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Soil moisture conservation practices on growth and yield of cotton under rainfed conditions of Tamil Nadu

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■ **ABSTRACT :** A field experiment was conducted at Cotton Research Station, Veppanthattai, Perambalur district of Tamil Nadu between October 2012 to March 2013 to study the effect of different *in situ* moisture conservation practices on cotton. The main plot treatments (4) comprised of summer ploughing + harrowing, chisel ploughing + harrowing, summer ploughing + chisel ploughing + harrowing and incorporating coir pith (5 tons/ha) by coir pith applicator. The subplot treatments (5) included broad bed furrow, ridges and furrow, random tied ridging, basin listing and conventional method. Significantly higher and consistent availability of soil moisture (9.4-29.1 %) was recorded by incorporating coir pith using coir pith applicator as compared to other main plot treatments and among subplots, broad bed furrow conserved higher soil moisture (29.5 %) followed by ridges and furrows (27.2 %). Maximum plant height (142.3 cm) and dry matter production (4632.0 kg/ha) was observed in coir pith application with broad bed furrow treatment. Broad bed furrow increased the yield by 19.23 % (2167.5 kg/ha) over the control. Hence coir pith application with broad bed furrow is found to be the best practice for enhanced soil moisture availability as compared to other conservation practices for deep clay soils.

■ **KEY WORDS :** *In situ* moisture conservation, Deep clay soils, Cotton, Broad bed furrow, Coir pith application

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The state of Tamil Nadu is located in the Northern hemisphere in the semi-arid climatic zone between 8° and13° N latitude and between 78° and 80° E longitude. The red, black, alluvial and loamy soils found in the state are highly productive and their capabilities can be sustained through proper and planned soil water management practices. Maize and wheat are important crops in the cropping system in India covering an area of 1.80 million hectares (M ha) (Jat *et al*., 2011).

The growth rates interms of area, production and productivity were estimated for major crops in Tamil Nadu and were found to be positive for four crops viz., maize, pulses, sugarcane and banana in Tamil Nadu. Maize and pulses have shown excellent growth trends which are the basic raw material for poultry / animal feed. Maize crop plays a major role in the growth of poultry industry in Tamil Nadu. These two crops are also quite impressive in increasing the income of the farmers through crop diversification.

Tamil Nadu has a total geographical area of 13 M ha of land and out of which net sown area is 5.04 M ha in which area under rainfed condition is 2.11 M ha (41.87

%). Research is needed on precision dry farming technologies including water harvesting, soil moisture conservation, supplemental micro-irrigation and farm mechanization for increasing the production. Presently, greater intra and inter season rainfall variability are observed which may lead to agricultural drought. Oweis and Hachum (2006) reported that water harvesting is one option that increases the availability of water per unit cropping area, thereby reducing the drought impact and enables the use of run-off beneficially. It is low-external-input technology that makes farming possible on part of the land, provided other production factors such as climate, soils and crops are favourable.

The value of rainfed agriculture has to be reassessed for food and water insecurity (Ahmad *et al.*, 2005). According to Gupta and Deshpande (2004) total water requirement of the country for various activities around the year 2050 will be 1450 km^3/yr. It is more than the current utilizable water resource potential (1122 km^3/yr).

Rockstrom *et al*. (2001) stated that there is significant scope for improving water productivity in rainfed farming through supplemental irrigation, especially if combined with soil fertility management. Surface run-off from small catchments (1–2 ha) was harvested and stored in manually dug farm ponds (100–250 m^3 storage capacity). Simple gravity fed furrow irrigation was used. Sharma *et al*. (2010) stated that water used in supplemental irrigation had the highest marginal productivity and increase in rainfed production above 12 % was achievable even under traditional practices.

Problems in dry farming :

While considerable importance has been given to increase the productivity of the irrigated lands under green revolution, sufficient attention has not been given to increase the productivity of the rainfed areas. The moisture is the key limiting factor in the rainfed farming and rainfall is the only source of water for these vast stretch of lands. Hence, it is necessary to harvest maximum rain water and adopt methods to maximise the retention of moisture. Further the following problems are observed in these dry land areas (Muthamilselvan *et al.,* 2006):

– Inadequate soil moisture is the major constraint in drylands where the annual rainfall is 500 mm to 1000 mm. The rainfall is not evenly distributed and highly variable and erratic.

