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Efficient land configurations and nutrient management in *Bt* cotton (*Gossypium herbaceum*)

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ABSTRACT

Field experiments were conducted during rainy (*kharif*) season, 2015 and 2016 to assess the impact of land configurations and nutrient management on *Bt* cotton (*Gossypium herbaceum* L.) at College Farm, College of Agriculture, Rajendranagar, Professor JayashankarTelangana State Agricultural University, Hyderabad, Telangana. Treatments consisted of four land configurations, viz. flat bed sowing, ridge and furrow, broad bed and furrow (BBF) and BBF laid with poly mulch as main plots and five nutrient management treatments in sub plots, viz. farmer's practice, 100% RDF-150:60:60 NPK kg/ha, 125% RDF, 100% RDF along with 25% N through farmyard manure and 100% RDF along with 25% N through pressmud laid out in triplicated strip plot design. Results revealed that yield attributes (bolls per plant and boll weight), seed cotton yield and field water use efficiency were significantly higher with BBF with poly mulch along with application of 100% RDF + 25% RDN through organics (pressmud or FYM) comparable to BBF laid with poly mulch and application of 125% RDF through inorganics. Soil moisture extraction by crop was higher from 0–15 cm and 15–30 cm depth in poly mulch + BBF over other land configurations.

Keywords: Broad bed and furrow, Field water use efficiency, Moisture extraction, Poly mulch, Pressmud, Seed cotton yield

Cotton (*Gossypium hirsutum* L.), the most important fibre crop constitutes livelihood for millions of people through cultivation, trade, transportation, ginning and processing. *Bt* cotton hybrids occupied an area of 96.14 lakh ha (88%) out of 110.0 lakh ha. During 2020–21, higher area (4.54 million ha) and production (10.1 million bales) were recorded in Maharashtra while, higher productivity was with Punjab (690 kg/ha). Telangana state ranked second in the area (2.35 million ha), producing 5.7 million bales and productivity of 418 kg/ha (CCI 2021).

Although recommended for black soils, owing to commercial importance more than 65% of cotton is grown in red soils with limited or no irrigation. Scanty rainfall with erratic distribution fails to synchronize with the evapotranspiration demand of crops in drylands. Hence, effective rainwater management through *in situ* agronomic practices, viz. furrow opening, intercropping, mulching, incorporating organic matter and other practices are crucial for achieving sustainable yields (Gokhale *et al.* 2012). Mulching significantly reduces the evaporation losses (Fuchs and Hadas 2011) and plastic mulches save 40–50% of soil moisture (Nalayini *et al.* 2009).

Imbalanced nutrient management and continuous use of high analysis fertilizers is another important agronomic factor apart from poor soil moisture for reduced cotton yields. Conjunctive application of inorganics and organics is crucial and need of the hour to achieve higher yields apart from sustaining soil health. Availability of farmyard manure (FYM) is becoming scarce due to insufficient or no maintenance of the farm cattle population. Due to high nutrient content, pressmud, a by-product of the sugarcane industry, is assumed as a potent alternative for an organic source (Ghulam *et al.* 2012). With the aforefacts, the current experiment was undertaken to investigate the *Bt* cotton performance under various land configurations and nutrient management strategies in Alfisols.

MATERIALS AND METHODS

Field investigations were carried out at College Farm, College of Agriculture, Rajendranagar, Professor

