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Influence of moisture conservation practices and integrated nutrient management practices on yield, quality and economics of Bt cotton

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Abstract
A field experiment was conducted at College farm, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad. During *kharif* 2015-16 and 2016-17. The experiment was laid out in strip-plot design with three replications to study the effect of moisture conservation practices and integrated nutrient management treatments and their integration effect on yield maximiation, quality and economics of Bt cotton. The treatments comprised of four moisture conservation treatments *viz.*, Flat bed sowing, ridge and furrow, broad bed and furrow (BBF) and poly mulch on BBF, while the sub plot treatments consisted of integrated nutrient management practices *viz.* farmer's practice, 100% RDF (150:60:60 NPK kg /ha), 125% RDF, 100% RDF along with 25% N through FYM and 100% RDF along with 25% N through press mud. Pooled data of two years indicated that poly mulch on broad bed increased the yield (2183 kg ha^{-1}), quality and net returns followed by ridge and furrow method, broad bed and furrow and flat bed methods respectively during both the years of experimentation. Among the nutrient management practices, application of 100% RDF along with 25% RDN through press mud improved the yield (2103 kg/ha), quality and net returns. Application of 100% RDF along with press mud equivalent to 25% RDN was on par with (S_4) 100% RDF + 25% RDN through FYM (2042 kg ha^{-1}) and S_4 was in turn on par with 125% RDF (1990 kg ha^{-1}) followed by (S_1) farmer's practice (1785 kg ha^{-1}) and (S_2) 100% RDF (1676 kg ha^{-1}).The highest net monetary returns and benefit cost ratio was recorded with application of 125% RDF which was at par with application of 100% RDF+ 25% RDN through pessmud. Treatment combination involving poly mulch on broad bed was more effective when RDF applied along with pressmud or FYM or 125% RDF alone.

Keywords: Bt cotton, poly mulch, ridge and furrow, broad bed and furrow, FYM, press mud, yield, quality and economics

Introduction
Cotton, the "*white gold or the king of fibres*" is one of the most important commercial crops in India. Cotton is known for the fibre and oil from seed, which plays a prominent role in the national and international economy. Average productivity of cotton in India is 504 kg lint kg ha^{-1}, which is lower when compared to the world average of 725 kg lint ha^{-1}. Cotton is grown in 7.8 m ha in 296 districts of which 5.1 m ha is rainfed in sixteen states of the country and about 85 percent of the rainfed cotton is grown in 30 districts (4.1 m ha). Major cause for low productivity of cotton is soil moisture stress, improper nutrition and erratic rainfall. Besides this, there are other reasons for poor cotton yield. There is ample scope to boost the yield by adopting soil management practices for soil moisture conservation, besides various factors responsible for low productivity, major one is nutrient management influencing nutrient availability.

More than 65% of the cotton in Southern Telangana Zone and Central Telangana Zone is cultivated in red soils although cotton is recommended for black soils. Under rainfed conditions, proper land configuration as per the soil type aids in efficient soil moisture conservation, apart from ensuring better stand, establishment, uniform growth, nutrient use efficiency and yield (Prasad and Sudhakara Babu, 1997) [8]. Among various modern and cost effective technologies for efficient utilization of natural resources, effective rain water management as *in-situ* moisture conservation comprising of opening of furrow, intercropping, mulching etc prove to be vital for attaining sustainable yields (Gokhale *et al*., 2012) [3]. Use of plastic mulch has confirmed water saving to about 40-50 percent in cotton (Nalayini *et al*., 2009) [7].

The other factor for reduced cotton yield is indiscriminate use of fertilizers that is resulting in micronutrient deficiencies and making the soil unproductive.

Integrated use of chemical fertilizers and organic manures is not only essential for achieving higher yields but also has crucial role in improving soil health. Although FYM is commonly recommended organic manure, its availability is becoming scarce on account of low or negligible maintenance of cattle population in the farm. In India huge accumulation of sugarcane byproducts with a lot of pressmd material not being utilized in a productive manner, while, this byproduct had the great potential when mixed into agricultural soils as organic fertilizer with many of benefits that can improve soil health, and sustainable agronomic productivity. Pressmud is a by-product of sugar industry and for every 100 tons of sugarcane crushed about 3 tons of pressmud cake is left behind as byproduct. when this byproduct composted, it converted into a very nutritive organic manure, because of composting is a most promising technology of waste disposal, enabling as the fertilizing agent which is rich in micro and macro nutrients with organic carbon or soil conditioner which increases the microbial population, maintains soil fertility and enhance sustainable crop production in the degraded lands due to continuous and excessive use of chemical fertilizers and pesticides. Pressmud as bio compost used to maintain soil fertility and enhance crop production because it is rich in sugar and contains appreciable amount of essential plant nutrients viz., organic carbon, nitrogen, phosphorus, potassium, calcium and magnesium along with traces of micronutrients viz., Zn, Fe, Cu and Mn (Laird *et al*., 2001) [6], so the beneficial effect of this bio compost for enhancing the soil fertility and thereby improving the crop productivity is well established (Banulekha., 2007) [1]. Keeping in view the above facts, the present study was initiated to maximize the yield of Bt cotton under different soil moisture conservation techniques and integrated nutrient management practices in red soils.

