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Impact of soil depth and management on performance of Bt cotton in *Alfisols*

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Abstract
On farm trials were conducted for three consecutive years (2013 to 2016) under rain fed conditions in Basavanagiri A and B haadi of H. D. Kote, Karnataka, to compare performance of different Bt cotton hybrids in red soils consisted of shallow, medium deep and deep soils with best management practice (BMP) and farmer's practice (FP). Results revealed that seed cotton yields were increased with soil depth. Hybrid Bahubali produced higher number of bolls per plant (38.2) and Minerva recorded maximum boll weight (4.1g). Highest seed cotton yield (9.7qha-1) was associated with BMP. Among interactions, hybrids performed better in the deep soils with BMP. Yield differences between soils and hybrids were greater due to soil conditions and genotypic effect respectively. Growing of bt cotton hybrids in deep red soils with BMP found more productive for Southern transition zone of Karnataka plateau.

Keywords: best management practice, Bt cotton hybrids, red soils, seed cotton yield

Introduction
Cotton the king of fibers, is one the most important commercial crops of India. India is the only country to grow all four species of cultivated cotton. *Gossypium hirsutum* L. represents more than 90 per cent of the hybrid cotton production in India and all the current Bt cotton hybrids are *G. hirsutum.* The yield per hectare which was stagnant at about 300 kg ha^{-1} for so many years, jumped to 472 kg in the year 2005-06 and now it reached to the level of 482 kg to 568 kg ha^{-1}. In Karnataka, cotton area increased from 3.9 to 8.1 lakh ha between 2002 to 2014-15, of which 95 per cent of cotton area is under Bt cotton (7.7 lakh ha). Several recent studies reported that benefits from adopting the Bt cotton hybrids in terms of increase in yields with decreased production costs, reduction in pesticide use and plant-protection costs, improved population of beneficial insects, substantial environmental and health benefits to farmer along with socio-economic benefits [1, 2, 9, 13]. The special features of Bt cotton such as shorter crop duration, compact crop canopy, synchronized boll bursting, capable of accommodating a higher plant population per unit area and to withstand high fertility conditions [18]. Cotton cultivation in Mysore district of Karnataka is mostly on red soils, soil depth varies from shallow to very deep. Farmer's prefer to grow cotton in all types of soils, though Bt. cotton is suitable to grow in medium deep to deep soils [11, 12, 19]. Participatory Rural Appraisal (PRA) exercises during 2012, in study area identified poor crop yield and low profit due to growing of cotton in all soil types, heavy incidence of sucking pests and non-availability of quality seeds of Bt. cotton hybrids are the serious constraints faced by the farmers. Hence, on-farm studies have been initiated to evaluate and identify suitable red soils (Alfisols) for Bt cotton hybrids and management strategy.

Materials and Methods
Field studies were carried out during the *kharif* season (monsoon) for three consecutive years (2013-14, 2014-15 and 2015-16) at Basavanagiri A and B haadi (12^{0}10'65" to 12^{0}11'36"N Latitude and 76^{0}26'83" to 76^{0}27'29"E Longitude) of H.D. Kote, Mysore district, Karnataka, India. Prior to the field trials, preliminary traverse was carried out by using 1: 5000 cadastral maps and drawn topo-sequences to locate profile points in a transect. The slope varied from 3 to 8 per cent and shallow soils were severely degraded. Profiles were opened at shallow, medium deep and deep soil sites and their morphology was studied as outlined by Soil Survey Staff (2006) [16]. Horizon wise collected soil samples were processed and analyzed for different physicochemical properties by following standard procedures. The soil characteristics of profiles of the study area are presented in Table 1.
During the three consecutive years of on-farm trial studies, three red soils (shallow, medium deep and deep), four popular hybrids of Bt cotton produced from different companies namely

