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Soil Moisture Content, Yield and Water-use Efficiency of Cotton in Relation to *in-situ* Moisture Conservation Practices and Organic Manures under Rainfed Conditions

U.K. Hulihalli* and V.C. Patil

University of Agricultural Sciences, Dharwad 580 005, India

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Abstract: Effect of *in-situ* moisture conservation practices and organic manures on soil moisture content, yield and water-use efficiency of cotton was studied at Agriculture Research Station, Annigeri, for two years. The compartment bunding (CB), broad furrow and ridge (BFR), and tied ridges furrows (TRF) resulted in significantly higher cotton yield as compared to flat bed (FB) and contour cultivation (CC). The water-use efficiency and net returns were also higher with CB, BFR and TRF. The yield was higher with farmyard manure (5 t ha^{-1}) and poultry manure (5 t ha^{-1}) as compared to cotton stalk incorporation @ 5 t ha^{-1}.

Key words: Compartment bunding, broad furrow and ridge, tied ridges and furrows, flat bed contour cultivation, *in-situ* moisture conservation, organic manures.

Rainfed agriculture has the problem of productivity due to low moisture in the root zone during the dry season. Northern dry zone of Karnataka is known for its erratic rainfall pattern. High intensity rainfall coupled with heavy black soil leads to large runoff losses. Appropriate moisture conservation measures are therefore necessary for improving the soil moisture content and soil fertility. The *in-situ* moisture conservation practices such as CB, BFR, TRF, CC, etc., are known to conserve more soil moisture (Surakod and Itnal, 1997; Patil, 1998). The continuous use of chemical fertilizers has resulted in deterioration of soil health and productivity. The long term experiments so far carried out in the country and elsewhere have clearly indicated that there is a need to integrate organic manures and inorganic fertilizers for sustainable crop production, maintenance of soil fertility and conservation of natural resources (Nambiar and Abrol, 1989). Little information is available on the performance of herbaceum cotton (cv. Jayadhar) in relation to *in-situ* moisture conservation practices and organic manures under rainfed conditions. Therefore, the present study was undertaken to study the response of herbaceum cotton to *in-situ* moisture conservation practices and organic manures.

Materials and Methods

A field experiment was conducted at Agricultural Research Station, Annigeri (Karnataka), for two years under rainfed condition. The soil of the experimental field was clayey in texture with a pH of 8.4, available nitrogen 222 kg ha^{-1}, available phosphorus 24 kg ha^{-1} and available potassium 425 kg ha^{-1}. The treatments included five *in-situ* moisture conservation practices viz., flat bed (FB), tied ridge and furrows (TRF), broad furrow and ridge (BFR), compartment bunding (CB), contour cultivation (CC), and three organic manures viz., farmyard manure (FYM) @ 5 t ha^{-1}, poultry manure (PM) @ 5 t ha^{-1} and cotton stalks (CS) @ 5 t ha^{-1}. The experiment was laid out in spilt plot design with three replications and the net plot size was 4.8 m x 4.8 m. Total rainfall received was 656.9 mm during first year and 451.0 mm during second year against the mean of 670.9 mm (average of 25 years). The *in-situ* moisture conservation structures were laid out during first week of July. The compartment bunds of 3.0 m x 3.6 m, the broad furrow and ridge at 1.2 m apart, and ridge and furrows at 60 cm apart and furrows tied at 1.2 m apart were formed and maintained throughout the cropping season. A uniform dose of 30, 15 and 15 kg N, P_2O_5 and K_2O ha^{-1} was given as basal dose at the time of sowing and organic manures were applied three weeks before sowing as per the treatment. The crop was sown at a spacing of 60 cm x 30 cm during last week of September in both the years. Uniform cultural practices were followed and need-based plant protection measures were taken.

The soil moisture content (gravimetric method) in 0-30, 30-60 and 60-90 cm soil depth at sowing, 30, 60, 90, 120, 150, and 180 days after sowing (DAS) was determined. The moisture used by the crop under different treatments was computed by summing up the volume of soil moisture depleted

*E-mail: ukhulihalli_uasd@rediffmail.com

from the profile during the cropping season. Water-use efficiency (WUE) of the crop was calculated (Prasad and Singh, 1998).

Results and Discussion

Soil moisture content

The pooled analysis of the data indicated the significant effect of *in-situ* moisture conservation practices on soil moisture content (Table 1a and 1b). The CB, TRF, BFR recorded significantly higher soil moisture in the top 90 cm soil profile during the growth period of rainfed cotton. The improvement in moisture in soil profile was mainly due to reduced runoff and more time available for infiltration (Surakod and Itnal, 1998). Similar trend was observed during individual years. Different organic manures did not influence soil moisture content at different growth stages of cotton both in pooled analysis as well as in individual years (Table 1a and 1b). The interaction effects of CB or TRF or BFR with any of the organic manures recorded higher soil moisture content as compared to FB or CC with organic manures at all stages of crop growth during 1998-99 and 1999-2000 as well as in pooled analysis.

