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Impact of Drip Fertigation on Yield and Nutrients Uptake by Chilli (*Capsicum annuum* L.)

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A B S T R A C T

This study was conducted at Horticulture Farm, Rajasthan College of Agriculture, MPUAT, Udaipur during the summer season in 2013-14 and 2014-15. The experiment consisted of 15 treatment combinations replicated three times which included 3 levels of irrigation viz., 80%, 60% and 40% PE through drip irrigation and five levels of fertigation viz., 100% RDF, 75% RDF, 50% RDF, 75% RDF + 2 foliar spray 1% urea phosphate, and 50% RDF + 2 foliar spray 1% urea phosphate through fertigation. Results showed that maximum fruit weight (3.73 g) and fruit yield ha^{-1} (16.13 t), nutrients uptake, net return and B: C ratio were recorded with 80% PE through drip irrigation over 40% PE. Similarly the highest fruit weight fruit^{-1}(3.72 g), average yield weight plant^{-1} (261.00 g) fruit yield plot^{-1} (47.34 kg), fruit yield ha^{-1} (15.94 t), nutrients uptake, net return and B: C ratio of chilli were obtained under treatment with 75% RDF through fertigation + 2 foliar spray 1% urea phosphate over 50 per cent RDF through fertigation. Highest water use efficiency was found under drip irrigation at 40 % PE (4.18 q ha^{-1} cm) over 60% PE and 80% PE. It was further concluded the application of 75% RDF through fertigation + 2 foliar spray 1% urea phosphates gave highest water use efficiency (3.26 q ha^{-1} cm) than other treatments.

Introduction

Water and nutrient management are the key factors for successful cultivation of vegetable crops, which responds well to nutrient and irrigation regime. In crop intensive agriculture, both irrigation and fertilizer management have contributed immensely in increasing the yield and quality of crops. Water plays vital role in improving plant growth and crop production; it is the most limiting factor in Indian agricultural scenario. In India, the potential for the drip irrigation system is estimated to be 21.27 mha (Narayanamoorthy, 2008). Water saving from drip irrigation system varied from 12 to 84% for different crops besides increasing the production of crops. Due to water scarcity, the available water resources should be very effectively utilized through water saving

irrigation technologies. The need of the hour is, therefore, to maximize the production unit-[1] of water. Hence, further expansion of irrigation may depend upon the adoption of new systems such as pressurized irrigation methods with the limited water resources. Amongst those pressurized irrigation methods, drip irrigation has proved its superiority over other methods of irrigation due to the direct application of water and nutrients in the vicinity of root zone. Drip irrigation is the concept where water is applied at low rate frequently near the root zone of the plant. Drip irrigation system can be easily used for fertigation through which the applied fertilizer is placed to the active root zone and crop nutrient requirement can be met accurately (Neilsen *et al.*, 2004). The reason why fertigation has become the state of art in plant nutrition particularly in arid environments is that nutrients can be applied in the correct dosage and at the required time appropriate for each specific growth stage. Fertilizers applied under conventional methods of irrigation are generally not efficiently used by the crop (Hebbar *et al.*, 2004). Proper fertigation management requires the knowledge of soil fertility status and nutrient uptake pattern of the crop. Monitoring of soil and plant nutrient status is an essential safeguard to ensure maximum crop productivity. Since, fertigation enhances the fertilizer use efficiency owing to the frequent application of fertilizer directly into the soil where root activity tends to be concentrated and hence reduction in fertilizer rate is possible without compromising the yield of crop.

Chilli (*Capsicum annuum* L.) is one of the most popular and high value vegetable crops grown for its immature fruits throughout the world. Chilli consumption in India has increased now- a- days due to increased demand by urban consumers. The nutritive value of chilli is excellent. It is also rich sources of vitamins, especially in A, B and C. India has produced about 65.9 thousand tonnes of Chilli with area of 7.7 thousand hectares and productivity 8.61 tonnes per hectares (Vegetable Statistics, 2013-14). Taking into account the above facts a field experiment was conducted to find out the effect of irrigation and fertigation levels on yield parameters, nutrients uptake, water use efficiency and economic of chilli (*Capsicum annuum* L.).

