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Effect of polythene mulch and irrigation levels on yield, water use efficiency and economics of bt cotton

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Abstract
A trial was conducted to study the effects of Polythene Mulch and Irrigation levels on growth, yield, water use efficiency and economics of Bt cotton at Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra (India) during *kharif* 2013-14 and 2014-15 on clayey soil. The experiment was laid out with eight treatment combinations in Factorial Randomized Block Design replicated thrice. Treatment comprises of without polythene mulch and with polythene mulch and four irrigation levels as 0.4 ETc, 0.6 ETc, 0.8 ETc,and 1.0 ETc constituted the factor I and the factor II respectively. Application of polythene mulch recorded significantly higher seed cotton yields Water use efficiency, highest gross monetary returns, net monetary returns and B:C ratio over without polythene mulch. The seed cotton yield ha^{-1} was significantly higher with irrigation level 0.8 ETc over other irrigation levels. However, water use efficiency was higher under irrigation level 0.4 ETc, followed by 0.6 ETc, 0.8 ETc, and lowest under the1.0 ETc. Significantly highest gross monetary returns, net monetary returns and B:C ratio were obtained with the irrigation level 0.8 ETc.

Keywords: Polythene mulch, irrigation scheduling, Bt cotton, benefit: cost ratio, ETc

Introduction
Cotton (*Gossypium* spp.) is grown mainly for its fibre used in the manufacture of cloth for mankind. It is a valuable product traded globally as well as an important employment creator. World widely, more than 100 millon farming units are directly involved in cotton production, in many more in its complementary activities. India will be a highly water stressed country 2020 onward (Anonymous, 2006) [1]. Population of India is expected to reach from 1027 million (2001, AD) to 1930 million by 2025. To meet the requirement of water scarcity, there are two options, either increase the gross irrigation potential or increase the water use efficiency. As water is becoming limiting resource, there is no scope to increase irrigation potential by using additional water. Hence, only way to increase fibre production is by increasing water use efficiency. In Vidarbha, cotton is grown as *rainfed* crop, as such about 89.1% cultivable land under *rainfed* farming and *rainfed* cotton production has direct bearing on the agrarian economy of the region. The low productivity is mainly due to maximum area under *rainfed* condition and erratic distribution of rainfall. As micro-irrigation system is found to be one of the advanced methods of irrigation. It is amply proved that method saves the irrigation water to the extent of 30 to 50% and enhances the crop yield by 15 to 20%. In addition, it saves the cost of inter cultivation, improves the fertilizer use efficiency, hasten the maturity of crop and improves the quality of the produce. Polythene mulch is crucial to Indian agriculture in view of the changing technological scenario for boosting crop yields and productivity. It is actually a boon to dry land farmers. The mulch raised the soil temperatures, resulting in rapid germination and early plant growth.
Micro-irrigation in the area as well as polythene mulching has production of cotton systems satisfactorily resulted. Hence, it is necessary to apply irrigation through drip and use of polythene mulch so as to get the more seed cotton yield. Therefore, field studies were conducted on drip irrigation under varying ETc irrigation levels. The present investigation was undertaken to study the effect of polythene mulch and irrigation scheduling on yield, water use efficiency and economics of Bt cotton.

Materials and Methods
The experiment was conducted during Kharif, 2014 at the Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra (India).

The design followed was in Factorial Randomized Block Design with eight treatments and three replications. The treatment consisted of two levels of mulch *viz.*, without polythene mulch and with polythene mulch and four levels of irrigation *viz.*, I_1 - 0.4 ETc, I_2 - 0.6 ETc, I_3 - 0.8 ETc. and 1.0 ETc, and check treatment was taken as farmers practice, sowing on ridges and furrow with polythene mulch and without polythene mulch.

