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Effect of Irrigation Methods and Plastic Mulches on Yield, Water-Use Efficiency and Economics of Watermelon

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A B S T R A C T

This study investigated the combined effects of irrigation methods and plastic mulches on yield, water-use efficiency and economic return of watermelon. The treatments of the study comprised different combinations of three irrigation methods viz., Irrigation in furrows at 100% of CPE (I_1), Irrigation in alternate furrows at 80% of CPE (I_2) and drip irrigation with fertigation system at 80% of CPE (I_3); and five mulches viz., without mulching (M_0), mulching with black polythene of 80 micron thickness (M_1), mulching with black polythene of 50 micron thickness (M_2), mulching with white polythene of 80 micron thickness (M_3) and mulching with white polythene of 50 micron thickness (M_4). The highest fruit yield (3321.31 q ha^{-1}), WUE (3953.94 kg ha^{-1} cm^{-1}), net returns (`2246111 $ha^{-1}$), B:C ratio (9.17) and water productivity (`26739 mm^{-1}) of watermelon was obtained when irrigation water applied through drip irrigation with fertigation + mulching with white polythene of 50-micron thickness (I_3M_4). The study thus reveals that drip irrigation with white polythene mulch has an explicit role in increasing the land and water productivity of watermelon during summer season.

***Key words*:** *Citrullus lanatus*, Yield, Irrigation methods, Mulches, Water use efficiency, Economics

Watermelon (*Citrullus lanatus* Thunb) is a wonderful fruit contains enormous antioxidant potential, low calorific value and about 93% of water, so its name called "water" melon. It is a popular dessert fruit and commercial vegetable fruit in India grown mostly in summer season so it required more irrigation water (400 mm to 600 mm) during the entire crop period. Irrigation water is often limited and therefore the techniques which help to conserve water in the field are needed. Efficient use of available irrigation water is essential for increasing agricultural productivity as well as water use efficiency. Surface irrigation method is most widely used all over the world as well as in India. Among the surface irrigation methods, Furrow irrigation is the most common irrigation method in the Madhya Pradesh. Recently, there has been an increasing trend in Madhya Pradesh to switch from furrow to drip irrigation in watermelon cultivation to save more irrigation water because of subsurface drip irrigation has been considered more efficient in reducing evaporation and runoff while applying water at crop's root zone. Drip irrigation is hi-tech methods receiving wider acceptance and adoption, particularly to make use of the available water with more productivity. Fertigation ensures higher fertilizer use efficiency, besides providing scope for making soil amendments and even biological methods of plant protection. In the fertigation method, fertilizers can be applied throughout the crop growing season in a phased manner, in various split doses, in any desired concentration. Inorganic materials or mulches like plastic films and polyethylene provide many advantages for the growers such as increased yields, early crop maturity, high quality produces, and insect and weed control [1]. Various colour and thickness of plastic mulches especially create a specific microclimate for plants [2]. The microclimate factors strongly affect the soil temperature and moisture in the root zone, which in turn may influence plant growth [3-4]. There are three major colours of plastic mulch used in commercial vegetable production: i.e., black, clear and white reflective mulches. This kind of mulch is recommended when lower soil temperatures are desirable for sowing vegetables, particularly in summer production under warmer arid regions compared with black plastic mulch [5]. Economics suggest that the film thickness should be minimum possible commensurate with desired life and strength [6]. This needs a change from maximizing productivity per unit of land area to maximizing productivity per unit of water consumed. In order to maximize WUE it is essential to save water and to encourage best crop growth [7]. Thus, irrigation and mulching practices may contribute to improve crop water productivity and watermelon production. The present study was conducted to determine watermelon production in summer season using suitable irrigation method along with polythene mulch of different thickness and colour in Malwa Region of Madhya Pradesh.

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MATERIALS AND METHODS

The experiment was carried out during rabi season of 2019 and 2020 at Village – Silotiya, Tehsil – Sawer, District – Indore (M.P.). The experiment was laid out in split plot design with 15 treatments combinations and 3 replications on black cotton soil. The main treatments were irrigation methods viz., Irrigation in furrows at 100% of CPE (I_1), Irrigation in alternate furrows at 80% of CPE (I_2) and drip irrigation with fertigation system at 80% of CPE (I_3) along with five plastic mulches as sub treatment viz., without mulching (M_0), mulching with black polythene of 80 micron thickness (M_1), mulching with black polythene of 50 micron thickness (M_2), mulching with white polythene of 80 micron thickness (M_3) and mulching with white polythene of 50 micron thickness (M_4). The irrigation was applied daily based on the cumulative pan evaporation data of previous day and information obtained from the agro meteorological data. The objective of the experiments was to find out suitable irrigation level and colour plastic mulch with different thickness for yield, WUE, water saving and economics of watermelon. The scheduling of irrigation was done at 50 mm cumulative pan evaporation (CPE) with 50 mm depth of irrigation water in furrow method while 50 mm cumulative evaporation (CPE) with 40 mm depth of irrigation water in alternate furrow and drip irrigation method.