Materials and Methods

The experiment was conducted at Horticulture Farm, Rajasthan College of Agriculture, MPUAT, Udaipur during *summer* season in 2013-14 and 2014-15. The soil was Haplustepts, clay loam in texture having pH 8.15, EC 0.67 dS m^{-1}, Organic carbon 0.71%, available nitrogen 296.45 kg ha^{-1}, available phosphorus 23.76 kg ha^{-1} and available potassium 318.65 kg ha^{-1}. The experiment was laid out in split plot design with 15 treatment combinations which consisted of 3 levels of drip irrigation (80%, 60% and 40% PE) and 5 levels of fertigation (100% RDF, 75% RDF, 50% RDF, 75% RDF + 2 foliar spray 1% urea phosphate, and 50% RDF + 2 foliar spray 1% urea phosphate through fertigation) were replicated three times. Four weekes old seedling of chilli variety Pusa Jwala was transplanted in last week of March and harvested in the last week of June. The water soluble fertilizers (urea, urea phosphate and potassium nitrate) were used in experiment through drip irrigation. The fertilizers were applied at fifteen days interval in 6 equal splits starting from 15 days after transplanting through drip irrigation according to fertilizer schedules. The fertilizer schedules was developed according to RDF (70-40-50 NPK kg ha^{-1}) for chilli crop. In drip irrigation scheduling was done based on pan evaporation and application of water three days interval according to requirement of the

crop. In order to determine the optimum water requirement for crops, three irrigation levels were adopted with 80, 60 and 40 percent (PE) water requirement of the crop. The discharge rate of the emitter was 4 liters per hour at nominal pressure of 1.5 kg cm^{-2}. The yield of fruits per hectare was calculated by multiplying the average yield of fruits per sq. meter and expressed in tan per hectare.

Uptake of macro (N, P, K) were computed from the data of N, P and K content in fruit and plant by using the following formula

$$\text{Nutrient uptake In fruit (kg ha}^{-1}) = \frac{(\%\text{ nutrient content in fruit}) \times \{\text{fruit yield (kg ha}^{-1})\}}{100}$$

$$\text{Nutrient uptake In plant (kg ha}^{-1}) = \frac{(\%\text{ nutrient content in plant}) \times \{\text{plant yield (kg ha}^{-1})\}}{100}$$

The water use efficiency was computed by dividing yield (q ha^{-1}) with total water applied (cm) including effective rainfall.

$$WUE\ (q/ha-cm) = \frac{Yield\ (kg/ha)}{Total\ water\ applied\ (cm)}$$

Results and Discussion

Yield and yield attributed

Yield and yield attributed of chilli as influenced by different levels of drip irrigation and fertigation are presented in Table 1 and Fig.2. A perusal of data indicated that the highest yield attributes viz., fruit weight per fruit (3.73 g) and fruit yield ha^{-1} (16.14 t), respectively were observed in the drip irrigation at 80% PE over 40% PE. The increase in yield might be due to better proportion of air-soil water which was maintained throughout the life period of crop in drip irrigation as reported by Kadam and Karthikeyan (2006). The increase in chilli yield under drip irrigation system may be due to the availability of water all the time when needed around the root zone at very low moisture tension. Singh and Kumar (2007) also reported the maximum fruit weight and tomato yield with 80% ET. Similar findings are also reported by Gupta and Chattoo (2014).

