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Insitu moisture conservation practices on silty loam soil on growth and yield of cotton under rainfed conditions

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■ **ABSTRACT :** A study was conducted at Agricultural Engineering College and Research Institute, Kumulur, Tiruchirappalli district of Tamil Nadu between September 2012 to March 2013 to study the effect of different soil moisture conservation practices. 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 were compartmental bunding, ridges and furrow, random tied ridging, basin listing and conventional method. Significantly higher and consistent availability of soil moisture (12.6-33.5 %) was recorded by incorporating coir pith using coir pith applicator as compared to other main plot treatments and among subplots, random tied ridging conserved higher soil moisture (33.5 %) followed by basin listing (31.4 %). Maximum plant height (175.3 cm) and dry matter production (11380 kg/ha) was observed in coir pith application with random tied ridging treatment. Random tied ridging increased the yield by 31.78 per cent (6529 kg/ha) over the control. Hence, coir pith application with random tied ridging was found to be the best practice for enhanced soil moisture availability as compared to other conservation practices for silty loam soils.

■ **KEY WORDS :** *Insitu* moisture conservation, Silty loam soils, Cotton, Random tied ridging, 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° and 13° 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).

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.

Deep tillage is used to break subsoil layers that limit infiltration and to increase profile drainage and to enhance crop rooting for increased water availability. Deep tillage of the soils was proposed as a way to increase infiltration of rain and irrigation by eliminating flow limiting subsoil layers and, consequently, increase the available soil water by increasing the volume of soil explored by crop roots. Generally, deep soil profile modification and tillage treatment to depths varying from 10 to 60 inches successfully disrupted the dense subsoil layers; thus, increasing infiltration and the depth that crops removed soil water (Schneider and Mathers, 1970).

Sharma *et al.* (2010) stated that water used in supplemental irrigation had the highest marginal productivity and increase in rainfed production above 12 per cent was achievable even under traditional practices. Summer deep ploughing increased black gram seed yield by 16 to 21 per cent over shallow tillage. Lower runoff and soil loss was recorded in raised bed of 40 cm width with summer deep ploughing (Jat *et al*., 2013). Palaniappan *et al.* (2009) observed that tied ridging produced the maximum yield of cowpea even in seasons with below normal rainfall. There is growing need for rainwater conservation and management since dryland farming occupied 47 per cent and 56 per cent area of arable land in the world and India, respectively (Singh and Venkateshwarlu, 2009).

METHODOLOGY

A field experiment was conducted during September, 2012 to March, 2013 at Agricultural Engineering College and Research Institute, Kumulur, Tiruchirappalli district of Tamil Nadu having semi-arid climate. The experimental site lies between 11° 18' 60" North latitude and 78° 50' 164' East longitude and is at an elevation of 72 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 688.9 mm. The soil texture was red silty loam in texture with 7.3 pH, 0.89 g/cm^3 bulk density, 0.36 EC (dS m^{-1}), 9.64 cm/hr infiltration rate. The soil had 0.25 per cent organic carbon and 167.9, 25.1 and 420.9 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 320.1 mm and there was a poor distribution (only 12 rainy days) of rainfall throughout the entire growth period. Between September to November, 2012 there was a good rainfall of 289.3 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 on third week of September, 2012 which saved run-off rain-water and in fourth week of September sowing was taken up.

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. Four times supplemental surface irrigation of 5 cm to 7 cm depth was provided for cotton crop during its critical growth period.

The experiment was laid out in an area of 65 m x 44 m in a strip plot design with 3 replications and the cotton hybrid RCH-2 was sown on 27 th September 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 monthly (40 DAS) 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. The details of the treatments imposed are given in Table A.

Table A : Details of soil and water conservation measures imposed for cotton crop
Main plot
Summer ploughing + harrowing
Chisel ploughing + harrowing
Summer ploughing + Chisel ploughing + harrowing
Incorporating coir pith (5 tons/ha) by using coir pith applicator
Sub plot
Compartmental bunding
Ridges and furrow
Random tied ridging
Basin listing
Conventional method (control)

