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Studies on yield, quality, water and fertilizer use efficiency of capsicum under drip irrigation and fertigation

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ABSTRACT

Drip irrigation and fertigation system are being adopted due to their numerous advantages over traditional methods of irrigation and fertilizer application. In this study, capsicum var. Nishat-1 was grown under drip irrigation with fertigation. The experiment was carried out in a factorial RBD consisted of 16 treatment combinations replicated four times. The treatments include four levels of irrigation *viz.*, 100, 80 and 60% ET through drip and 100% surface irrigation; and four levels of fertilizers application *viz.,* 100, 80 and 60% recommended NPK through fertigation and 100% recommended NPK through manual. Surface irrigation and manual fertilizer application were treated as control. The results revealed that there was significant improvement in yield, quality, water and fertilizer use efficiencies of capsicum under drip irrigation and fertigation. However, the combined effect of drip irrigation and fertigation was found superior than their individual effects. The treatment combination of 80% ET through drip and 80% recommended NPK through fertigation registered maximum fruit yield (366.48 q/ha). The highest water use efficiency (29.40 q/ha-cm) was observed with the treatment combination of 60% ET through drip + 80% recommended NPK through fertigation. However, the fertilizer use efficiency was found maximum (NUE-4.89 q/kg N, PUE-6.53 q/kg p and KUE-9.79 q/kg k) with the treatment combination of 80% ET though drip + 60% recommended NPK through fertigation.

Key words: Micro-irrigation, water and fertilizer use efficiency, fruit quality, bell pepper.

INTRODUCTION

Land and water are the indispensable resources of life system. Water is a vital component for successful vegetable production. There are several methods of providing irrigation to the vegetable crops, however drip irrigation is the most efficient system and has proved its superiority over other methods including surface irrigation. It is a concept where water is applied at low rates frequently near the root zone of the plant and is successfully applied to the vegetable crops. The work done on drip irrigation in different parts of India revealed that besides improved yield, water and fertilizer saving, drip irrigation is very effective in improving the quality of vegetable crops. Singh *et al.* (12) reported that drip irrigation showed the way for increase yield in vegetables with water use efficiency nearly twice as high as with other methods. Researches carried out by several workers like Rezuwan *et al.* (11), Tumbare and Nikam (13), Qawasmi *et al*. (8), Bahadur and Rai (2), Gupta *et al*. (4), and Veeranna *et al*. (14) reported similar benefits of increase yield, water and fertilizer use efficiency and better fruits quality in capsicum. The success of drip irrigation system is uniformly applicable to a wide variety of hydro-agro-climatic conditions. However, very little information is available regarding such systems under Kashmir. Hilly and mountainous terrain makes harnessing of river water difficult. Besides, topography is undulating and terraced irregular shape fields make mechanization difficult demanding intensive promotion of drip irrigation system. Keeping the above mentioned facts in view, an attempt has been made to study the response of capsicum var. Nishat-1 under drip irrigation and fertigation system in Kashmir region.

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MATERIALS AND METHODS

The present investigation was carried out during *Kharif* season of 2007-08 at the Experimental Farm of Division of Olericulture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar (J&K). The experiment was laid out in a factorial randomized block design and replicated four times with sixteen treatment combinations. The treatments include four irrigation levels, *viz.,* 100, 80 and 60% ET through drip and 100% surface irrigation; and four fertigation levels, *viz.,* 100, 80 and 60% recommended NPK through fertigation and 100% recommended NPK through manual. Surface irrigation and manual fertilizer application were treated as control.

The volume of water required under drip irrigation system was computed using following equation: V =

[DE × CF × AA × PC]/IE. Where, V = volume of water required (lit/plant/day), DE = daily pan evaporation from class A pan (mm), CF = crop factor, AA = Area allotted per plant (sq m), PC = pan coefficient and IE = Irrigation efficiency as a decimal. The data on average pan evaporation (Ep) and monthly effective rainfall (Re) during the cropping period are given in Table 1. The pan factor value was 0.75 as suggested for USDA class A pan. The area allotted per plant was 0.24 m^2. Estimation of water requirement under drip irrigation in cm-ha by dividing water requirement (l/plant) × 10,000 with area (m^2/plant) × 1,00,000.

