Madras Agric. J., 103 (10-12): 327-332, December 2016
https://doi.org/10.29321/MAJ.10.001043

Performance of Cotton Varieties under Organic Management System in Tamil Nadu

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A field trial was conducted on a sandy clay loam soil during winter seasons of 2012-13 and 2013-14 at Tamil Nadu Agricultural University, Coimbatore to evaluate prominent ten cotton varieties under organic management system. The experiment was laid out in randomized complete block design and replicated thrice. Experimental results indicated that SVPR 4 variety produced the tallest plants. Higher number of sympodial branches plant^{-1} was recorded with KC 3 variety which was on par with SVPR 4 and MCU 12. Number of bolls plant^{-1} and boll setting percentage were higher in KC 3 and MCU 12 varieties over others. Variety MCU 12 recorded significantly higher seed cotton yield (1751 kg ha^{-1}) compared to other varieties. Fibre quality parameters were the maximum with MCU 12 variety. Nutrients (N, P and K) uptake and available nutrients after harvest were higher with MCU 9 and MCU 12 varieties over others.

Key words: Organic farming, Cotton varieties, Seed cotton yield, Fibre quality characters, Nutrient status

Cotton, being the most important fibre crop of South East Asia, especially in India and Pakistan, occupies a pre-eminent place among cash crops. Cotton is the backbone of Indian textile industry, accounting for 75 per cent of total fibre consumption and 38 per cent of the country's export. Area under cotton cultivation in India is 11 million ha with an average productivity of 518 kg ha^{-1} (Indiastat, 2010).

Green revolution technologies involving greater use of synthetic agro-chemicals such as fertilizers, pesticides and adoption of nutrient-responsive, high-yielding varieties have boosted the productivity of many crops in India (Ramesh *et al.,* 2010). Although the use of chemical fertilizer is the fastest way of meet-out the nutrient depletion, its increasing cost prevented the farmers from using these inputs (Jayakumar *et al.,* 2014). Stagnation of yield levels due to continuous use of inorganic fertilizers and decreased the net returns of farmers due to high input cost in many developing countries including India (Eyhorn *et al.,* 2007). Cotton being is the highest pesticide consuming crop in India and repeated usage of insecticides developed resurgence to many insects and higher usage of fertilizers without organic amendments reduced the soil fertility too. Hence, rethinking of research should be aimed for not only improving the yield potentials but also, protecting the environment in crops especially in cotton.

Choice of variety is more critical in organic situation than for conventional fields. Varieties must have better yielding ability under organically managed system with less depletion of soil nutrients, are the prime characters to select the varieties in organic farming condition. Current high yielding varieties and hybrids are inadvertently selected for high input systems; are likely to behave differently under organic conditions in terms of growth, yield, fibre quality, nutrient uptake of cotton and available nutrients in soil after harvest. Hence, a study was conducted with an objective to assess the ruling cotton varieties under organic production system in Tamil Nadu.

Materials and Methods

A field experiment was conducted at Eastern block farm of Tamil Nadu Agricultural University, Coimbatore during winter (August–January) season of two years (2010-11 and 2011-12). Experimental site is situated in the southern part of India at 11^{o}N latitude, 77^{o}E longitude at an altitude of 427 m above mean sea level with semi-arid tropical climate. Soil of the field was sandy clay loam in texture with the pH of 8.57. Organic carbon of initial soil was 0.60 per cent with available nitrogen of 195 kg ha^{-1}, available phosphorus of 17.5 kg ha^{-1} and available potassium of 712 kg ha^{-1}. The experiment was laid out in randomized complete block design and replicated three times with ten varietal treatments such as, V_1- MCU 5, V_2 - MCU 7, V_3 - MCU 9, V_4 - MCU 12, V_5 - MCU 13, V_6 - SVPR 2, V_7 - SVPR 4, V_8 – Suraj, V_9 - KC 3 and V_{10} - LRA 5166.