Growth and yield

The higher soil moisture storage due to *in-situ* moisture conservation increased the productivity of cotton in the present study both in pooled analysis as well as during each year. The yield was significantly higher with CB (1022 kg ha^{-1}), BFR (1014 kg ha^{-1}) and TRF (997 kg ha^{-1}) compared to FB (902 kg ha^{-1}) and CC (897 kg ha^{-1}). The yield differences due to *in-situ* moisture conservation practices were due to better expressions of growth parameters like plant height, number of monopodial and sympodial branches per plant (Table 2a and 2b), leaf area index and total dry matter production per plant, which improved the yield attributes such as number of squares per plant, number of bolls per plant, mean boll weight and yield per plant (Table 3). Similar results were reported by Pendke *et al*. (2000) and Koraddi *et al.* (1993).

The yield was significantly influenced by organic manures during individual years as well as in pooled analysis (Table 4). Application of FYM (1000 kg ha^{-1}) and PM @ 5 t ha^{-1} recorded significantly higher yield over incorporation of CS @ 5 t ha^{-1}. Increase in yield due to FYM or PM was mainly through enhanced growth and yield attributes like mean boll weight, seed cotton yield per plant, number of squares and boll per plant, plant height, number of monopodial and sympodial branches per plant, leaf area index and dry matter production per plant. The low yield with CS was mainly due to temporary immobilization of nutrients by the micro-organisms during initial years of cotton crop residue application (Babalad, 1999).

The interaction effects were significant in pooled data as well as individual years (Table 2). BFR + FYM (1071 kg ha^{-1}) and CB + FYM (1068 kg ha^{-1}) recorded significantly higher yield compared to FB with organic manures and CC with organic manures. A similar trend was followed in growth and yield components. The results confirmed the findings of Patil (1998) in sorghum.

Net returns

The pooled data indicated significantly higher net returns with CB (Rs. 11130 ha^{-1}), BFR (Rs. 10980 ha^{-1}) and TRF (Rs. 10510 ha^{-1}) than in FB (Rs. 9397 ha^{-1}) and CC (Rs. 9328 ha^{-1}). Increase in the net returns with CB, BFR and TRF was due to higher yield than in FB and CC.

The *in-situ* moisture conservation practices did not influence the net returns during first year as compared to second year of experimentation. This was due to heavy rains received during the months of September and October which nullified the effect of *in-situ* moisture conservation practices and resulted in little variation in yield. However, organic manures did not influence the net returns both in pooled analysis as well as individual years. This might be due to the fact that the yield advantage was nullified by higher cost of cultivation in case of FYM and PM. The interaction effects of BFR + FYM (Rs. 11590 ha^{-1}) and CB + FYM (Rs. 11550 ha^{-1}) recorded higher net returns compared to FB or CC with organic manures. The higher net returns were due to higher yield registered in the above treatments.

Water-use efficiency (WUE)

The higher WUE of cotton (Table 2) was noticed with CB (6.59 kg ha^{-1} mm^{-1}), BFR (7.01 kg ha^{-1} mm^{-1}) and TRF (6.76 kg ha^{-1} mm^{-1}) compared to FB (5.93 kg ha^{-1} mm^{-1}) and CC (5.88 kg ha^{-1} mm^{-1}). Similar findings have been reported by Kaushik and Lal (1998), Pendke *et al.* (2000). Organic manures did not influence the WUE. The interaction effects of CB or BFR or TRF with organic manures recorded higher WUE compared to FB or CC with organic manures.

Table 1a. Effect of in-situ moisture conservation practices and organic manures on soil moisture content (cm/0-90 cm soil depth) during the cotton growth period