Bahubali, Minerva, 6188 and Mahadev (produced from Mahyco, Boyers bio-seeds research and US agri-seeds, respectively) and two management practices (BMP and FP) were compared. Each experiment site consisted of 0.4 ha area. There were three farmers on each soil, which served as replications. Sowing was done with the onset of monsoon (last week of April) in all the years. The experimental sites were invariably rain fed, no additional irrigation was given during cropping season. The Best Management Practice (BMP) consisted of sowing of high yielding good quality Bt hybrids with 90 x 60 cm spacing, 3-4 times intercultivation (Crisscross harrowing) and dead furrows were opened at final harrowing perpendicular to slope, application of soil test based NPK. As per recommendations 150 kg N: 75 kg P2O5: 75 kg K2O ha-1 was calculated and applied through urea, single super phosphate and murate of potash. 50 per cent of N and 100 per cent of P and K was applied as basal dose at the time of sowing and remained N was top dressed at 60 days after sowing (DAS). To protect crop from pest (in particular jassids and aphids) infestation dimethoate 30EC @ 1.7ml ltr-1 insecticide was sprayed at 30 DAS. Whereas, farmers practice (FP) comprises of planting of locally available Bt cotton hybrids sowing at a spacing 90 x 90 cm, 3-4 times harrowing as inter cultivation and application of 100kg of DAP or urea per ha. At harvest, 10 plants were randomly selected for recording number of bolls plant -1and boll wt. Seed cotton yield per ha was estimated by multiplying 2.5 for yield of 0.4 ha.

The data was analyzed by using Factorial design, considering soils as one factor, hybrids as second factor and management practices as third factor [7] by using WASP 2.0 software (www.ccari.res.in). Correlation and regression analysis was done using MS-Excel.

Results and Discussions

Year effects on yield

Bt cotton hybrids performance was largely influenced by soils, genetic potential of hybrids and their response to different soils and management practices. Among years, though all three years of study period were normal years, received good amount of rainfall, in 2013-14 mean yields were comparatively lower than 2014-15 and 2015-16 (Fig.1). Despite of normal rainfall, the lower yields during 2013-14 mainly because of flowering period coincided with heavy rainfall (Fig. 1A), resulting in rotting and premature drop of flower buds.

Effects of soils on seed cotton yield

Seed cotton yield significantly increased with the soil depth in 2014-15 and 2015-16 (Table 2). However, deep soils were found to be best suited for Bt cotton with the highest yield potential of 9.9 q ha^{-1}. There was 39% and 45 % enhancement of seed cotton yield in medium deep and deep soils as compared to shallow soils respectively. Similar trend was also observed with respect to number bolls per plant and boll weight. Positive association of seed yield is essentially a pattern related to number of bolls per plant (26.5 to 34.0, pooled data) and boll wt (2.8 to 3.6 g boll^{-1}, pooled data) with increasing soil depth. Cotton being a long duration crop, has strong lateral and deep rooting pattern, prefers a deep, friable soil with a good fertility and moisture holding capacity. Deep soils with finer soil texture supports better root development and holds higher moisture in the solum [4], favouring increased nutrient availability and corresponding uptake by cotton plants ultimately results in high seed cotton yield [21]. In this study also, the better performance of Bt cotton in deep soils attributed to texture and depth. This is also evident from linear analysis, which indicated a strong positive association of soil depth and soil texture with seed cotton yield (Fig. 2).

Performance of hybrids

The four tested hybrids exhibited significant differences in seed cotton yield and yield related traits. Seed cotton yield ranged between 7.7 q ha^{-1} (6188) to 10.4 q ha^{-1} (Bahubali). Bahubali significantly out yield the other hybrids excelling 20-39% in seed cotton yield. Both Minerva and Mahadev equally productive, but were found superior to 6188 (Table 2).This differential performance of hybrids attributable to genetic potential of hybrids especially with respect to yield traits [15]. Hybrid Bahubali with 31-58% more boll number and Minerva with 32-41% more boll weight contributed to higher yields.