Material and methods

A field experiment was conducted during *kharif*, 2015 and 2016 at College farm, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Hyderabad under rainfed conditions. The soil of the experimental site was sandy loam with soil pH of 7.33, low available N (182 kg ha^{-1}), medium in P_2O_5 (46.8 kg ha^{-1}) and high in K_2O (432 kg ha^{-1}). The experiment was laid out in strip plot design with three replications. The size of gross and net plots were 7.2 m x 5.4 m and 5.4 m x 4.2 m respectively. There were twenty treatments comprised of four *in-situ* moisture conservation practices *viz.,* flat method (M_1), ridge and furrow (M_2), broad bed and furrow (M_3) and poly mulch on BBF (M_4) as main plots and five integrated nutrient management practices as sub plots were as follows farmer's practice (S_1), 100% RDF (S_2), 125% RDF (S_3), 100% RDF along with 25% N through FYM (S_4) and 100% RDF along with 25% RDN through press mud (S_5) as sub plots. Neeraja BT-II Bt cotton seeds were dibbled @ 1 seed/hill on 8th July during 2015 and 3rd July during 2016. Entire P fertilizer was applied as basal and N and K are applied at 20, 40, 60 and 80 days after sowing in equal splits. In integrated nutrient management treatments (S_4 & S_5), 25 percent nitrogen is applied through organic manures as basal and remaining as that of recommended dose of fertilizers (100% RDF). After laying land configurations, FYM and pressmud were applied in INM treatment plots. Foliar application of micro nutrient mixture @ 1% at 45 and 75 DAS (common to all treatments). A total rainfall of 375.3 mm was received in 27 rainy days during 2015-16 and 741.1 mm in 37 rainy days during 2016-17 respectively against the decennial average of 616 mm received in 37 rainy days for the corresponding period indicating 2016-17 as comparatively wet year. The crop was sprayed with monocrotophos @ 1 ml/lt against aphids and bollworms and carbendazim @ 1g/l of water against wilt. The seed cotton was harvested thrice, when the bolls were fully burst at 100 DAS, 125 DAS and 150 DAS respectively during both the years of experimentation. The crop was harvested on 17th December during 2015 and 23rd December during 2016. Prior to harvesting of the net plot area, two border rows and two plants from each row on either side were removed from each plot. The seed cotton in the net plot was harvested separately. The total seed cotton yield was obtained by adding the weight from each picking and expressed as kg ha^{-1}. For quality estimation Bt cotton samples were sent to Central Institute of Cotton Research laboratory, Coimbatore.

Results and Discussion

Influence of moisture conservation treatments on yield

The data indicated significant effect of moisture conservation treatments on seed cotton yield. During both the years, poly mulch on broad bed method (M_4) recorded significantly higher seed cotton yield (2183 kg ha^{-1}) as compared to other moisture conservation treatments (Table 1). The highest yield under poly mulch on broad bed method was due to conservation of soil moisture coupled with restricted weed growth and optimum soil temperature thereby preventing the loss of nutrients and favorable soil micro climate which was congenial for better growth and development of the cotton crop. The present results are in line of those reported by Hugar and Halemani (2010) [4], who also reported improved seed cotton yield under polyethylene mulch to the extent of 11 to 27 percent as compared to no mulch. The next best treatment was ridge and furrow (M_2), which also recorded significantly higher seed cotton yield (2009 kg ha^{-1}) as compared to broad bed & furrow (1823 kg ha^{-1}) and flat bed methods during both the years.