The plastic films (silver up and black down) of 30 µm thickness were used to cover the treatments of every replications and remaining treatment were without polythene mulch. The experimental plot was ploughed once and harrowed twice to ensure proper tilth for easy sowing and better emergence before laying the experiment. Farm yard manure 5 t ha^{-1} was applied in the field and thoroughly mixed in the soil at the time of field preparation. The crop was fertilized with nitrogen, phosphorus, and potassium as per the recommended dose (100:50:50 kg N, P_2O_5, K_2O ha^{-1}, respectively.) Nitrogen applied through urea, phosphorus is applied through single super phosphate and potassium through murate of potash. The basal fertilizer (½ N, fill K and full P) was given as basal before spreading the polythene mulch. The remaining dose of fertilizer was given after 30 days of emergence by the fertigation. Certified seeds of *Bt* cotton variety Paras Brahama were obtained from the open market. The dibbling method was used for the sowing of cotton. The irrigation was scheduled on every alternate days for cotton crop. The daily water requirement of cotton crop was worked out on the basis of class 'A' open pan evaporation and crop factor. The value of pan coefficient was taken as 0.8. The duration of operation of drip system was worked out for the different treatments (0.4 ETc, 0.6 ETc, 0.8 ETc, with polythene mulch and without polythene mulch). The observations were subjected to statistical analysis according to the procedures given by Panse and Sukhatme (1967) [8].

Results and Discussion

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

Effect of mulch

Significantly higher seed cotton yield (3168 kg ha^{-1}) was observed under polymulch treatment than without polymulch(2321 kg ha^{-1}) during 2013-14. Similarly, similar treand was observed during 2014-15 and pooled mean

The increase in seed cotton yield under the polymulch might be because of increased nutrient and moisture availability, improved absorption better vegetative growth, and yield attributing characters as compared to without polythene mulch. Similar results were also reported by Ghadage *et al.* (2005) [3] and Nalayini *et al.* (2006) [5].

Effect of Irrigation levels

Irrigation level of 0.8 ETc recorded significantly higher seed cotton yield (2948 kg ha^{-1}) over, 0.6 ETc (2650 kg ha^{-1}) and 0.4 ETc (2488 kg ha^{-1}) irrigation levels during 2013-14. However it was comparable with 1.0 ETc in respect of seed cotton yield (kg ha^{-1}.) Similar treand was observed during 2014-15 and pooled analysis over two years.

The increase in seed cotton yield in irrigation level of 0.8 ETc was mainly due to better vegetative growth increased nutrient availability and absorption by the crop at the optimum moisture supply coupled with poly mulch and better formation and translocation of assimilates from source to sink. The results obtained are in conformity with the findings of Sagarika *et al.* (2002) [10], Halemani *et al.* (2009) [4], Rajendran *et al.* (2012) [9], Tekale *et al.* (1999) [12], Bhalerao *et al.* (2011) [2] Ghadage *et.al*. (2005) [3]. and Singh *et al* (2012) [11]

Interaction effect

Interaction effect between polythene mulch and irrigation levels on seed cotton yield was found to be significant during 2013-14. The treatment combination (PM2xI3) of 0.8 ETc with polythene mulch recorded the highest seed cotton yield (kg ha^{-1}) over rest of the treatment combinations..

Check

The check treatment of ridges and furrows with polymulch significantly improved the seed cotton yield during both the years and pooled.

Total Water applied (ha-cm.)

Total Water applied. (ha cm) during 2013-14 and 2014-15 are given in Table 1. The data reveals that the mean amount of irrigation water applied to with and without polymulch were common ie.26.24 and 32.32 ha-cm. during 2013-14 and 2014-15 respectively. Irrigation applied at 0.4 ETc, 0.6 ETc, 0.8 ETc and 1.0 ETc with polymulch and without polymulch were 14.99, 22.49.29.99, 37.49 and 48.10 ha–cm respectively during 2013-14. where as, it was 18.5, 27.66, 36.99, 46.15 and 52.30 ha–cm respectively, during 2014-15. Irrigation applied on pooled mean basis for 0.4 ETc,0.6 ETc, 0.8 ETc and 1.0 ETc with polymulch and without polymulch were16.74,25.07,33.49,41.82, and 50.20 ha–cm respectively. Soil moisture conservation due to polymulching was reported by Halemani *et al* (2009) [4] Nalayini *et al* (2006) [5]

Mulched cotton consumed lesser water due to lesser evaporative loss of water and weed free environment.

Table 1: Seed cotton yield (kg ha^{-1}), Water applied (ha cm), Water Use Efficiency (kg ha $^{-1}$ mm^{-1}) as influenced by different treatments during 2013-14, and 2014-15.