Treatments	At sowing			30 DAS			60 DAS		
	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled
Moisture Conservation Practices (MCP)									
Flat bed (FB)	35.82c	31.72c	33.77c	35.34b	32.35c	33.85c	34.06b	29.56b	31.71b
Tied ridge & furrows (TRF)	37.21a	34.07a	35.64a	36.30a	34.50b	35.40b	34.83a	31.85a	33.34a
Broad furrow & ridge (BFR)	36.76ab	33.81a	35.29a	36.46a	34.84ab	35.65ab	34.67a	32.30b	33.48a
Compartment bunding (CB)	36.98a	34.10a	35.54a	36.52a	34.98a	35.75a	34.96a	32.31a	33.64a
Contour cultivation (CC)	36.13bc	32.20b	34.17b	35.18b	32.63c	33.90c	33.72c	29.82b	31.77b
S.E.	0.20	0.11	0.12	0.11	0.14	0.09	0.10	0.18	0.10
Organic Manures (OM)									
Farm yard manure (FYM) @ 5t ha^{-1}	36.47a	33.12ab	34.79a	35.93a	33.88a	34.90a	34.34a	31.22a	32.78a
Cotton stalks (CS) @ 5 t ha^{-1}	36.64a	33.07b	34.85a	36.08a	33.76a	34.92a	34.44a	30.96a	32.70a
Poultry manure (PM) @ 5 t ha^{-1}	36.63a	33.35a	34.99a	35.87a	33.94a	34.90a	34.57a	31.32a	32.95a
S.E.	0.16	0.09	0.09	0.15	0.12	0.10	0.14	0.12	0.10
Interactions (MCP x OM)									
FB+FYM @ 5 t ha^{-1}	35.38c	31.88b	33.63d	35.19de	32.18b	33.68b	34.80cd	29.48c	31.64c
FB+CS @ 5 t ha^{-1}	36.13bc	31.22c	33.68d	35.52b-e	32.36b	33.94b	34.33b-d	29.32c	31.83c
FB+PM @ 5 t ha^{-1}	35.95bc	32.05b	34.00cd	35.32c-e	32.51b	33.91b	34.05b-d	29.87bc	31.96c
TRF FYM @ 5 t ha^{-1}	37.55a	34.04a	35.80ab	36.34a-c	34.48a	35.41a	35.04ab	31.78a	33.41ab
TRF+CS @ 5 t ha^{-1}	37.07ab	33.76a	35.42ab	36.62ab	34.33a	35.47a	34.56a-d	31.66a	33.11b
TRF+PM @ 5 t ha^{-1}	37.00ab	34.39a	35.70ab	35.96a-e	34.69a	35.32a	34.90ab	32.10a	33.56ab
BF +FYM @ 5 t ha^{-1}	37.05ab	33.90a	35.47ab	36.72a	34.83a	35.78a	34.83a-c	32.14a	33.50ab
BFR+CS @ 5 t ha^{-1}	36.58ab	33.77a	35.17ab	36.21a-d	34.79a	35.50a	34.59a-d	32.30a	33.45ab
BFR+PM @ 5 t ha^{-1}	36.64ab	33.77a	35.21ab	36.43a-c	34.90a	35.67a	34.58a-d	32.45a	33.51ab
CB+FYM @ 5 t ha^{-1}	36.50a-c	33.91a	35.21ab	36.52ab	34.81a	35.67a	34.38b-d	32.33a	33.35ab
CB+CS @ 5 t ha^{-1}	36.93ab	34.20a	35.56ab	36.74a	33.05a	35.90a	34.97ab	32.26a	33.62ab
CC+PM @ 5 t ha^{-1}	37.52a	34.19a	35.86a	36.29a-d	35.09a	35.69a	35.53a	32.36a	33.94a
CC+FYM @ 5 t ha^{-1}	35.87bc	31.86b	33.87cd	34.88e	33.07b	33.97b	33.63d	30.39b	32.01c
CC+CS @ 5 t ha^{-1}	36.48a-c	32.39b	34.44c	35.33c-e	32.29b	33.81b	33.72d	29.25c	31.49c
CC+PM @ 5 t ha^{-1}	36.04bc	32.35b	34.19cd	35.3c-e	32.53b	33.93b	33.82cd	29.83bc	31.82c
S.E.	0.35	0.20	0.58	0.34	0.27	0.21	0.31	0.28	0.21

*Means followed by same letters do not differ significantly.

Table 1b. Effect of in-situ moisture conservation practices and organic manures on soil moisture content (cm/0-90 cm soil depth) during the cotton growth period