Data further revealed that the highest fruit weight $fruit^{-1}$ (3.72 g) and fruit yield ha^{-1} (159.39 t), respectively were obtained by application of 75% RDF through fertigation + 2 foliar spray of 1 % urea phosphate which was significant superior than other treatments on the pooled basis (Table 1 and Fig.2). The important reasons responsible for better production of yield and yield attributes might be 75% RDF due to better performance under drip fertigation as compared to conventional method of fertilizer application can be attributed to maintenance of favourable nutrient-water interaction in the root zone, which in turn might have helped the plant to utilige nutrients more efficiently. These results are in agreement with the findings of several researchers in different vegetable crops such as Kadam *et al.*, (2006) and Vjekoslav *et al.*, (2010) and Ayyadurai and Manickasundaram (2014).

Nutrient uptake

N, P and K uptake of chilli crop as influenced by different levels of drip irrigation and fertigation are presented in Table 2. Results showed that increasing the levels of drip irrigation significantly increased N, P and K uptake by chilli. Data on pooled basis showed that the highest nitrogen (94.91 kg ha^{-1}), phosphorus (20.11kg ha^{-1}) and potassium (140.29 kg ha^{-1}) uptake in chilli were observed under application of drip irrigation

at 80 % PE over drip irrigation at 40 % PE. Drip irrigation (80% PE) increase the nutrient uptake, it may be due to approaching towards meeting the daily evaporation demand through drip irrigation, increased the availability of moisture resulting in higher nutrient uptake through its influence on biomass production and on the availability of nutrients. Preferential uptake of water from the sufficiently moist soil promoted the movement of nutrient ions towards roots and their uptake (Sanchez *et al.*, 2001).

Fig.1 Experiment site of chilli

Fig.2 Effect of drip irrigation and fertigation levels on fruit weight and fruit yield

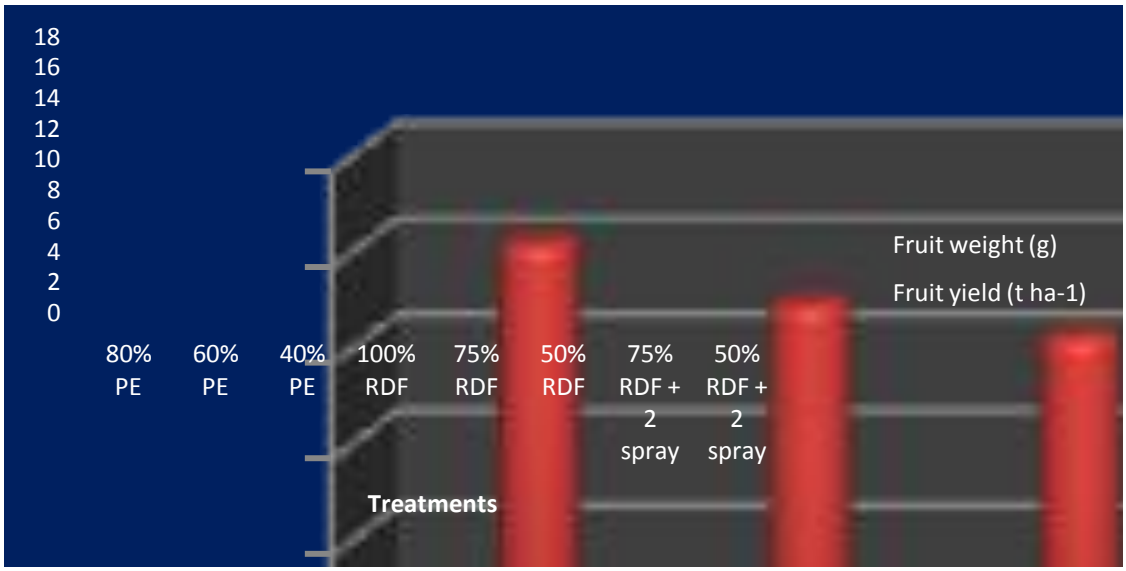

Table.1 Effect of drip irrigation and fertigation levels on fruit weight, fruit yield, Net returns, B: C ratio and water use efficiency of chill

