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Research Article

Crop Productivity, Water Use and Weed Control Efficiency of Capsicum (*Capsicum annum* L.) Under Drip Irrigation and Mulching

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ABSTRACT

A field experiment was conducted during 2006-07 and 2007-08 at Precision Farming Development Centre, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, to evaluate the crop productivity, water use and weed control efficiency of capsicum (*Capsicum annum* L.) as influenced by drip irrigation and mulches. Experiment was laid out in a split plot design replicated thrice with irrigation levels 1.0 Epan (Pan evaporation) through drip, 0.8 Epan through drip, 0.6 Epan through drip and 1.0 Epan with flood irrigation in main plot and mulches (*i.e.* no mulch (glyphosate 41 SL@ 6.0 ml/l followed by 2 hand weeding), black polythene mulch (BPM), transparent polythene mulch (TPM), paddy straw mulch (PSM) in sub-plots. The growth parameters like number of primary and secondary branches, leaf area, leaf area index and total dry weight were maximum with drip irrigation at 1.0 Epan with BPM followed by drip irrigation at 0.8 Epan. The water use efficiency was recorded highest with drip irrigation at 0.6 Epan with BPM. Whereas, weed dry weight and root dry weight were lower with BPM. However, harvest monitory benefit was highest with drip irrigation at 1.0 Epan with BPM and least on flood irrigation at 1.0 Epan with no mulch.

Key words: Capsicum, Drip, Mulch, Yield, Water use efficiency, Weed control efficiency

Introduction

In the sub tropical region, for all the practical purpose, fresh water resources are inadequate, and the major impasse of the region is facing for balancing of the demand and supply of water to ensure self-sufficiency in agriculture. Current trends indicate that several regions are facing water shortage during post rainy season. Therefore, water saving irrigation methods should be followed in order to save water and maximize yield. Due to greater competition of water for urban and rural use and other sectors, the value of water will most probably rise, thus, appropriate irrigation scheduling with real time weather data, advanced irrigation method and moisture conservation techniques such as mulch are prerequisite for maximizing the yield and water use (Ertek *et al.*, 2007). As capsicum is important and high value crop of the region, due to its susceptibility to moisture excess and drought, irrigation and drainage is required. Optimum quantity of water must be applied during the different crop growth periods in order to get higher capsicum yield. It is very much required to determine the water consumption of plants and periods that plants are susceptible for water beside the irrigation intervals in order to increase the crop yield. There are reports that use of drip irrigation along with mulch increase the yield and

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WUE (Palada *et al.*, 2001 in vegetables; Choudhary *et al.,* 2006 in baby corn; Ertek *et al.*, 2007 in capsicum; Patel *et al.*, 2009 in okra) but there are no reports available for capsicum on this part of the country. Therefore, keeping the performance on other crop drip irrigation and mulch were selected for study of yield, water use and weed control efficiency on capsicum.

Materials and Methods

A field study was conducted at Precision Farming Development Centre, Indira Gandhi Krishi Vishwavidyalaya, Raipur during 2006-07 and 2007-08. The place receives an average annual rainfall of 1200-1400 mm, most of which (about 85 per cent) is received from third week of June to mid September and little during October and February. The soil samples were taken from 20 cm soil depths and a composite sample was drawn for analysis. The soil was silty clay loam, neutral in reaction (pH 7.06), medium in organic carbon (0.49 per cent), low in nitrogen (236.5 kg/ha), medium in phosphorus (18.8 kg/ ha), high in available potassium (310.5 kg/ha) and normal in EC (0.42 dS/m at 25^{o}C). Capsicum (cv. *Agnirekha*) was taken as test crop during study. The experiment was laid out in a split plot design with three replications, Main plots were allotted for irrigation levels [*i.e.* 1.0 Epan (Pan evaporation) through drip, 0.8 Epan through drip, 0.6 Epan through drip and 1.0 Epan with flood irrigation (FI)] and sub plots were engaged for mulches [i.e. no mulch (glyphosate 41 SL @ 6.0 ml/l followed by 2 hand weeding), black polythene mulch (BPM; 40 μ thickness), transparent polythene mulch (TPM; 40 μ thickness), paddy straw mulch (PSM; 5 t/ha)]. Planting geometry was maintained as per recommended spacing of 60 cm x 45 cm. All other cultural practices were done as per the standard recommendation for capsicum. Soil characters are given in Table 1.

Seedlings were raised in a nursery and after preparing the main field, five week old seedlings were transplanted. Drip laterals were placed at 8th days after transplanting (DAT) and started imposing the allotted treatments from 10 DAT. Mulches were placed on bed carefully at 12 DAT. During course of investigation growth parameters, yield, water use and weed control efficiency, root dry weight and harvest monitory benefit were observed.

