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Drip irrigation water requirement of capsicum under sub-humid sub-temperate region of Himachal Pradesh

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ABSTRACT

A field experiment was conducted on sandy loam soils 'Inceptisols' to evaluate the effect of different drip irrigation levels (100% crop evapotranspiration, 80% crop evapotranspiration and 60% crop evapotranspiration) along with black polyethylene mulch as compared to surface irrigation on growth and yield of capsicum. The treatments included different irrigation levels based on pan evaporation, pan and crop factors under polyethylene mulch and un mulched condition. Drip irrigation at 0.8'V' volume of water gave significantly higher yield (116.69 qha^{-1}) as compared to surface irrigation. Drip irrigation plus polyethylene mulch raised the yield further to 131.47 qha^{-1}. Water Use Efficiency at drip irrigation alone, drip irrigation plus polyethylene mulch and surface irrigation was 3.73, 3.88 and 2.35 respectively. Drip irrigation plus polyethylene mulch besides giving a saving of 55.6 per cent water resulted in 37 per cent higher yield as compared to surface irrigation only. The benefit cost ratio of capsicum cultivation under drip irrigation, drip irrigation plus polyethylene mulch and surface irrigation came out to be 2.66, 2.77 and 2.27, respectively.

Key words : Capsicum, Drip irrigation.

INTRODUCTION

Capsicum is major cash crop of mid hill zone of Himachal Pradesh but mostly it is rainfed or rarely through surface irrigation. In hill regions, the system of surface irrigation is not suitable under sloppy conditions, light textured soils of low water holding capacity with shallow soil depth whereas drip irrigation has proved its superiority over other irrigation methods in fruit and vegetable crops, owing to precise and direct application of water in the root zone. Optimum soil moisture regime plays a major role in the development of vegetative growth as well as fruit production and supplement of water through irrigation is necessary to maintain a proper soil moisture regimes particularly during summer season. Water is becoming a limiting factor in crop production with growing needs for intensive cropping. Thus, to use the scarce water resources, whether it is tural stream flow, spring water or harvested rain water, drip irrigation system being efficient and with high frequency, seems to be suitable alternative of surface irrigation under hill conditions. Chundawat (1990) reported water loss under surface irrigation upto 35-50 per cent, compared with 2-3 per cent under drip irrigation. An optimum irrigation schedule aims at achieving more yield with higher water use efficiency.

Mulch materials are well known to improve conservation of soil moisture during dry period in comparison to clean cultivation. The use of black polyethylene mulch has been reported to control the weed incidence reduce nutrient loss and improve the hydrothermal regime of soil (Ashworth and Harrison, 1983). Baskett (1960) reported reduction of watering in vegetables by using black polyethylene sheet for mulching. However, no attempt has so far, been made to study the effect of drip irrigation alone and in conjunction with plastic mulch as compared to surface irrigation on yield and irrigation water requirement of capsicum in mid hills of Himachal Pradesh. Therefore, the present studies were undertaken to study the effect of different levels of drip irrigation with and without plastic mulch on yield and irrigation water requirement of capsicum.

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MATERIALS AND METHODS

The experiment was conducted on loamy sand 'Inceptisols". The soil of the experimental area was having pH 7.28, Ec 0.314, OC 2.01, texture loamy sand while available N, P and K were 307.32, 358.40 and 198.40 kgha^{-1}, respectively. The following treatments, in triplicate, were tried in randomized block design.

T_1- Drip irrigation with 'V' volume of water (DV)
T_2- Drip irrigation with '0.8V' volume of water (0.8DV)
T_3- Drip irrigation with '0.6V' volume of water (0.6DV)
T_4- Surface irrigation (S)
T_5- T_1 + Plastic mulch (DV+M)
T_6- T_2 + Plastic mulch (0.8DV+M)
T_7- T_3 + Plastic mulch (0.6DV+M)
T_8- T_4 + Plastic mulch (S+M)

The 'V' volume of water requirement was computed using following equation:

$$V = E_p \times K_c \times K_p \times W_p \times N - R_e \times A$$

Where,

V= volume of water required (litres)
E = Pan evaporation (mm/day)
K^p= Crop factor
K^c= Pan factor
W^p = Wetting percentage
N^p= Number of days
R = Effective rainfall
A_e=Area of plot