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Jayashankar Telangana State Agricultural University, Hyderabad, Telangana (17º19' N, 78º23' E and at an altitude of 542 m amsl) during rainy seasons, 2015 and 2016. Experiment soil was sandy loam in texture with *p*H 7.33, low available N (182 kg/ha), medium P_2O_5 (46.8 kg/ha) and high K_2O content (432 kg/ha). The experiment was laid down in strip plot design and replicated thrice. Gross and net plot size were 7.2 m × 5.4 m and 5.4 m × 4.2 m, respectively. Treatment comprised of 4 different land configuration, viz. M1, Flat bed (control); M2, Ridge and furrow; M3, Broad bed furrow; M4, Poly mulch on broad bed furrow as main plots and 5 nutrient management practices as sub plots, viz. S1, Farmer's practice; S2, 100% RDF; S3, 125% RDF; S4, 100% RDF + FYM equivalent to 25% RDN and; S5, 100% RDF + Pressmud equivalent to 25% RDN, respectively. In 2015 and 2016, *Bt* hybrid Neeraja (*Bt*-II) seed was sown at 1 seed/hill on July 7th and July 2nd, respectively. In Telangana state, 150:60:60 N, P_2O_5, and K_2O kg/ha of fertilizer was recommended for cotton. Following a survey of the management of nutrients in 30 cotton-growing farmer's fields in Telangana and the nutrient management in farmer's practice was fixed at 3.75 tonnes FYM/ha and 184-101-92 kg N, P_2O_5 and K_2O/ha. The nitrogen content in pressmud and FYM was 1.92, 2.24% and 0.49 and 0.72% during 2015 and 2016, respectively. The spacing between the ridges and furrows was 90 cm. While, in BBF treatment, elevated (broad) beds measuring 120 cm in width and 60 cm in length were laid out (M3 and M4) and polythene mulch with a thickness of 25 microns was spread before the crop was sown on the raised (wide) beds. During 2015 and 2016, there were 27 and 37 rainy days, respectively, with a total of 375.3 and 741.1 mm rainfall. The crop was harvested on 10th December and 6th December during 2015 and 2016. Cumulative yield from each picking was used to calculate total seed cotton yield (kg/ha). Data was statistically analyzed using the analysis of variance technique as outlined by Panse and Sukhatme (1967).

Moisture retention capacity of the experimental soil was estimated using pressure plate apparatus (Richards 1949) and was -0.1 M Pa (Field capacity) and -1.5 M Pa (Permanent wilting point) and the bulk density was estimated using the core sampler method for every 15 cm of soil depth up to 60 cm. By summing the moisture content of each layer, the total quantity of moisture stored in the 0–60 cm soil profile was calculated to be 104.9 mm. The total amount of moisture storage in 0–60 cm soil profile was computed by adding the moisture content of each layer is 104.9 mm. The field capacity (%), permanent wilting point (%), bulk density (g/cc) and total available soil moisture (mm) in 0–15 cm is (20.5, 9.5, 1.57, 25.9), 15–30 cm (21.0, 10.0, 1.58, 26.1), 31–45 cm (21.5, 10.6, 1.61, 26.3) and 46–60 cm (21.7, 10.9, 1.64, 26.6), respectively. After each irrigation, soil samples were taken at different depths (0–15, 15–30, 30-45 and 45–60 cm) at 30, 60, 90 and 120 DAS as well as during harvest to assess the soil moisture gravimetrically (Dastane *et al.* 1972). Soil moisture extraction pattern (SME) expressed as a percentage of soil moisture extracted from each layer of effective crop root zone depth (60 cm) during the crop growing season. Field water use efficiency (FWUE) was calculated as ratio of economic yield (kg/ha) achieved to amount of water applied (mm). A total of three (150 mm) and two (100 mm) irrigations were scheduled during 2015 and 2016, respectively. Effective rainfall was calculated to estimate FWUE (USDA method 1967).

RESULTS AND DISCUSSION

Bolls per plant and boll weight (g): Perusal of the data (Table 1) revealed that interaction of land configurations and nutrient management practices was significant on mean number of bolls and boll weight. BBF laid with poly mulch and 100% RDF in conjunction either with 25% RDN through pressmud or FYM recorded a significantly higher number of bolls (30.3 and 30.1) and boll weight (6.2 and 6.0 g). The improvement in no. of bolls was 72.15 and 71.0% and boll weight was 44.19 and 39.53%, respectively in these treatments over flat bed (control) + farmer's practice. The increase in the number of bolls and boll weight in these treatments was probably due to the conservation of moisture and release of major and micronutrients from organics apart from better partitioning of assimilates (Halemani *et al.* 2009, Narkhede *et al.* 2015, Diaz 2016).

