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Effect of rain water conservation practices on soil moisture status in rainfed *Bt.* Cotton (*Gossypium hirsutum* L.)

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Abstract
Field trials were conducted during *kharif* 2018 at Agronomy Research farm, Department of Agronomy, VNMKV, Parbhani. To study the Effect of Rain Water Conservation Practices on soil Moisture Status of Rainfed *Bt.* Cotton (*Gossypium hirsutum* L). The experiment was laid out in randomized block design, replicated thrice with seven treatments. Treatments were T_1 - Opening furrow (Every row) 30 DAS, T_2 - Opening furrow (Alternate row) 30 DAS, T_3 - Straw mulching 30 DAS, T_4 - Application of herbicide (Pyrithiobac sodium PE + POE), T_5 - Application of Superabsorbent @ 5 kg ha^{-1}, T_6 - Intercropping (Cotton + soybean (1:2)), T_7 - Recommended practices (Control). The study shows that the rain water conservation practices like treatment (T_1) Opening furrow (Every row) 30 DAS recorded the higher mean moisture content at 15, 30 and 45 cm depth at all growth stages of crop and water productivity (Kg m^3) and rain water use efficiency (Kg ha^{-1} mm^{-1}) over the other treatment followed by treatment (T_3) straw mulching and treatment (T_2) Opening furrow in (Alternate row) 30 DAS.

Keywords: *Gossypium hirsutum*, soil moisture, rain water

Introduction
Cotton contributes significantly to the development of both the agricultural and industrial (textile) sectors in India. The crop is grown mainly in Maharashtra, Gujarat, Andhra Pradesh, and Tamil Nadu. With a cultivated area of 12.29 million hectares (MHA) in 2015-16, cotton accounts for 11% of the net cropped area (GoI 2017b). While making up 33% of the world's total acreage, India contributes only 23% of world production (GoI 2017a), and productivity is one of the lowest in the world. In India, cotton is cultivated predominantly under rainfed conditions, which increase the risk in getting yield because of uncertainty in rainfall and reduced moisture availability about 67% of the cotton crop was cultivated under rainfed conditions even during 2015-16 (GoI 2017b).

Rainfed agriculture has the problem of productivity due to low moisture in the root zone during the dry season. High intensity rainfall coupled with heavy black soil leads to large runoff losses. 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. Availability of moisture conservation measures is therefore necessary for improving the soil moisture content and soil fertility. To overcome these problems, the current cultural practices should be improved and certain engineering measures are necessary to be practiced (Muthamilselvan *et al.*, 2006) [4].

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 this vast stretch of lands. Hence, it is necessary to harvest maximum rain water and adopt methods to maximize the retention of moisture.

In-situ rain water conservation practice like opening furrows in between rows, often help in conserving soil moisture and ultimately enhance water use efficiency as well. The cost effective technologies for efficient utilization of rain water management as in-situ moisture conservation comprising the opening of furrow, may prove vital in enhancing and stabilizing the yield.

Materials and Methods
A field experiment was conducted during *Kharif* 2018 at Agronomy Research farm Department of Agronomy, VNMKV, Parbhani.

The Soil of the experimental field was clay in texture, slightly alkaline in reaction (7.7), low in available nitrogen and phosphorus and very high in available potash. The experiment was laid out in randomized block design with three replication and seven treatments. The rain water conservation treatments were T_1 - Opening furrow (Every row) 30 DAS, T_2 - Opening furrow (Alternate row) 30 DAS, T_3 - Straw Mulching 30 DAS, T_4 - Application of herbicide (Pyrithiobac sodium PE + POE), T_5 - Application of Superabsorbent @ 5 kg ha^{-1}, T_6 - Intercropping (Cotton + soybean (1:2)), T_7 - Recommended practices (Control). The region receives an average annual rainfall of 885 mm in about 57 days and grouped under assured rainfall zone. During 2018 the total annual rainfall was received 727 mm and effective rainfall was the 562 mm. sowing was done on 3rd July 2018. The *hirsutum Bt.* hybrid (Ajeet-155) was dibbled at spacing of 150 x 30 cm. Fertilizers (120:60:60 NPK Kg/ha^{-1}) were applied as per the recommendations. Other agronomic practices and plant protection measures were followed as per recommendation. The soil moisture content (Gravimetric method) in 0-15, 15-30 and 30-45 cm soil depth at various growth stages of rainfed *Bt.* cotton like Emergence stage (15 DAS), Squaring stage (30 DAS), Flowering stage (60 DAS), Boll formation stage (90 DAS), Boll development stage (120 DAS), Boll bursting stage (150 DAS) and at harvest was determined by using the following formula-