Treatments	Fruit weight (g)			Fruit yield (t ha^{-1})			Net returns (Rs. ha^{-1})			B:C ratio			WUE(q ha^{-1} cm)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Irrigation levels															
Drip at 80% PE	3.29	4.17	3.73	15.74	16.53	16.14	221997	238584	230291	2.05	2.19	2.12	2.59	1.97	2.28
Drip at 60 % PE	3.07	3.96	3.51	14.50	15.23	14.87	198359	213665	206012	1.87	2.01	1.94	3.25	2.54	2.89
Drip at 40% PE	2.74	3.63	3.18	13.77	14.63	14.20	185294	203477	194386	1.78	1.96	1.87	4.68	3.68	4.18
SEm ±	**0.066**	**0.086**	**0.054**	**3.680**	**3.35**	**2.487**	**7729**	**7028**	**5223**	**0.072**	**0.065**	**0.048**	**0.085**	**0.046**	**0.048**
CD (P = 0.05)	**0.184**	**0.239**	**0.125**	**10.218**	**9.290**	**5.735**	**21459**	**19512**	**12044**	**0.199**	**0.181**	**0.112**	**0.237**	**0.127**	**0.112**
Fertigation levels															
100% RDF	3.20	4.08	3.64	15.28	15.94	15.58	206881	222126	214503	1.84	1.97	1.91	3.64	2.78	3.21
75% RDF	3.02	3.91	3.46	14.72	15.44	15.08	201750	217073	209411	1.88	2.02	1.95	3.55	2.73	3.14
50% RDF	2.76	3.65	3.20	13.67	14.63	14.4	184864	205563	195213	1.81	2.02	1.92	3.23	2.61	2.92
75% RDF + 2 foliar spray	3.28	4.17	3.72	15.50	16.39	15.94	217852	236724	227288	2.03	2.20	2.11	3.70	2.82	3.26
50% RDF + 2 foliar spray	2.90	3.79	3.34	14.30	14.93	14.61	198069	211393	204731	1.94	2.07	2.00	3.41	2.71	3.06
SEm ±	**0.067**	**0.069**	**0.048**	**2.198**	**2.178**	**1.547**	**4616**	**4574**	**3249**	**0.043**	**0.043**	**0.030**	**0.066**	**0.051**	**0.042**
CD (P = 0.05)	**0.139**	**0.143**	**0.097**	**4.537**	**4.496**	**3.111**	**9527**	**9440**	**6533**	**0.089**	**0.089**	**0.061**	**0.137**	**0.104**	**0.084**

Table.2 Effect of drip irrigation and fertigation levels on total N, P and K uptake after harvest of chilli

Treatments	Total N uptake (Kg ha^{-1})			Total P uptake (Kg ha^{-1})			Total K uptake (Kg ha^{-1})		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Irrigation levels									
Drip at 80% PE	91.21	98.62	94.91	18.50	21.72	20.11	135.03	145.54	140.29
Drip at 60 % PE	81.24	88.03	84.63	15.83	18.39	17.11	120.53	130.32	125.43
Drip at 40% PE	75.77	82.54	79.15	13.62	15.72	14.67	110.67	121.95	116.31
SEm ±	**2.274**	**2.03**	**1.525**	**0.540**	**0.49**	**0.363**	**3.247**	**3.39**	**2.345**
CD (P = 0.05)	**6.313**	**5.64**	**3.517**	**1.498**	**1.35**	**0.838**	**9.016**	**9.40**	**5.409**
Fertigation levels									
100% RDF	88.16	95.92	92.04	17.98	20.44	19.21	131.37	141.13	136.25
75% RDF	82.47	89.22	85.85	15.49	18.51	17.00	123.48	131.54	127.51
75% RDF + 2 foliar spray	89.68	98.04	93.86	17.98	20.90	19.44	133.07	144.95	139.01
50% RDF	74.24	81.06	77.65	13.68	16.07	14.87	107.78	120.70	114.24
50% RDF + 2 foliar spray	79.13	84.42	81.78	14.77	17.13	15.95	114.68	124.71	119.69
SEm ±	**1.412**	**1.8979**	**1.183**	**0.309**	**0.3493**	**0.233**	**2.232**	**2.0963**	**1.531**
CD (P = 0.05)	**2.915**	**3.9171**	**2.378**	**0.638**	**0.7209**	**0.469**	**4.607**	**4.3266**	**3.078**