Seed cotton yield (SCY): An overview of pooled data on seed cotton yield revealed that it was relatively higher during 2016 over 2015 on account of higher amount of rainfall received coupled with higher soil moisture content (Table 2). Interaction effect on a pooled basis indicated that, mean SCY was significantly higher with poly mulch on BBF applied either with 25% RDN through pressmud (2370 kg/ha) or FYM (2346 kg/ha). The yield advantage with these treatments was to the extent of 63.8 and 62.1% over flat bed sowing and Farmer's practice of nutrient management, which recorded the lowest SCY (1447 kg/ha). This indicated that poly mulch was more effective with an additional fertilizer dose of 25% equivalent RDF applied either through organic (pressmud or FYM) or inorganic source. Improved SCY under BBF laid with poly mulch might be ascribed to the adequate and extended moisture retention in the root zone of the soil coupled with slow N mineralization from organic manures and additional doses of inorganic N that lead to higher uptake of nutrients and yield attributes. These results are in conformity with Hugar and Halemani (2010), Tayade *et al.* (2012), and Patel *et al.* (2015).

Field water use efficiency (FWUE): Applied water was 430.4 and 654.2 mm during 2015 and 2016 respectively, with sum total of rainfall (375.3, 741.1 mm), effective rainfall (280.4, 554.2 mm) and irrigation (150, 100 mm @50 mm/irrigation). Data revealed that FWUE was higher during 2015 as compared to 2016 indicating that applied water (430.4 mm) was efficiently utilized in 2015 over 2016 (654.2 mm). Based on the pooled results, it was evident that BBF laid with poly mulch achieved a noticeably greater FWUE (4.14 kg/ha-mm), which could be ascribed to the improved seed cotton yield coupled with lower evaporation loss (Fig 1).

Table 1 Effect of land configuration and nutrient management on bolls per plant and boll weight of *Bt* cotton

Treatment	No. of bolls per plant (2015)						No. of bolls per plant (2016)						No. of bolls per plant Pooled					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
M1	17.7	16.1	20.8	21.3	22.0	19.6	21.6	19.2	21.8	22.6	23.9	21.8	19.7	17.6	21.3	22.0	23.0	20.7
M2	23.4	22.4	25.6	26.4	26.8	24.9	24.8	23.3	26.7	27.5	28.3	26.1	24.1	22.9	26.2	27.0	27.5	25.5
M3	21.4	20.3	23.9	24.6	25.1	23.1	22.6	21.5	24.6	25.3	26.4	24.1	22.0	20.9	24.3	25.0	25.7	23.6
M4	27.3	26.0	28.8	28.8	28.8	27.9	27.6	26.0	30.9	31.4	31.8	29.5	27.5	26.0	29.9	30.1	30.3	28.7
Mean	22.5	21.2	24.8	25.3	25.7	23.9	24.2	22.5	26.0	26.7	27.6	25.4	23.3	21.8	25.4	26.0	26.6	24.6
		Main	Sub	M × S	S × M			Main	Sub	M × S	S × M			Main	Sub	M × S	S × M	
SEm±		0.4	0.3	0.3	0.5			0.5	0.3	0.3	0.5			0.4	0.2	0.2	0.4	
CD (P=0.05)		1.5	0.8	0.8	1.6			1.6	0.9	0.9	1.8			1.4	0.7	0.4	1.5	
CV		7.9						8.1						7.5				
Treatment	*Boll weight (g) 2015*						*Boll weight (g) 2016*						*Boll weight (g) Pooled*					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
M1	4.4	4.1	4.6	4.7	4.1	4.4	4.9	4.5	5.0	4.9	5.0	4.9	4.7	4.3	4.8	4.8	4.6	4.7
M2	5.0	4.7	5.4	5.6	5.6	5.3	5.4	5.3	6.0	6.0	6.2	5.8	5.2	5.0	5.7	5.8	5.9	5.6
M3	4.7	4.6	5.0	5.2	5.8	5.0	5.1	5.0	5.4	5.6	6.0	5.4	4.9	4.8	5.2	5.4	5.9	5.2
M4	5.6	5.3	5.8	5.8	5.9	5.7	6.2	5.7	6.2	6.2	6.5	6.2	5.9	5.5	6.0	6.0	6.2	6.0
Mean	4.9	4.7	5.2	5.3	5.3	5.1	5.4	5.1	5.7	5.7	5.9	5.5	5.2	4.9	5.5	5.5	5.6	5.3
		Main	Sub	M × S	S × M			Main	Sub	M × S	S × M			Main	Sub	M × S	S × M	
SEm±		0.1	0.2	0.2	0.2			0.1	0.1	0.1	0.2			0.1	0.1	0.2	0.2	
CD (P=0.05)		0.4	0.4	0.5	0.5			0.3	0.3	0.3	0.4			0.3	0.3	0.4	0.5	
CV		8.7						7.2						7.9				