Influence of moisture conservation treatments on quality

The fiber fineness was not significantly influenced by moisture conservation practices and integrated nutrient management practices during both the years of experimentation. However, the fibre fineness values varied between 3.44 to 3.79 ug $inch^{-1}$. However, in case of moisture conservation treatments, poly mulch on broad bed produced finer fibres (3.79 ug $inch^{-1}$). The interaction effect was also found to be non significant. Pooled data of two years indicated that poly mulch on broad bed (45.7) recorded higher uniformity ratio during both the years as compared to other moisture conservation treatments and it was found on par with ridge & furrow (45.6) and BBF (45.0) and significantly superior over flat bed (44.4). The fiber length was not influenced by moisture conservation practices and integrated nutrient management practices during both the years. However, the fibre length values varied between 31.2 to 32.8 mm. in case of fibre strength, poly mulch on broad bed method (24.3 g tex^{-1}) recorded significantly higher fibre strength during both the years compared all other moisture conservation treatments. Poly mulch on broad bed was comparable with ridge & furrow (23.4 g tex^{-1}) and broad bed & furrow (22.9 g tex^{-1}). Broad bed and furrow in turn was on par with flat bed method (21.9 g tex^{-1}).

Influence of moisture conservation treatments on economics

The data indicated significant effect of moisture conservation treatments on net returns and B:C ratio. Poly mulch on broad bed method (₹ 38,251 ha^{-1} and 1.76) recorded significantly higher net returns and benefit cost ratio during both the years compared to all other moisture conservation treatments. Poly mulch on broad bed and ridge and furrow (₹ 35,266 ha^{-1} and 1.76) were recorded significantly comparable net returns and benefit cost ratio.

Influence of integrated nutrient management on yield

kapas yield (2103 kg ha^{-1}) was significantly higher in 100% RDF + 25% RDN through Press mud (S_5) treatment and was on par with (S_4) 100% RDF + 25% RDN through FYM (2042 kg ha^{-1}). Application of 100% RDF + 25% RDN through FYM (S_4) was in turn on par with 125% RDF (1990 kg ha^{-1}) followed by (S_1) Farmers practice (1785 kg ha^{-1}) and (S_2) 100% RDF (1676 kg ha^{-1}). Use of organic manures like press mud and FYM increases the microbial activity which helps in transformation of nutrients thus making them more available to plants. Juwarkar *et al*. (1993) [5] reported that application of 20 t/ha pressmud and addition of NPK equivalent to 75% of recommended dose to each crop through fertilizers were found to be beneficial and resulted 21-43% higher crop yield.

Influence of integrated nutrient management on quality

Significantly higher ginning percentage was recorded in (S_5) 100% RDF + 25% RDN through pressmud treatment. S_5 treatment was on par with (S_4) 100% RDF + 25% RDN through FYM (36.6%). Lower ginning percent was recorded with (S_3) 125% RDF and it was found on par with 100% RDF.

The fiber fineness was not significantly influenced by moisture conservation practices and integrated nutrient management practices during both the years of experimentation. Higher uniformity ratio was recorded in (S_5) 100% RDF + 25% RDN through Press mud treatment and was on par with (S_4) 100% RDF +25% RDN through FYM. These results are in conformity with those of Devraj *et al.* (2008) [2]. The fiber length was not influenced by integrated nutrient management practices during both the years. Significantly higher fiber strength was recorded in (S_5) 100% RDF + 25% RDN through pressmud treatment followed by (S_4) 100% RDF + 25% RDN through FYM and was on par with farmers practice.

Influence of integrated nutrient management on economics

Integrated nutrient management practices also significantly influenced the net returns of *Bt* cotton. Significantly higher net returns (₹ 37,640 ha^{-1}) were accrued from (S_5) 100% RDF + 25% RDN through press mud treatment. S_5 treatment was on par with application of 125% RDF (₹36,720 ha^{-1}) fb (S_4) application of RDF + FYM equivalent to 25% RDN (₹ 32,643 ha^{-1}). However, this was fb 100% RDF and farmer's practice. Integrated nutrient management practices also significantly influenced the B: C ratio of *Bt* cotton. Significantly higher B: C ratio (1.83) was accrued from (S_3) application of 125% RDF. S_3 treatment was on par with (S_5) 100% RDF + Press mud equivalent to 25% RDN (1.78) treatment and (S_4) application of RDF + FYM equivalent to 25% RDN (1.65). This was followed by 100% RDF and farmer's practice. High cost incurred towards purchase of FYM and pressmud leads to lower B: C ratio in S_4 and S_5 compared to S_3.

Interaction between soil moisture conservation practices and integrated nutrient management

Interaction between soil moisture conservation practices and integrated nutrient management practices was found to be significant during both the years of experimentation as well as in pooled results. Treatment combination involving poly mulch on broad bed and application of RDF along with press mud (M_4S_5) recorded significantly highest mean seed cotton yield (2370 $kgha^{-1}$). This treatment was comparable with (M_4S_4) poly mulch on broad bed and application of RDF along with FYM equivalent to 25% RDN (2346 $kgha^{-1}$). M_4S_5 and M_4S_4 treatments were in turn on par with poly mulch on broad bed and application of 125% RDF (M_4S_3).