– The soils are light/medium textured and their water holding capacity is low.

– The lands are often having rolling topography and the rain water runs off quickly, eroding the soil and fertilizers.

– Subsoil hard pan is formed due to continuous use of implements upto certain depths constantly, which inturn precipitate the clay in the subsoil horizon.

– To overcome these problems, the current cultural practices should be improved and certain engineering measures are necessary to be practiced.

METHODOLOGY

A field experiment was conducted during October, 2012 and March, 2013 at Cotton Research Station, Veppanthattai, Perambalur district of Tamil Nadu having semi-arid climate. The experimental site lies between 10° 56' 19" North latitude and 77° 34' 113' East longitudes and is at an elevation of 121 m above mean sea level (MSL). The mean slope of the experimental site is 2 per cent. The study area had a semi-arid climate with an average annual rainfall of 643.9 mm. The soil texture was deep clay in texture with 8.3 pH, 1.51 g/cm^3 bulk density, 0.20 EC (dS m^{-1}), 64.10 % water holding capacity. The soil had 0.51 % organic carbon and 219.0, 24.0 and 390.0 kg/ha of available N, P_2O_5 and K_2O, respectively.

Effect of rainfall distribution and supplemental irrigation on growth of cotton:

The soil moisture content was measured using Theta Probe at two depths *viz.*, 15 cm and 30 cm for every 20 days interval after sowing and at the time of harvest. Total rainfall received during the crop season was 226.5 mm and there was a poor distribution (only 14 rainy days) of rainfall throughout the entire growth period. During October and November, 2012 there was a good rainfall of 188.0 mm resulting in large proportion of run-off water and there after very few amount of rainfall was received. Soil moisture conservation treatments were made during first week of October, 2012 which saved run-off rain-water and in second week of October sowing was taken up. The details of the treatments imposed are given in Table A.

Supplemental irrigation is a common practice in the dry regions and the aim is to improve and stabilize crop yields by adding small amounts of water to rain-fed crops

during the times when rainfall fails to provide sufficient moisture for normal plant growth. Shortage of soil moisture in the dry rainfed areas occur during the most sensitive growth stages of cotton crop. As a result, rainfed crop growth is poor and yield is consequently low. Three times supplemental surface irrigation of 5 cm to 7 cm depth was provided for cotton crop during its critical growth period.

Table A : Details of soil and water conservation measures imposed for cotton crop

Main plot	Sub Plot
Summer ploughing + harrowing	Broad bed furrow
Chisel ploughing + harrowing	Ridges and furrow
Summer ploughing + Chisel ploughing + harrowing	Random tied ridging
Incorporating coir pith (5 tons/ha) by using coir pith applicator	Basin listing
	Conventional method (control)

The experiment was laid out in a total area of 65 m x 44 m in a strip plot design with 3 replications and the cotton hybrid RCH-2 was sown on 11 th October 2012. Each treatment consisted of 27 plants with 120 cm x 90 cm plant spacing and the plot size was 10 m x 4 m. The fertilizer dose applied was 200, 100 and 100 kg/ha of N, P_2O_5 and K_2O, respectively. Plant growth attributes *i.e.*, plant height, dry matter production were recorded at for every 40 days interval. Yield attributes like number of monopodial branches, number of sympodial branches, number of balls/plant, boll weight and yield were also recorded. The growth parameters and yield attributes were statistically analyzed and data were tested to assess the existence of significant differences between the treatments. The volumetric soil moisture content was estimated by using Theta probe instrument. Soil moisture status (using theta probe) were recorded for every 20 days interval at two depths *viz.*, 15 cm and 30 cm.

RESULTS AND DISCUSSION

Data on soil moisture conserved during the entire cotton growing period indicated that incorporating coir pith using coir pith applicator (main plot) with broad bed furrow (sub plot) conserved the highest soil moisture followed by incorporating coir pith using coir pith applicator with ridges and furrow (sub plot) (Table 1). Among the main plot treatments, the highest moisture conserved was in incorporating coir pith using coir pith applicator followed by summer ploughing + chisel ploughing + harrowing treatment. Chisel ploughing + harrowing treatment was superior over the summer ploughing + harrowing and control.

