4 m^2 and 16.2 m^2, respectively. Sixteen treatment combinations comprising of four moisture conservation practices (M_1 - control *i.e.* flat bed; M_2 - opening of furrow at 60 DAS; M_3 - application of superabsorbent @ 12.5 kg ha^{-1} and M_4 - broad bed and furrow) in main plot and four fertilizer (NPK) levels (F_1 - 80:40:40 NPK kg ha^{-1}; F_2 - 100:50:50 NPK kg ha^{-1}; F_3 - 120:60:60 NPK kg ha^{-1} and F_4 - 140:70:70 NPK kg ha^{-1}) were evaluated in sub plot. The *Bt* cotton hybrid NHH 44 (BG II) was dibbled at 120 × 45 cm spacing in 28 SMW and 25 SMW during *kharif* 2019 and 2020, respectively. Opening of furrow was done between every row at 60 DAS stage with tied harrow. Superabsorbent material in '*Starch-g-poly*' form (*Zeba*) was applied @ 12.5 kg ha^{-1} mixed with basal dose of fertilizers. Broad bed and furrows having 120 cm width at base and 90 cm at top were prepared before sowing. Fertilizer doses were applied as per treatment schedule. Nitrogen was applied in three splits (40% as basal at sowing, 30% each at 4 WAS and 8 WAS). Complete dose of phosphorus and potassium was as basal. Crop protection measures were adopted as per university recommendations. Excess rainfall (1150 mm and 977 mm, respectively against average of 900 mm) was received during 2019 and 2020. Number of bolls were counted from 1 m^{-2} area in net plot. Seed cotton from net plot was subjected to ginning and lint yield was calculated based on ginning out turn (%). Oil content in cotton seed was determined by Soxhlet apparatus method and oil yield was calculated considering seed cotton yield, lint yield and oil content in seed. Lint samples were evaluated for fiber parameters *viz.*, upper half mean length (UHML), micronaire, uniformity index, tenacity and elongation by HVI mode and pooled mean data of fiber characteristics is discussed.

RESULTS AND DISCUSSION

Significant increase in number of bolls m^{-2}, seed cotton yield ha^{-1}, lint yield ha^{-1}, oil yield ha^{-1} was observed due to moisture conservation practices and fertilizer levels (Table 1). The pooled mean fiber characteristics of *Bt* cotton hybrid NHH 44 (BG II) as influenced by moisture conservation practices and fertilizer levels are tabulated in Table 2.

Table 1: Number of bolls m^{-2}, Seed cotton yield, lint yield, oil yield of *Bt* cotton hybrid NHH 44 as influenced by different treatments.

Treatments	No. of bolls m^{-2}			Seed cotton yield (kg ha^{-1})			Lint yield (kg ha^{-1})			Oil yield (kg ha^{-1})		
	2019-20	2020-21	Pooled mean	2019-20	2020-21	Pooled mean	2019-20	2020-21	Pooled mean	2019-20	2020-21	Pooled mean
Main plot : Moisture conservation methods												
M_1 : Control (Flat bed)	70.36	84.67	77.51	2027	2277	2152	680	762	721	445	509	477
M_2 : Opening of furrow at 60 DAS	76.21	91.42	83.81	2175	2483	2329	733	841	787	481	560	521
uperabsorbent application @ 12.5 kg ha^{-1}	72.47	88.00	80.23	2073	2389	2231	696	808	752	453	533	493
M_4 : Broad bed and furrow	77.25	91.50	84.38	2214	2510	2362	746	854	800	494	568	531
SE±	1.35	2.34	1.05	38.42	32.97	28.05	10.62	11.68	8.47	7.00	7.89	4.99
CD at 5%	3.95	N.S.	3.07	111.96	96.11	81.75	30.95	34.03	24.69	22.51	22.98	14.54
Sub plot : Fertilizer levels												
F_1 : 80 : 40 : 40 NPK kg ha^{-1}	68.25	85.08	76.67	1918	2211	2065	642	742	692	423	496	459
F_2 : 100 : 50 : 50 NPK kg ha^{-1}	72.27	87.33	79.80	2066	2362	2214	694	795	744	460	534	497
F_3 : 120 : 60 : 60 NPK kg ha^{-1}	77.34	90.58	83.96	2213	2514	2364	746	851	798	489	567	528
F_4 : 140 : 70 : 70 NPK kg ha^{-1}	78.43	92.58	85.50	2291	2572	2432	773	877	825	501	574	538
SE±	1.94	1.72	1.40	43.38	42.67	30.40	15.97	16.66	12.11	11.23	11.81	9.01
CD at 5%	5.64	5.01	4.08	126.44	124.36	88.60	46.55	48.54	35.29	32.72	34.41	26.26
Interaction M x F												
SE±	3.87	3.44	2.80	86.77	85.34	60.80	31.95	33.31	24.22	22.46	11.81	18.02
CD at 5%	N.S.	10.01	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
CV (%)	9.05	6.69	6.95	7.08	6.12	6.49	7.75	7.07	6.48	8.31	7.54	6.17
GM	74.07	88.90	81.48	2122	2415	2268	714	816	765	468	543	506

Table 2: Fiber properties of *Bt* cotton hybrid NHH 44 as influenced by different treatments (pooled mean).