Effect of BMP on yield attributes and yield

BMP significantly increased the seed cotton yield and yield components except boll weight across the years. Maximum boll number per plant (34.5), corresponding 32 % higher seed cotton yield with BMP was observed over farmers practice (Table 2). There was strong positive association between number of bolls plant^{-1} and seed cotton yield (Fig. 2). The yield improvements with the BMP could be either or combination of appropriate seed rate, time of sowing, crop geometry, timely application of balanced NPK, weed and pest control, improved moisture availability due to adoption of moisture conservation techniques i.e., earthing up and opening of broad furrow at last harrowing. Opening of furrows in every row after the last inter cultivation found to be efficient for in situ soil moisture conservation in sole rainfed cotton areas [14]. Effective management of soil moisture is crucial for productivity gains of Bt cotton in rainfed areas [19]. A better available nutrient status of soil in BMP resulted in more number of bolls retained on the plant as compared to farmer's practice [6].

Interaction effects

The significant soil and hybrids interaction for seed cotton yield, number of bolls per plant and boll weight is attributed to differential response of hybrids to soil parameters. Bahubali grown on deep soils recorded significantly higher seed cotton yield (13.8 q ha^{-1}) followed by Minerva in medium deep soils (10.7 q ha^{-1}) with a yield enhancement of 89% and 64% respectively in comparison to shallow soils (Table 2). This was attributed to the variations in soil parameters like depth, texture, clay and organic carbon content and cation exchange capacity (Table 1).

The interaction effects of soil and management on seed cotton yield in 2014-15 and 2015-16 were statistically significant (Table 2). Seed cotton yield enhanced by 32% in shallow and medium deep soils with BMP, whereas it was only 13% in deep soils over farmers practice. BMP included balanced and split application of fertilizers resulted in timely availability of nutrients to cotton plants. Thus, yield response to management was more in shallow and medium deep soils as compared to deep soils [12].

There was significant hybrid and management interaction on boll number per plant and seed cotton yield all the years (Table 2). Bahubali produced significantly higher number of bolls plant^{-1} (44.1) followed by Mahadev (34.8) under BMP, whereas, Minerva produced least number of bolls plant^{-1} (21.1) under FP. This could be result of genotypic variability among hybrids and their response to management practice. Number of bolls per plant is the major determinant of seed cotton yield [4].

Soils, hybrids and management interaction on seed cotton yield were significant during 2014-15 and 2015-2016 (Table 2). Among treatments, growing of Bahubali in deep soils with BMP (S3V1M1) recorded significantly higher seed cotton yield followed by growing of Minerva in medium deep soils with BMP (S2V2M1) and S3V1M2. Similar trend was also observed with respect to number of bolls plant^{-1}. Bt cotton hybrids are nutrient exhausters and are more efficient in mobilizing photosynthates to reproductive sink [10] and also in retaining more bolls [8].

Table 1: Description of the soil profile characteristics of Basavanagari, H. D Kote, Karnataka

Soils	Soil depth	Texture	pH	EC	OC	Available				Exchangeable		DTPA extractable				CEC
						N	P_2O_5	K_2O	S	Ca	Mg	Cu	Fe	Mn	Zn	
	cm			dsm^{-1}	%	kg ha^{-1}			mgkg^{-1}	meq100g^{-1}		mgkg^{-1}				cmolkg^{-1}
Shallow soils	0-17	Sandy clay loam	6.60	0.04	1.19	188.2	21.4	304.5	1042.7	242.7	12.9	2.2	17.3	42.5	0.1	11.0
	17-45	Sandy clay loam	6.89	0.03	0.93	156.8	7.9	239.6	1169.7	325.4	6.4	3.1	15.2	25.9	0.1	14.0
Medium deep soils	0-19	Clay loam	8.33	0.14	1.04	125.4	16.1	308.4	3271.1	594.0	16.4	3.5	17.0	26.2	0.1	37.0
	19-38	Clay loam	7.93	0.13	0.48	62.7	1.1	244.2	2295.4	680.9	13.6	3.7	22.0	28.3	0.1	22.0
	38-72	clay	7.84	0.16	0.44	78.0	8.2	291.5	2800.8	725.7	18.6	3.9	20.8	28.4	0.5	28.0
	72-102	clay	8.43	0.19	0.22	62.7	2.5	382.1	3343.7	567.0	7.1	4.0	16.5	32.3	0.4	28.0
Deep soils	0-12	Sandy clay loam	6.11	0.03	1.41	109.8	16.8	244.3	1050.1	412.5	12.9	2.6	12.4	2.4	1.1	13.0
	12-36	Clay Loam	6.05	0.03	0.96	203.8	5.9	105.3	1085.2	530.7	15.0	2.2	13.8	4.1	0.6	15.0
	36-70	clay	6.33	0.03	0.63	188.2	8.3	106.4	1087.1	533.0	12.9	2.9	10.7	9.8	0.9	12.0
	70-106	clay	6.33	0.06	0.33	172.5	8.8	108.9	1248.8	518.0	14.3	1.7	19.0	7.1	0.5	16.0
	106-145	clay loam	6.67	0.05	0.18	172.5	8.2	112.4	1500.2	497.7	15.0	2.8	22.0	24.3	0.7	17.0