The treatment combination (M_4S_5) involving poly mulch on broad bed and application of RDF along with 25% RDN through pressmud recorded significantly higher uniformity ratio. This treatment was found on par with (M_4S_4) poly mulch on broad bed along with application of 100% RDF plus 25% RDN through FYM, (M_4S_3) poly mulch with 125% RDF, (M_4S_2) poly mulch with 100% RDF and (M_4S_1) poly mulch with farmers practice.

The fiber length was not influenced by moisture conservation practices and integrated nutrient management practices during both the years. In case of fibre strength, treatment combination (M_4S_5) involving poly mulch on broad bed and application of RDF along with pressmud recorded significantly higher fibre strength. This treatment was found on par with (M_4S_4) poly mulch on broad bed along with application of 100% RDF plus 25% RDN through FYM, (M_4S_3) poly mulch with 125% RDF, (M_4S_2) poly mulch with 100% RDF and (M_4S_1) poly mulch with farmers practice.

Significantly higher net returns were recorded with treatment combination involving (M_4S_3) poly mulch on broad bed and application of 125% RDF (₹ 45,392ha^{-1}). However, (M_4S_5) Application of RDF along with 25% RDN through pressmud (₹ 44,864 ha^{-1}) recorded significantly comparable net returns as that of M_4S_3 and it was followed by M_2S_5, which in turn was on par with M_2S_3. Treatment combination involving (M_4S_3) poly mulch on broad bed and application of 125% RDF (1.95) recorded significantly highest B: C ratio. However, (M_2S_3) ridge and furrow along with application of 125% RDF (1.94) recorded significantly comparable B: C ratio as that of M_4S_5 and these two treatments were on par with M_2S_3, M_2S_5, M_3S_3 and M_3S_5.

Table 1: Influence of moisture conservation practices and INM on kapas yield and ginning percent of Bt cotton

Treatments	Yield parameters (Pooled data of 2015 and 2016)											
	Kapas yield (kg ha^{-1})						Ginning percent					
	Sub plots											
Main treatments	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**
M_1 - Flat bed (control)	1566	1447	1695	1758	1843	1662	35.1	33.3	32.9	35.3	35.6	34.4
M_2 - Ridge & furrow	1871	1779	2076	2125	2195	2009	36.7	35.4	35.8	37.0	37.3	36.4
M_3 - Broad bed	1687	1590	1898	1938	2004	1823	36.2	35.1	35.5	36.7	35.7	35.8
M_4 - Poly mulch on broad bed	2018	1888	2293	2346	2370	2183	36.8	36.5	36.6	37.6	38.2	37.1
Mean	1785	1676	1990	2042	2103	1919	36.2	35.1	35.2	36.6	36.7	36.0
		Main	**Sub**	**MXS**	**SXM**			**Main**	**Sub**	**MXS**	**SXM**	
S.Em±		26	21	18	29			0.3	0.1	0.3	0.4	
C.D at 5%		89	68	53	100			1.2	0.5	0.9	1.4	
CV		7.2						7.1				

Sub treatments (S) S_1: Farmers practice, S_2: 100% RDF, S_3: 125% RDF, S_4: 100% RDF + FYM equivalent to 25% RDN, S_5: 100% RDF + Press mud equivalent to 25% RDN

Table 2: Influence of moisture conservation practices and INM on quality of Bt cotton

Treatments	Quality parameters (Pooled data of 2015 and 2016)											
	Uniformity ratio						Fibre strength (g tex^{-1})					
	Sub plots											
Main treatments	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**
M_1 - Flat bed (control)	44.3	43.9	43.9	45.0	45.1	44.4	22.0	20.8	21.2	22.2	22.5	21.7
M_2 - Ridge & furrow	45.7	45.6	45.5	45.7	45.5	45.6	22.4	22.5	23.1	23.7	24.1	23.1
M_3 - Broad bed	45.2	44.9	44.4	45.3	45.4	45.0	22.6	21.7	21.9	22.5	23.9	22.5
M_4 - Poly mulch on broad bed	45.7	45.6	45.7	45.7	46.0	45.7	24.1	23.1	23.6	24.5	24.6	24.0
Mean	45.2	45.0	44.9	45.4	45.5	45.2	22.8	22.0	22.4	23.2	23.8	22.8
		Main	**Sub**	**MXS**	**SXM**			**Main**	**Sub**	**MXS**	**SXM**	
S.Em±		0.2	0.1	0.1	0.2			0.4	0.1	0.2	0.5	
C.D at 5%		0.7	0.2	0.4	0.7			1.5	0.4	0.7	1.6	
CV		6.6						7.2				