The data on average pan evaporation (E_p), monthly effective rainfall (R_e) and 'V' volume of water applied are cited in table1. The crop factor (K_c) values were taken as 0.67, 0.73, 0.81 and 0.87 for May, June, July and August, respectively based on the existing relative humidity and wind velocity and crop stage. The pan factor (K_p) value was 0.75 as suggested for USDA class 'A' pan. The area of plot was $9m^2$ and the 'N' number of days in a month. The 'V' volume of water requirement for the entire month (Table 1) was calculated considering the number of day in that month. The 'V' volume of irrigation water applied (Table 2) was expressed in cm which came out to be 22.04 cm. The treatments T_2 and T_6 and T_3 and T_7 comprised 80 and 60 per cent of 'V' volume respectively. Irrigation was applied biweekly through drip system. In treatment T_4 and T_8 six surface irrigations each of 5 cm depth were applied at 5, 13, 28, 39, 52 and 65 days after transplanting (recommended practice). The remaining quantity included conveyance loss and water applied for field preparation. Capsicum was transplanted at 60x45 cm. recommended dose of N, P and K as basal doses were applied as CAN, SSP and MOP, respectively. For mulching black polyethylene mulch of 25 micron thickness having holes of 40 mm diameter at a distance of 45 cm was spread over the field and plants transplanted. Volumetric method was used to compute the uniformity coefficient (U_c) of drip irrigation system (eq. 2). In all, 10 in line emitters were used in each lateral line at 50 cm distance. The uniformity coefficient was measured using following equation:

$$U_c = \frac{1 - \delta q}{q} \qquad \text{——— (2)}$$

where,

q = mean emitter discharge rate (lhr^{-1})

dq =mean deviation of the emitter discharge from mean value

The water use efficiency was computed as yield of capsicum in qha^{-1} divided by total water applied (cm) including effective rainfall.

RESULTS AND DISCUSSION

Uniformity Coefficient:

The uniformity coefficient of drip irrigation system was found to be 94.63 per cent. The high values of uniformity coefficient indicate excellent performance of drip system in supplying water uniformly throughout the lateral lines.

The data clearly indicate that available soil moisture (Table 1), plant height, number of fruits/plant, fruit weight and fruit yield (Table4) were significantly influenced by drip irrigation regimes under both plastic and with out plastic mulch treatments. The mean available soil moisture, mean plant height, number of fruits/plant and fruit weight were observed to be highest in the treatments T_5 (Drip irrigation with 'V' volume of water + plastic mulch) whereas mean fruit yield was maximum in the treatment T_6 (Drip irrigation at 80 per cent of 'V' volume + plastic mulch) which was closely followed by the treatment T_5. The mean minimum available soil moisture, plant height, number of fruit/plant, fruit weight and fruit yield was observed in the treatment T_4 (Surface irrigation without mulch).

The available soil moisture was recorded maximum under the treatment T_5 (24.22%) and was closely followed by the treatment T_6 (24.20%) while minimum available soil moisture was recorded under the treatment T_4 (19.10%). The plant height was highest (68.83 cm) under the treatment T_5 but was statistically at par with the treatment T_6 (66.73 cm) and T_7 (66.65 cm) but was statistically superior to all other treatments. Number of fruit/plant and fruit weight were also greatly influenced by the drip irrigation regimes and plastic mulch. But significant effect was observed in the treatment T_5(DV+M), where irrigation was applied at 100 per cent 'V' volume of water along with plastic mulch but was statistically superior to all other treatments. Number of fruits/plant and fruit weight of capsicum increased with the frequency of irrigation i.e. from irrigation at 60-80 and 80-100 per cent of 'V' volume of water in plastic as well as with out plastic mulch treatment (Table 4). This could be associated with the results of Raina et al (1998) and Singh et al (2002) who have ascribed that higher soil moisture regimes in root zone increased the availability of mineral nutrients in soil for plant use. Fruit yield increase was 27.39 and 27.50 per cent under M+DV and 0.8DV+M, respectively, over surface irrigation (conventional) with plastic mulch. However, in unmulched treatment there was 21.97 and 21.84 per cent increase in fruit yield irrigated at DV and 0.8DV, respectively over surface irrigation (conventional). These results are in conformity with those of Menzel et al (1986) and Singh et al (1998) who emphasized the