The moisture content in dry weight basis may be calculated using the following formula (Black 1965) [1].

$$\text{Moisture content (\%)} = \frac{\text{(Weight of wet soil)} - \text{(weight of dry soil)}}{\text{(Weight of wet soil)}} \times 100$$

The moisture content on volume basis can be computed by following formula (Hulihali 2004).

$$\text{Moisture content (cm)} = \frac{\text{Moisture \% X Bulk density X soil depth (cm)}}{100}$$

Water productivity (kg m^3)

The water productivity (kg m^3) was computed using the following equation. (Pradhan *et al.*, 2013) [7].

$$Wp = \frac{Ya}{TWU} = \frac{Ya}{P/\Delta SW}$$

Where,

Ya= Actual harvestable yield (Kg/ha^{-1}); TWU = Total water use (m^3/ha); P is precipitation (m^3/ha), ΔSW is the difference in soil water content between planting and harvest (m^3/ha).

Rain water use efficiency (Kg $ha^{-1}mm^{-1}$)

The rain water use efficiency was calculated as a ratio of the grain yield attained by a treatment and the amount of rainfall received and runoff occurred from sowing to harvest.

Effective rainfall

Water in the root zone is measured by sampling and oven drying the soil before and after every shower of rain. The increase in soil moisture, plus evapo-transpiration loss (ETa) from the time the rain starts until the soil is sampled is the amount of effective rainfall. After heavy rainfall, evapo-transpiration can be assumed to be at the potential rate during the short period from cessation of rainfall until the sampling time. This can be taken as 0.4 to 0.8 times the evaporation value of the class A Pan.

$$ER = M_2 - M_1 + Kp\ Ep$$

Where,

ER = Effective rainfall

Ep = Class a Pan Evaporation value

M_1& M_2 = Moisture status in the effective root zone before and after rain respectively.

Kp = Pan coefficient.

Climatic variability at parbhani during 2018

The climate of Parbhani is characterized by a hot summer and general dryness throughout the year except during period of south-west monsoon. Agriculturally the year is divided in to two seasons *viz*., *kharif* covering June to September and *rabi* October to March. About 75 per cent of rainfall is received in *kharif* and remaining during *rabi*. Parbhani receives an annual mean precipitation of 885 mm in about 57 days and grouped under assured rainfall zone. The effective rainfall was 562 mm against total rainfall received 727 mm. In July and august there was 176.4 and 274.6 mm rainfall, During Flowering, boll formation and boll development crop growth period (September, October and November) there was dry spell observed of about (86 days). The mean maximum temperature varies from 28.62^{0}C to 40.9^{0}C in May, whereas the mean temperature varies from 8.7^{0}C during winter to 26.60^{0}C in summer. The data collected on mean daily total rainfall, rainy days, mean maximum and minimum temperature, mean relative humidity (AM and PM), mean evaporation (mm day^{-1}) and mean bright sunshine hour per day of corresponding weeks at meteorological observatory, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during the period of experimentation.