The results are in good agreement with those of Manohar Jesudas (2011) who reported that subsoil coir pith application increased the growth parameters and yield of cotton as compared with chisel ploughing and control treatments. The yield of cotton in subsoil mulched plot was 46.4 % and 29.4 % higher than the chiselled and control treatments. Also the yield of cotton in chiseled plot was 13.2 % higher than the control.

Gajri *et al.* (1997) reported that the deep tillage significantly improved the grain yield of wheat by 27% over conventional tillage on an alluvial sand; light and frequent irrigation significantly improved the grain yield of wheat over heavy and infrequent irrigation which was attributed to the fact that deep tillage and the frequent small irrigation regime modified the soil physical environment so as to favour root proliferation and increased the ability of the root to utilize subsoil water and nutrients.

The mean monthly rainfall increased upto November 2012, hence, highest soil moisture content was noticed during grand growth stage in cotton production system. When the mean monthly rainfall falls down from December 2012 to March 2013, the soil moisture content decreased upto 15-17.6 %. Hence, three times supplemental surface irrigation was given to maintain the soil moisture status for cotton to save the crop.

Among the main plots, maximum mean moisture conservation (9.4-29.1 %) was recorded by incorporating coir pith using coir pith applicator treatment while the lowest (6.7-24.4 %) was under summer ploughing + harrowing treatment (Table 1). In sub plots, the highest moisture conservation was observed in broad bed furrow (29.5 %) followed by ridges and furrow (27.2 %) and random tied ridging (26.1 %). The soil moisture content was more in sub surface soil (30 cm) than surface soil (15 cm) throughout the crop growth period due to evaporation of moisture in the top layer. Since, under rainfed condition, if enough soil moisture is present at sub surface (root zone), crop can utilize the available moisture for its growth and also surface evaporation loss can be minimized.

The difference in plant height and dry matter production between the treatments were not significant

in the beginning which may be due to availability of enough soil moisture irrespective of treatment effects (during October and November 2012). There is increase and difference in plant height and dry matter production was observed over period of time from December 2012 to March 2013 due to the maintenance of soil moisture status in the profile by various treatment effects. The highest plant height and dry matter production was observed in coir pith application with broad bed furrow treatment followed by summer ploughing + chisel ploughing combination (main plot) and the lowest in control. In main plots, coir pith application significantly increased the plant height and dry matter production by 8.6 and 10.2 per cent over the summer ploughing + harrowing treatment during the entire period. Similarly, in subplots, broad bed furrow significantly increased the plant height and dry matter production by 10.5 and 11.9 per cent over the control (Table 2 and 3). The increased growth in coir pith application was due to higher moisture conservation and better growth of plants. These findings are in agreement with Singh *et al.* (2007) who studied the effect of moisture management practices on runoff and soil loss and crop yield. It was observed that improved management practice for soil and water conservation in vertisols decreased surface runoff by 24 to 27 % and soil loss by 44 to 47 % compared to traditional moisture management practices.

The difference in yield and yield attributes between the treatments was due to enough soil moisture availability at 30 cm depth of soil during the entire crop period. Among the different moisture conservation treatments the highest number of monopodial branches, number of sympodial branches, number of balls/plant and boll weight registered in the treatment with coir pith

Table 1 : Soil moisture variation under different stages of cotton crop

Treatments	Volumetric Soil moisture (%)															
	20 DAS		40 DAS		60 DAS		80 DAS		100 DAS		120 DAS		140 DAS		At harvest	
	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm	15 cm	30 cm
M_1	21.3	24.4	16.3	20.3	20.9	23.5	17.2	20.5	13.3	16.2	12.0	14.8	16.9	21.6	6.7	10.5
M_2	22.8	25.3	17.3	21.4	21.6	24.6	18.3	22.4	15.0	16.8	12.8	15.7	19.5	22.6	7.7	11.9
M_3	23.1	26.2	18.2	21.8	22.9	25.1	19.0	22.8	14.6	17.3	14.5	17.2	19.1	22.8	8.4	13.1
M_4	25.3	29.1	20.3	23.8	24.6	27.1	20.6	24.6	16.3	19.5	16.3	19.8	21.2	24.7	9.4	14.9
S_1	25.6	29.5	19.7	24.0	24.5	27.4	21.1	25.1	16.3	19.2	15.2	19.0	21.4	25.0	9.3	14.4
S_2	24.1	27.2	18.8	23.3	23.3	26.1	19.6	24.2	15.7	18.9	14.5	18.0	19.9	23.8	8.6	13.7
S_3	23.3	26.1	18.2	22.3	22.9	25.1	18.9	22.8	14.9	17.6	14.1	16.9	19.2	23.8	8.0	12.8
S_4	22.6	25.3	17.3	20.6	22.0	24.3	18.1	21.6	14.1	16.6	13.5	15.9	18.6	21.8	7.8	11.9
S_5	20.1	23.0	16.1	18.9	19.9	22.5	16.2	19.2	13.0	15.0	12.3	14.7	16.8	20.3	6.8	10.3