RESULTS AND DISCUSSION

Effect on yield

Perusal of data revealed that combination of irrigation methods and plastic mulches had significant effect on fruit yield of watermelon. The irrigation water applied through drip irrigation with fertigation + mulching with white polythene of 50 micron thickness (I_3M_4) resulted in significantly highest fruit yield (3321.31 q ha^{-1}) of watermelon which was followed by treatment I_3M_3 (Drip irrigation with fertigation at 80% of CPE + mulching with white polythene of 80 micron thickness) while, significantly lowest fruit yield was recorded with treatment I_2M_0 (Irrigation in alternate furrows at 80% of CPE + without mulch). The higher yield obtained by this treatment combination I_3M_4 due to the irrigation applied through drip method with fertigation system at frequent intervals provides a consistent moisture regimes and nutrient pool in the root zone increases the availability of nutrients and translocation of food materials which accelerate the vegetative growth of plant parts and maintain the soil moisture as well as temperature at optimum level [8-9] while, mulching with white polythene arrested weed growth for a prolonged period, conservation of soil moisture, better supply of nutrients, modification of soil temperature for improving root growth and better absorption of nutrients which will give 100 percent evaporation replenishment [10-14]. Bitter gourd under clear plastic mulch along with drip fertigation during the last week of February resulted in advancing the crop by 15 days and getting 55 percent yield increase over the control [15]. The increased yield under polyethylene mulch with lower water regime might have resulted from better water utilization, higher uptake of nutrient and excellent soil-water-plant relationship [16]. The increment in yield parameters was slightly higher during second year which might be due to application of FYM and nutrients in the first year would have depleted in the subsequent year's and improved the fertility of experimental soil which provides comparatively more nutrients to plants resulted more growth and yield of watermelon.

Table 1 Effect of irrigation methods and plastic mulches on depth of irrigation water applied, water saving, yield and WUE under watermelon (Pooled)

	Treatment	Quantity of water applied (cm)	Water saving (%)	Yield (q ha^{-1})	WUE (kg ha^{-1} cm^{-1})
I_1M_0	Irrigation in furrows at 100% of CPE + Without mulching	105	-	1246.31	1186.97
I_1M_1	Irrigation in furrows at 100% of CPE + Mulching with black polythene of 80 micron thickness	105	-	1534.91	1461.82
I_1M_2	Irrigation in furrows at 100% of CPE + Mulching with black polythene of 50 micron thickness	105	-	1657.24	1578.33
I_1M_3	Irrigation in furrows at 100% of CPE + Mulching with white polythene of 80 micron thickness	105	-	2097.53	1997.65
I_1M_4	Irrigation in furrows at 100% of CPE + Mulching with white polythene of 50 micron thickness	105	-	2348.43	2236.60
I_2M_0	Irrigation in alternate furrows at 80% of CPE + Without mulching	84	20	784.8	934.29
I_2M_1	Irrigation in alternate furrows at 80% of CPE + Mulching with black polythene of 80 micron thickness	84	20	1045.92	1245.14
I_2M_2	Irrigation in alternate furrows at 80% of CPE + Mulching with black polythene of 50 micron thickness	84	20	1257.18	1496.64
I_2M_3	Irrigation in alternate furrows at 80% of CPE + Mulching with white polythene of 80 micron thickness	84	20	1598.37	1902.83
I_2M_4	Irrigation in alternate furrows at 80% of CPE + Mulching with white polythene of 50 micron thickness	84	20	1806.66	2150.78
I_3M_0	Drip irrigation with fertigation system at 80% of CPE + Without mulching	84	20	1574.97	1874.97
I_3M_1	Drip irrigation with fertigation system at 80% of CPE + Mulching with black polythene of 80 micron thickness	84	20	2103.43	2504.08
I_3M_2	Drip irrigation with fertigation system at 80% of CPE + Mulching with black polythene of 50 micron thickness	84	20	2402.81	2860.49
I_3M_3	Drip irrigation with fertigation system at 80% of CPE + Mulching with white polythene of 80 micron thickness	84	20	2978.65	3546.01
I_3M_4	Drip irrigation with fertigation system at 80% of CPE + Mulching with white polythene of 50 micron thickness	84	20	3321.31	3953.94
	SEm±	-	-	31.36	35.38
	CD at 5% level	-	-	92.68	104.52

Water applied and water use efficiency

As the irrigation water is the main concern in this study, WUE is playing major role in judging of consumption of irrigation water. The experimental results revealed that there was considerable amount of water saving by using different irrigation levels. The depth of irrigation water applied 84 mm at 80% CPE to treatment I_2 (Irrigation in alternate furrows at 80% of CPE) and I_3 (Drip irrigation with fertigation system at 80% of CPE) as compare to treatment I_1 (Irrigation in furrows at 100% of CPE) wherein 105 mm irrigation water applied at 100% CPE. The water saving over 100% CPE was 20% under both I_2 and I_3 treatments.