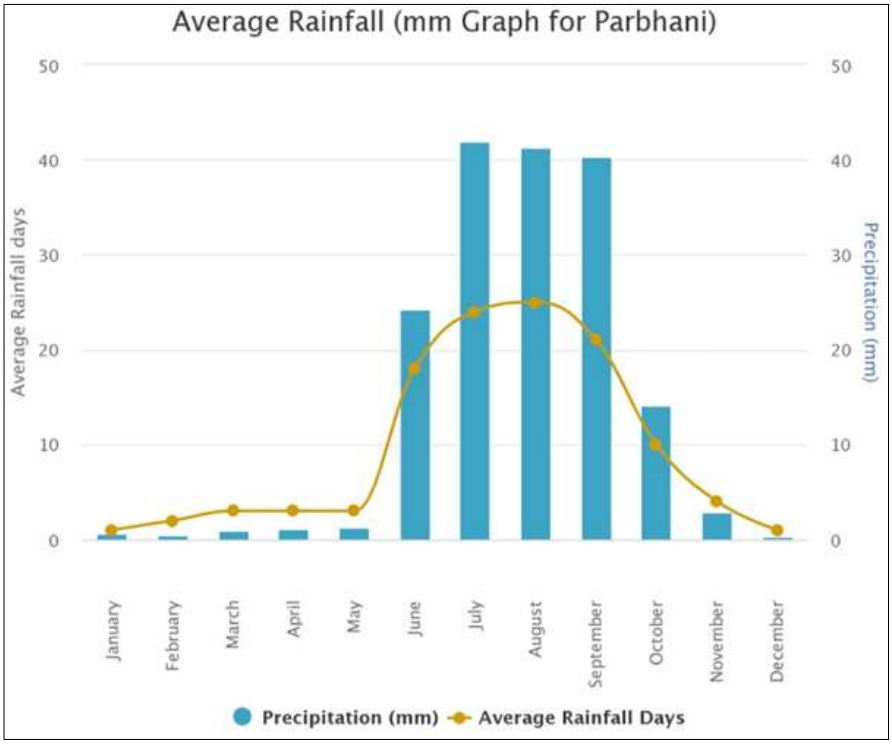

Fig 1: Average rainfall (mm) graph of parbhani

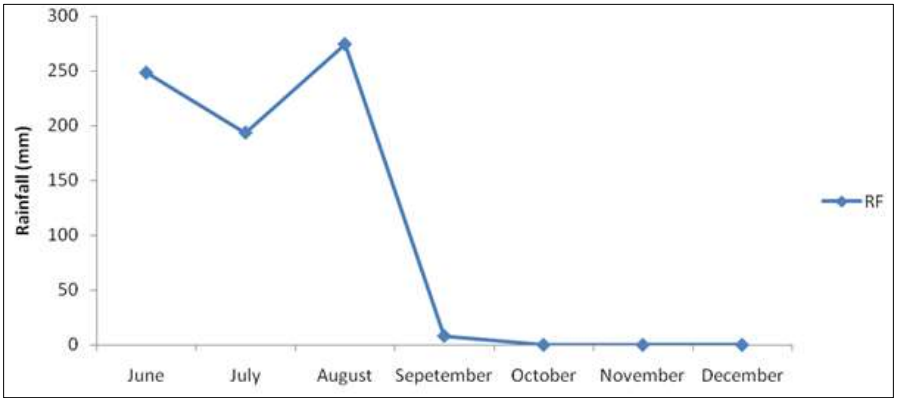

Fig 2: Rainfall (mm) graph at parbhani during 2018

Result and Discussion

Soil moisture status (cm)

The soil moisture status (cm) at different crop growth stages of cotton was recorded in Table 1. The data on mean soil moisture status (cm) initially increased at emergence stage. Finally it was declined from flowering to boll formation stage towards up to harvest of crop. In the study, the rain water conservation practices influenced the soil moisture (cm) Table 1 and Fig. 2. Due to the rainfall events occurred (on 6 July 28.6 mm rainfall) after allocation of the treatments (30 DAS), the soil moisture content increased giving the treatment effects of rain water and moisture conservation. The highest mean moisture content was recorded at Emergence stage at 15 cm (5.42 cm), 30 cm (10.73 cm) and 45 cm (17.55 cm) and square formation stage at 15 cm (4.27 cm), 30 cm (12.17 cm) and at 45 cm (27.02 cm) respectively. A total rainfall 727 mm of was received during the crop growing season. The rain water conservation treatments of opening furrow every row 30 DAS were imposed during last intercultural operation and the data on soil moisture was recorded at emergence, square formation stage, flowering stage, boll formation stage, boll development stage and at harvest revealed that maximum soil moisture (%) was recorded in treatment (T_1) Opening furrow (Every row) 30 DAS followed by (T_2) Opening furrow (Alternate row) 30 DAS and (T_3) Straw mulching 30 DAS and the lowest soil moisture was recorded with Control (Recommended practices). At the Flowering, boll formation, boll development, boll bursting and at harvest of *Bt.* cotton crop growth period (September, October and November) there was dry spell observed of about 86 days and the availability of more soil moisture in these treatments might be due practices of opening furrow every row 30 DAS which serve as retention of moisture during dry spells. These results are in conformity with Narayana *et al.*, (2011) [5], Tayade and meshram (2013) [9], Paslawar and Deotalu (2015) [6] and Ganpathi *et al.*, (2018) [2].

Table 1: Soil moisture status (cm) of soil at 15, 30, 45 cm depth of rainfed *Bt.* cotton as influenced by different rain water moisture conservation practices

