Research Article

CONJUNCTIVE STIMULUS OF IRRIGATION REGIMES FREQUENCY AND MULCHING ON Bt. COTTON

G.V. Prajapati[1*], R. Subbaiah[2], N.S. Vithlani[3], H.Y. Maheta[4], J.J. Makwana[5] and P.V. Patel[6]

[1]Centre of Excellence on Soil & Water Management, [3,5]Research, Testing and Training Centre, [4]Post Graduate Institute of Agricultural Business Management, [6]Director of Students' Welfare, Junagadh Agricultural University, Junagadh, Gujarat, INDIA
[2]College of Agricultural Engineering and Technology, Anand Agricultural University, Godhra, Gujarat, INDIA
**Corresponding author's E-mail: prajapati_girish@jau.in*

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ABSTRACT
Lower unit cost of production and increase in yield by 29% higher yield in Bt. cotton than hybrid cotton pleased the Saurashatra farmers to adopt Bt. cotton on large scale. Cotton in general does not withstand heavy irrigations. Scheduling of irrigation thus become important in cotton since water is valuable, costly and scarce on one hand. Water availability for agricultural use is declining all over the world due to the scarcity of water resource. Irrigation schedule needs proper irrigation regime, frequency under a particular set of conditions. To study conjunctive impact of different mulches (silver black plastic mulch &wheat straw mulch) irrigation regimes (0.6 ET_c, 0.8 ET_c, 1.0 ET_c) frequency (2 days, 3 days and 5 days) on growth and yield parameter of Bt. cotton. An experiment was undertaken consecutively for two years (2013-14 and 2014-15). Irrigation scheduling was done based on actual evapotranspiration measured with help of soil moisture sensors. The control treatment was taken as drip with no mulch. Silver black plastic mulch recorded 22.40% more plant height, 27.83%number of sympodial branches, 26.23% number of monopodial branches, 28.46% number of bolls, 26% mean boll weight and 38.68% more seed cotton yield than to control at 0.8 ET_c and 3 days irrigation frequency. Highest water use efficiency (20.48 kg $ha^{-1}mm^{-1}$), BC ratio (3.2) and Internal Rate of Return (141.52%) was observed under silver black plastic mulch with 0.8 ETc and 3 days frequency of irrigation.

INTRODUCTION

Cotton acreage in Saurashtra is around 18.5 lakh hectares, out Gujarat's total 27.58 lakh hectares under than hybrid cotton pleased the Saurashatra farmers to adopt Bt. cotton on large scale. Cotton in general does not withstand heavy irrigations. Scheduling of irrigation thus become important in cotton since water is valuable, costly and scarce on one hand. Water availability for agricultural use is declining all over the world due to the scarcity of water resource. On the other hand, excess water encourages vegetative growth. Excess growth of cotton is conducive for pests and disease attack. It also reduces the flow of air and incidence of sunlight resulting in reduced reproductive growth and finally lower yields. Thus, due to different growth habit and duration of Bt. cotton with that of non-Bt. cotton, the existing schedule of irrigation may become improper, if the same is followed and there is need to work out the irrigation schedule. Drip irrigation generally save 30% of water (Mukesh *et al.,* 2009) and increase yield (Sivanappan, 2004), provides high water use efficiency, higher crop yield, less labour requirement (Rajendran *et al.,* 2012) and relatively low operating cost, less weed growth, less insect and pest attacks, shorter growing season and cotton crop. Lower unit cost of production and increase in yield by 29% higher yield in Bt. cotton earlier harvest of the crop. If mulch is conjointly adopted with drip system more water can be saved which is generally lost in evaporation from moisture bulb. Mulching also regulate soil temperature, control weeds and increase water use efficiency in cotton (Ramesh *et al.,* 2006; Naliyani *et al.,* 2009; Murugan and Gopinath, 2001; Prajapati and Subbaiah, 2015). Reflective plastic mulches can reduce the incidence of aphid-borne viruses and exclude some species of pest (Schalk *et al.,* 1979). Hence for appropriate water management, this sound practice is adopted for Bt. cotton. Relatively few studies were conducted to analyze the combined influence of drip irrigation with silver black plastic mulch and wheat straw plastic mulch on productivity of Bt. cotton under variable irrigation regimes and frequency. Hence, present investigation was aimed to find out optimum moisture regime and frequency for mulched drip irrigated Bt. cotton.