Thirty-day-old seedlings of capsicum var. Nishat-1 were transplanted on 26th May 2007 with 3 rows per plot keeping row to row and plant to plant distance 60 and 40 cm, respectively. The drip system was laid out parallel to the crop rows and each lateral with emitter distance at 40 cm with the 2.2 litre per hour discharge rate. The amount of water actually applied by way of drip irrigation system was based on climatological approach. Irrigation was scheduled on alternate days in case of drip irrigation, whereas surface irrigation was given according to the locally adopted frequency. Fertigation with RFD (recommended fertilizer dose) 120:90:60 kg NPK/ha was given according to the treatments in 10 split doses at 10 days interval beginning 10 days after transplanting. However, in case of manually fertilized plots, half dose of nitrogen (urea) and full doses of phosphorus (SSP) and potassium (MOP) were applied as basal dose. While the remaining half dose of nitrogen was applied at 20 and 40 days after transplanting as top dressing. All other package of practices were adopted as recommended for the region. Capsicum fruits were harvested several times and data was added to estimate the total yield. Average fruit weight, total soluble solids (TSS), vitamin C and chlorophyll contents were determined using standard procedures. Volumetric method was used for calculating the uniformity coefficients of drip irrigation system (Raina *et al*., 9). The water use efficiency (WUE) was computed by dividing yield (q/ha) with total water applied (cm) including effective rainfall.

WUE (q/ha-cm) = Yield (q/ha) / total water applied (cm)

The fertilizer use efficiency was worked out separately for N, P and K by dividing total yield (q/ha) with total fertilizer applied (kg/ha), *i.e.* for estimation of nitrogen use efficiency (NUE):

NUE (q/kg N) = Yield (q/ha) / total nitrogen applied (kg/ha)

RESULTS AND DISCUSSION

The performance of drip irrigation system was studied before conducting the experiment. The uniformity coefficient of drip irrigation system was found to be 94.2%. The high value of uniformity coefficient indicates the excellent performance of drip irrigation system in supplying water uniformly throughout the laterals.

The results obtained as depicted in Table 2, confirmed that superiority of drip irrigation over surface irrigation in terms of increased crop yield. The yield under various levels of drip irrigation was always superior to that of surface irrigation. However, 80% ET through drip produced highest average fruit weight (99.7 g) and thereby registered the maximum fruit yield (354.79 q/ha). The minimum average fruit weight (76.8 g) and yield (287.44 q/ha) was recorded with surface irrigation. The increased capsicum yield under drip irrigation might be attributed to the all time availability of water around the root zone. Similar results were also reported by Remesh (10), and Veeranna *et al.* (14).

Fertigation levels also exhibited a significant effect on yield and yield attributing character (Table 3). Among different fertigation levels, 80% of recommended NPK through fertigation produced the highest average fruit weight (95.0 g) and maximum fruit yield (349.83 q/ha). Whereas, manual fertilizer application recorded the lowest average fruit weight (81.0 g) and fruit yield

Table 1. Pan evaporation, effective rainfall, crop factor and volume of water applied during the cropping period.

Month	Average pan evaporation (mm/day)	Effective rainfall (mm)	Crop factor	Volume of water applied (cm)
May	3.6	9.0	0.30 (after 26 May)	0.37
June	4.7	52.3	0.30 (up to 25 June) 0.60 (from 26 June)	3.02
July	4.5	54.0	0.60	2.90
August	5.0	46.4	0.60 (up to 4 August) 0.95 (from 5 August)	8.15
September	3.4	23.2	0.95 (up to 3 Sept.) 0.80 (from 4 Sept.)	5.30
October	2.6	-	0.80 (up to 4 Oct.)	0.49

Table 2. Effect of drip irrigation on yield, quality and water use efficiency in capsicum.

Treatment	Yield (q/ha)	Av. fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	TSS (%)	Dry matter content (%)	Chlorophyll content (mg/100 g)	Vitamin C content (mg/100 g)	Water applied (cm)	WUE (q/ha-cm)
I_1	323.72	82.20	4.54	5.30	4.8	4.61	0.80	25.5	20.10	16.10
I_2	354.79	99.70	5.47	5.54	5.3	5.17	0.77	23.3	16.08	22.06
I_3	340.62	90.60	5.01	5.43	5.1	5.00	0.74	21.3	12.06	28.24
I_4	287.44	76.80	4.06	5.25	4.4	4.46	0.72	20.0	30.24	9.50
CD at 5%	18.42	2.95	0.24	0.32	0.38	0.35	0.01	1.49	-	-

I_1 = 100% ET through drip irrigation; I_2 = 80% ET through drip irrigation; I_3 = 60% ET through drip irrigation; I_4 = 100% Surface irrigation; WUE = Water use efficiency.

Table 3. Effect of fertigation on yield, quality and fertilizer use efficiency in capsicum.