Sr. No	Treatments	Seed Cotton yield (kg ha^{-1})			Water applied (ha cm)			Water Use Efficiency (kg ha $^{-1}$ mm^{-1})		
		2013-14	2014-15	Pooled	2013-14	2014-15	Pooled mean	2013-14	2014-15	Pooled mean
Mulch										
PM1	Without Polymulch	2321	2131	2226	26.24	32.32	29.28	16.81	11.66	14.23
PM2	With Polymulch	3168	3027	3098	26.24	32.32	29.28	22.02	16.69	19.35
SE (m) =		23.94	32.36	21.79	-	-	-	-	-	-
CD (P= 0.05)		72.59	98.14	66.08	-	-	-	-	-	-
Levels of Irrigation										
I1	Irrigation at 0.4 ETC	2488	2304	2396	14.99	18.50	16.74	29.13	19.69	24.41
I2	Irrigation at 0.6 ETC	2650	2404	2527	22.49	27.66	25.07	19.88	13.96	16.92
I3	Irrigation at 0.8 ETC	2948	2844	2896	29.99	36.99	33.49	16.41	12.69	14.55
I4	Irrigation at 1.0 ETC	2892	2765	2828	37.49	46.15	41.82	12.23	10.37	11.30
	SE (m)±	21.85	29.54	19.89						

	CD (P= 0.05)	66.27	89.59	60.32						
Interaction PM X Irrigation										
SE (m)±		53.52	72.36	48.72						
CD (P= 0.05)		162.32	NS	NS						
GM		2745	2579	2662	26.24	32.32	29.28	19.41	14.18	16.79
Check										
Ch1	Ridges and Furrows	1730	1550	1640	48.10	52.30	50.20	5.95	5.08	5.51
Ch2	R F with Poly Mulch	2296	2083	2189	48.10	52.30	50.20	8.40	5.85	7.12
	SE (m)±	72.10	87.10	62.30	-	-	-	-	-	-
	CD (P= 0.05)	214.20	258.73	185.08	-	-	-	-	-	-

Table 1(a): Seed cotton yield (kg ha^{-1}) as influenced by Interaction of PM x Irrigation during 2013-14.

2013-14	I1	I2	I3	I4
PM1	2109	2265	2384	2526
PM2	2868	3035	3512	3258
SE m ±	53.52		CD (P= 0.05)	162.32

Table 2: Gross Monetary Returns (Rs/ha) Net Monetary Returns (Rs/ha) and B.C Ratio as influenced by different treatments during 2013-14 and 2014-15

		Cost of cultivationn (Rs/ha)			Gross Monetary Returns (Rs/ha)			Net Monetary Returns (Rs/ha)			B.C Ratio		
Sr. No	Treatments	2013-14	2013-14	Pooled	2013-14	2013-14	Pooled	2013-14	2013-14	Pooled	2013-14	2014-15	Pooled
Levels of Mulch													
PM1	Without Polymulch	54382	55287	54835	98229	92257	95243	43847	36970	40408	1.81	1.66	1.74
PM2	With Polymulch	72271	76370	74320	133970	130906	132438	61699	54537	58118	1.85	1.71	1.78
	SE (m)±	96	129	87	1013	1400	935	917	1271	848	-	-	-
	CD (P= 0.05)	290	393	264	3071	4247	2836	2780	3854	2571	-	-	-
Levels of Irrigation													
I1	Irrigation at 0.4 ETc	62302	64727	63514	105343	99826.	102585	43042	35099	39071	1.69	1.53	1.61
I2	Irrigation at 0.6 ETc	62949	65127	64038	112156.	104076	108116	49207	38949	44078	1.78	1.59	1.68
I3	Irrigation at 0.8 ETc	64141	66888	65514	124611	122942	123776	60471	56054	58262	1.93	1.83	1.88
I4	Irrigation at 1.0 ETc	63916	66571	65243	122287	119481	120884	58372	52911	55641	1.92	1.80	1.86
	SE (m)±	837	1160	774	924.30	1278.	853	837	1160	774	-	-	-
	CD (P= 0.05)	2538	3519	2347	2803.16	3876.	2588	2538	3519	2347	-	-	-
Interaction PM X Irrigation													
	SE (m)±	NS	NS	NS	2264	3131	2090	2050	2842	1896			
	CD (P= 0.05)	649	878	591	6866	NS	NS	6217	NS	NS			
	GM=	63327	65828	64577	116100	111582	113841	52773	45753	49263			
Check													
Ch1	Ridges and Furrows	47732	48473	48102	73376	67229	70303	25644	18757	22200	1.54	1.39	1.46
Ch2	R F with Poly Mulch	60392	59707	60050	97209	90336	93772	36817	30628	33722	1.61	1.51	1.56
	SE (m)±	288	348	249	3051	3770	2672	2763	3422	2422	-	-	-
	CD (P= 0.05)	857	1035	740	9065	11199	7936	8208	10165	7196	-	-	-