MATERIALS AND METHODS

An experiment was conducted at Research cum Demonstration farm of Centre of Excellence on Soil

and Water Management, Junagadh Agricultural University(21°30' N, 70°27' E and 77.5 above mean sea level) to study combined influence of irrigation regimes 0.6 $ET_c(I_1)$, 0.8 $ET_c(I_2)$, 1.0 $ET_c(I_3)$, irrigation frequency 2 days (F_1), 3 days (F_2) 5 days (F_3)with silver black plastic mulch (M_1)and wheat straw mulch (M_2)on Bt. cotton (Hy-6, BG-II) along with no mulch (C) as controlfor two consecutive years during *Kharif* season of 2013-14 and 2014-15.Statistically, split-split plot design was adopted with twenty seven treatment combinations. Each treatment was replicated thrice. Recommended package of agronomical practices was adopted. Irrigation scheduling was done based on actual evapotranspiration measured with the help of soil moisture sensors installed at 10cm and 50cm from top of the soil near the root zone of cotton crop in different treatments through drip irrigation. Morphological and yield attributes were monitored at the end of experiment.

RESULTS AND DISCUSSION

Cotton plant height, number of sympodial branches, number of monopodial branches, number of bolls per plant, mean boll weight and yield per hectare was recorded during both the years. Significant difference was observed among the treatments during the both year. Drip irrigation with silver plastic mulch at 0.80 $ET_c$with 3 days irrigation frequency recorded taller plants, with more number of sympodia, monopodia and bollsper plant than the other treatments. Silver black plastic mulchattained 14.58% and 22.40% more plant height of cotton compared to wheat straw mulch and control respectively at I_2F_2.$I_2F_2M_1$ at par with I_3F_1C and $I_3F_2M_1$.$I_1F_2M_1$at par with I_3F_3C. Silver black plastic mulch performs well as compared to wheat straw mulch and control. Significant difference was observed among all the treatments. 20.39% more sympodial branches and 19.67% more monopodial branches as well as 27.83% more sympodial branches and 26.23% more monopodial branches were observed under silver black plastic mulch compared to wheat straw mulch and control respectively at I_2F_2. Enhanced sympodial branches might be due to better partitioning of assimilates towards reproductive parts as the source was not limiting under mulching. Healthier root growth under mulching caused higher partitioning of assimilates towards reproductive structure as could be seen from the production of 28.46% more bolls per plant as against control at I_2F_2. Silver black plastic mulch also recorded 16.24% and 38.68% more seed cotton yield compared to wheat straw mulch and control at 0.80 $ET_c$and 3 days irrigation frequency (I_2F_2) (Table 1). Significant difference was observed among all the treatments at 5% significance level. Treatment $I_1F_2M_1$ at par with I_3F_2C. Treatment $I_1F_3M_1$ at par with $I_3F_3M_2$ and I_3F_3C. This shows that response of silver black plastic mulch with lower irrigation regimes performed better as compared to wheat straw mulch and control irrigated withhigher irrigation regimes at same irrigation frequency.

Table 1. Morphological and yield attribute of Bt. cotton

Treatments	Plant Height (m)	Number of Sympodia per plant (Nos.)	Number of Monopodia per plant (Nos.)	Number of bolls per plant (Nos.)	Mean boll weight (g)	Seed cotton yield (kg ha^{-1})
$I_1F_1M_1$	1.47	22.1	4.4	49.2	3.19	3197
$I_1F_1M_2$	1.12	16.8	3.4	36.7	3.06	2384
I_1F_1C	0.79	11.9	2.6	26.3	2.20	1712
$I_1F_2M_1$	1.37	20.5	4.0	45.3	3.16	3020
$I_1F_2M_2$	1.06	15.9	3.2	35.7	3.03	2322
I_1F_2C	0.78	11.7	2.4	22.8	2.74	1610
$I_1F_3M_1$	1.25	18.7	3.8	39.7	3.02	2647
$I_1F_3M_2$	0.93	14.0	2.9	31.0	2.59	2336
I_1F_3C	0.76	11.4	2.3	23.3	2.26	1431
$I_2F_1M_1$	1.65	24.7	5.0	55.0	4.30	4078
$I_2F_1M_2$	1.60	23.9	4.8	52.2	4.11	3486
I_2F_1C	1.41	21.2	4.2	47.0	3.67	3136
$I_2F_2M_1$	1.92	30.9	6.1	61.5	4.77	4661
$I_2F_2M_2$	1.64	24.6	4.9	55.4	4.37	3904
I_2F_2C	1.49	22.3	4.5	44.0	3.53	2858
$I_2F_3M_1$	1.60	24.0	4.8	50.7	3.98	3677
$I_2F_3M_2$	1.47	22.1	4.3	49.0	3.84	3184
I_2F_3C	1.25	18.7	3.8	38.6	3.15	2578
$I_3F_1M_1$	1.31	19.6	3.8	43.7	3.65	2917
$I_3F_1M_2$	1.41	21.1	4.1	46.1	3.84	3246
I_3F_1C	1.71	25.6	5.0	56.8	4.42	3540
$I_3F_2M_1$	1.70	25.5	5.1	56.3	4.48	3824