Water use efficiency (WUE, in kg/ha/mm) was calculated from economic yield (EY, kg/ha) and ET (mm) (Eq. 1). Here, we assumed that there were no losses via deep drainage and runoff during the growing season.

$$WUE = EY/ET \quad \ldots(1)$$

Harvest monitory benefit (HMB) was worked out for efficient utilization of available and irrigated water *i.e.* amount of money earned from one mm of water used, calculated by applying the methodology described by Scott (2001) using the following (Eq. 2):

$$HMB = \text{Net return (Rs/ha)}/\text{ rainfall (mm)} \quad \ldots(2)$$

Statistical analysis was done in all parameters by adopting the procedures of Gomez and Gomez (1984).

Results and Discussion

Growth parameters

Drip irrigation at 1.0 Epan produced maximum plant height, numbers of primary and secondary branches, stem girth, leaf area, leaf area index, dry weight accumulation at different plant

Table 1. Soil characteristics of experimental site

Depth (cm)	Bulk Density (Mg m^{-3})	Field capacity (%)	Wilting point (%)	Saturation (%)
0-30	1.40	15.2	8.1	40.2
30-60	1.44	16.4	9.7	40.7
60-90	1.47	18.3	10.1	41.0

Table 2. Growth parameters as influenced by drip irrigation and mulches in capsicum (mean of both the years)

Treatment	Plant height (cm)	Branches		Stem girth (cm)	Leaf area (dm^2) (120 DAS)	Leaf area index (120 DAS)	Dry weight (g/ plant)			Total dry weight (g/ plant)
		Primary	Secondary				leaf	stem	fruit	
Drip irrigation levels										
1.0 Epan	63.2	9.30	14.13	2.31	81.95	3.04	7.57	17.29	21.32	45.92
0.8 Epan	61.9	8.42	13.07	2.26	80.39	2.98	6.97	16.74	20.11	43.72
0.6 Epan	59.2	7.74	11.34	2.05	77.93	2.89	6.33	15.07	17.23	38.54
FI (1.0 Epan)	56.0	7.10	9.35	1.88	73.67	2.73	5.55	13.57	15.67	34.74
C.D. (P=0.05)	2.29	1.14	1.11	0.15	4.22	0.16	0.60	1.07	2.86	3.19
Mulches										
No mulch	56.5	6.80	10.01	1.96	74.82	2.77	5.86	14.48	16.07	36.27
BPM	63.1	9.41	13.95	2.32	82.52	3.06	7.43	16.94	21.19	45.45
TPM	58.5	7.25	10.57	1.98	75.86	2.81	6.03	15.00	16.90	37.78
PSM	62.1	9.09	13.34	2.24	80.74	3.00	7.09	16.25	20.15	43.40
C.D. (P=0.05)	4.67	0.66	1.04	0.21	4.47	0.17	0.82	1.25	2.57	3.16

FI, Flood irrigation; BPM, Black polythene mulch; TPM, Transparent polythene mulch; PSM, Paddy straw mulch

parts (leaf, stem and fruit) and total dry weight but were statistically close to drip irrigation at 0.8 Epan (Table 2). The moisture content was found sufficient for these treatments throughout the crop growth which provided conducive environmental condition. With drip irrigation levels, a small portion of soil volume were irrigated, which reduced the evaporation loss and eliminated runoff. The loss of water was low due to slow flow rate and better canopy coverage. All the growth parameters are having prime importance for better availability of solar radiation and responsible to produce higher photosynthates (Choudhary *et al.,* 2012). Whereas, lower values of growth parameters were recorded with flood irrigation at 1.0 Epan followed by drip irrigation at 0.6 Epan.

All the growth parameters were maximum with BPM followed by PSM. However, lower values of all the growth parameters were obtained with no mulch followed by TPM (Table 2). The increase in dry matter production/plant and its accumulation in leaf, stem and fruits were influenced by favourable growth in terms of maximum plant height and number of primary and secondary branches/plant. The higher dry matter production might be due to higher leaf area and leaf area index. The prerequisite for high yield is the maximum dry matter production/plant coupled with higher photosynthetic rate for building of organic substances in the plant (Choudhary *et al.,* 2006).