The experimental field was brought to good tilth condition by ploughing with tractor drawn disc plough followed by tiller plough. Organic amendments such as farmyard manure (FYM) and vermi-compost were applied on N equivalent basis to cater the N requirement (80 kg ha^{-1}) of cotton. Of the required N, 50 per cent each was met through above two amendments equally. The nutrient content and quantity of organic amendments applied are given in Table 1. Ridges and furrows were formed at 75 cm

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spacing and the treatments were allotted at random to the plots. A seed rate of 15 kg ha^{-1} was adopted. Seeds of the different varieties were treated with fresh cow-dung slurry (1% solution) a day before sowing and shade dried for six hours. Then, the seeds were treated with bio-control agent, *Trichoderma viride* @ 4 g kg^{-1} and also bio-fertilizer, *Azophos* @ 1200 g with 15 kg of seeds before sowing. *Azophos* and *Pseudomonas florescence* @ 5 kg ha^{-1} and 2.5 kg ha^{-1}, respectively were mixed with 25 kg of soil and applied to the field uniformly. Two seeds hill^{-1} were dibbled on one side of the ridges with a spacing of 30 cm between plants and after 15 days after sowing (DAS), one healthy seedling was left removing another by thinning. Neem oil @ 3 per cent was sprayed on cotton crop three times from 45 DAS at 15 days interval against sucking pests at initial growth stages. *Acorus calamus* dusting was done twice to control the sap feeders. The predator, *Chrysoperla* spp. @ 500 ha^{-1} was released two times at 20 and 35 DAS to control sucking pests. Egg parasite, *Trichogramma chilonis* @ 2.5 cc ha^{-1} was released on 45 DAS to control bollworms in cotton. TNAU *Panchagavya* (3% spray) was given on 45, 60 and 75 DAS as foliar growth regulator.

Growth parameters *viz.,* plant height, leaf area index (LAI), drymatter production (DMP) (kg ha^{-1}); and yield attributes such as number of sympodial branches plant^{-1}, number of bolls plant^{-1}, number of fruiting points and boll weight (g) of cotton were recorded using standard procedures (Madhavi Latha, 1988). Boll setting percentage was worked out as follows.

$$\text{Boll setting (\%)} = \frac{\text{Total number of bolls}}{\text{Total number of fruiting points}} \times 100$$

The seed cotton yield was obtained by combining all five harvests and weighed and expressed in kgha^{1}. Kapas sample having 100 seed cotton from each plot was taken and weighed. The seed and lint weight were recorded after ginning. The ginning percentage was calculated by using the procedure suggested by Santhanam (1976).

$$\text{Ginning percentage} = \frac{\text{Weight of lint (g)}}{\text{Weight of seed cotton (g)}} \times 100$$

The seed obtained from ginning of hundred seed cotton was weighed (g) and expressed as seed index and the lint obtained was weighed (g) and expressed as lint index (Santhanam, 1976). The mean fibre length was determined by high volume instrument (HVI) where the weight ratio method was adopted and expressed in mm. Fibre strength is the ratio of the breaking strength of a bundle of fibres to its weight. It was expressed in tenacity at 1/8" gauge on HVI, using the standard methods (Sundaram, 1979).

Representative soil samples taken from each field before sowing and after the last harvest of cotton are subjected to analysis to know the influence of soil nutrient status by different cotton varieties. Samples were analyzed for various parameters using standard procedures. The N, P, and K content in plant parts were analyzed at harvest stage using standard analytical procedures and expressed as percentage on dry weight basis and computed to kg ha^{-1}.

Mean data of two years are subjected to statistical analysis (Gomez and Gomez, 2010), wherever the critical differences values were at probability level $P \leq 0.05$, the treatments are considered as significantly varied among them. The non-significant differences between treatments were denoted as NS.

Results and Discussion

Growth characters

Statistical analysis revealed that cotton varieties varied significantly under organic farming with respect to growth characters *viz.,* plant height at harvest, DMP at harvest and LAI at 90 DAS (Table 2). Cotton variety SVPR 4 grew taller (91.9 cm) than other varieties, which was on par with MCU 12, MCU 13 and MCU 5 and SVPR 2. More DMP (4301 kg ha^{-1}) was recorded in MCU 9 variety compared to others; however, MCU 12 variety had statistical parity with MCU 9. Also, enlarged leaf surface (LAI) values (3.45) were noted with MCU 9 variety and were comparable with other varieties (SVPR 4, MCU 7, MCU 13, MCU 5 and MCU 12). In general, growth characters of any varieties are genetically made and less influenced by environmental factors. In the present investigation, all the varieties tested are in the same environmental situation; and hence, alteration of plant was solely due to genetic nature of the variety. Earlier research works reported variation on growth characters due to varieties of cotton (Sangshetty, 2006; Lokesh, 2007).

