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Response of Red Hot Pepper (*Capsicum annum* L.) to Water and Nitrogen under Drip and Check Basin Method of Irrigation

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Abstract: The present investigation was undertaken for the period of two years (2004 and 2005) to evaluate the effect of various levels of water and N application through drip irrigation on red hot pepper yield, Water Use Efficiency (WUE) and Nitrogen Use Efficiency (NUE). In this experiment various combination of three irrigation treatments (Drip irrigation at 0.5 and 1.0×Epan, check basin method of irrigation at 1.0×Epan) and three nitrogen levels (50, 75 and 100% of recommended nitrogen) were compared in split plot design having three replications. The results revealed that when the same quantity of water and nitrogen (100% of recommended) was supplied through drip irrigation system, it increased the red hot pepper yield to 277.4 q ha^{-1} (an increase of 28.4%) under check basin method of irrigation. In check basin method of irrigation, the highest red hot pepper yield (216.1 q ha^{-1}) obtained at 100% of recommended N, while in drip irrigation at 1.0×Epan, the yield was highest at 75% of recommended N. When water and nitrogen was supplied through drip at 0.5×Epan, the yield remained statistically same at all the levels of nitrogen, however proved superior over drip irrigation at 1.0×Epan at all the levels of N. When half the recommended amount of N was supplied through drip at 0.5×Epan.,WUE and NUE increased by 232.1 and 38.7% over check basin method of irrigation. At lower level of drip irrigation 0.5×Epan, Root length increased significantly with drip irrigation treatments as compared to check basin method of irrigation and found maximum (36.3 m) at lower level of drip irrigation 0.5×Epan. Thus drip irrigation at 0.5x Epan is beneficial for red hot pepper in term of yield, better morphological characters, viz, plant height, number of branches, root length, size and weight of fruits along with 58.6% saving of irrigation water over check basin method of irrigation.

Key words: Chilli, *Capsicum annum*, drip irrigation, check basin method, irrigation, WUE (Water Use Efficiency), NUE (Nitrogen Use Efficiency), root length

INTRODUCTION

Globally, India is leading country in context of area covered in chilli production making it most dominant player in the world chilli market. In India, it is grown mainly during hotter parts of the year (March-October), when the evapo-transpiration rates are very high. Water is an important input for growing this crop during this season. Pepper is most susceptible horticultural plants to drought stress because of the wide range of transpiring leaf surface, high stomatal conductance (Alvino *et al.*, 1994) and having a shallow root system. (Dimitrov and Ovtcharrow, 1995). For higher yield, an adequate water supply and relatively moist soils are required during the entire growing season. Low water availability prior to flowering of pepper reduced the number of flowers and retarded the occurrence of maximum flowering. The water deficit during the period between flowering and fruit development reduced final fruit production (Jaimez *et al.*, 2000). So, chilli crop require good and precise amount of water for higher yield and quality. In this direction, drip irrigation offers great opportunity for precise application of water and nutrients to the crop. The system has proved its superiority over other conventional method of irrigation, especially in fruits and vegetable crops owing to precise and direct application of water in the root zone (Bhella, 1988; Raina *et al.*, 1998). Further due to severe competition for water from human beings, intensive agriculture, flora and fauna, etc. value of water will go up in the century (Bouwer, 2000). So, proper irrigation scheduling is required for maximizing yield and water use. Sivanappan and Padmakumari (1980) compared drip irrigation and furrow irrigation systems and found that about 1/3rd to 1/5th of the normal quantity water was enough for the drip irrigated plots compared to normal quantity of water applied to plots under surface irrigation in vegetable crops. The fertigation of chilli with 100% recommended nitrogen saved 40% water and produced

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52% higher yield over check basin and only 50% N applied through fertigation produced equivalent amount of fruit to check basin (Singh *et al.*, 1999). The fruit yield of chilli increased significantly when nitrogen was applied through fertigation over surface application method and resulted 30% saving of nitrogen (Tumbare and Bhoite, 2002). Mohammad (2004) confirmed, by the use of ^{15}N, that fertilizer N utilization efficiency was lower with soil application than with fertigation and fertigation also improved WUE. It is evident that different quantities of water supply and N rates have different effect in different crops and under different climatic condition. The information on the combined effect of varying amount of water and N fertilizer through drip irrigation on the yield, water use and nitrogen use efficiency in chilli is missing. Hence an experiment was conducted to study the yield response of chilli, its WUE and NUE in relation to varying amount of water and N fertilizer through drip irrigation.