Table 1 : Available soil moisture under different treatments

Treatments	Soil moisture (%)				
	May	Jun	Jul	Aug	Mean
T_1	20.3	23.9	20.9	27.4	23.12
T_2	20.0	22.0	20.7	25.5	22.05
T_3	19.2	22.1	20.7	27.0	22.25
T_4	18.3	18.5	22.3	20.3	19.10
T_5	22.3	23.4	24.3	26.9	24.22
T_6	21.4	23.3	24.6	27.5	24.20
T_7	21.0	23.0	21.9	27.3	23.30
T_8	19.9	19.6	20.3	22.3	20.52

maintenance of optimum soil moisture in already available form during the growing season for better growth and yield. The minimum yield under water stress treatment (T_3, T_4, T_7 and T_8) is understandable due to lower moisture availability causing reduction in cell enlargement (Hsiao, 1973). The response of mulch varied under different levels of irrigation. The relatively higher response of mulch varied under wetter treatment T_5 compared to drier treatment T_6 and T_7 may be attributed to higher rooting density in surface layers because of optimum soil water condition resulting thereby in higher nutrient uptake and yield. However, under treatment T_6 and T_7, soil water might not have been sufficient enough to achieve the same rooting density in surface layers which resulted in comparatively lower yields. Bhella (1988) observed that root system of plants grown under soil water stress and mulch was minimally developed and root penetrated deeper soil layer than those plants under optimum soil water and plastic mulch condition where feeder roots remained on the surface resulting in higher nutrient uptake and yield of watermelon.

Table 2 : Pan evaporation, effective rainfall, 'Irrigation water applied, crop water requirement and crop factors for capsicum during the experimental period

Month	E_p (mm/day)	R_e (mm)	Irrigation water applied (mm)	Crop water requirement (lt.)	Crop factor (K_c)
May	7.07	16.8	51.44	613.8	0.67
June	4.48	38.8	84.60	1110.6	0.73
July	3.89	38.2	89.00	1144.8	0.81
August	2.5	48.7	77.40	1134.9	0.87

Scheduling of irrigation:

The effect of drip irrigation regimes and plastic mulch treatments on yield and other parameters (Table 4) were higher under irrigation at 100% 'V' volume + plastic mulch as compared to irrigation at 60% 'V' volume + plastic mulch and surface irrigation but was statistically at par with irrigation at 80% 'V' volume + plastic mulch. This suggests that plant water deficit in 0.8DV+M was critical and below this there was reduction in yield. Therefore, it can be concluded that for optimum growth and fruit yield of capsicum, the plants need to be irrigated at 80% 'V' volume under mulched conditions with no deleterious effect of water stress and saved 20% irrigation water over the irrigation at 100% 'V' volume (unmulched).

Drip Irrigation water requirement *:*

During cropping season, total rainfall received was 61.9 cm. The total depth of irrigation water applied varied from 18.74 to 40.61 cm under different treatments (Table 3). The water use efficiency (WUE) of capsicum was different not only under drip irrigation and surface irrigation but also under drip irrigation + plastic mulch (Table 3). Drip irrigation both with and without plastic mulch registered much higher WUE as compared to surface irrigation. Considering all the tried levels of irrigation, drip irrigation without plastic mulch gave WUE of 3.73 qha-cm^{-1} against 2.35 qha-cm^{-1} under surface irrigation. The corresponding values for drip irrigation + plastic mulch and surface irrigation + plastic mulch were 3.88 and 2.53 qha-cm^{-1}, respectively. Since the rate of water loss as evaporation was higher under surface irrigation hence, WUE was lower as compared to drip irrigation. The results are in close agreement with the findings of Raina et al (1998). The drip irrigation crop water requirement varied from 613.8 lt to 1144.8 lt/month. In the months of May drip irrigation was started from 19th May

Table 3 : Amount of irrigation water applied and Water Use Efficiency (WUE) under different irrigation treatments in capsicum under drip and surface irrigation

Treatments	Quantity of water applied (cm)	Water Use Efficiency (qha-cm^{-1})
T_1 (DV)	31.24	3.73
T_2 (0.8DV)	24.99	4.66
T_3 (0.6DV)	18.74	5.90
T_4 (S)	40.61	2.35
T_5 (DV+M)	31.24	3.88
T_6 (0.8DV+M)	24.99	4.86
T_7 (0.6DV+M)	18.74	6.34
T_8 (S+M)	40.61	2.53

onwards and the irrigation was given on alternated days in the months of May and June while bi-weekly in July and August. While applying irrigation, R_e was taken into account.

marketing (Rs. 15,765.00). In case of drip irrigation only, Rs. 1800.00 was spent on weeding and hoeing whereas in case of surface irrigation a sum of Rs. 19,700.00/ha was

Table 4 : Effect of drip soil moisture regimes on plant height, number of fruits/plant, fruit weight and fruit yield of capsicum.