Tr. No.	Treatment	Depth of soil	Growth stages of Rainfed *Bt.* Cotton						
			Emergence	square formation	flowering	Boll formation	Boll development	Boll bursting	At Harvest
T_1	Opening furrow (Every row) 30 DAS	15	5.42	4.27	4.69	4.07	2.47	1.36	0.90
		30	10.73	12.17	9.93	12.13	6.95	4.39	3.41
		45	17.55	27.02	26.03	17.28	12.29	8.97	7.23
		Total	33.71	43.46	40.65	33.49	21.72	14.73	11.55
T_2	Opening furrow (Alternate row) 30 DAS	15	7.40	4.90	4.73	3.78	2.38	1.15	0.73
		30	11.78	12.24	10.15	9.21	6.58	4.76	3.51
		45	18.09	22.33	21.87	18.86	11.96	7.98	6.30
		Total	37.28	39.47	32.87	31.86	21.93	13.91	10.54
T_3	Straw mulching 30 DAS	15	6.83	4.42	5.11	3.56	2.38	1.10	0.66
		30	11.17	11.24	10.24	10.87	6.10	4.63	3.36
		45	17.17	24.65	22.4	17.98	12.46	8.85	6.80
		Total	35.17	40.31	37.75	32.45	20.95	14.59	10.84
T_4	Application of herbicide (Pyrithioback sodium PE + POE)	15	5.68	5.07	4.51	3.27	1.96	1.00	0.51
		30	10.95	12.18	10.36	10.88	5.84	4.01	2.87
		45	17.05	21.30	18.72	16.65	10.91	6.93	5.30
		Total	33.68	38.55	33.59	30.81	18.71	11.95	8.68
T_5	Application of superabsorbent @ 5 Kg ha^{-1}	15	5.68	5.05	5.07	3.17	1.81	0.86	0.46
		30	10.95	11.95	10.66	10.80	5.78	3.95	2.84
		45	17.05	22.92	15.83	17.37	11.37	7.46	5.73
		Total	33.68	39.92	31.56	31.35	18.96	12.27	9.03
T_6	Intercropping (Cotton + soybean (1:2))	15	6.39	5.09	4.3	3.57	1.46	0.595	0.21
		30	12.37	11.93	9.47	9.58	4.67	2.82	1.78
		45	19.39	19.97	15.62	14.76	9.94	4.57	4.33
		Total	38.15	36.99	29.39	27.91	16.08	7.99	6.33
T_7	Control (Recommended practices).	15	4.95	4.94	4.51	3.42	1.86	0.82	0.35
		30	13.18	9.94	10.25	11.51	5.90	3.40	2.63
		45	20.41	19.89	16.18	15.59	10.59	6.27	5.00
		Total	38.55	41.40	30.94	30.52	18.36	10.50	7.99
General Mean		15	6.05	4.82	4.70	3.55	2.04	0.98	0.54
		30	11.59	11.66	10.15	10.17	5.97	3.99	2.91
		45	18.10	22.58	19.52	16.92	11.36	7.29	5.81

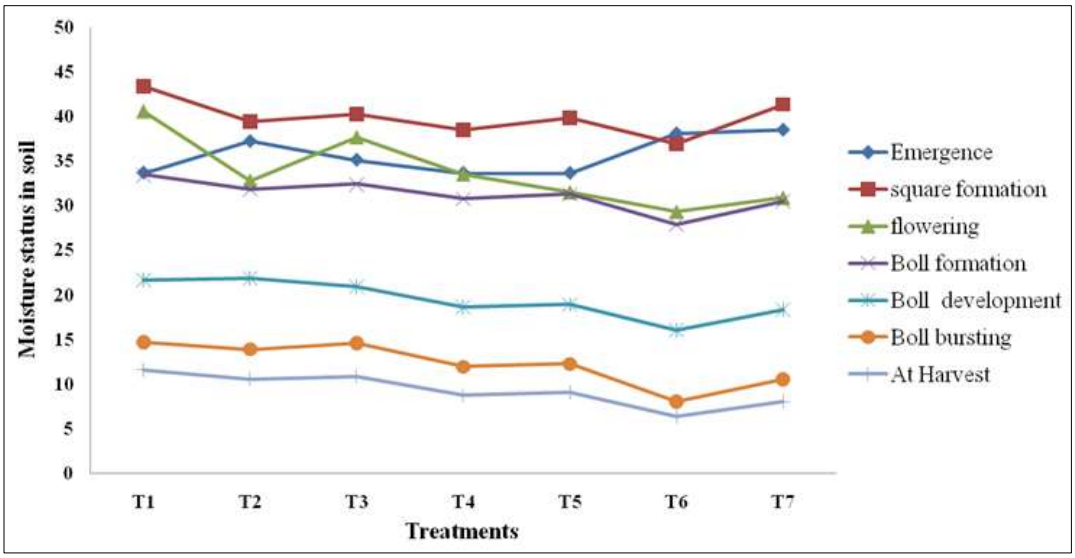

Fig 3: Soil moisture status (cm) at various growth stages of rainfed *Bt.* Cotton

Data on seed cotton yield (kg ha^{-1}), water productivity (kg m^3), and rain water use efficiency (kg $ha^{-1}mm^{-1}$) of rainfed *Bt.* cotton as influenced by different rain water moisture conservation practices is presented in Table 2.