$I_3F_2M_2$		1.47	22.1	4.5	49.7	4.14	3049
I_3F_2C		1.54	23.2	4.6	45.4	3.79	2952
$I_3F_3M_1$		1.42	21.3	4.3	44.7	3.73	2984
$I_3F_3M_2$		1.21	18.1	3.6	40.1	3.34	2606
I_3F_3C		1.33	19.9	4.0	40.8	3.06	2506
I	0.019	0.288	0.074	0.607	0.143	39.95	44.69
	0.065	0.942	0.244	1.98	0.87	130.31	145.76
F	0.0177	0.283	0.058	0.539	0.051	38.25	37.63
	0.05	0.83	0.17	1.57	0.15	111.66	109.83
M	0.02	0.33	0.06	0.68	0.05	46.54	51.38
	0.06	0.94	0.18	1.91	0.13	131.37	145.04
I x F	0.03	0.49	0.10	0.93	0.09	66.26	65.17
	0.09	1.44	0.29	2.73	NS	193.41	NS
I x M	0.04	0.57	0.11	1.17	0.08	80.61	89.00
	0.11	1.62	0.31	3.31	0.23	227.53	251.22
F x M	0.04	0.57	0.11	1.17	0.08	80.61	89.00
	NS	1.62	0.31	3.31	0.23	227.53	251.22
I x F x M	0.06	0.99	0.19	2.03	0.14	139.61	154.15
	0.18	2.81	0.54	5.73	0.39	394.10	435.13

Irrigation water and water use efficiency

Actual evapotranspiration measured with the help of soil moisture sensors installed with data loggers in different treatments, accordingly irrigation water applied. The sensors were calibrated for local condition and moisture content calculated based on calibrated soil moisture characteristic curve. Actual crop evapotranspiration was calculated considering the root depth of cotton with model developed by Fereres *et al.* 1981. Silver black plastic mulch saved 19.77% irrigation water at 0.6 ET_c followed by 15.43% and 11.45% at 1.0ET_c and 0.8 ET_c respectively as compared to control. The mean irrigation water use efficiency (WUE) for different treatments depicted in Figure2. It ranged from 20.48kg $ha^{-1}mm^{-1}$ to 7.13kg $ha^{-1}mm^{-1}$. Highest mean WUE (20.48 kg $ha^{-1}mm^{-1}$) was observed in silver black plastic mulch scheduled at 0.8 ET_c with 3 days irrigation frequency and lowest WUE (7.13kg $ha^{-1}mm^{-1}$) was observed in control scheduled at 0.6 ET_c with 5 days irrigation frequency. This may be due to effective soil moisture conservation and prevalence of congenial soil temperature under silver black plastic mulched plots (Braunacka *et al.,* 2015).