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 random tied ridging (sub plot) conserved the highest soil moisture followed by incorporating coir pith using coir pith applicator with basin listing (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 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 8-12 per cent. Hence, 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 (12.4-31.6%) was recorded with incorporating coir pith using coir pith applicator treatment while the lowest (7.0-27.0%) was under summer ploughing + harrowing treatment (Table 1). In sub plots, the highest moisture conservation was observed in random tied ridging followed by basin listing and compartmental bunding. The soil moisture content was more in sub surface soil (30 cm) than surface soil (15 cm) throughout the entire crop growth 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 are not significant in the beginning which may be due to availability of enough soil moisture irrespective of treatment effects (during September 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 random tied ridging 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

Table 1: Soil moisture variation under different stages for cotton for silty loam soils

Treat-ments	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	14.7	18.1	21.4	25.4	20.6	25.5	7.0	10.9	23.8	27.0	15.2	20.6	24.5	26.8	12.9	14.4
M_2	15.8	18.2	22.7	26.3	22.0	25.9	8.2	12.0	24.3	28.0	16.1	21.5	24.8	27.3	13.3	15.4
M_3	16.3	18.2	23.3	27.2	21.4	26.2	10.2	12.9	25.0	29.7	17.4	22.2	25.7	28.3	13.6	16.1
M_4	18.4	21.9	24.2	30.7	24.3	28.4	12.4	14.4	26.2	31.6	18.6	24.3	27.3	31.4	15.2	18.8
S_1	16.7	19.5	23.2	28.4	22.4	27.3	9.6	12.9	24.9	29.7	17.2	22.5	25.5	28.8	14.1	16.7
S_2	14.8	17.2	22.3	26.0	21.0	25.7	8.9	11.7	24.2	28.2	15.9	21.0	24.2	27.2	13.3	15.2
S_3	18.9	22.4	25.2	30.6	24.7	29.0	11.1	14.6	26.9	31.5	18.5	24.6	28.3	30.9	14.9	18.0
S_4	17.7	20.8	24.0	28.9	23.1	27.9	10.0	13.3	25.7	30.2	17.3	23.1	26.9	29.6	14.3	16.9
S_5	13.5	15.8	19.7	23.4	19.1	22.7	7.6	10.3	22.5	25.8	15.2	19.6	23.1	26.0	12.4	14.2

16.20 and 9.0 per cent over the summer ploughing + harrowing treatment during the entire period. Similarly, in subplots, random tied ridging significantly increased the plant height and dry matter production by 9.40 and 9.20 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. Kannan *et al*. (2013) reported that plant height, length of the cob and stover yield of maize was higher under coir pith compost applied field compared to control plot. Higher yield of maize grain (17%) was achieved with the application of coir pith compost compared to normal practice due to the higher soil moisture content with the application of coir pith compost in rainfed maize.

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 were registered in the treatment with coir pith application with random tied ridging 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 7.0, 11.36, 8.8 and 5.3 per cent, respectively over the summer ploughing + chisel ploughing treatment. Similarly in subplots, random tied ridging significantly increased the number of monopodial branches, number of sympodial branches, number of balls/plant and boll

Table 2 : Plant height for cotton under different moisture conservation treatments for silty loam 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	38.4	39.0	40.33	38.2	60.4	61.9	63.8	65.3	62.8	97.6	101.9	104.7	105.9	102.5	128.6	135.2	137.2	142.3	135.8
S_2	34.2	37.6	38.3	40.23	37.6	59.0	60.6	61.7	63.6	61.2	94.2	98.9	103.2	103.5	99.9	126.3	132.4	134.9	137.8	132.8
S_3	38.6	41.4	44.3	44.97	42.3	63.2	64.9	66.2	69.4	65.9	101.0	105.0	108.3	110.2	106.1	135.3	139.0	141.6	148.3	141.0
S_4	36.7	38.7	41.5	42.47	39.8	61.5	62.4	64.3	67.4	63.9	98.9	102.1	106.1	107.1	103.6	132.8	137.4	138.8	145.3	138.5
S_5	34.6	36.0	37.6	38.60	36.7	59.3	58.0	59.9	62.2	59.8	91.5	96.3	99.3	103.2	97.6	121.8	126.1	132.2	135.8	129.0
Mean	37.2	38.4	40.1	41.3	38.9	60.7	61.6	63.2	65.5	62.7	96.6	100.8	104.3	106.0	101.9	129.0	134.0	136.9	141.9	135.4
	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. ±	0.95	0.87	1.29	1.21		0.76	0.37	1.61	1.43		0.56	0.32	0.92	0.78		0.60	0.85	1.43	1.52	
C.D. (P=0.05)	2.31	2.00	3.05	2.80		1.85	0.85	3.89	3.29		1.38	0.75	2.21	1.79		1.47	1.96	3.35	3.50	