Table 2 Effect of irrigation methods and plastic mulches on economics of watermelon (Pooled)

Treatment		Gross income (`)	Cost of cultivation (`)	Net return (`)	B:C ratio	Water productivity (` mm^{-1})
I_1M_0	Irrigation in furrows at 100% of CPE + Without mulching	934735	170871	763864	4.47	7275
I_1M_1	Irrigation in furrows at 100% of CPE + Mulching with black polythene of 80 micron thickness	1151186	205871	945314.9	4.59	9003
I_1M_2	Irrigation in furrows at 100% of CPE + Mulching with black polythene of 50 micron thickness	1242933	203871	1039062	5.10	9896
I_1M_3	Irrigation in furrows at 100% of CPE + Mulching with white polythene of 80 micron thickness	1573148	208871	1364277	6.53	12993
I_1M_4	Irrigation in furrows at 100% of CPE + Mulching with white polythene of 50 micron thickness	1761320	205871	1555449	7.56	14814
I_2M_0	Irrigation in alternate furrows at 80% of CPE + Without mulching	588601	168871	419729.5	2.49	4997
I_2M_1	Irrigation in alternate furrows at 80% of CPE + Mulching with black polythene of 80 micron thickness	784439	203871	580567.6	2.85	6912
I_2M_2	Irrigation in alternate furrows at 80% of CPE + Mulching with black polythene of 50 micron thickness	942884	201871	741012.6	3.67	8822
I_2M_3	Irrigation in alternate furrows at 80% of CPE + Mulching with white polythene of 80 micron thickness	1198780	206871	991908.8	4.79	11808
I_2M_4	Irrigation in alternate furrows at 80% of CPE + Mulching with white polythene of 50 micron thickness	1354991	203871	1151120	5.65	13704
I_3M_0	Drip irrigation with fertigation system at 80% of CPE + Without mulching	1181230	209871	971359.1	4.63	11564
I_3M_1	Drip irrigation with fertigation system at 80% of CPE + Mulching with black polythene of 80 micron thickness	1577569	244871	1332698	5.44	15865
I_3M_2	Drip irrigation with fertigation system at 80% of CPE + Mulching with black polythene of 50 micron thickness	1802108	242871	1559237	6.42	18562
I_3M_3	Drip irrigation with fertigation system at 80% of CPE + Mulching with white polythene of 80 micron thickness	2233984	247871	1986113	8.01	23644
I_3M_4	Drip irrigation with fertigation system at 80% of CPE + Mulching with white polythene of 50 micron thickness	2490982	244871	2246111	9.17	26739
	SEm±	23522.98	-	23522.98	0.10	265.33
	CD at 5% level	69513.89	-	69513.89	0.31	783.76

The present study shows the significant interaction effects of drip irrigation and plastic mulch on crop water requirement and WUE. The results of the study indicated that irrigation water applied through drip irrigation with fertigation system at 80% of CPE + mulching with white polythene of 50 micron thickness (I_3M_4) was obtained highest WUE (3953.94 kg ha^{-1} cm^{-1}) because, this treatment consumed about 20% less water and produced comparatively higher yield. The higher WUE obtained by this treatment combination due to irrigation applied through drip method with fertigation system at frequent intervals provides a consistent moisture regimes and nutrient pool in the root zone which helps to maintain the soil moisture as well as temperature at optimum level whereas, white plastic is preferred during the summer growing season in warmer regions of the world compared with black plastic because it has the ability to maintain soil moisture while having cooler temperatures due to favourable hydro-thermal regime of soil and complete weed free environment as well as minimize evapo-transpiration losses of irrigation water which ultimately helps to increase water use efficiency (WUE) of the crop [17-18]. The lowest WUE realized with treatment I_2M_0 (Irrigation in alternate furrows at 80% of CPE + without mulch) during both the crop growing years and their pooled basis also. This might be due to higher evaporation losses, improper moisture distribution in root zone, and competition between plants and weeds during entire crop growth period in both the experimental years. The increment in water use efficiency (WUE) was slightly higher during second year which might be due to FYM and nutrients added in the first year would have depleted in the subsequent year's and improved the fertility of experimental soil which provides comparatively more nutrients to plants resulted more yield and WUE under watermelon cultivation.

Economic analysis

The combinations of irrigation methods and plastic mulching had significant effect on economics and water productivity of watermelon crop. The combination of I_3M_4

(Drip irrigation with fertigation at 80% of CPE + mulching with white polythene of 50 micron thickness) was realized significantly higher net returns (`2246111 $ha^{-1}$), B:C ratio (9.17) and water productivity (`26739 mm^{-1}) followed by combination of I_3M_3 (Drip irrigation with fertigation at 80% of CPE + mulching with white polythene of 80 micron thickness) while lowest values for these parameters were obtained with combination of I_2M_0 (Irrigation in alternate furrow at 80% of CPE + without mulch) [19-22].

CONCLUSION

From the aforementioned investigation it could be concluded that drip irrigation with white polythene mulch has an explicit role in increasing the land and water productivity of watermelon during summer season.

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