Sub treatments (S) S_1: Farmers practice, S_2: 100% RDF, S_3: 125% RDF, S_4: 100% RDF + FYM equivalent to 25% RDN, S_5: 100% RDF + Press mud equivalent to 25% RDN

Table 3: Influence of moisture conservation practices and INM on quality of Bt cotton

Treatments	Fibre fineness (micronaire)	Fibre length (mm)
Main treatments		
M_1 – Flat bed (control)	3.44	31.2
M_2 – Ridge & furrow	3.7	32.2
M_3 – Broad bed and furrow	3.56	31.9
M_4 – Poly mulch on broad Bed	3.79	32.8
S.Em±	0.09	0.6
CD at 5%	NS	NS
Sub treatments		
S_1	3.61	32.1
S_2	3.53	31.7
S_3	3.56	31.8
S_4	3.68	32.2
S_5	3.73	32.4
S.Em±	0.05	0.2
CD at 5%	NS	
CV	9.5	NS
Interaction		
M XS		
S.Em±	0.1	0.4
CD at 5%	NS	NS
S X M		
S.Em±	0.1	0.6
CD at 5%	NS	NS

Sub treatments (S) S_1: Farmers practice, S_2: 100% RDF, S_3: 125% RDF, S_4: 100% RDF + FYM equivalent to 25% RDN, S_5: 100% RDF + Press mud equivalent to 25% RDN

Table 4: Economics of *Bt* cotton as influenced by moisture conservation and integrated nutrient management practices.

Sub treatments ((Pooled data of 2015 and 2016))						
Cost of cultivation(` ₹ ha^{-1})						
	S1	**S2**	**S3**	**S4**	**S5**	**MEAN**
M_1 - Flat bed (control)	47890	41134	42495	49344	46168	45406
M_2 - Ridge & furrow	49090	42334	43695	50544	47368	46606
M_3 - Broad bed	48690	41934	43295	47455	46968	45668
M_4 - Poly mulch on broad bed	53429	45423	48034	54883	51707	50695
Mean	49775	42706	44380	50556	48052	47094
Gross returns(` ₹ ha^{-1})						
M_1 - Flat bed (control)	63851	58996	69096	71672	75152	67753
M_2 - Ridge & furrow	76294	72537	84632	86649	89462	81915
M_3 - Broad bed	68791	64826	77384	79044	81722	74353
M_4 - Poly mulch on broad bed	82272	76964	93470	95623	96617	88989
Mean	72802	68330	81146	83247	85738	78252

Table 5: Effect of moisture conservation practices and INM on economics of Bt cotton

Treatments	**Economics**											
	Net returns(` ₹ ha^{-1})						**B:C ratio**					
	Sub plots											
Main treatments	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**
M_1 - Flat bed (control)	15911	17818	26556	22281	28935	22300	1.33	1.43	1.63	1.45	1.63	1.49
M_2 - Ridge & furrow	27160	30153	40895	36063	42058	35266	1.55	1.71	1.94	1.71	1.89	1.76
M_3 - Broad bed	20055	22852	34035	31533	34702	28635	1.41	1.55	1.79	1.67	1.74	1.63
M_4 - Poly mulch on broad bed	28805	31499	45392	40696	44864	38251	1.54	1.69	1.95	1.74	1.87	1.76
Mean	22983	25581	36720	32643	37640	31113	1.46	1.60	1.83	1.65	1.78	1.66
		Main	Sub	MXS	SXM			Main	Sub	MXS	SXM	
S.Em±		685	787	729	883			0.03	0.03	0.05	0.06	
C.D at 5%		2369	2566	2128	3057			0.1	0.1	0.2	0.2	
CV		9						7.6				

Sub treatments (S) S_1: Farmers practice, S_2: 100% RDF, S_3: 125% RDF, S_4: 100% RDF + FYM equivalent to 25% RDN, S_5: 100% RDF + Press mud equivalent to 25% RDN

Conclusion

On the basis of two years field experimentation, it was concluded that maximum yield, quality and economics from Bt cotton can be obtained by application of pressmud or FYM equivalent to 25% RDN or 125% RDF with *in-situ* moisture conservation practice (poly mulch on broad bed) in red soils of Telangana.

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