Treatment details given under Materials and Methods.

Table 2 Effect of land configurations and nutrient management on seed cotton yield (kg/ha) of *Bt* cotton

	Sub treatment					
Main treatment	S_1	S_2	S_3	S_4	S_5	Mean
			2015			
M1	1369	1269	1514	1571	1644	1474
M2	1696	1583	1909	1958	2052	1840
M3	1508	1430	1682	1714	1797	1626
M4	1864	1723	2118	2171	2185	2012
Mean	1609	1502	1806	1854	1920	1738
		Main	Sub	M × S	S × M	
SEm±		43	25	19	45	
CD (P=0.05)		150	81	55	157	
CV		9.6				
			2016			
Main treatment	S_1	S_2	S_3	S_4	S_5	Mean
M1	1762	1624	1875	1944	2042	1849
M2	2046	1974	2243	2293	2337	2179
M3	1866	1750	2114	2162	2212	2021
M4	2172	2052	2468	2520	2555	2353
Mean	1962	1850	2175	2230	2286	2100
		Main	Sub	M × S	S × M	
SEm±		37	24	27	42	
CD (P=0.05)		127	78	78	145	
CV		8.4				
			Pooled (2015 and 2016)			
Main treatment	S_1	S_2	S_3	S_4	S_5	Mean
M1	1566	1447	1695	1758	1843	1662
M2	1871	1779	2076	2125	2195	2009
M3	1687	1590	1898	1938	2004	1823
M4	2018	1888	2293	2346	2370	2183
Mean	1785	1676	1990	2042	2103	1919
		Main	Sub	M × S	S × M	
SEm±		26	21	18	29	
CD (P=0.05)		89	68	53	100	
CV		7.2				

Treatment details given under Materials and Methods.

These results are consistent with those of Mukherjee *et al.* (2010). The existence of moisture conservation structures (furrows) that operate as a barrier to runoff water and harvest the most rain water into the soil may be the cause of higher FWUE with ridge and furrow and BBF. These results were in accordance with Nalayini *et al.* (2009).

Application of 100% RDF + pressmud equivalent to 25% RDN (3.98 kg/ha-mm), which was statistically comparable to 100% RDF + FYM equivalent to 25% RDN had highest FWUE among various nutrient management techniques. On the contrary, lowest moisture use efficiency was with 100% RDF alone (3.16 kg/ha-mm). Interaction data on a pooled basis indicated that FWUE was greater in BBF laid with poly mulch and applied with 100% RDF + 25% RDN through pressmud (4.5 kg/ha-mm) and was statistically at par (4.45 kg/ha-mm) with 100% RDF + 25% RDN through FYM with poly mulch on BBF.