Treatment	Yield (q/ha)	Av. fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	TSS (%)	Dry matter content (%)	Chlorophyll content (mg/100 g)	Vitamin C content (mg/100 g)	NUE (q/kg N)	PUE (q/kg P)	KUE (q/kg K)
F_1	322.21	84.40	4.76	5.41	4.80	4.70	0.77	24.6	2.68	3.58	5.37
F_2	349.83	95.00	4.97	5.46	5.20	5.19	0.77	22.9	3.64	4.85	7.28
F_3	334.12	89.00	4.85	5.48	5.00	4.90	0.76	22.0	4.64	6.18	9.28
F_4	300.41	81.00	4.50	5.18	4.50	4.43	0.73	20.6	2.50	3.33	5.00
CD at 5%	18.42	2.95	0.24	0.32	0.38	0.35	0.01	1.49	-	-	-

F_1 = 100% RFD through fertigation; F_2 = 80% RFD through fertigation; F_3 = 60% RFD through fertigation; F_4 = 100% RFD through manual application; NUE = Nitrogen use efficiency, PUE = Phosphorus use efficiency, KUE = Potash use efficiency.

(300.41 q/ha). The increased yield under fertigation might be due to the efficient use of nutrients at various stages of crop growth and no leaching of nutrients in the form of runoff. Deolankar and Firake (3) reported that fertigation supplying 75% of recommended dose of NPK was better than the manual fertilizer application. Drip irrigation along with fertigation proved always superior to their individual effects (Table 4). The treatment combination of 80% ET through drip + 80% recommended NPK through fertigation produced maximum value for average fruit weight (107.41 g) leading to maximum yield (366.48 q/ha). Whereas, the minimum average fruit weight (70.06 g) and yield (231.75 q/ha) was noticed with the conventional method of irrigation and fertilizer application. The increased yield under drip irrigation and fertigation might be due to the uniform distribution and adequate availability of nutrients and moisture in the root zone of the crop. These findings are in accordance with the findings of Hatlge *et al.* (6), and Veeranna *et al.* (14).

Quality characteristics of capsicum were significantly influenced under drip irrigation and fertigation (Table 2). Among various irrigation levels, drip irrigation at 80% ET recorded the maximum fruit length (5.47 cm), fruit diameter (5.54 cm), total soluble solids (5.3%) and fruit dry matter content (5.17 %). Veeranna *et al*. (14) also reported the better quality of chilli with 80% ET through drip. Fertigation levels exhibited a significant improvement in fruit quality parameters of capsicum. All the fertigation levels proved significantly superior and produced better quality fruits than traditional method of fertilizer broadcasting (Table 3). Fertigation with 80% of recommended NPK resulted in maximum fruit length (4.97 cm), total soluble solids (5.2 %), fruit dry matter (5.19 %) and chlorophyll content (0.77 mg/100 g). However, fruit diameter was found maximum (5.48 cm) with 60% recommended NPK through fertigation which was statistically at par with 80% recommended NPK through fertigation (5.46 cm). An increasing trend of vitamin C content was observed with increased fertigation levels. Fertigation with 100% recommended NPK produced maximum vitamin C content (24.6 mg/100 g).

Drip irrigation in conjunction with fertigation improves water use efficiency as well as fertilizer use efficiency compared to the traditional methods, thereby resulting in a substantial improvement in quality

Table 4. Interaction effect of drip irrigation and fertigation on yield, quality, water and fertilizer use efficiency in capsicum.

Treatment combination	Yield (q/ha)	Av. fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	TSS (%)	Fruit dry matter content (%)	Chlorophyll content (mg/100 g)	Vitamin C content (mg/100 g)	Water applied (cm)	WUE (q/ha-cm)	NUE (q/kg N)	PUE (q/kg P)	KUE (q/kg K)
I_1F_1	308.79	79.31	4.55	5.40	4.26	4.45	0.82	28.27	20.10	15.36	2.57	3.43	5.14
I_1F_2	351.85	87.83	4.73	5.35	4.82	5.17	0.81	26.03	20.10	17.50	3.66	4.88	7.33
I_1F_3	333.79	84.52	4.62	5.45	4.60	4.62	0.80	25.27	20.10	16.60	4.63	6.18	9.27
I_1F_4	300.46	77.41	4.30	5.03	3.87	4.22	0.77	22.57	20.10	14.94	2.50	3.33	5.00
I_2F_1	351.85	95.83	5.58	5.45	4.96	5.03	0.79	24.73	16.08	21.88	2.93	3.90	5.86
I_2F_2	366.48	107.41	5.78	5.73	5.30	5.43	0.79	23.63	16.08	22.79	3.81	5.09	7.63
I_2F_3	352.70	103.30	5.60	5.68	5.12	5.30	0.78	23.37	16.08	21.93	4.89	6.53	9.79
I_2F_4	348.14	92.53	4.93	5.35	4.75	4.93	0.73	21.85	16.08	21.65	2.90	3.86	5.80
I_3F_1	337.96	86.11	4.83	5.40	4.42	4.97	0.75	23.97	12.06	28.02	2.81	3.75	5.63
I_3F_2	354.62	102.34	5.26	5.50	5.03	5.26	0.76	21.23	12.06	29.40	3.69	4.92	7.38
I_3F_3	348.61	90.05	5.18	5.50	4.79	5.24	0.75	20.37	12.06	28.90	4.81	6.45	9.68
I_3F_4	321.29	84.28	4.80	5.35	4.11	4.55	0.72	19.77	12.06	26.64	2.67	3.56	5.35
I_4F_1	290.27	76.39	4.10	5.43	3.44	4.38	0.74	21.53	30.24	9.59	2.41	3.22	6.04
I_4F_2	326.38	82.62	4.15	5.28	4.25	4.95	0.73	21.00	30.24	10.79	3.39	4.53	6.79
I_4F_3	301.38	78.34	4.01	5.33	3.92	4.47	0.72	19.27	30.24	9.96	4.18	5.58	8.37
I_4F_4	231.75	70.06	4.02	5.00	3.10	4.06	0.71	18.23	30.24	7.66	1.93	2.57	3.86
CD at 5%	36.72	5.91	0.48	0.64	0.28	0.70	0.02	2.99	30.24	-	-	-	-