Treatments	90 DAS			120 DAS			150 DAS			180 DAS		
	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled
Moisture Conservation Practices (MCP)												
Flatbed (FB)	31.59b*	26.27b	28.93b	25.00b	19.69c	22.34b	28.56b	22.92b	25.74b	21.01b	16.10d	18.55b
Tied ridge & furrows (TRF)	32.71a	28.85a	30.78a	26.60a	22.49b	24.54a	30.05a	26.02a	28.03a	22.35a	19.41b	20.88a
Broad furrow & ridge (BFR)	32.67a	29.18a	30.92a	26.23a	23.16a	24.70a	29.77a	26.40a	28.09a	21.68ab	19.96a	20.82a
Compartment bunding (CB)	32.71a	29.24a	30.98a	26.40a	23.29a	24.85a	29.69a	26.54a	28.11a	21.81a	20.26a	20.04a
Contour cultivation (CC)	31.46b	26.56b	29.01b	25.17b	19.88c	22.53b	28.69b	23.18b	25.93b	20.94b	16.91c	18.92b
S.E.	0.15	0.16	0.10	0.15	0.19	0.12	0.15	0.17	0.11	0.22	0.14	0.13
Organic Manures (OM)												
Farm yard manure (FYM) @ 5 t ha^{-1}	32.03a	28.12a	30.07ab	25.77a	21.71a	23.74a	29.19a	25.11ab	27.15a	21.41a	18.61a	20.01a
Cotton stalks (CS) @ 5 t ha^{-1}	32.23a	27.73b	29.98b	26.00a	21.48a	23.74a	29.41a	24.70b	27.06a	21.79a	18.30a	20.05a
Poultry manure (PM) @ 5 t ha^{-1}	32.42a	28.21a	30.32a	25.88a	21.91a	23.90a	29.45a	25.22a	27.33a	21.47a	18.67a	20.07a
S.E.	0.16	0.11	0.10	0.17	0.17	0.12	0.15	0.14	0.11	0.18	0.17	0.12
Interactions (MCP x OM)												
FB+FYM @ 5 t ha^{-1}	31.33cd	26.53cd	28.93b	25.18c-e	19.55c	22.37b	28.59c	23.23bc	25.91b	21.07bc	16.11d	18.59b
FB+CS @ 5 t ha^{-1}	31.98b-d	25.97d	28.98b	25.05de	19.61c	22.33b	28.52c	22.54c	25.53b	21.28a-c	15.96d	18.62b
FB+PM @ 5 t ha^{-1}	31.45cd	26.33d	28.89b	24.78e	19.90c	22.34b	28.56c	22.98bc	25.77b	20.68bc	16.22d	18.45b
TRF FYM @ 5 t ha^{-1}	32.84ab	28.49b	30.67a	26.41a-c	22.54ab	24.48a	29.95ab	25.85a	27.90a	21.87a-c	19.41b	20.64a
TRF+CS @ 5 t ha^{-1}	32.43a-d	28.75ab	30.59a	26.79a	21.92b	24.35a	30.28a	25.72a	28.00a	22.58a	19.01b	20.79a
TRF+PM @ 5 t ha^{-1}	32.85ab	29.31ab	31.08a	26.59a	23.01ab	24.80a	29.91ab	26.49a	28.20a	22.59a	19.82ab	21.20a
BF +FYM @ 5 t ha^{-1}	32.71ab	28.99ab	30.85a	26.29a-d	23.03ab	24.66a	30.02ab	26.26a	28.14a	21.57a-c	19.94ab	20.75a
BFR+CS @ 5 t ha^{-1}	32.50a-c	29.00ab	30.75a	26.42a-c	23.19a	24.80a	29.78ab	26.19a	27.98a	22.03ab	19.99ab	21.01a
BFR+PM @ 5 t ha^{-1}	32.79ab	29.55a	31.17a	26.00a-e	23.26a	24.63a	29.50a-c	26.76a	28.13a	21.46a-c	19.94ab	20.70a
CB+FYM @ 5 t ha^{-1}	31.99b-d	29.27ab	30.63a	25.95a-e	23.05ab	24.50a	29.89bc	26.51a	27.70a	21.45a-c	20.11ab	20.78a
CB+CS @ 5 t ha^{-1}	32.88ab	29.12ab	31.00a	26.53ab	23.34a	24.94a	29.91ab	26.44a	28.17a	22.02ab	19.95ab	20.99a
CC+PM @ 5 t ha^{-1}	33.26a	29.34ab	31.30a	26.73a	23.49a	25.11a	30.27a	26.67a	28.47a	21.96a-c	20.73a	21.35a
CC+FYM @ 5 t ha^{-1}	31.29d	27.30c	29.29b	25.02de	20.37c	22.69b	28.52c	23.70b	26.11b	21.10bc	17.49c	19.30b
CC+CS @ 5 t ha^{-1}	31.36cd	25.84d	28.60b	25.20c-e	19.36c	22.28b	28.59c	22.64c	25.61b	21.05bc	16.61cd	18.83b
CC+PM @ 5 t ha^{-1}	31.75b-d	26.55cd	29.15b	25.28b-e	19.92c	22.60b	28.98bc	23.19bc	26.09b	20.65c	16.64cd	18.65b
S.E.	0.35	0.26	0.22	0.39	0.38	0.27	0.34	0.32	0.24	0.40	0.37	0.27

*Means followed by same letters do notdiffer significantly.