Table 2: (a) Gross Monetary Returns (Rs/ha) as influenced by Interaction of PM x Irrigation during 2013-14.

2013-14	I1	I2	I3	I4
PM1	89339	95888	100847	106844
PM2	121349	128425	148375	137732
SE m ±	2264		CD P= 0.05	6866

Water use efficiency (kgha^{-1}mm^{-1})

The water use efficiency as measured by the ratio of seed cotton produced to the water consumed by the cotton crop. The data presented in table reveled that the amount of irrigation water applied through drip irrigation at 0.4 ETc,0.6 ETc, 0.8 ETc,1.0 ETc and check treatment ridges and furrow with polymulch and without polymulch influenced the water use efficiency.

Effect of mulch

Water use efficiency of crop with mulch showed highest water use efficiency under the polymulch. The higher water use efficiency (22.02 kgha-1mm-1) was recorded by polymulch over without polymulch (16.81 Kgha-1mm-1) during 2013-14. Similar trend was observed during 2014-15. In pooled mean. the higher water use efficiency was recorded with polymulch (19.35 kg ha^{-1} mm^{-1}) over without mulch (14.23 kg ha^{-1} mm^{-1}). Similar results obtained are in conformity with findings of Ghadage *et al.* (2005) [3]. Nalayini *et al.* (2007) and Nalayini *et al.* (2017) [7] The response under mulched condition might be due to avoidance of direct contact of sunlight on mulched soil keeping the evaporative loss at its minimum.

Effect of irrigation levels

The highest water use efficiency (29.13 kgha-1mm-1) was recorded by treatment 0.4 ETc fallowed by 0.6 ETc (19.88 kgha-1mm-1), 0.8 ETc, (16.41 Kgha-1mm-1), 1.0 ETc (12.23 kgha-1mm-1) during 2013-14. Similar trend was also observed during 2014-15 and in pooled. . The higher yield and better growth under mulched condition at lower moisture regime were due to better moisture conservation and favourable condition for plant growth. It was observed that more the quantity of irrigation water applied lowers the water use efficiency. The above results agreed with the findings reported by Bhalerao *et al.* (2011) [2], Naliyini *et al.* (2009) [6] and Rajendran *et al.* (2012) [9]. Naliyini *et al.* (2017) [7]

Check treatment

Planting cotton on ridges and furrows with polymulch recorded higher water use efficiency (8.40 kgha-1mm-1) over without mulch (5.95 kgha-1mm-1) during the 2013-14 Similar trend was observed during 2014-15 and pooled mean.

Economics.

Gross monetary returns

Effect of mulch

Data presented in Table 2 reveals that application of mulching significantly influenced the gross monetary returns during both the years and pooled mean. The significantly higher gross monetary returns on pooled mean were obtained (132438 Rs. ha^{-1}) with application of polythene mulch over without polythene mulch (95243 Rs. ha^{-1}). It was due to higher seed cotton and cotton stalk yields (kg ha^{-1}) with polythene mulch. Similar results were reported by Ghadage *et al.* (2005) [3].

Effect of irrigation levels

Gross monetary returns were significantly influenced by different irrigation levels. Irrigation level of 0.8 ETc (123776 Rs. ha^{-1}) recorded significantly highest gross monetary returns on pooled mean basis over Irrigation at 0.4 ETc(102585 Rs. ha^{-1}), Irrigation at 0.6 ETc (108116 Rs. ha^{-1}) and Irrigation at 1.0 ETc (120884 Rs. ha^{-1}). It might be due to higher seed cotton and cotton stalk yields (kg ha^{-1}) with 0.8 ETc irrigation level. Similar result reported by Singh *et al* (2012) [11]

Interaction

Interaction effect of polythene mulch with irrigation was found significant during 2013-14,. indicated that treatment combination of (I3xPM2) polymulch with 0.8 ETc irrigation recorded significantly higher gross monetary returns148375 Rs. ha^{-1} during 2013-14 over rest of the treatment combinations.