Relation between seed cotton yield, yield components and soils

Correlation and regression analysis is a statistical tool used to investigate the relationships between variables. Results of correlation analysis showed that significant and positive correlation for soil depth (r=0.712**), texture (r=0.464*) and number of bolls per plant (r=0.673**) with seed cotton yield (Table 3). Seed cotton yield is largely depend on yield attributes like boll number, boll weight [20] and soil parameters like soil depth and texture [21]. Further, number of bolls per plant had positive correlation with soil depth (r=0.547*) and texture (r=0.404*). When soil parameters are regressed on seed cotton yield, the coefficient of determination (R^2) revealed that 58% and 39% variation in the seed cotton yield per ha is due to soil depth and texture, respectively (Fig. 2 A & B). Among yield components, number of bolls/plant alone contributed to 60% of total seed cotton yield indicating strong positive association with yield (Fig. 2 C). These results are in consistent with Soomro *et al.*, 2005 and Copur (2006) [17, 5].

In summary, Bt cotton performs better in red deep soils having sandy clay loam to clay loam texture. Bahubali hybrid outperformed over other hybrids tested. Best management practice enhanced seed cotton yield and yield attributes of all hybrids and in all the soil depths. However, response to BMP was more in shallow soils than medium and deep soils. Growing of Bt cotton hybrids in deep red soils with BMP found more productive for Southern transition zone of Karnataka plateau.

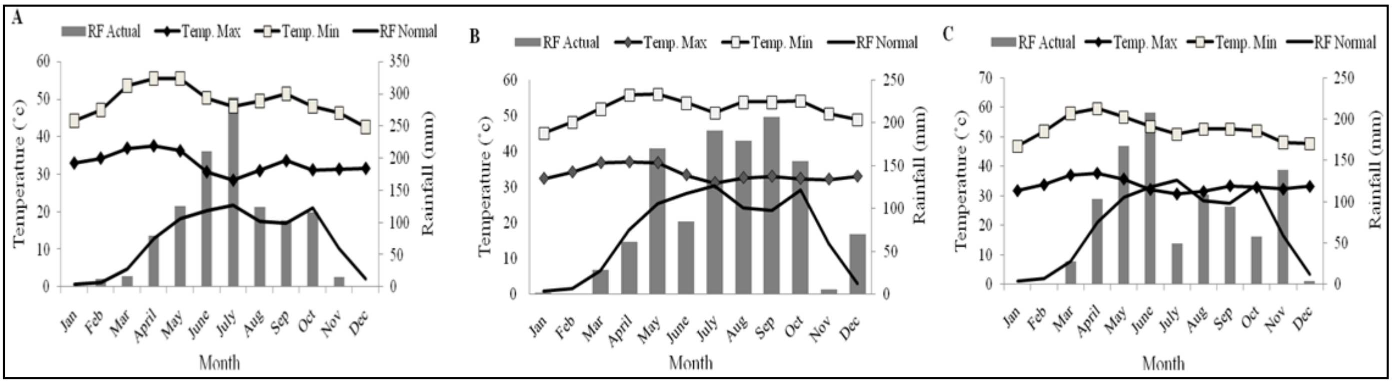


Fig 1: Monthly rainfall and temperature in the study area in 2013(A), 2014(B) and 2015 (C)