Table 2a. Effect of in-situ moisture conservation practices and organic manures on growth parameters of cotton (G. herbaceum) variety Jayadhar

Treatments	Plant height (cm) at 180 DAS			No. of mono. br/plant 180 DAS			No. of sym. br/plant 180 DAS		
	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled
Moisture Conservation Practices (MCP)									
Flatbed (FB)	108.0a*	71.7c	89.8c	4.13a	3.91b	4.02ab	13.87a	9.73b	11.80b
Tied ridge & furrows (TRF)	110.8a	82.0a	96.4a	4.13a	4.11ab	4.12a	14.00a	11.73a	12.87a
Broad furrow & ridge (BFR)	107.8a	80.2ab	94.0ab	4.11ab	4.18a	4.14a	13.51a	11.62a	12.57a
Compartment bunding (CB)	108.9a	79.4ab	94.1ab	3.91c	4.11ab	4.01ab	13.29a	11.62a	12.46a
Contour cultivation (CC)	107.1a	74.0bc	90.5bc	3.93bc	3.96ab	3.94b	13.62a	9.93b	11.78b
S.E.	1.43	1.93	1.20	0.19	0.22	0.32	0.22	0.26	0.17
Organic Manures (OM)									
Farm yard manure (FYM) @ 5 t ha^{-1}	109.0a	78.3a	93.7a	4.11a	4.05a	4.08a	13.75ab	11.13a	12.44a
Cotton stalks (CS) @ 5 t ha^{-1}	107.1a	74.3b	90.7b	3.88b	3.99a	3.93b	13.05b	10.49b	11.77b
Poultry manure (PM) @ 5 t ha^{-1}	109.5a	79.7a	94.6a	4.15a	4.12a	4.13a	14.17a	11.16a	12.67a
S.E.	1.08	1.33	0.86	0.14	0.15	0.10	0.24	0.12	0.13
Interactions (MCP x OM)									
FB+FYM @ 5 t ha^{-1}	108.6a	73.1b-d	91.9bc	4.27ab	3.93ab	4.10a-d	14.27a-c	9.67d	11.97cd
FB+CS @ 5 t ha^{-1}	106.9a	68.2d	87.6c	3.87cd	3.80b	3.83e	13.07a-c	9.40d	11.23d
FB+PM @ 5 t ha^{-1}	108.3a	73.7b-d	91.0bc	4.27ab	4.00ab	4.13a-c	14.27a-c	10.13cd	**12.20bc**
TRF FYM @ 5 t ha^{-1}	109.5a	82.5ab	96.0ab	4.13a-c	4.07ab	4.10a-d	14.60a	12.13a	13.37a
TRF+CS @ 5 t ha^{-1}	111.3a	76.0b-d	93.7a-c	3.87cd	4.00ab	3.93b-e	13.73a-c	11.40ab	12.57a-c
TRF+PM @ 5 t ha^{-1}	111.5a	87.3a	99.4a	4.40a	4.27a	4.33a	13.67a-c	11.67a	12.67a-c
BF +FYM @ 5 t ha^{-1}	107.4a	80.1a-c	93.7a-c	4.13a-c	4.20a	4.17ab	13.20a-c	12.13a	12.67a-c
BFR+CS @ 5 t ha^{-1}	105.7a	78.1a-d	91.9bc	4.07a-d	4.20a	4.13a-c	13.33a-c	10.60bc	12.97cd
BFR+PM @ 5 t ha^{-1}	110.2a	82.4ab	96.3ab	4.13a-c	4.13ab	4.13a-c	14.00a-c	12.13a	13.07ab
CB+FYM @ 5 t ha^{-1}	110.7a	80.3a-c	95.5ab	4.07a-d	4.13ab	4.10a-d	12.73bc	11.80a	12.27bc
CB+CS @ 5 t ha^{-1}	106.3a	76.9b-d	91.6bc	3.73d	4.00ab	3.87de	12.67bc	11.33ab	12.00cd
CC+PM @ 5 t ha^{-1}	109.7a	80.9a-c	95.3ab	3.93b-d	4.20a	4.07b-e	14.47ab	11.73a	13.10ab
CC+FYM @ 5 t ha^{-1}	108.7a	75.6b-d	92.1bc	3.93b-d	3.93ab	3.93b-e	13.93a-c	9.93cd	11.93cd
CC+CS @ 5 t ha^{-1}	105.1a	72.1cd	88.6c	3.87cd	3.93ab	3.90c-e	12.47c	9.73cd	11.10d
CC+PM @ 5 t ha^{-1}	107.5a	74.3b-d	90.9bc	4.00b-d	4.00ab	4.00b-e	14.47ab	10.13cd	12.30bc
S.E.	2.45	2.47	1.92	0.31	0.34	0.22	0.53	0.27	0.30

*Means followed by same letters do not differ significantly, mono.: monopodial; sym.: sympodial.