Data further revealed that the fertigation had significantly increased nitrogen (93.86 kg ha^{-1}), phosphorus (19.44 kg ha^{-1}) and potassium (139.01kg ha^{-1}) uptake in chilli were registered with 75 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate (Table 2). However, different between fertigation with 75 % RDF + 2 foliar spray of 1 % urea phosphate and 100 % RDF were found at par. Highest uptake of nitrogen, phosphorus and potassium with increasing fertigation level might be due to the fact that nitrogen increases the cation exchange capacity of plant roots and these make them more efficient in absorbing other nutrient ions like phosphorus and potassium. Higher nitrogen uptake at higher fertigation level was due to increased availability of nitrogen in soil with higher rate of application (Shinde *et al.,* 2006, Kumar and Sahu 2013 and Kohire and Das 2015).

Water use efficiency

Water use efficiency of chilli was increased significantly with decreasing level of drip irrigation (Table 3). Data on pooled basis showed that the highest water use efficiency (4.18 q ha^{-1} cm) was recorded with application of drip irrigation at 40 % PE followed by 2.89 q ha^{-1}cm at 60 % PE which resulted in significant increase of 83.33 and 26.75 per cent water use efficiency of chilli over drip irrigation at 80 % PE. Since the rate of water losses through evaporation, percolation and leaching was much lower under drip irrigation, hence water use efficiency was found under lower levels of drip irrigation as compared to higher level of drip irrigation. These results are in agreement with the earlier findings of Thompson *et al.,* (2000) and Gupta *et al.,* (2010).

Maximum water use efficiency was obtained under 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate by (3.26 q ha^{-1} cm) and minimum (2.92 q ha^{-1} cm) with 50 % RDF fertigation (Table 3). These attributes were found significantly higher with 75% RDF + 2 foliar spray of urea phasphate may be efficiently utilized water and fertilizer for getting higher yield. Water use efficiency was higher under drier regimes and higher fertigation levels and maximum water use efficiency was observed at 75% RDF + 2 foliar spray of urea phasphate (3.26 q ha^{-1} cm).The present findings are in good accordance with the results of Singandhupe *et al.,* (2003), Ramachandrappa *et al.,* (2010) and Kapoor *et al.,* (2014).

Economics

Data revealed that net return and B: C ratio increased significantly with the increase level of drip irrigation (Table 3). Highest net returns (230291 Rs. ha^{-1}) and B:C ratio (2.12) were recorded with application of drip irrigation at 80 % PE. Maximum net return (227288 Rs. ha^{-1}) and B: C ratio (2.11) were observed with 75 % RDF through fertigation + 2 foliar spray of 1% urea phosphate compared to other treatments. This might be due to the fact that under these treatments the cost of input added was low as compared to output obtained, therefore, higher fruit yields resulted in higher net returns and B: C ratio. These findings are similar to those Muralikrishnasamy *et al.,* 2006 and Vijayakumar *et al.,* 2010.

From the above mention result emanated from present investigation conducted during *summer* season 2013-14 and 2014-15 it can be concluded that the higher yield and nutrient uptake of chilli can be achieved by drip irrigation at 80 % PE along with 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate. Water use efficiency increased under 40% PE drip irrigation along with 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate. The highest net return

and benefit cost ratio of chilli was obtained with the combined application of 80% PE through drip irrigation + 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate.

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