Table 1. Nutrient content of organic amendments

Organic amendments	Nutrient concentration (%)						Quantity applied (t ha^{-1})	
	2012			2013				
	N	P	K	N	P	K	2012	2013
FYM	0.65	0.40	0.78	0.50	0.38	0.72	6.15	7.50
Vermi-compost	1.28	0.53	0.78	1.74	0.56	1.34	3.13	2.15

Yield attributes and seed cotton yield

The data pertaining to yield attributes and the variation due to different varieties are presented in Table 3. Number of sympodial branches plant^{-1} showed significant variation among varieties. Comparatively, more number of sympodial branches plant^{-1} was observed with KC 3 (13.74) and it was on par within the following order, MCU 12 > SVPR 4 > MCU 13 > MCU 9. Sympodial branches from principal segment of super structure in cotton where the fruiting bodies develop at different growth stages. Higher number of sympodia indicates the formation of more fruiting points (Khorgade and Ekbote, 1980). The difference in number of sympodial branches plant^{-1} might be attributed to the genetic make-up of the varieties. Significant differences among varieties for number of sympodial branches plant^{-1} have also been reported by Copur (2006) and Sangshetty (2006).

Table 2. Influence of varieties on growth characters of cotton*

Treatments	Plant height (cm) at harvest	DMP (kg ha^{-1}) at harvest	LAI at 120 DAS
T_1 - MCU 5	86.5	3485	3.23
T_2 - MCU 7	81.0	3594	3.34
T_3 - MCU 9	78.7	4301	3.45
T_4 - MCU 12	91.3	4179	3.23
T_5 - MCU 13	91.1	3293	3.25
T_6 - SVPR 2	83.8	2643	2.92
T_7 - SVPR 4	91.9	3874	3.03
T_8 - Suraj	69.0	3698	2.57
T_9 - KC 3	70.6	2971	2.40
T_{10} - LRA 5166	72.7	3423	2.81
SEd	4.6	178	0.18
CD (P=0.05)	9.6	374	0.37

* Mean data for two years

Total number of bolls that cotton plant bears at maturity is an important yield component, have the greatest effect on seed cotton yield. This character is greatly influenced both by physiological and environmental factors. Varieties also showed significant changes in case of number of bolls plant^{-1}. On perusal of mean data of two years, significantly higher number of bolls plant $^{-1}$ (19.1) was recorded with KC 3 variety than the rest, was followed by MCU 12 (18.0) and was on par with the former. Production of more number of sympodial branches in these varieties was the main reason for production of increased number of bolls plant^{-1}. Generally, sympodial branches are fruiting branches in cotton and increase of sympodial branches has always positive correlation with the number of bolls plant^{-1}. Hussain *et al.* (2000) also reported significant variation in number of bolls plant^{-1} due to different varieties.

Mean data of two years indicated that higher boll setting percentage was noted with KC 3 (43.5) and was comparable with MCU 12 (40.1). Yu and Huang (1990) inferred that increased percentage of boll setting was obtained from earlier produced flowers supported these results. Thus, earliness appears to have a distinct advantage, since KC 3 and MCU 12 are early maturing varieties and were lesser prone to attack by boll worms compared to late maturing varieties.

Kapas weight boll^{-1} is directly related to the final seed yield of cotton. Different varieties exhibited perceptible variation in influencing the boll weight. Significantly higher boll weight was observed with Suraj (4.82 g) and was on par with MCU 12 (4.63 g) compared to rest of the varieties. Boll weight is mainly influenced by genetic nature of varieties, besides, little influence by the environment. Gumber *et al.* (2009) also recorded variation of boll weight among varieties.

Table 3. Influence of varieties on yield attributes and seed yield of cotton*

Treatments	Sympodial branches plant^{-1}	Number of bolls plant^{-1}	Boll setting percentage	Boll weight (g)	Seed cotton yield (kg ha^{-1})
T_1 - MCU 5	10.1	12.3	35.1	3.33	1236
T_2 - MCU 7	10.3	14.0	36.0	3.96	1211
T_3 - MCU 9	11.5	14.9	38.0	4.50	1335
T_4 - MCU 12	13.1	18.0	40.1	4.63	1751
T_5 - MCU 13	11.6	14.3	34.7	4.49	1426
T_6 - SVPR 2	9.5	10.8	32.0	4.32	997
T_7 - SVPR 4	12.6	15.9	36.8	4.11	1446
T_8 - Suraj	10.0	11.7	33.3	4.82	1368
T_9 - KC 3	13.7	19.1	43.5	3.41	1461
T_{10} - LRA 5166	10.6	14.4	39.1	3.67	1099
SEd	0.9	0.9	2.0	0.14	66
CD (P=0.05)	2.0	1.8	4.1	0.30	139