Treatments	UHML (mm)	Micronaire (µg / inch)	Uniformity index (%)	Tenacity (g tex^{-1})	Elongation (%)
Main plot : Moisture conservation methods					
M_1 : Control (Flat bed)	25.41	4.61	82.33	24.54	5.55
M_2 : Opening of furrow at 60 DAS	25.53	4.64	82.50	24.79	5.58
M_3 : Superabsorbent application @ 12.5 kg ha^{-1}	25.55	4.63	82.46	24.65	5.56
M_4 : Broad bed and furrow	25.58	4.64	82.58	24.74	5.58
SE±	0.09	0.05	0.36	0.09	0.03
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
Sub plot : Fertilizer levels					
F_1 : 80 : 40 : 40 NPK kg ha^{-1}	25.21	4.63	81.83	24.39	5.54
F_2 : 100 : 50 : 50 NPK kg ha^{-1}	25.44	4.64	82.29	24.65	5.56
F_3 : 120 : 60 : 60 NPK kg ha^{-1}	25.67	4.62	82.75	24.79	5.57
F_4 : 140 : 70 : 70 NPK kg ha^{-1}	25.76	4.63	83.00	24.88	5.59
SE±	0.13	0.02	0.28	0.13	0.02
CD at 5%	N.S.	N.S.	0.80	N.S.	N.S.
Interaction M x F					
SE±	0.26	0.04	0.55	0.26	0.05
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.
CV (%)	2.74	1.47	2.16	1.81	1.44
GM	**25.52**	**4.63**	**82.47**	**24.68**	**5.57**

A. Effect of moisture conservation practices

Broad bed and furrow treatment recorded significantly greater mean number of bolls m^{-2} (M_4 - 84.38) and was at par with opening of furrow at 60 DAS (M_2 - 83.81). Both these treatments were significantly superior over control *i.e.*, flat bed (M_1 - 77.51) and application of superabsorbent (M_3 - 80.23) for number of bolls m^{-2}. During individual years, broad bed and furrow (M_4) was significantly superior for seed cotton yield ha^{-1} over control *i.e.*, flat bed (M_1) and application of superabsorbent @ 12.5 kg ha^{-1} (M_3). However, on pooled mean basis, broad bed and furrow (M_4 - 2362 kg ha^{-1}) as well as opening of furrow at 60 DAS (M_2 - 2329 kg ha^{-1}) were significantly superior over control *i.e.*, flat bed (M_1 - 2152 kg ha^{-1}) and application of superabsorbent (M_3 - 2231 kg ha^{-1}). Moisture conservation practices *viz.*, opening of furrow at 60 DAS (M_2), application of superabsorbent @ 12.5 kg ha^{-1} (M_3) and broad bed and furrow (M_4) has increased pooled mean seed cotton yield by 8.22 per cent, 3.67 per cent and 9.76 per cent over control *i.e.*, flat bed (M_1), respectively. The increased soil moisture and interception of solar radiation in moisture conservation practices was efficiently utilized at the flowering and boll development period of crop. It has benefited in increasing number of bolls m^{-2} and seed cotton yield plant ha^{-1}. Advantage of broad bed and furrow were reported earlier by Asewar *et al.* (2008); Gnanasoundari and Balusamy (2015); Aslam *et al.* (2018); Ashraf *et al.* (2020). Many researchers have reported positive effects of opening of furrow with respect to improvement in seed cotton yield over flat bed (Narkhede *et al.*, 2015; Pragathi Kumari *et al.*, 2019 and Ghogare *et al.*, 2020).

Lint yield ha^{-1} was significantly higher in broad bed and furrow (800 kg ha^{-1}) and opening of furrow at 60 DAS (787 kg ha^{-1}) over control *i.e.*, flat bed (721 kg ha^{-1}) and application of superabsorbent (752 kg ha^{-1}) during individual seasons and on pooled mean basis. Availability of sufficient moisture during boll development period in moisture conservation practices might have resulted in better development of cotton fibers. Odunze *et al.* (2012) also reported significant increase in lint yield due to moisture conservation practice of opening of furrow. Pettigrew (2004) has reported reduction in lint yield of cotton which has experienced moisture stress condition.