Evapotranspiration (ETc) and moisture extraction pattern: Comparison of data from 2015–2016 indicated that the cumulative evapotranspiration was greater in 2016. This could be explained by the fact that higher rainfall in 2016 led to soil layers with higher soil moisture content, which increased crop ETc. Furthermore, a healthy plant population and good soil moisture range contributed to increased plant growth, which reflected in higher ETc. Poly mulch on broad bed recorded high cumulative ETc of 338.8 mm in 2015 and 350.5 mm in 2016, while, flat bed recorded the lowest ETc of 303.7 mm in 2015 and 312.7 mm in 2016. The flat bed approach registered comparatively lower crop ETc due to lower soil moisture storage. Flat bed method of sowing need to be avoided since, cotton is a long-lasting crop that requires conservation of soil moisture through better land configuration. Both the broad bed method and ridge and furrow method of sowing showed equal ETc values during 2015–2016 (335.9 and 330.3, respectively). This was corroborated by Ambika *et al.* (2017), who claimed that both these approaches were efficient *in situ* moisture conservation methods.

From the interaction data on ETc it was clear that plots with BBF laid with poly mulch along with combined use of 100% RDF + 25% RDN via organics (pressmud or FYM) and 125% RDF through inorganics revealed higher values of ETc during 2015 (352.8, 344.5 and 339.6 mm) and during 2016 (366.2, 357.0 and 351.2 mm), respectively and the lowest ETc was registered with flat bed with 100% RDF (289.4 and 294.3 mm) during 2015 and 2016. These results are in line with those of Satyanarayana Rao and Janawade (2009).

All the land configurations had recorded higher soil moisture content over flat bed method. Among the treatments, BBF laid with poly mulch extracted maximum soil moisture from the top soil depth 0–15 cm (41.82 and 44.02%) and from 15–30 cm depth (30.80 and 32.0%) and it decreased gradually with each successive increment in depth and the lowest moisture extraction was registered from 45–60 cm soil depth (9.18 and 7.59%) during 2015 and 2016, respectively (Fig 2a and b). This could be attributed to the reduced evaporation rate in the mulched plots that retained higher soil moisture in the top soil layers and reflected in higher seed cotton yield owing to adequate moisture availability (Snowden *et al.* 2013).

On the other hand, crop raised in ridge and furrow, BBF plots extracted relatively lesser moisture from the top 0–15 and 15–30 cm layers. Lower soil moisture availability in the upper quarter of the root zone resulted in low soil moisture extraction. The soil moisture extraction increased gradually up to 120 days and thereafter, it declined due to crop senescence and leaf fall. These findings are consistent with those of Sarkar *et al.* (2007), who found