Table 2 : Plant height for cotton under different moisture conservation treatments for deep clay soils

Treatments	Plant height (cm)																			
	40 DAS					80 DAS					120 DAS					At harvest				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	42.0	43.3	45.6	47.9	44.1	64.0	66.7	68.6	69.5	67.2	103.7	107.2	109.5	113.7	108.5	136.7	142.4	145.3	149.3	143.4
S_2	37.1	40.4	42.1	46.1	41.4	62.2	63.8	64.8	68.4	64.8	101.4	104.3	105.5	108.5	104.9	133.3	138.2	141.6	146.6	139.9
S_3	35.5	38.8	40.4	43.6	39.6	60.1	61.7	63.0	65.4	62.5	98.5	101.6	103.4	106.2	102.4	131.4	135.5	138.1	141.3	136.6
S_4	34.5	36.6	39.4	40.5	37.7	58.4	59.3	61.3	64.5	60.9	95.0	97.7	100.4	103.3	99.3	128.8	131.7	135.4	138.9	133.7
S_5	33.8	35.0	36.4	38.2	35.8	56.6	58.3	59.6	62.3	59.2	92.5	94.8	97.8	100.9	96.5	124.7	127.3	131.3	135.5	129.7
Mean	36.5	38.8	40.8	43.3	39.7	60.3	61.9	63.5	66.0	62.9	98.4	101.1	103.3	106.5	102.3	131.0	135.0	138.3	142.3	136.7
	Main	Sub	M at S	S at M		Main	Sub	M at S	S at M		Main	Sub	M at S	S at M	Main	Main	Sub	M at S	S at M	Main
S.E.±	0.39	0.57	0.76	0.85		0.39	0.60	0.83	0.93		0.19	0.37	0.65	0.71		0.14	0.22	0.64	0.64	
C.D. (P=0.05)	0.95	1.31	1.77	1.95		0.95	1.38	NS	NS		0.47	0.85	NS	NS		0.34	0.51	1.49	1.49	

NS=Non-significant

Table 3 : Dry matter production for cotton under different moisture conservation treatments for deep clay soils

Treatments	Dry matter production (kg/ha)																			
	40 DAS					80 DAS					120 DAS					At harvest				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	549	567	584	606	576	1500	1647	1711	1934	1698	3497	3604	3739	3951	3698	4448	4552	4675	4881	4639
S_2	509	533	561	584	547	1434	1503	1619	1818	1594	3407	3529	3678	3836	3613	4332	4435	4587	4761	4529
S_3	482	505	542	560	522	1348	1414	1536	1763	1515	3320	3447	3556	3722	3511	4216	4344	4490	4632	4421
S_4	467	488	511	522	497	1302	1355	1485	1641	1446	3188	3305	3413	3570	3369	4109	4166	4345	4528	4287
S_5	433	454	482	500	467	1235	1300	1414	1571	1380	3113	3212	3294	3480	3275	3912	4035	4276	4360	4146
Mean	488 Main	509 Sub	536 M at S	554 S at M	522	1364 Main	1444 Sub	1553 M at S	1745 S at M	1526	3305 Main	3419 Sub	3536 M at S	3712 S at M	3493 Main	4203 Main	4306 Sub	4475 M at S	4632 S at M	4404 Main
S.E.±	5.72	5.97	12.2	12.0		8.09	7.66	16.1	15.5		9.76	16.5	25.2	27.9		13.4	17.3	29.6	30.8	
C.D. (P=0.05)	14.0	13.7	NS	NS		19.7	17.6	38.1	35.8		23.9	38.1	NS	NS		33.0	39.9	NS	NS	

NS=Non-significant

Table 4 : Yield attributes of cotton under different moisture conservation treatments