Table 2: Effect of soil depth, hybrids and management practices on yield attributes and seed cotton yield

	No.Bolls plant^{-1}				Boll wt. (g boll^{-1})				Seed cotton yield (q ha^{-1})			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
Soils												
S1-Shallow soil	23.5	28.3	27.9	26.5	2.9	2.9	2.8	3.0	6.0	7.2	7.1	6.8
S2-Modium deep soils	27.0	32.4	32.0	30.4	3.5	3.5	3.5	3.5	8.4	10.1	9.9	9.5
S3-Deep soils	30.2	36.2	35.9	34.0	3.1	3.6	3.6	3.5	8.8	11.0	10.8	9.9
CD (P=0.05)	1.15	1.40	1.60	1.38	0.27	0.18	0.20	0.30	0.61	0.14	0.15	0.73
Hybrids												
V1-Bahubali	33.8	40.8	40.2	38.2	3.0	3.0	3.0	3.1	9.3	11.2	11.0	10.4
V2-Minerva	21.4	25.8	25.5	24.1	4.0	4.0	4.0	4.1	7.6	9.1	8.9	8.6
V3-6188	26.4	31.7	31.5	29.8	2.9	3.0	3.0	2.9	6.8	8.7	8.5	7.7
V4-Mahadev	25.8	30.9	30.6	29.1	2.6	3.2	3.1	3.1	7.3	8.8	8.6	8.2