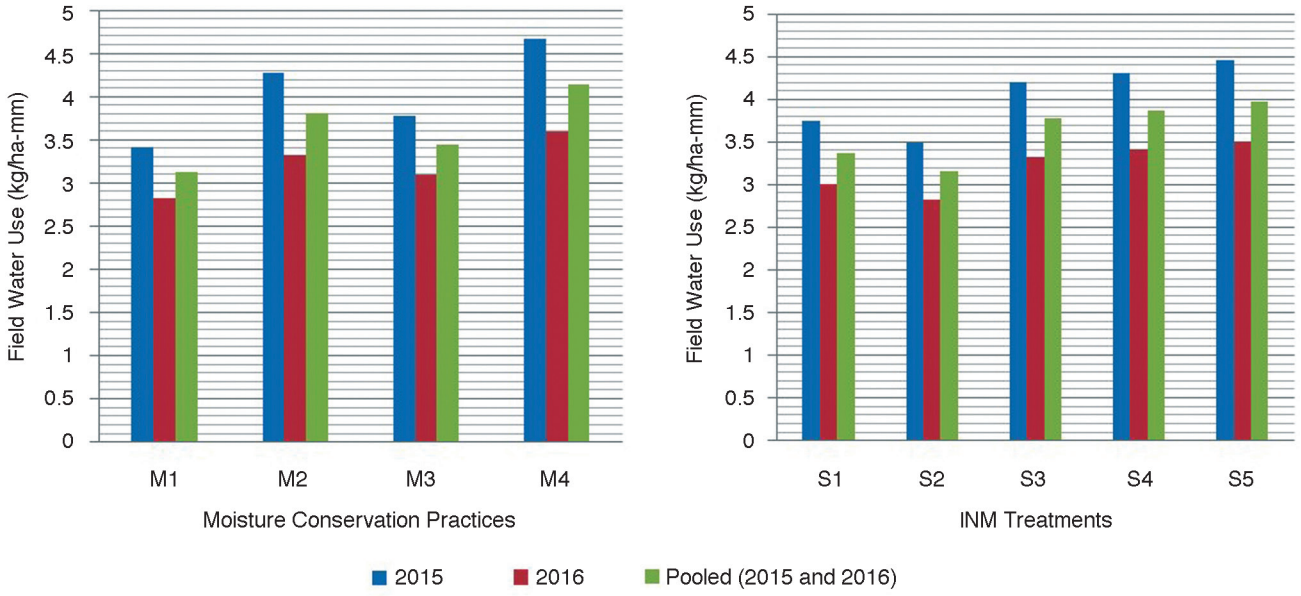

Fig 1 Effect of land configuration and nutrient management on field water use efficiency (kg/ha-mm) of *Bt* cotton. Treatment details given under Materials and Methods.

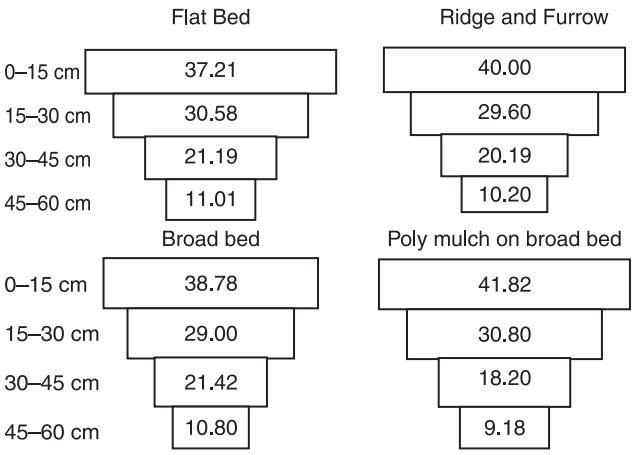

Fig 2a Moisture extraction pattern (%) by *Bt* cotton as influenced by land configurations during 2015.

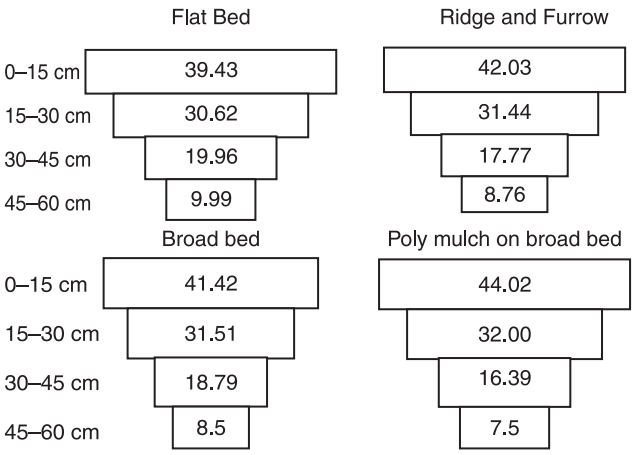

Fig 2b Moisture extraction pattern (%) by *Bt* cotton as influenced by land configurations during 2016.

that soil moisture depletion in mulched treatment from the upper soil layer (0–15 cm) over non-mulched plots. This could be attributed to higher soil moisture conservation in mulched plots that encouraged better root proliferation and reflected in higher transpiration rate. Contrary to the land configuration treatments, nutrient management practices exerted a relatively lesser effect on soil moisture extraction. Among the nutrient management treatments, lower moisture extraction was recorded at different soil depths in plots applied with 100% RDF alone as compared to rest of the nutrient management treatments.

It can be concluded that adoption of BBF laid with poly mulch or ridge furrow method and conjunctive application of 100% RDN + 25% RDN through pressmud or FYM organics in *Bt* Cotton hybrid resulted in higher no. of bolls, boll weight, seed cotton yield and field water use efficiency in Alfisols of Telangana.