* Mean data for two years

The varieties differ with respect to yield, which could be attributed to both genetic and environmental factors. Highly positive correlations between yield and its components such as number of fruiting points, boll numbers, yield plant^{-1} and number of seeds plant^{-1} was observed earlier (Wankhade and Bathkal, 1994; Kattimani, 1995). In the present study carried out to evaluate the cotton varieties under organic production system, the varieties differed significantly with respect to seed cotton yield. Among the varieties, MCU 12 recorded significantly higher seed cotton yield (1751 kg ha^{-1}) compared to other varieties. This was followed by KC 3 (1461 kg ha^{-1}) and SVPR 4 (1446 kg ha^{-1}). With the production of more sympodial branches, higher number of bolls plant^{-1}, increased boll setting percentage and individual boll weight in these varieties, in turn produced more seed cotton yield. The varieties SVPR 2 and LRA 5166 were the poor performers under organic production system. The growth and yield attributes cumulatively determined the performance of individual varieties and therefore, differences were noticed with respect to seed cotton yield (Ehsan *et al.,* 2008).

Fibre quality characters

Fibre quality characters ultimately decide the longevity of the variety in farmers' cultivation. Seed index, although considered as non-economic part of crop, showed a strong positive association with seed cotton yield. In the present investigation, seed index recorded by the varieties MCU 13, MCU 9, MCU 12, Suraj and MCU 5 are higher (Table 4) and statistically not differed; the highest being with MCU 13 (12.10). The lowest seed index (9.23) was recorded in KC 3. Same nature of results was reported with respect to lint index also. The present results are in accordance with the findings of Arshad *et al.* (2007).

Significant variation was observed on ginning percentage among different cotton varieties evaluated. The variety SVPR 2 recorded higher ginning percentage of 38.91, and it was on par with all the other varieties barring MCU 5, MCU 7 and SVPR 4. This was similar with the findings of Hassan *et al.* (2006) who reported that ginning out turn (GOT) was affected by cultivars. The variation due to environmental or genetic factor/ heterosis on GOT (%) among different strains was also reported (Wu *et al.,* 2000).

Table 4. Influence of cotton varieties on fibre quality characters*

Treatments	Seed index	Lint index	Ginning percentage	Fibre length (mm)	Fibre strength (g tex^{-1})
T_1 - MCU 5	11.70	6.45	35.20	35.03	24.30
T_2 - MCU 7	10.78	6.21	35.52	28.30	22.13
T_3 - MCU 9	11.90	6.55	36.11	32.87	23.27
T_4 - MCU 12	11.77	6.98	36.69	33.40	23.23
T_5 - MCU 13	12.10	7.51	37.55	32.37	21.77
T_6 - SVPR 2	9.53	5.26	38.65	26.30	19.93
T_7 - SVPR 4	10.55	5.45	34.30	29.13	21.23
T_8 - Suraj	11.80	6.59	36.72	31.93	23.73
T_9 - KC 3	9.23	5.11	37.00	27.83	20.67
T_{10} - LRA 5166	9.50	5.36	36.05	30.43	22.67
SEd	0.38	0.21	1.37	0.85	0.89
CD (P=0.05)	0.79	0.44	2.96	1.80	1.88

* Mean data for two years

Fibre length was differed significantly among the different cotton varieties evaluated in organic management system. The variety MCU 5 recorded the highest mean fibre length (35.03 mm) and it was on par with MCU 12. The lowest fibre length was recorded in the SVPR 2 variety. This was on contrary with the statement given by Hassan *et al.* (2006) that varieties with high fibre length were unable to get high ranking position in case of seed cotton yield. However, it was agreed that in staple length is heritable character; it is less subjected to environmental changes.

Fibre strength or bundle strength (g tex^{-1}) are important trait in determining yarn spinnability, because, weak fibres (low strength) are difficult to handle during manufacturing process (Saleem *et al.,* 2010). Among the different cotton varieties evaluated under organic production system, MCU 5 recorded the highest fibre strength (24.30 g tex^{-1}) which was on par with other varieties such as Suraj, MCU 9, MCU 12 and LRA 5166. The variety SVPR 2 had the lowest fibre strength. Linear correlation coefficient for GOT (%) vs. fibre strength (g tex^{-1}) showed that fibre strength decreased with increase in GOT (Saleem *et al.,* 2011). Variation among the varieties for fibre strength had research similarity of Faircloth (2007).