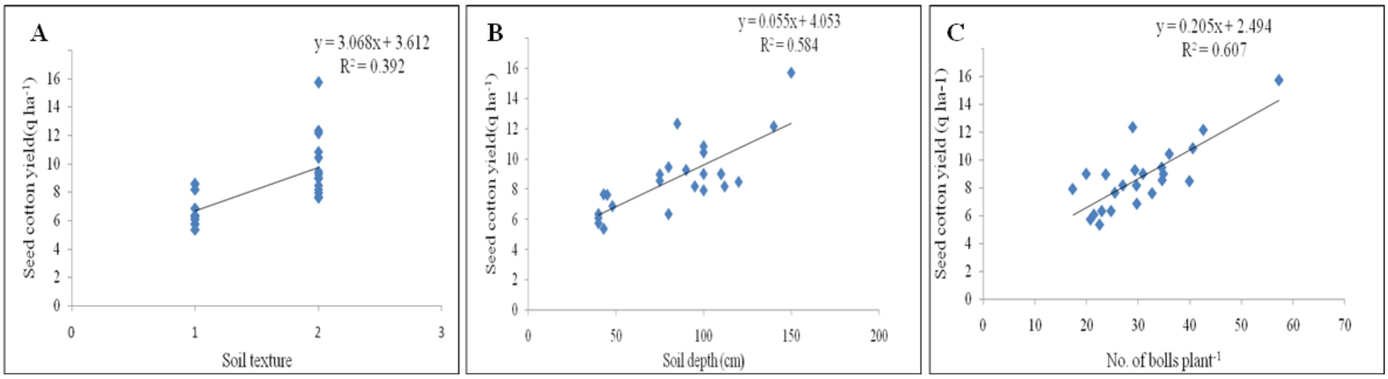
CD (P=0.05)	1.33	1.62	1.84	1.59	0.31	0.21	0.23	0.34	0.71	0.16	0.17	0.84
Management												
M1-Best Management Practice (BMP)	30.6	36.9	36.4	34.5	3.2	3.3	3.3	3.3	8.6	10.6	10.4	9.7
M2-Farmers Practice (FP)	23.1	27.8	27.4	26.1	3.1	3.4	3.4	3.4	6.9	8.3	8.1	7.8
CD (P=0.05)	0.94	1.14	1.30	1.13	NS	NS	NS	0.24	0.50	0.12	0.12	0.59
Interaction												
S1V1	26.3	31.8	31.2	29.7	2.8	2.8	2.8	3.0	6.6	8.0	7.8	7.3
S1V2	24.5	29.5	29.0	27.5	2.6	2.6	2.6	2.8	5.8	6.9	6.8	6.5
S1V3	22.3	26.8	26.8	25.3	2.8	2.8	2.8	3.0	5.6	6.7	6.6	6.3
S1V4	20.8	25.2	24.5	23.3	3.2	3.2	3.2	3.2	6.1	7.3	7.2	6.8
S2V1	31.0	37.3	36.7	35.2	3.2	3.2	3.2	3.2	8.9	10.7	10.5	10.2
S2V2	23.3	28.0	27.8	26.3	4.4	4.5	4.4	4.5	9.5	11.4	11.1	10.7
S2V3	25.5	30.7	30.3	28.5	3.0	3.0	3.0	3.0	7.0	8.4	8.3	8.0
S2V4	28.0	33.5	33.2	31.7	3.3	3.3	3.2	3.2	8.3	9.9	9.7	9.2
S3V1	44.2	53.2	52.7	49.8	3.1	3.1	3.1	3.2	12.4	14.9	14.6	13.8
S3V2	16.5	19.8	19.7	18.5	5.1	5.1	5.1	5.0	7.5	9.0	8.8	8.5
S3V3	31.3	37.7	37.3	35.5	2.8	3.2	3.2	2.8	7.8	11.0	10.8	8.8
S3V4	28.7	34.2	34.0	32.3	1.4	2.9	2.9	3.0	7.6	9.2	9.0	8.5
CD (P=0.05)	2.31	2.80	3.19	2.76	0.54	0.37	0.39	0.59	1.22	0.29	0.29	1.45
S1M1	27.2	32.8	32.3	30.7	2.8	2.8	2.8	3.0	6.8	8.2	8.0	7.7
S1M2	19.8	23.9	23.5	22.3	2.9	2.9	2.9	3.0	5.2	6.3	6.2	5.8
S2M 1	31.1	37.4	37.0	35.0	3.5	3.5	3.4	3.4	9.6	11.5	11.3	10.8
S2M 2	22.8	27.3	27.0	25.8	3.5	3.5	3.5	3.5	7.3	8.7	8.6	8.2
S3M 1	33.7	40.4	40.0	37.8	3.3	3.5	3.5	3.3	9.4	12.1	11.8	11.1
S3M 2	26.7	32.0	31.8	30.3	2.9	3.6	3.6	3.7	8.3	9.9	9.7	9.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.20	0.21	NS
V1M1	39.1	47.1	46.6	44.1	2.9	2.9	2.9	3.0	10.4	12.5	12.2	11.7
V1M2	28.6	34.4	33.8	32.3	3.2	3.2	3.1	3.2	8.2	9.9	9.7	9.2
V2M1	24.1	29.1	28.7	27.1	4.1	4.1	4.1	4.2	8.6	10.3	10.1	9.7
V2M2	18.8	22.4	22.3	21.1	4.0	4.0	4.0	4.0	6.6	7.9	7.7	7.4