Treatments	Plant height (cm)	No. of fruit/plant	Fruit weight (gm)	Fruit yield (qha^{-1})
T_1 (DV)	62.73	18.76	27.44	116.69
T_2 (0.8DV)	61.64	18.45	28.63	116.57
T_3 (0.6DV)	61.78	17.73	27.45	110.56
T_4 (S)	56.48	14.47	22.18	95.67
T_5 (DV+M)	68.83	22.93	31.86	131.36
T_6 (0.8DV+M)	66.73	21.14	30.45	131.47
T_7 (0.6DV+M)	66.65	20.45	28.99	118.85
T_8 (S+M)	59.88	16.88	24.63	103.11
$CD_{0.05}$	2.45	0.86	0.94	1.87

Benefit Cost ratio :

The total seasonal cost of cultivation per hectare for raising capsicum crop under conventional, drip only and drip plus plastic mulch was Rs. 42,015.00, Rs. 43,815.00 and Rs. 42,115.00, respectively (Table 5). The cost of cultivation amounting to Rs. 22,315.00/ha common for all treatments included cost of land preparation (Rs. 2300.00), seed (Rs. 1250.00), fertilizer (Rs. 1500.00), insecticide/ fungicide (Rs. 1500.00) and labour charges for picking and spent on weeding, hoeing, manual irrigation and fertilizer application. Although there was no expenditure on weeding in case of mulch + drip irrigation treatments, yet a sum of Rs. 19,800/ha was spent towards the cost of plastic mulch. Thus, the total seasonal cost/ha comes out to be Rs. 42,015.00, Rs. 43,815.00 and Rs. 42,115.00 for conventional, drip only and drip plus plastic mulch, respectively. The seasonal income under drip irrigation only and drip irrigation+ plastic mulch was 23.93 and 26.85 per

Table 5 : Benefit cost ratio of capsicum under drip irrigation, drip irrigation+plastic mulch and surface irrigation

	Cost economic	Drip irrigation	Drip irrigation +plastic mulch	Surface irrigation
	Drip System			
1 (A).	Fixed Cost (Rs.)	1,00,000.00	80,000.00	-
i)	Life (seasons)	20	20	-
ii)	CRF*	17700.00	17700.00	-
iii)	Repair & maintenance @ 2% cost of system	2000.00	1600.00	-
	Total (ii+iii)	19700.00	19300.00	-
B)	Plastic mulch (Rs.)	-	19800	-
	Life (season)		3	
	Depreciation @16.67%	-	3300.00	
	Interest @ 12%	-	2376.00	-
	Grand Total (A+B)	19700.00	24976.00	-
2.	Cost of Cultivation ($Rs.\ ha^{-1}$)	24115.00	22315.00	42015.00
3.	Seasonal total cost (1+2)	43815.00	47291.00	42015.00
4.	Water use (mm)	220.4	220.4	397.30
5.	Yield of Produce (qha^{-1})	116.69	131.36	95.67
6.	Selling price ($Rs.\ q^{-1}$)	1000.00	1000.00	1000.00
6.	Income from produce (5x6)	1,16,690.00	1,31,360.00	95,670.00
7.	B:C ratio	2.66	2.77	2.27

* Cost Recovery Factor $= \frac{I(1+I)^n}{(1+I)^n-1}$

cent higher as compared to conventional method of irrigation. Drip system proved very effective and efficient method of irrigation saving 44.52 per cent of water which irrigates an additional area of . With drip irrigation water saving to the extent of 53 per cent in tomato have been reported by Bafna *et al.* (1993). The B:C ration was 2.66 and 2.77 under drip irrigation and drip irrigation+ plastic mulch, respectively compared to conventional irrigation (2.27).

Thus, it can be concluded from these results that drip irrigation system is very effective and efficient method of irrigation for raising capsicum, especially on light textured soils under water scarcity areas. The system besides giving considerable savings of irrigation water improved the yield and WUE. The BC ration was also higher for drip irrigation as compared to surface irrigation.

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