Table 2: Seed cotton yield (kg ha^{-1}), water productivity (kg m^3) and rain water use efficiency (Kg ha^{-1}mm^{-1}) of rainfed *Bt.* cotton as influenced by different rain water conservation practices

Tr. No.	Treatments	Seed cotton yield (kg ha^{-1})	Water Productivity (kg m^3)	RWUE (kg ha^{-1}mm^{-1})
T_1	Opening furrow (Every row) 30 DAS	2116.41	0.54 (58.82 %)	3.76
T_2	Opening furrow (Alternate row) 30 DAS	1863.49	0.48 (41.17 %)	3.31
T_3	Straw mulching 30 DAS	1945.82	0.50 (47.05 %)	3.45
T_4	Application of herbicide (Pyrithioback sodium PE +POE)	1635.41	0.42 (23.52 %)	2.90
T_5	Application of Superabsorbent @ 5 Kg ha^{-1}	1719.87	0.44 (29.41%)	3.05
T_6	Intercropping (Cotton + soybean (1:2))	1126.77 (CEY=573.22)	0.51 (50 %)	3.02
T_7	Control (Recommended practices)	1311.84	0.34	2.33
General mean		1674.23	0.46 (35.71 %)	2.97

Seed cotton yield (kg ha^{-1})

The data on mean seed cotton yield (kg ha^{-1}) of rainfed *Bt.* cotton as influenced by different t rain water conservation practices were present in Table 2. The mean seed cotton yield (kg ha^{-1}) was 1674.23 Kg ha^{-1}.

Significantly affected by rain water conservation practices maximum seed cotton yield (2116.41Kg ha^{-1}) was recorded with treatment (T_1) Opening furrow (Every row) 30 DAS and which is followed by rain water conservation treatment (T_2) Opening furrow (Alternate row) 30 DAS and (T_3) Straw mulching 30 DAS. Similar results were observed by Rajendran *et al.*, (2011) [8] and Ganpathi *et al.*, (2018) [2].

Water productivity (Kg m^3)

Values in Table 2 indicate mean water productivity of rainfed *Bt.* cotton which is influenced by different rain water conservation practices. Mean water productivity of rainfed *Bt.* cotton is 0.46 Kg m^3. This reveals that 0.46 Kg of seed cotton was obtained after every 1 m^3 water received through rainfall under rainfed conditions.

Water productivity of treatments (T_1) opening furrow every row 30 DAS recorded highest value i.e. 0.54 Kg m^3, followed by treatment (T_6) intercropping (cotton + soybean (1:2)) i.e. 0.51 Kg m^3 which was more than other treatments. Treatment (T_7) Control recorded the lowest water productivity i.e. (0.34 kg m^3). These result are recorded due to more moisture were conserved due to implication of rain water conservation practices like opening furrow every row. Similar kinds of observations were recorded by- Hulihali and patil (2005) [3], Tehereema *et al.*, (2010) [10].

Rain water use efficiency (Kg ha^{-1}mm^{-1})

The data on mean rain water use efficiency of rainfed *Bt.* cotton as influenced by different rain water conservation practices were present in Table 2. The mean rain water use efficiency was 2.97 Kg ha^{-1}mm^{-1}.

Rain water use efficiency of rainfed *Bt.* cotton was recorded in the range 2.33 to 3.76 (Kg ha^{-1}mm^{-1}). The highest rain water use efficiency was obtained from opening furrow every row (T_1) (3.76 Kg ha^{-1}mm^{-1}). Among the rain water conservation practices (T_6) Intercropping (Cotton + soybean (1:2)) recorded the rain water use efficiency is (3.02 Kg ha^{-1}mm^{-1}). Application of herbicide (Pyrithioback sodium PE + POE) (T_4) recorded lowest rain water use efficiency (2.90 Kg ha^{-1}mm^{-1}), while control (T_7) treatment recorded minimum value of (2.33 Kg ha^{-1}mm^{-1}). The increase in rain water use efficiency by various rain water conservation practices indicates conservation of moisture due to its application. These results are in conformity with - Ugale *et al.*, (2000) [11].

Conclusion

Soil moisture status during the rainy season varied with the moisture conservation practices. Higher soil moisture retention can be achieved through treatment opening furrow every row 30 DAS resulting in higher yield (38.07 %) as compared to control. In case of rainfed *Bt.* cotton, with no moisture conservation practices, there was yield reduction due to moisture stress induced due to dry spells (86 days) was observed to be (30.02 %) when it occurred at Flowering, boll formation and boll development growth stage.

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