Yield

Drip irrigation at 1.0 Epan produced the highest capsicum yield, which was comparable to drip irrigation at 0.8 Epan. On the contrary, flood irrigation at 1.0 Epan had reduction in capsicum yield by 56.12, 45.73 and 24.52 per cent compared to drip irrigation at 1.0, 0.8 and 0.6 Epan, respectively (Table 3). Higher level of drip supplied water drop by drop with slow flow rate restricted the losses and allowed the plants to absorb available soil moisture from the root zone. Hence, they increased the productivity of capsicum. The main reason for better yield at higher level of drip irrigation was due to better growth parameters and also improved soil moisture status, which always remained in the sufficiency range throughout the crop growth period. Under flood irrigation most of the applied water was lost through evaporation and

Table 3. Water use, yield and water use efficiency as influenced by drip irrigation levels and mulches in capsicum (mean of both the years)

Treatment	Irrigation water applied (mm)	Effective rainfall(mm)	Total water used*(mm)	Yield (Mg ha^{-1})	Water use efficiency (kg ha^{-1} cm^{-1})
			Drip irrigation levels		
1.0 Epan	468.5	11.75	510.2	32.02	629.0
0.8 Epan	374.8	11.75	416.5	29.89	719.0
0.6 Epan	281.1	11.75	322.9	25.54	792.0
FI (1.0 Epan)	454.8	24.9	509.7	20.51	403.0
C.D. (P=0.05)				2.26	68.00
			Mulches		
No mulch	394.8	15.04	439.8	22.56	532.0
BPM	394.8	15.04	439.8	31.24	736.0
TPM	394.8	15.04	439.8	24.77	583.0
PSM	394.8	15.04	439.8	29.40	692.0
C.D. (P=0.05)				2.03	49.0

* 30 mm of irrigation water was considered which was applied to bring field capacity
Details are given in Table 1

percolation due to fast rate of application. At the beginning, the crop experienced excess moisture conditions, which enhanced the leaching of available nutrients. The crop was under favourable condition only for a short span of time and due to high evaporation rate from soil surface most of the water lost and at the end of the irrigation cycle, availability of moisture became insufficient, which created the stress (Choudhary *et al.*, 2006; Ertek *et al*., 2007).

The yield of capsicum differed significantly due to different mulches (Table 3). Placement of BPM recorded the highest yield of capsicum, which was 6.25, 26.12 and 28.48 per cent higher than PSM, TPM and no mulch, respectively. BPM along with PSM had better dry matter accumulation, dry mater partitioning at different plant parts, and crop growth parameters which led to higher capsicum yield than other mulches. The results in the present investigation also corroborate the observations of other for different crops (Tiwari *et al.,* 2003; Patel *et al.,* 2009).

Water use efficiency

Irrigation water was applied as per the predefined treatments and total water use throughout the crop period ranges from 322.9 to 510.2 mm (Table 3). The drip irrigation scheduled at 1.0 Epan used the highest amount of water, which was closely followed by flood irrigation at 1.0 Epan. The lowest amount of water was used under the irrigation schedule of 0.6 Epan. Among the mulch treatments, the mean of the imposed irrigation treatments was 439.8 mm. WUE was recorded higher in drip irrigation at lower levels. This is due to better utilization of water through out the growth period for better yield attributes. The yield attributes formation with least expenses of water under drip irrigation at 0.6 Epan (792.0 kg/ha/cm). The amount of water applied was fully utilized and loss of water through evaporation and percolation was limited due to less exposed surface area and slow rate of supply (Palada *et al.,* 2001; Ertek *et al.*, 2007) whereas lowest WUE were recorded when crop was scheduled flood irrigation at 1.0 Epan (403.0 kg/ha/cm). During the beginning of irrigation crop suffers from excess moisture and it was available sufficiently for 2-3 days and again crop suffers from dry stress during end of the irrigation cycle (Choudhary *et al*., 2006). Similarly application of mulches also influenced the water use efficiency (Table 3). BPM and PSM used water more efficiently than

Table 4. Weed parameters, harvest monitory benefit and root dry weight as influenced by drip irrigation levels and mulches in capsicum (mean of both the years)

Treatment	Weed dry weight ($g\ m^{-2}$) at 75 DAP	Weed control efficiency (%)	Harvest monitory benefit (Rs $ha^{-1}\ mm^{-1}$)	Root dry weight (g $plant^{-1}$) 120 DAP
1.0 Epan	15.91(4.05)	32.4	495.7	8.80
0.8 Epan	13.90(3.79)	40.9	559.0	9.54
0.6 Epan	12.41(3.59)	47.3	588.9	10.26
FI (1.0 Epan)	23.53(4.90)	-	278.3	11.62
C.D. (P=0.05)	2.66		45.54	0.74
No mulch	23.83(4.93)	-	385.3	11.06
BPM	6.16(2.58)	74.1	542.6	9.06
TPM	19.36(4.46)	18.8	396.3	10.50
PSM	16.38(4.11)	31.3	535.9	9.60
C.D. (P=0.05)	2.87		39.32	1.08

Figures in parenthesis are square root transformed values $\sqrt{x + 0.5}$

other mulches (736.0 and 692.0 kg/ha/cm, respectively). It is due to better availability of applied water, reduced loss of water due to lesser evaporation, percolation and lower weed density throughout the crop growth period (Tiwari *et al.*, 2003). However, WUE was low with no mulch followed by transparent polythene mulch (532.0 and 587.0 kg/ha/cm, respectively).