Table 2b. Effect of in-situ moisture conservation practices and organic manures on growth parameters of cotton

Treatments	Leaf area index at 90 m DAS			DM in rep. part (g/pl) at 180 DAS			TDM (g/pl) at 180 DAS		
	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled
Moisture Conservation Practices (MCP)									
Flat bed (FB)	1.529a*	1.024c	1.276b	31.16a	21.48b	26.32a	61.05a	41.46b	51.66b
Tied ridge & furrows (TRF)	1.511a	1.248a	1.380a	31.76a	24.00a	27.88a	62.08a	47.54a	54.81a
Broad furrow & ridge (BFR)	1.490a	1.217a	1.353ab	30.16a	24.01a	27.08a	62.58a	47.35a	54.97a
Compartment Bunding (CB)	1.507a	1.180ab	1.343ab	31.70a	24.07a	27.89a	62.98a	47.43a	55.20a
Contour cultivation (CC)	1.506a	1.066bc	1.286b	31.20a	21.40b	26.30a	62.87a	42.00b	52.44b
S.E.	0.033	0.041	0.026	0.84	0.6	0.51	1.00	0.75	0.62
Organic Manures (OM)									
Farm yard manure (FYM) @ 5 t ha^{-1}	1.545a	1.200a	1.373a	31.94a	23.49a	27.71a	62.85a	45.96a	54.41a
Cotton stalks (CS) @ 5 t ha^{-1}	1.458b	1.062b	1.260b	31.42a	21.92b	26.17b	60.78b	43.00b	51.89b
Poultry manure (PM) @ 5 t ha^{-1}	1.522a	1.179a	1.350a	31.23a	23.57a	27.40a	63.79a	46.51a	55.15a
S.E.	0.014	0.026	0.014	0.61	0.39	0.36	0.51	0.49	0.35
Interactions (MCP x OM)									
FB+FYM @ 5 t ha^{-1}	1.563a	1.052c-e	1.308b-e	31.80ab	21.36c-e	26.58a-c	62.07a-c	41.73e-g	52.22de
FB+CS @ 5 t ha^{-1}	1.520a-d	0.980de	1.250ef	30.14ab	20.53d-e	25.34bc	59.37c	39.33 g	49.35 f
FB+PM @ 5 t ha^{-1}	1.503a-d	1.039c-e	1.271d-f	31.53ab	22.54a-e	27.03a-c	63.48ab	43.31d-f	53.40cd
TRF FYM @ 5 t ha^{-1}	1.563a	1.295ab	1.429a	32.57a	24.72ab	28.65a	60.87a-c	48.81ab	54.84a-c
TRF+CS @ 5 t ha^{-1}	1.440cd	1.126b-d	1.283c-f	30.49ab	23.39a-d	26.94a-c	61.08a-c	44.79c-e	52.93c-e
TRF+PM @ 5 t ha^{-1}	1.530a-d	1.323a	1.427a	32.21a	23.89a-c	28.05ab	64.29a	49.01ab	56.65a
BF +FYM @ 5 t ha^{-1}	1.540a-c	1.226a-c	1.383a-c	31.88ab	24.57ab	28.22a	63.10a-c	47.43a-c	55.26a-c
BFR+CS @ 5 t ha^{-1}	1.430d	1.141a-d	1.285c-f	31.14ab	22.35a-e	26.75a-c	61.91a-c	45.39b-d	53.65b-d
BFR+PM @ 5 t ha^{-1}	1.500a-d	1.283ab	1.391ab	27.45b	25.10a	26.28a-c	62.75a-c	49.23a	55.99ab
CB+FYM @ 5 t ha^{-1}	1.520a-d	1.229a-c	1.375a-d	31.93ab	24.77ab	28.35a	63.98ab	48.51ab	56.28a
CB+CS @ 5 t ha^{-1}	1.450b-d	1.134a-d	1.292b-e	30.12ab	23.09a-e	26.61a-c	60.29bc	45.43b-d	52.86c-e
CC+PM @ 5 t ha^{-1}	1.550ab	1.176a-c	1.363a-d	33.06a	24.34a-c	28.70a	64.68a	48.30a-c	56.49a
CC+FYM @ 5 t ha^{-1}	1.540a-c	1.198a-c	1.369a-d	31.49ab	22.05b-e	26.77a-c	63.60ab	43.27d-f	53.44cd
CC+CS @ 5 t ha^{-1}	1.450b-d	0.930e	1.190 f	30.21ab	20.21e	25.21c	61.26a-c	40.04 fg	50.65ef
CC+PM @ 5 t ha^{-1}	1.527a-d	1.072c-e	1.299b-e	31.90ab	21.95b-e	26.93a-c	63.75ab	42.69d-g	53.22cd
S.E.	0.032	0.058	0.032	1.37	0.88	0.81	1.14	1.10	0.79

*Means followed by same letters do not differ significantly.