V3M1	30.8	37.0	36.8	34.8	2.7	2.9	2.9	2.7	7.3	9.9	9.7	8.4
V3M2	22.0	26.4	26.2	24.8	3.1	3.1	3.1	3.2	6.2	7.5	7.4	7.0
V4M1	28.6	34.2	33.7	32.0	3.1	3.1	3.1	3.1	8.0	9.6	9.4	9.0
V4M2	23.1	27.7	27.4	26.2	2.2	3.2	3.2	3.1	6.6	8.0	7.8	7.3
CD (P=0.05)	1.88	2.28	2.60	2.25	0.44	NS	NS	NS	NS	0.23	0.24	NS
S1V1M1	30.7	37.0	36.7	34.7	2.7	2.7	2.7	3.0	7.6	9.1	8.9	8.3
S1V1M2	22.0	26.7	25.7	24.7	2.8	2.8	2.8	3.0	5.6	6.8	6.6	6.3
S1V2M1	29.0	35.0	34.3	32.7	2.6	2.6	2.6	3.0	6.8	8.1	7.9	7.7
S1V2M2	20.0	24.0	23.7	22.3	2.6	2.6	2.6	2.7	4.8	5.7	5.6	5.3
S1V3M1	26.3	31.7	31.7	30.0	2.6	2.6	2.6	2.7	6.1	7.3	7.2	7.0
S1V3M2	18.3	22.0	22.0	20.7	3.1	3.1	3.1	3.3	5.1	6.1	6.0	5.7
S1V4M1	22.7	27.3	26.3	25.3	3.3	3.3	3.3	3.3	6.8	8.2	8.0	7.7
S1V4M2	19.0	23.0	22.7	21.3	3.1	3.1	3.1	3.0	5.4	6.5	6.4	6.0
S2V1M1	36.0	43.3	42.7	40.7	2.9	2.9	2.9	3.0	9.6	11.6	11.4	11.0
S2V1M2	26.0	31.3	30.7	29.7	3.5	3.5	3.5	3.3	8.2	9.9	9.7	9.3
S2V2M1	25.7	31.0	30.7	29.0	4.7	4.7	4.7	4.7	11.0	13.2	12.9	12.3
S2V2M2	21.0	25.0	25.0	23.7	4.2	4.2	4.2	4.3	8.0	9.6	9.4	9.0
S2V3M1	30.7	37.0	36.7	34.3	3.0	3.0	3.0	3.0	8.4	10.1	9.9	9.7
S2V3M2	20.3	24.3	24.0	22.7	3.1	3.1	3.1	3.0	5.6	6.8	6.7	6.3
S2V4M1	32.0	38.3	38.0	36.0	3.2	3.2	3.2	3.0	9.3	11.1	10.9	10.3
S2V4M2	24.0	28.7	28.3	27.3	3.3	3.3	3.3	3.3	7.3	8.7	8.5	8.0
S3V1M1	50.7	61.0	60.3	57.0	3.0	3.0	3.0	3.0	14.0	16.7	16.4	15.7
S3V1M2	37.7	45.3	45.0	42.7	3.2	3.2	3.2	3.3	10.8	13.0	12.7	12.0
S3V2M1	17.7	21.3	21.0	19.7	5.0	5.0	5.0	5.0	8.0	9.6	9.4	9.0
S3V2M2	15.3	18.3	18.3	17.3	5.1	5.1	5.1	5.0	7.0	8.5	8.3	8.0
S3V3M1	35.3	42.3	42.0	40.0	2.4	3.2	3.2	2.3	7.5	12.4	12.1	8.7
S3V3M2	27.3	33.0	32.7	31.0	3.2	3.2	3.2	3.3	8.0	9.6	9.4	9.0
S3V4M1	31.0	37.0	36.7	34.7	2.9	2.9	2.8	3.0	8.0	9.6	9.4	9.0
S3V4M2	26.3	31.3	31.3	30.0	0.0	3.0	3.0	3.0	7.3	8.7	8.5	8.0
CD (P=0.05)	3.26	3.96	NS	3.90	0.76	NS	NS	NS	NS	0.40	0.42	NS