I_1 = 100% ET through drip irrigation; I_2 = 80% ET through drip irrigation; I_3 = 60% ET through drip irrigation; I_4 = 100% Surface irrigation.

F_1 = 100% RFD through fertigation; F_2 = 80% RFD through fertigation; F_3 = 60% RFD through fertigation; F_4 = 100% RFD through manual application

WUE = Water use efficiency, NUE = Nitrogen use efficiency, PUE = Phosphorus use efficiency, KUE = Potash use efficiency.

parameters as (given in Table 4). The treatment combination of 80% ET through drip and 80% recommended NPK through fertigation registered maximum values for fruit length, fruit diameter, total soluble solids and fruit dry matter content. However, chlorophyll content (0.82 mg/100 g) and vitamin C content (28.27 mg/100 g) were found maximum with 100% ET through drip + 100% recommended NPK through fertigation. The improved quality might be due to the fact that drip irrigation and fertigation permit better utilization of water and nutrients, lower leaching losses and more controllable application of nutrients during the growing season as compared to other methods of water and nutrient supply. Similar results of quality improvement were also reported by Qawasmi *et al*. (8), and Alcantar *et al.* (1).

The results suggested that high yield of capsicum fruits was obtained with substantial use of water and fertilizer under drip irrigation and fertigation leading to higher water and fertilizer use efficiencies in comparison to normal practice of irrigation and fertilizer application. Water use efficiency was found maximum (28.24 q/ha cm) with 60% ET through drip (Table 2). Whereas, the efficiency was further increased with drip irrigation in conjunction with fertigation and found maximum (29.40 q/ha cm) with the treatment combination of 60% ET through drip and 80% recommended NPK through fertigation (Table 4). This might be attributed to the fact that drip irrigation system ensured the availability of soil moisture at low tensions with reduced surface evaporation. These findings are in accordance with the findings of Gupta *et al*. (5), Prabhakar and Hebbar (7), and Veeranna *et al*. (14).

Application of fertilizers through fertigation reduces fertilizer usage and leaching losses of nutrients thereby enhancing fertilizer use efficiency. All the fertigation levels resulted in better fertilizer use efficiency compared to the traditional method of fertilizer application (Tables 3 & 4). Application of 60% recommended NPK through fertigation recorded the maximum fertilizer use efficiency (NUE - 4.64 q/ha N, PUE-6.18 q/kg P and KUE - 9.28 q/kg K). The same fertigation level *i.e.*, 60% recommended NPK through fertigation with 80% ET through drip further enhanced fertilizer use efficiency (NUE - 4.89 q/kg N, PUE - 6.53 q/kg P and KUE - 9.79 q/kg K). This might be due to the precise application of fertilizers to the restricted volume of soil where the active roots were concentrated and hence was available to plants fully. Deolankar and Firake (3) also reported the maximum fertilizer use efficiency with 75% recommended NPK in chilli. Similar findings are also reported in pepper by Qawasmi *et al.* (8), Haltlge *et al.* (6), and Rezuwan *et al.* (11).

It can be concluded that proper management of drip irrigation and fertigation with appropriate amount of water and fertilizer significantly enhance the yield and quality of capsicum with maximum water and fertilizer use efficiency. The results of the present study revealed that the treatment combination of 80% ET through drip and 80% recommended NPK through fertigation is best in term of yield and quality characteristics of capsicum. Whereas, the water use efficiency was found maximum with the treatment combination of 60% ET through drip and 80% recommended NPK through fertigation. The fertilizer use efficiency was recorded maximum with the treatment combination of 80% ET through drip and 60% recommended NPK through fertigation.

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