Nutrient uptake

There was a significant difference between varieties in respect of uptake of N, P and K (Table 5). With respect to N uptake, the variety MCU 9 recorded higher uptake of 69.58 kg ha^{-1} at 120 DAS when compared to all the other varieties except MCU 12 which was statistically on par. This differential pattern in uptake may be explained by the fact that capacity of root architecture of a cultivar to mineralize the N. Nutrient uptake is a product of nutrient concentration and DMP. Though the nutrient concentration of nitrogen is not varied among varieties, higher DMP recorded in MCU 9 and MCU 12 varieties influenced the nutrient uptake. Sangshetty (2006) had reported similar type of varietal variation in the nutrient uptake of N among the cotton cultivars.

The cultivars MCU 9 and MCU 12 recorded higher P uptake when compared to all the other varieties evaluated. The differences among the varieties of a species in P uptake was attributed to the differences in root growth (Krannitz *et al.,* 1991) and differences in relation to external critical levels of P, transport and utilization efficiencies, exudation pattern and root morphology (Aziz *et al.,* 2005) which ultimately influenced the uptake pattern of P in cotton.

Table 5. Influence of cotton varieties on nutrient uptake (kg ha^{-1})*

Treatments	Nitrogen uptake (kg ha^{-1})	Phosphorus uptake (kg ha^{-1})	Potassium uptake (kgha^{-1})
T_1 - MCU 5	55.0	9.36	57.2
T_2 - MCU 7	56.9	9.76	58.8
T_3 - MCU 9	69.6	13.05	69.9
T_4 - MCU 12	67.7	12.54	68.1
T_5 - MCU 13	51.7	8.68	54.4
T_6 - SVPR 2	40.9	6.55	44.9
T_7 - SVPR 4	61.5	10.95	62.7
T_8 - Suraj	58.9	10.41	60.6
T_9 - KC 3	46.6	7.87	50.1
T_{10} - LRA 5166	53.9	9.14	56.3
SEd	2.5	0.43	2.1
CD (P=0.05)	5.3	0.90	4.4

* Mean data for two years

Considerable variation in efficiency of K uptake and utilization had been identified among existing genotypes of cotton (Zhang *et al.,* 2007). MCU 9 had been reported to have higher potassium uptake when compared to all the other varieties. However, similar to N and P uptake, the variety MCU 12 maintained its parity with MCU 9. The lowest nutrient uptake was recorded in the variety SVPR 2. Differential root exudation could be at least partly responsible for differential K uptake efficiency of different genotypes (Trehan *et al.,* 2005). Genotypic differences in capacity to utilize K were attributed to differences in the partitioning and re-distribution of K (Gerloff, 1987) which in turn might have influenced the variation among varieties on K uptake.

Table 6. Influence of cotton varieties on post-harvest available nutrients status of soil*

Treatments	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
T_1 - MCU 5	200.69	14.16	452.7
T_2 - MCU 7	200.18	13.36	450.7
T_3 - MCU 9	215.14	15.56	485.2
T_4 - MCU 12	210.26	20.39	480.1
T_5 - MCU 13	201.42	13.67	451.3
T_6 - SVPR 2	197.55	13.27	456.9
T_7 - SVPR 4	206.52	17.38	464.7
T_8 - Suraj	204.22	14.73	464.5
T_9 - KC 3	208.40	17.90	467.8
T_{10} - LRA 5166	198.22	14.03	455.2
SEd	2.79	0.86	19.74
CD (P=0.05)	5.87	1.81	NS

* Mean data for two years

Soil available nutrients

The data on post-harvest available soil values showed that there was a significant influence on the available soil nitrogen due to the different cotton varieties evaluated organically (Table 6). Higher available N (215.14 kg ha^{-1}) was left-out in MCU 9 grown plots and was on par with MCU 12. The post-harvest soil N was the least in SVPR 2. Similar nature of results was recorded with post-harvest soil P also. Due to better performance in terms of growth and yield characters in these varieties, more quantity of nutrients might have been mineralized and brought to available status and left even after higher uptake. Among the varieties, there was no significant influence on the post-harvest soil available potassium.

Conclusion

Two years results indicated that the performance and behaviour of cotton varieties differed significantly among them. SVPR 4 recorded higher plant height and sympodial branches plant^{-1}. Variety KC 3 dominated in terms of sympodial branches plant^{-1}, number of bolls plant^{-1} and boll setting percentage. Sympodial branches plant^{-1}, number of bolls plant^{-1}, boll setting percentage, seed cotton yield, most of fibre quality characters, nutrient uptake of N, P and K and also soil available N and P were higher with MCU 12 variety. Thus, from two years study, it can be concluded that cotton variety MCU 12 was superior under organic production system not only in terms of production and quality characters but also sustaining soil health semi-arid tropical conditions of Tamil Nadu.

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Received after revision : December 28, 2016; Accepted : December 31, 2016