REFERENCES

Ambika V, Yadahalli G S, Chittapur B M, Shamrao Kulkarni, Vidyavathi G Yadahalli and Siddu Malakannavar. 2017. Influence of land configurations and nutrient levels on growth, yield and economics of *Bt* Cotton. *International Journal of Current Microbiology and Applied Science* **6**(12): 3095–102.

CCI. 2021. Cotton Corporation of India. http://cotcorp.gov.in/statistics.aspx.

Dastane. 1972. *A practical Manual for Water Use Research in Agriculture*. Navabharat Prakashan, Pune.

Diaz P M. 2016. Consequences of compost pressmud as fertilizers. *DJ International Journal of Advances in Microbiology & Microbiological Research* **1**(1): 28–32.

Fuchs M and Hadas A. 2011. Mulch resistance to water vapour transport. *Agricultural Water Management* **98**: 990–98.

Ghulam S, Khan M J, Usman K and Ullah S. 2012. Effect of different rates of pressmud on plant growth and yield of lentil in calcareous soil. *Sarhad Journal of Agriculture* **28**(2): 249–52.

Gokhale D N, Chavan A S and Raskar S K. 2012. Influence of *in situ* soil moisture conservation and INM techniques on yield and economics of rainfed *Bt* cotton. *Journal of Cotton Research and Development* **26**(2): 190–93.

Halemani H L, Hugar A Y, Aladakatti Y R and Nandagavi R A. 2009. Studies on the effect of polyethylene mulching on cotton genotypes under rainfed conditions. Influence on growth, yield components and seed cotton yield. *Karnataka Journal of Agricultural Sciences* **22**: 280–83.

Hugar A Y and Halemani H L. 2010. Influence of polyethylene mulching on soil moisture, nutrient uptake and seed cotton yield. *Indian Journal of Agriculture Research* **44**: 189–94.

Mukherjee A, Kundu M and Sarkar S. 2010. Role of irrigation and mulch on yield, evapotranspiration rate and water use pattern of tomato (*Lycopersicon esculentum* L.). *Agricultural Water Management* **98**: 182–89.

Nalayani P, Anandham R, Sankarnarayanan K and Rajendran T P. 2009. Polyethylene mulching for enhancing crop productivity and water use efficiency in cotton (*Gossypium hirsutum*) and maize (*Zea mays*) cropping system. *Indian Journal of Agronomy* **54**(4): 409–14.

Narkhede W N, Nayak S, Sutar V K and Jaware B H. 2015. Effect of land configuration and nutrient management on yield, quality and moisture use efficiency of *Bt* cotton. *Agriculture for Sustainable Development* **3**(1): 60–63.

Panse V G and Sukhatme P V. 1967. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi, India.

Patel P, Patel J C, Mehta R S and Vyas K G. 2015. Response of *Bt* and non *Bt* cotton (*Gossypium hirsutum* L.) hybrids to varying sowing time. *Journal of Cotton Research* **29**(2): 273–76.

Richards L A. 1949. Methods of measuring soil moisture tension. *Soil Science* **68**(1): 95.

Sarkar S, Pramanick M and Goswami S B. 2007. Soil temperature, water use and yield of yellow sarson (*Brassica napus* L.) in relation to tillage intensity and mulch management under rainfed low land ecosystem in eastern India. *Soil and Tillage Research* **93**: 94–01.

Satyanarayana Rao and Janawade A D. 2009. Influence of integrated nutrient management practices on physico-chemical properties of cotton growing soils. *Journal of Cotton* Research and Development **23**(1): 60–63.

Snowden C, Ritchie G and Thompson T. 2013. Water use efficiency and irrigation response of cotton cultivars on subsurface drip in West Texas. *The Journal of Cotton Science* **17**: 1–9.

Tayade A S and Dhoble M V. 2012. Effect of *Bt* and non *Bt* cotton hybrids, nutrient and pest management on ginning outturn, seed and lint indices. *Journal of Cotton Research and Development* **26**(1): 96–98.

USDA. 1967. Irrigation water requirements. Tech. Release No. 21, United States Department of Agriculture. *Soil Use and Management* **59**: 67–75.