Broad bed and furrow (M_4) treatment was the highest for oil yield during 2019-20, 2020-21 and in pooled mean (531 kg ha^{-1}). All the three moisture conservation practices had significantly superior oil yield over control (477 kg ha^{-1}). Increase in seed cotton yield ha^{-1} in moisture conservation treatments and oil content (%) in the respective treatment has resulted to increase in oil yield ha^{-1} in moisture conservation practices.

The fiber properties *viz.*, UHML (staple length), micronaire (fiber fineness), uniformity index, tenacity and elongation were not affected significantly moisture conservation practices. Marginal improvement in UHML of fibers, uniformity index, tenacity and elongation were observed in broad bed and furrow and opening of furrow treatments over control. Non-significant improvement in fiber UHML due to moisture conservation measures were noted by Jaybhay *et al.* (2015); Ehsanullah *et al.* (2017); Veeranna *et al.*, (2017); Pragathi Kumari *et al.* (2018).

B. Effect of fertilizer levels

Highest mean number of bolls m^{-2} (85.50) and mean seed cotton yield (2432 kg ha^{-1}) was obtained with highest fertilizer level of 140:70:70 NPK kg ha^{-1} (F_4) which was significantly superior over lower levels of 80:40:40 NPK kg ha^{-1} (F_1 - 2065 kg ha^{-1}) and 100:50:50 NPK kg ha^{-1} (F_2 - 2214 kg ha^{-1}). The fertilizer level of 120:60:60 NPK kg ha^{-1} (F_3) was on par with highest level (F_4) for number of bolls m^{-2} and seed cotton yield per ha. On an average of the two seasons, additional seed cotton yield of 17.77 per cent, 14.48 per cent and

7.22 per cent was received due to application of 140:70:70 NPK kg ha^{-1} (F_4), 120:60:60 NPK kg ha^{-1} (F_3) and 100:50:50 NPK kg ha^{-1} (F_2) over lowest level of 80:40:40 NPK kg ha^{-1} (F_1). Nitrogen and phosphorus play an important role in flowering, square formation and setting of seeds. Whereas, phosphorus is the major element of nucleic acids and enzymes which are taking part in many metabolic activities of plant and are also responsible for metabolism of nitrogen compound. Whereas, potassium is major constituent of seed. The significant increase in seed cotton yield with higher level over its lower level up to F_3 might be the result of increase in plant growth resulting increased number of picked bolls m^{-2}. These results are in line with earlier reported by Pandagale *et al.* (2015); Honappa *et al.* (2019); Solanki *et al.* (2020).

Increase in fertilizer level has resulted significant increase in lint yield over its preceding lower levels up to fertilizer level of 120:60:60 NPK kg ha^{-1} (F_3) during both the years and in pooled results. However, the fertilizer level of 140:70:70 NPK kg ha^{-1} (F_4) was the highest for lint yield (825 kg ha^{-1}) and was at par with fertilizer level of 120:60:60 NPK kg ha^{-1} (798 kg ha^{-1}). Thus, higher fertilizer levels of F_3 and F_4 have increased lint yield by 15.32 per cent and 19.22 per cent over lowest level F_1. Increase in lint yield ha^{-1} in higher fertilizer levels was the product of increase in seed cotton yield and numerical increase in ginning out turn, which were higher in those treatments. These results are in conformity with Shukla *et al.* (2014); Singh *et al.* (2017).

Increase in seed cotton yield and oil content (%) in incremental fertilizer levels has resulted to increased oil yield over its next incremental level of fertilizer. The fertilizer level of 120:60:60 NPK kg ha^{-1} (528 kg ha^{-1}) and 140:70:70 NPK kg ha^{-1} (538 kg ha^{-1}) out yielded significantly over lowest level of 80:40: 40 NPK kg ha^{-1} (459 kg ha^{-1}). Kumbhar *et al.*, (2008) reported increase in seed oil content due to increased N and P nutrients over lower levels thereby increased oil yield ha^{-1}.

Incremental levels of fertilizers have improved fiber properties. However, the differences were non-significant for fiber UHML, micronaire, tenacity and elongation. The uniformity index of NHH 44 *Bt* hybrid fibers was significantly improved with fertilizer level of 140:70:70 NPK kg ha^{-1} (F_4) by 1.17 per cent over lowest level of 80:40:40 NPK kg ha^{-1} (F_1). Raju and Thakare (2012); Pandagale *et al.* (2015) also reported improvement in uniformity index due to higher fertilizer level whereas, non-significant differences in other characteristics are reported by Pandagale *et al.* (2015); Singh *et al.* (2017); Solanki *et al.* (2020).

CONCLUSION

Sowing of *Bt* cotton hybrid on broad bed and furrow was found to increase seed cotton yield, lint yield and oil yield over control and application of superabsorbent. The fertilizer level of 120:60:60 NPK kg ha^{-1} was found optimum for *Bt* cotton hybrid under rainfed condition.

Conflict of Interest. None.

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