Table 3. Effect of in-situ moisture conservation practices and organic manures on yield components of cotton

Treatments	No. of bolls at 180 DAS			Mean boll weight (g plant^{-1})			Seed cotton yield (g plant^{-1})		
	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled
Moisture Conservation Practices									
Flat bed (FB)	16.10a*	10.67ab	13.38a	1.76a	1.11b	1.43b	26.89a	16.96c	21.92b
Tied ridge & furrows (TRF)	17.82a	12.20a	15.01a	1.73a	1.51a	1.62a	27.44a	19.80ab	23.62ab
Broad furrow & ridge (BFR)	17.51a	11.89a	14.70a	1.70a	1.51a	1.60a	27.91a	20.56a	24.23a
Compartment Bunding (CB)	17.44a	12.47a	14.96a	1.79a	1.51a	1.65a	27.80a	19.64ab	23.72ab
Contour cultivation (CC)	16.80a	10.04b	13.42a	1.73a	1.16b	1.44b	27.22a	17.64bc	22.43ab
S.E.	0.95	0.52	0.54	0.07	0.04	0.04	1.03	0.67	0.62
Organic Manures									
Farm yard manure (FYM) @ 5 t ha^{-1}	17.81a	11.57a	14.69a	1.84a	1.40a	1.62a	28.61a	19.65a	24.13a
Cotton stalks (CS) @ 5 t ha^{-1}	16.17b	10.83b	13.50b	1.53b	1.26b	1.40b	25.52b	17.91b	21.71b
Poultry manure (PM) @ 5 t ha^{-1}	17.42a	11.86a	14.69a	1.85a	1.42a	1.63a	28.23a	19.20a	23.71a
S.E.	0.39	0.24	0.23	0.04	0.02	0.04	0.69	0.46	0.41
Interactions (MCP x OM)									
FB+FYM @ 5 t ha^{-1}	16.80ab	10.73c-g	13.77b-f	1.84a-c	1.16d-f	1.50c-e	27.67a	17.53b-f	22.60a-d
FB+CS @ 5 t ha^{-1}	16.00ab	9.87 fg	12.93ef	1.50d	1.01 f	1.25 f	25.60a	16.07 f	20.83d
FB+PM @ 5 t ha^{-1}	15.50ab	11.40b-f	13.45d-f	1.93a	1.16d-f	1.55b-d	27.40a	17.27d-f	22.33b-d
TRF FYM @ 5 t ha^{-1}	18.47a	12.07a-d	15.27a-c	1.90ab	1.47ab	1.69ab	28.87a	19.93a-e	24.40ab
TRF+CS @ 5 t ha^{-1}	16.87ab	11.87a-e	14.37a-e	1.53cd	1.49ab	1.51c-e	24.60a	20.07a-e	22.33b-d
TRF+PM @ 5 t ha^{-1}	18.33a	12.67ab	15.40a-c	1.77a-d	1.56ab	1.67a-c	28.87a	19.40a-f	24.13a-c
BF +FYM @ 5 t ha^{-1}	17.67ab	12.13a-d	14.90a-d	1.80a-d	1.62a	1.71ab	29.33a	21.73a	25.53a
BFR+CS @ 5 t ha^{-1}	16.80ab	10.67d-g	13.73c-f	1.50d	1.29cd	1.39d-f	25.53a	19.13a-f	22.33b-d
BFR+PM @ 5 t ha^{-1}	18.07a	12.87ab	15.47ab	1.79a-d	1.62a	1.71ab	28.87a	20.80a-c	24.83ab
CB+FYM @ 5 t ha^{-1}	18.20a	12.53a-c	15.37a-c	1.85a-c	1.57ab	1.71ab	29.40a	20.67a-d	25.03ab
CB+CS @ 5 t ha^{-1}	16.33ab	11.53a-f	13.93a-f	1.57b-d	1.43bc	1.50c-e	27.67a	17.33c-f	22.00b-d
CC+PM @ 5 t ha^{-1}	17.80ab	13.33a	15.57a	1.94a	1.55ab	1.74a	27.33a	20.93ab	24.13a-c
CC+FYM @ 5 t ha^{-1}	17.93a	10.44d-g	14.17a-f	1.81a-d	1.20de	1.51c-e	27.80a	18.40a-f	23.10a-d
CC+CS @ 5 t ha^{-1}	14.87b	10.20e-g	12.53 f	1.57b-d	1.10ef	1.34ef	25.20a	16.93ef	21.07cd
CC+PM @ 5 t ha^{-1}	17.60ab	9.53 g	13.57d-f	1.79a-d	1.19de	1.49c-e	28.67a	17.60b-f	23.13a-d
S.E.	0.87	0.55	0.51	0.10	0.05	0.05	1.55	1.02	0.93

*Means followed by same letters do not differ significantly.