Table 3 : Dry matter production for cotton under different moisture conservation treatments for silty loam soils

Treat-ments	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	450	478	495	526	487	1329	1419	1549	1707	1501	3222	3348	3477	3651	3424	4147	4288	4444	4453	4333
S_2	429	453	475	510	467	1255	1353	1421	1613	1410	3140	3224	3353	3536	3313	4087	4210	4375	4382	4264
S_3	474	496	530	575	519	1446	1604	1680	1892	1655	3417	3546	3650	3871	3621	4358	4492	4698	4748	4574
S_4	459	489	522	540	502	1345	1464	1575	1797	1545	3324	3410	3551	3732	3504	4193	4365	4470	4586	4404
S_5	412	438	464	492	451	1210	1308	1361	1544	1356	3048	3129	3253	3357	3196	3880	4279	4267	4325	4187
Mean	445	471	497	529	485	1317	1429	1517	1710	1493	3230	3331	3457	3629	3412	4133	4327	4378	4499	4334
	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.±	2.96	5.34	7.86	8.85		16.38	17.46	42.79	42.07		20.98	30.23	49.50	52.90		21.02	30.04	47.37	50.91	
C.D. (P=0.05)	7.25	12.3	NS	NS		40.08	40.26	NS	NS		51.34	69.72	NS	NS		51.44	69.28	110.8	117.4	

NS= Non-significant

weight by 42.40, 16.42, 24.47 and 16.87 per cent over control (Table 3). The highest yield was obtained in coir pith application with random tied ridging and the lowest in control. In main plots coir pith application treatment significantly increased the yield by 4.40 per cent over the summer ploughing + chisel ploughing while, in subplots random tied ridging significantly increased yield by 17.56 per cent over the control (Table 5). The above findings are in agreement with Araya and Stroosnijder (2010) reported that *in situ* soil conservation practices resulted in significantly low runoff. Tied ridging increased the soil water in the root zone by 13 per cent when compared with the control. Consequently, grain yield and rainwater use efficiency increased significantly with tied ridging as compared to control. Tied ridging increased the grain yield by 44 per cent over the control.

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 plant growth, yield

Table 4 : Yield attributes for 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	1.60	14.67	16.20	3.89
M_2	1.93	16.20	17.40	4.11
M_3	1.87	17.67	19.33	4.31
M_4	2.00	19.60	21.00	4.54
S.E.±	0.13	0.20	0.27	0.07
C.D. (P= 0.05)	0.33	0.48	0.66	0.17
S_1	1.75	17.08	18.33	4.20
S_2	1.67	16.17	17.42	4.06
S_3	2.25	18.42	20.75	4.57
S_4	1.92	17.50	19.25	4.33
S_5	1.58	15.83	16.67	3.91
S.E.±	0.15	0.27	0.44	0.04
C.D. (P= 0.05)	0.34	0.63	1.02	0.10
M at S S.E. ±	0.37	0.67	0.71	0.13
C.D. (P= 0.05)	NS	NS	NS	NS
S at M S.E.±	0.36	0.68	0.77	0.12
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	1815	1916	2132	2194	2014
S_2	1752	1818	2066	2103	1934
S_3	1897	2090	2201	2300	2122
S_4	1848	1964	2137	2211	2040
S_5	1690	1749	1800	1981	1805
Mean	1800	1907	2067	2158	1983
	Main	Sub	M at S	S at M	
S.E. ±	16.60	19.76	31.58	32.67	
C.D. (P=0.05)	40.61	45.57	74.19	75.33	

parameters and yield. This treatment produced significantly superior plant height (141.0 cm), dry matter (4499 kg/ha), number of monopodial branches/plant (2.0), number of sympodial branches/plant (19.6), number of bolls/plant (21.0), boll weight (4.54 g) and the seed cotton yield (2158 kg/ha) which was superior among all the treatments with a B:C ratio of 4.92. Among the subplots, random tied ridging was found to be superior practice in terms of plant height (141.0 cm), dry matter production (4574 kg/ha), number of monopodial branches/plant (2.25), number of sympodial branches/plant (18.42), number of bolls/plant (20.75), boll weight (4.57 g) and seed cotton yield (2122 kg/ha) as compared with other treatments.

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