Treatments	No. of monopodial branches/plant	No. of sympodial branches/plant	No. of bolls /plant	Boll weight (g)
M_1	1.73	15.13	16.80	4.26
M_2	1.93	16.33	18.13	4.39
M_3	2.00	18.20	20.07	4.79
M_4	2.40	20.47	22.07	4.96
S.E.±	0.24	0.36	0.36	0.03
C.D. (P= 0.05)	NS	0.88	0.89	0.08
S_1	2.50	19.75	22.25	5.08
S_2	2.17	18.58	20.33	4.83
S_3	2.00	17.58	19.25	4.63
S_4	1.83	16.67	17.92	4.39
S_5	1.58	15.67	16.58	4.08
S.E.±	0.22	0.46	0.64	0.05
C.D. (P= 0.05)	0.51	1.06	1.48	0.11
M at S SE±	0.39	0.81	0.84	0.08
C.D. (P= 0.05)	NS	NS	NS	NS
S at M SE±	0.37	0.84	0.98	0.09
C.D. (P= 0.05)	NS	NS	NS	NS

NS=Non-significant

Table 5 : Seed cotton yield under different moisture conservation treatments

Treatments	M_1	M_2	M_3	M_4	Mean
S_1	1914.00	2106.33	2232.00	2417.67	2167.50
S_2	1855.33	2056.67	2182.33	2212.67	2076.75
S_3	1752.33	1900.00	2119.00	2231.33	2000.67
S_4	1710.00	1863.33	1925.33	2123.33	1905.50
S_5	1654.67	1754.00	1827.67	2035.00	1817.83
Mean	1777.27	1936.07	2057.27	2204.00	1993.65
	Main	Sub	M at S	S at M	
S.E.±	19.43	18.35	42.71	41.15	
C.D. (P=0.05)	47.55	42.32	100.98	94.89	

application with broad bed furrow followed by summer ploughing + chisel ploughing combination (main plot) and the lowest in control. In main plots coir pith application significantly increased the number of monopodial branches, number of sympodial branches, number of balls/plant and boll weight by 20, 12.4, 9.9 and 3.5 per cent, respectively over the summer ploughing + chisel ploughing treatment. Similarly in subplots, broad bed furrow significantly increased the number of monopodial branches, number of sympodial branches, number of balls/plant and boll weight by 58.22, 26.03, 34.19 and 24.50 per cent over control (Table 4). The highest yield was obtained in coir pith application with broad bed furrow and the lowest in control. In main plots coir pith application treatment significantly increased the yield by 24.02 per cent over the summer ploughing + chisel ploughing while, in subplots broad bed furrow significantly increased the yield by 19.30 per cent over the control (Table 5).

Mohamed (1996) compared tillage practices *viz.*, post harvest offset disking (8-10 cm deep), post harvest chisel ploughing (with 5 cm spikes at 10-15 cm deep), pre-seeding chisel ploughing and reported that an effective soil moisture penetration resulted from the pre-seeding shovelled chisel ploughing improving the plant height, dry matter, soil moisture content available for plant use which resulted in higher yields. An on-farm studies made during 2000-2003 post-rainy seasons showed that chickpea yield (1.25 t/ha) increased by 127 % over the control yield (0.55 t/ha), and groundnut pod yield (1.3 t/ha) increased by 59 % over the control yield (0.82 t/ha) by the application of two supplemental irrigations of 40 mm (ICRISAT, 2004).

Conclusion :

All the soil moisture conservation practices, in general, had favourable effect on growth of cotton crop. Among the main plots, incorporating coir pith using coir pith applicator treatment was found to be the best practice in terms of enhanced soil moisture availability for entire duration, leading to enhanced cotton growth, yield parameters and yield. The treatment produced significantly superior plant height (142.3 cm), dry matter (4632 kg/ha), number of monopodial branches/plant (2.4), number of sympodial branches/plant (20.5), number of bolls/plant (22.1), boll weight (4.9 g) and the seed cotton yield (2204 kg/ha) which was superior among all the treatments with a B:C ratio of 4.88. Among the subplots, broad bed furrow was found to be superior practice in terms of plant height (143.4. cm), dry matter production (4639 kg/ha), number of monopodial branches/plant (2.5), number of sympodial branches/plant (19.8), number of bolls/plant (22.3), boll weight (5.1 g) and seed cotton yield (2168 kg/ha) as compared with other treatments.

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