Weeds

Weed dry weight was recorded highest with flood irrigation at 1.0 Epan (Table 4). Whereas, drip irrigation at 0.6 Epan recorded lowest weed dry weight with 47.3 per cent weed control efficiency, followed by drip irrigation at 0.8 Epan (40.9 per cent). These might be due to the restricted wetting area near the plant parts in drip irrigated plants. The weed dry weight was more because flood irrigation induces the weed seeds to germinate and emerge quickly. Yield was inversely linearly related with weed dry weight (R^2=0.60, Fig 1a). Among the mulches, BPM recorded the minimum weed dry weight throughout the crop growth period with 74.1 per cent weed control efficiency (WCE). However, the maximum weed dry weight throughout the crop growth period was observed with no mulch. It was also noticed that TPM induces grasses (*Echinochloa colona* and *Cynodon dactylon*) to emerge quickly over others and accumulate more dry weight because of having the higher photosynthetic efficiency, therefore WCE was comparatively lower (Patel *et al.*, 2009). But sedges and broadleaves were more with no mulch having profuse canopy coverage and high competing ability.

Root dry weight

The lowest root dry weight was measured from drip irrigation at 1.0 Epan. But, flood irrigation at 1.0 Epan had highest root dry weight. This was due to crop plants were suffered from adverse condition during first 1-3 days of irrigation cycle due to suffocation and stress during end of the irrigation cycle. The unavailability of water helps the plant roots to grow still deeper (Sahu, 2003; Choudhary *et al.*, 2006).

No mulch had maximum root dry weight (11.06 g/plant) followed by TPM. But, lower root dry weight was observed with BPM followed by PSM (Table 4). In BPM and PSM, the loss of water was very meager due to less exposed area and low weed density. These led to uptake water by plant for longer time with sufficient quantity therefore the development of root was near the surface of ground. Yield was inversely linearly related with root dry weight (R^2= 0.98) (Fig. 1b).

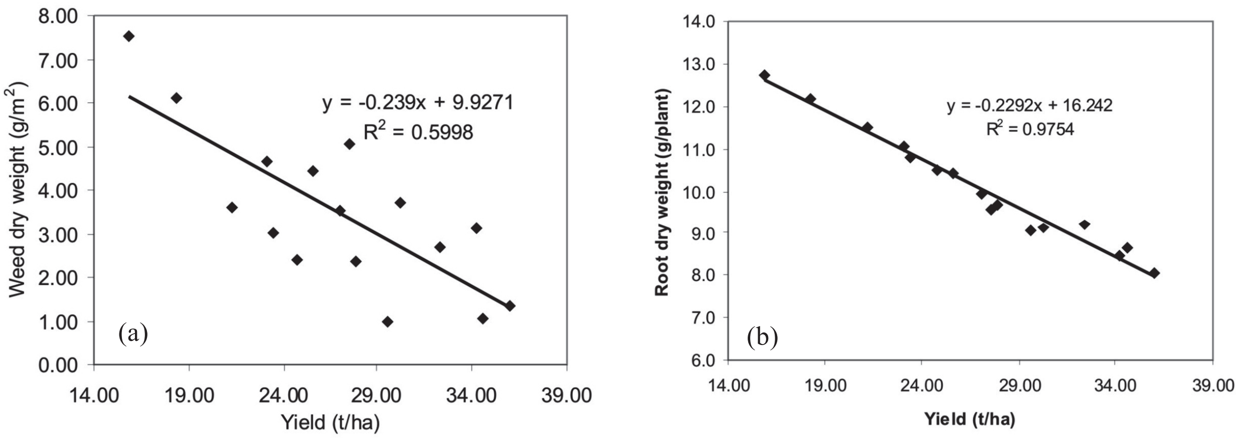

Fig. 1. Relationship of yield with a) weed dry weight and b) root dry weight as influenced by drip irrigation and mulches in capsicum (mean of both the years)

Conclusions

Drip irrigation and mulching play a crucial role in the growth, development and finally yield of capsicum. Drip irrigation at 1.0 Epan with BPM, harvested with higher yield and harvest monitory benefits. Use of drip and mulch materials reduces the water loss and weed emergence. Therefore, as per the water and material available for mulching, the same may be used to harvest higher yield.

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