MATERIALS AND METHODS

The experiment was conducted at Research Farm of Punjab Agricultural University Department of Soil and Water Engineering, Ludhiana (30°56'N, 75°52'E and 247 m.s.l.) in India during the summer 2004 and 2005 (first week of march to first fortnight of October). Geologically the farm area forms a part of the trans Indo-Gangetic alluvial plains. The soil of the experimental field was loamy sand in texture. The soil was low in available nitrogen, medium in available phosphorus and rich in available potassium (Table 1).

The soils have no salinity and drainage problem and water table is more than 20 m deep. The treatment comprised two levels of water supply through drip and one through check basin method of irrigation. In check basin (surface flooded) method the irrigations were provided on the basis of 1.0 cumulative pan evaporation (1.0×Epan). For each check basin method of irrigation water was applied when cumulative Epan become 7.5 and irrigation water measurements were made by Parshall Flume. However, in drip irrigation water was applied every second day of irrigation equivalent to cumulative Epan or 50% of it depending upon the treatment. In check basin method total 12 irrigations were applied throughout the season. The N was tried at the rate of 100, 75 and 50% of recommended dose of 75 kg ha^{-1} at all the three irrigation treatments. All these treatments combinations were sown in paired row planting. The paired row planting method was used to reduce the cost of drip irrigation system as there was one lateral for two rows of each pair instead of two laterals. In paired sowing, the row to row space between paired rows was 30 cm and row space between

Table 1: Physical and chemical properties of soil

Bulk density of soil layer (Mg m^{-3})	1.48
Organic nitrogen (mg kg^{-1})	215.00
pH	7.80
EC (dm^{-1})	0.18
Phosphorus (mg kg^{-1})	8.00
Potassium (mg kg^{-1})	424.00

pairs was 60 cm and plant to plant spacing in a row is 30 cm. The schematic representation of the layout of the experiment and drip in the experimental plot is detailed in Fig. 1. The experiment was conducted in split plot design having two levels of water supply through drip and one through check basin method of irrigation in main plot while nitrogen treatments placed in sub plot having three replications. The cultivar CH-1 of hybrid chilli was used for experimental study in both the seasons. In check basin method of irrigation half the N was applied after first irrigation and second half after first picking. Whole of phosphorus was basal applied (before sowing) in all the treatments. For the establishment of crop after transplanting, the crop was irrigated at regular interval for 1st 15 days irrespective of irrigation treatments and thereafter it was irrigated on the basis of Epan ratio. The drip system consisted of polyethylene lateral of 12 mm in diameter, laid along each row. The laterals have in line dripper at 30 cm distance. The drippers had a discharge rate of 3 L h^{-1} under an operation pressure of 1 kg cm^{-2}. The different levels of water supply were maintained by managing the number of holes in each lateral. In drip irrigation system, N was supplied at 20 day interval in eight equal doses starting from 15 days after transplanting. All other recommended package of practices relating to weed and plant protection measures were followed. Different plant growth characteristics, yield attribute and yield were recorded for all the treatments. For computation of water use efficiency, red pepper yields per hectare were divided by irrigation water applied and expressed as q (ha cm)$^{-1}$. Similarly for agronomic efficiency of nitrogen, red pepper yield were divided by the amount of N in kg ha^{-1} applied in different treatments. This AEN has been reported as q (yield) kg^{-1} N. For root length measurement, plants were harvested with most care. The sides of plants, 60 cm from each side were dug 1m deep and the plant along with the soil was lifted. Later the roots were washed with a fine jet of water by keeping it over a set of sieves of varying pore size. The soil particles were separated from the roots. Root length was estimated by modifying the method of Habib (1988). In order to measure the root length, the following procedure was adopted. The roots of capsicum were divided into categories: L_1 (1-2 cm diameter), L_2 (1-2 mm diameter), L_3 (1-0.05 mm diameter), L_4 (<0.05 mm diameter). The lengths

Replication I			Replication II			Replication III		
DI 0.5	DI 1.0	C.B.	C.B.	DI 1.0	DI 0.5	DI 0.5	DI 1.0	C.B.
N_1	N_3	N_2	N_1	N_3	N_3	N_2	N_1	N_3
Irrigation channel								
N_3	N_1	N_1	N_2	N_2	N_2	N_1	N_2	N_2
N_2	N_2	N_3	N_3	N_1	N_1	N_3	N_3	N_1
Irrigation channel								