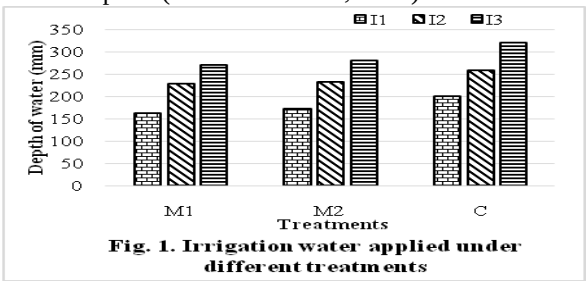

Fig. 1. Irrigation water applied under different treatments

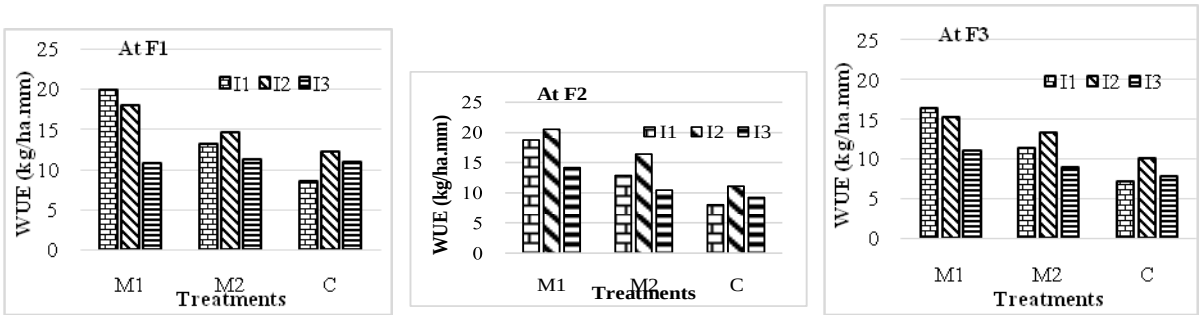

Fig. 2. Water Use Efficiency at different treatments

Economics

Economics of drip with silver black plastic mulch, wheat straw mulch and drip without mulch for one hectare was estimated based on prevailing rate of year 2015. Benefit cost ratio for various treatments ranges from 1.33 to 3.28 (Fig. 3) and Internal rate of return ranges from 3.74 to 141.52%. Highest BC ratio (3.28) and Internal rate of return (141.52%) was observed for silver black plastic mulch scheduled at 0.8 ET_c with 3 days irrigation frequency. Internal rate of return of silver black plastic mulch was 49.09% and 18.47% higher than wheat straw mulch and control respectively at I_2F_2. The system cost can be covered within year. Even if you count the interest also the payback period of the system remains invariant because of the additional revenue from saved irrigation water and towards cost towards weeding.

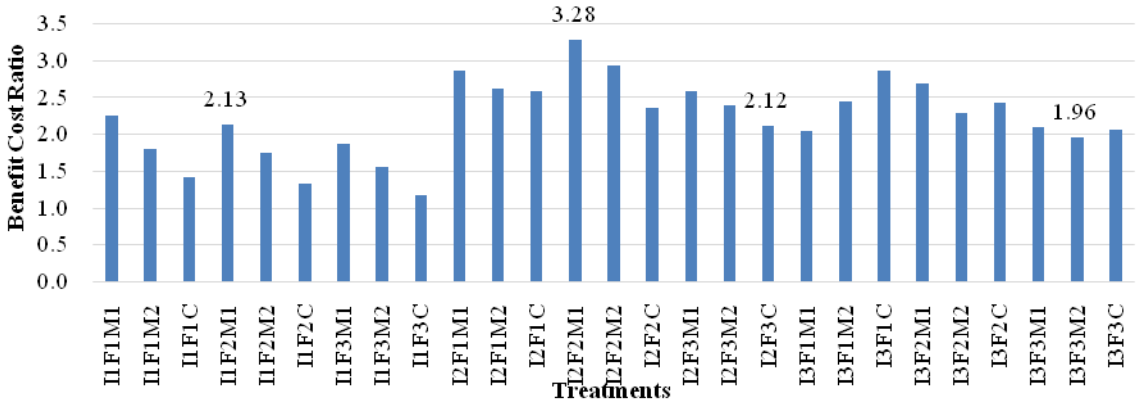

Fig. 3. Benefit cost ratio of different treatment

CONCLUSION

Silver black plastic mulch coupled with drip irrigation scheduled at $0.8ET_c$ with 3 days irrigation frequency resulted in better performance of morphological variables, yield attributes, and WUE than drip irrigated wheat straw mulch and control. Silver black plastic mulch enhanced seed cotton yield by 38.68% and 16.24% yield than wheat straw mulch and control scheduled at 0.8 ET_c with 3 days irrigation frequency.Higher benefit cost ratio (3.28), water use efficiency (20.48 kg $ha^{-1}mm^{-1}$) attained under silver black plastic mulch compared to wheat straw mulch and control. Internal rate of return of silver black plastic mulch was 49.09% and 18.47% higher than wheat straw mulch and control respectively at 0.8 ET_c with 3 days irrigation frequency.

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