Check treatment

Application of polymulch on ridges and furrow registered higher gross monetary returns during both the year of investigation and on pooled mean basis. (93772 Rs. ha^{-1}).

Net monetary returns (Rs. ha^{-1})

Effect of mulch

Data on net monetary returns (Rs. ha^{-1}) obtained by different treatments reveals that mulching significantly influenced the net monetary returns during 2013-14 , 2014-15 and pooled also.The significantly higher net monetary returns were obtained with polythene mulch (58118 Rs ha^{-1}) over without polythene mulch (40408 Rs ha^{-1}). on pooled mean basis. It was due to higher seed cotton and cotton stalk yields (kg ha^{-1}) with polythene mulch than without polythene mulch. Similar result was reported by Ghadage *et al.* (2005) [3].

Effect of Irrigation levels

Irrigation level of 0.8 ETc recorded significantly highest net monetary returns (58262 Rs. ha^{-1}) over 0.4 ETc (39071 Rs. ha^{-1}) and 0.6 ETc (40078 Rs. ha^{-1}) on pooled mean basis , It was due to higher seed cotton and cotton stalk yields (kg ha^{-1}) under 0.8 ETc irrigation level. Similar results were reported by Singh *et al* (2012) [11].

Interaction effect

Interaction effect was found significant during 2013-14, Data indicated that treatment combination of polymulch with 0.8 ETc (I3xPM2) has recorded significantly higher NMR (74729 Rs. ha^{-1}), over rest of the treatment combinations

Check Treatment

Ridges and furrow with polymulch recorded higher net monetary returns (Rs. ha^{-1}) during 2013-14 and 2014-15 over without polymulch.

Cost of Cultivation (Rs/ha)

Effect of mulch

Data presented in Table 2 reveals that polythene mulch significantly influenced the cost of cultivation (Rs/ha) during both the years and pooled mean. The higher cost of cultivation was registered due to polythene mulch during 2013-14, 2014-15 and pooled .It was due to higher cost of polythene mulch.

Effect of irrigation levels

Irrigation level of 0.8 ETc recorded highest cost of cultivation (65514 Rs/ha) on pooled mean basis The irrigation at 0.4 ETc recorded lowest cost of cultivation (63514 Rs. ha^{-1}) on pooled mean.

Interaction effect

Interaction effect of polymulch with irrigation levels on cost of cultivation was found non significant during both the years and pooled mean.

Check Treatment

Ridged and Furrow with Polymulch recorded higher cost of cultivation (Rs. ha^{-1}) during 2013-14 and 2014-15 and pooled over ridges and furrow without polymulch.

Benefit. Cost Ratio

Effect of mulch

Benefit. Cost ratio (B:C) as influenced by different treatments presented in Table 2 reveals that polythene mulch recorded higher B.C ratio (1.78) than without polythene mulch (1.74). on pooed mean basis. The higher cost of polymulch influenced the B.C ratio Similar result was obtained by Ghadage *et al.* (2005) [3].

Effect of irrigation levels

Irrigation level of 0.8 ETc registered maximum B. C ratio of 1.88 followed by 1..0 ETc (1.86), 0.6 ETc (1.68) and 0.4 ETc (1.61).on pooled mean basis. The higher B. C ratio might be due to higher yield under 0.8 ETc Irrigation level. Similar result was reported by Singh *et al* (2012) [11]

Check

Check treatment Ridged and Furrow with polymulch (1.56) recorded higher B.C ratio over without polymulch (1.46) on pooled mean basis.

Conclusion

From this study it is concluded that, application of polythene mulch with 0.8 ETc has recorded higher gross monetary returns, net monetary returns and B:C ratio over without polythene mulch in Bt.cotton. However, drip irrigation at 0,4 ETc under polymulch recorded maximum water use efficiency followed by 0.6 ETc,0.8 ETc, and lowest under the1.0 ETc..

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