NS: Non-significant

Table 3: Correlation studies between soil parameters, yield components and seed cotton yield

Parameters	Yield	No. of bolls plant $^{-1}$	Boll weight	Depth	Texture
Yield	1				
No. of bolls plant^{-1}	0.673**	1			
Boll weight	0.303	-0.452	1		
Depth	0.712**	0.547**	0.242	1	
Texture	0.464*	0.404*	0.136	0.521**	1

*p<0.05; **p<0.01



*1- Sandy clay loam; 2 – Clay

Fig 2: Relation between soil depth, soil texture and number of bolls plant-1 with seed cotton yield

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References

1. Ahuja SL. Evaluation for the retention of reproductive structures by bt and non-Bt intra-hirsutum cotton hybrids in different sowing dates and spacings. African J. Biotech. 2006; 5:862-865.
2. Bennett R, Kambhapati U, Morse S, Ismael Y. Farm level economic performance of genetically modified cotton in Maharashtra. Indian Review of Agricultural Economics. 2006; 28(1):59-71.
3. Blaise D. Yield, boll distribution and fiber quality of hybrid cotton (*Gossypium hirsutum* L.) as influenced by organic and modern methods of cultivation. J. Agron. Crop Sci. 2006; 192:248-256.
4. Blaise D, Majumdar G. Tekale KU. On-farm evaluation of fertilizer application and conservation tillage on productivity of cotton + pigeonpea strip intercropping on rainfed Vertisols of central India. Soil Tillage Res. 2005; 84:108-117.
5. Copur O. Determination of yield and yield components of some cotton cultivars in semi-arid conditions. Pakistan J. Bio. Sci. 2006; 9(14):2572-2578.
6. Gerik TJ, Fava HL, Thaxton PM, El-Zik KM. Late season water stress in cotton. Plant growth, water use, and yield. Crop Sci. 1996; 36:914-921.
7. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd ed., New York: John Wiley and Sons, Inc, 1984, 108-116.
8. Hebbar KB, Rao MRK, Khadi BM. Synchronized boll development of Bt cotton hybrids and their physiological consequences. Curr. Sci. 2007; 93:693-695.
9. Monga D. Problem and prospects of cultivation of by hybrids in the North India cotton zone. ICAC Recorder. 2008; 26(4):8-9.
10. Prakash AH, Bandyopadyaya KK, Gopal krishnan N. Growth and biomass portioning in Bt vs non Bt cotton hybrids in winter irrigated situation in southern zone of India. J. Indian Soc. Cotton Improvement, 2008, 129-142.
11. Ramamurthy V, Singh SK, Ramesh Kumar SC, Nair KM, Patil NG, Shivappa Angadi. Integrated Land Use Planning for enhanced tribal livelihood in H.D. Kote taluk of Mysore district, Karnataka. NBSS Publn.1082, 2015, 34.
12. Ramamurthy V, Venugopalan MV. Performance of Bt. cotton hybrid on shrink-swell soils of central India. Indian J. Agric. Sci. 2009; 79(12):1026-1029.
13. Ramasundaram P, Vennila S, Ingle RK. Bt cotton performance and constrains in Central India. Outlook Agric. 2007; 36(3):175-180.
14. Shinde VS, Deshmukh LS, Shinde SA, Zade KK. Influence of rainwater management through different agro techniques on yield, yield attributing characters and economics of cotton. J. Cotton Res. Dev. 2009; 23(1):51-55.
15. Singh D, Bhardwaj SN. Physiological analysis of yielding ability in hirsutum cottons. Indian J. Physiol. 1983; 26(3):264-275.
16. Soil Survey Staff. Keys to Soil Taxonomy, 10th ed. 2006, United States Department of Agriculture, Washington.
17. Soomro AR, Kakar RG, Ali H, Abid SA. Comparison of yield and its components in some commercial cotton varieties. Industrial J. Plant Sci. 2005; 4(4):545-552.
18. Venugopal K. Changing paradigms (avenues/ approaches) in cotton production technologies for improving productivity and fibre quality of cotton. In: Internation. Symp. Strategies for Sustainable Cotton Prod. - A Global Vision, 23-25 November, 2004. Crop Production, 2, 1-6.
19. Venugopalan MV, Tiwary P, Ramamurthy V, Hebbar KB, Challa O, Sonune BA. Effect of soil type and nitrogen levels on the productivity and crop water balance in rainfed diploid cotton (*Gossypium arboreum*). Indian J. Agric. Sci. 2007; 77(4):225-230.
20. William R, Meredith Jr, Bridge RR. Yield, yield components and fibre property variations of cotton (*G. hirsutum* L.) within and among environments. Crop Sci. 1973; 13:307-312.
21. Yadav SC, Sehgal JL, Shivaramu HS, Kandal BK. Impact of crop management and soils site parameters on growth and yield of cotton. Agropedology. 1994; 4:81-90.