Table 4. Seed cotton yield, net returns, moisture use and WUE of cotton as influenced by in-situ moisture conservation practices and organic manures

Treatments	Seed cotton yield (kg ha^{-1})			Net Returns (Rs. ha^{-1})			Moisture use (mm)	WUE (kg ha^{-1} mm^{-1})
	1998-99	1999-2000	Pooled	1998-99	1999-2000	Pooled		
Moisture Conservation Practices (MCP)								
Flat bed (FB)	1120b*	683b	902b	12460a*	6329b	9397b	152.2	5.93
Tied ridge& furrows (TRF)	1166ab	827a	997a	12810a	8205a	10510a	147.6	6.76
Broad furrow & ridge (BFR)	1212ab	815a	1014a	13720a	8239a	10980a	144.7	7.01
Compartment Bunding (CB)	1225a	821a	1022a	13930a	8325a	11130a	155.0	6.59
Contour cultivation (CC)	1151ab	644b	897b	12950a	5706b	9328b	152.5	5.88
S.E.	27	25	18	437	400	296		
Organic Manures (OM)								
Farm yard manure (FYM) @ 5 t ha^{-1}	1224a	775a	1000a	13660a	7321a	10520a	147.8	6.65
Cotton stalks (CS) @ 5 t ha^{-1}	1096b	722b	909b	12470a	7324a	9899a	148.0	6.14
Poultry manure (PM) @ 5 t ha^{-1}	1205a	777a	991a	13390a	7387a	10390a	149.2	6.64
S.E.	31	14	17	480	215	263		
Interactions (MCP x OM)								
FB+FYM @ 5 t ha^{-1}	1166ab	651d	909c-e	12920a	5553e	9236cd	150.4	6.04
FB+CS @ 5 t ha^{-1}	1044b	670d	857e	11810a	6651c-e	9230cd	150.6	5.69
FB+PM @ 5 t ha^{-1}	1150ab	729cd	940b-e	12670a	6783c-e	9725a-d	155.5	6.05
TRF FYM @ 5 t ha^{-1}	1224ab	836ab	1030a-c	13450a	8111a-c	10780a-d	151.6	6.79
TRF+CS @ 5 t ha^{-1}	1078ab	811a-c	945b-e	11950a	8488ab	10220a-d	146.3	6.46
TRF+PM @ 5 t ha^{-1}	1198ab	832ab	1015a-d	13040a	8015a-c	10530a-d	145.0	7.00
BF +FYM @ 5 t ha^{-1}	1256ab	887a	1071a	14090a	9093a	11590a	147.2	7.29
BFR+CS @ 5 t ha^{-1}	1107ab	717cd	912c-e	12630a	7234b-d	9930a-d	141.6	6.44
BFR+PM @ 5 t ha^{-1}	1273ab	842ab	1058ab	14440a	8391ab	11410ab	145.1	7.29
CB+FYM @ 5 t ha^{-1}	1294a	842ab	1068a	14710a	8391ab	11550a	144.3	7.40
CB+CS @ 5 t ha^{-1}	1142ab	771bc	956a-e	13170a	8077a-c	10620a-d	145.7	6.56
CC+PM @ 5 t ha^{-1}	1239ab	849ab	1044ab	13890a	8507ab	11200a-c	145.1	7.19
CC+FYM @ 5 t ha^{-1}	1180ab	661d	921c-e	13140a	5709de	9426cd	145.7	6.32
CC+CS @ 5 t ha^{-1}	1108ab	639d	874e	12810a	6169de	9490b-d	156.1	5.70
CC+PM @ 5 t ha^{-1}	1164ab	631d	898de	12900a	5239e	9067d	155.4	5.78
S.E.	68	31	37	1074	481	588		

*Means followed by same letters do not differ significantly.

It is concluded that *in-situ* moisture conservation practices such as CB, TRF and BFR with FYM and PM @ 5.0 t ha^{-1} may be adopted for getting higher yield, net returns, moisture use and WUE under rainfed cultivation of cotton in black soils of semi-arid tropics.

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