N_1: 50% of recommended nitrogen, N_2: 75% of recommended nitrogen, N_3: 100% of recommended nitrogen. DI 0.5 = 0.5×Epan, DI 1.0 = 1.0×Epan, C.B. = Check basin method of irrigation

Fig. 1a: Layout of experimental site

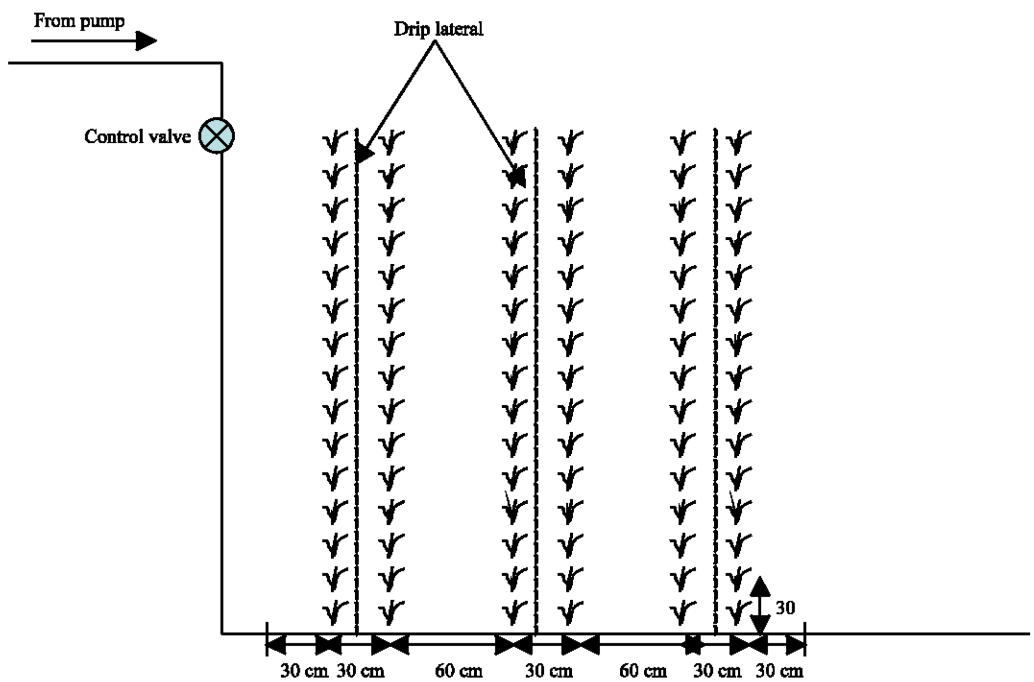

Fig. 1b: Layout of the drip system in the experimental plot

of 50 randomly selected roots were measured using a scale in each category (A). This material was subsequently dried and weighed (X). The rest of the roots in this category were also dried and weighed for the total weight of roots (Y). Total root weight was M.

$$M = X+Y$$

A factor (F) was derived by dividing the length of 50 roots by its dry weight

$$F = A/X$$

This factor was multiplied with total dry weight of the root (M). The result gave the length of root in this category

$$L_1 = FM$$

The same procedure was repeated for the roots in different categories. Finally the length obtained for different categories were added up to get the total length of the roots

$$L = L_1 + L_2 + L_3 + L_4$$

Results were statistically analysed using standard procedure for split plot design. Means were compared using Least Significant Differences (LSD) at the 5% probability level as per Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Vegetative growth and yield parameters: The plant height and branches/plant responded significantly with different levels of drip and check basin method of irrigation. The highest plant height (62.5 cm) was recorded with drip irrigation at 1.0×Epan, while the lowest at (52.8 cm) with check basin method of irrigation at 1.0 ×Epan (Table 2). More branches/plant were recorded with drip irrigation than check basin method of irrigation. There was a significant increase in size (length) and weight of fruits in the plots irrigated through drippers compared to surface irrigated plots. The maximum fruit weight was observed under drip irrigation at 0.5×Epan followed by drip irrigation at 1.0×Epan. Irrespective of irrigation treatments, with 50% decrease in rate of N application than recommended dose, there was an significantly fall in plant height, branches/plant and fruit size. Highest red pepper yields were recorded from the plants irrigated through drip irrigation compared to check basin method of irrigation. The highest yield (274.09 q ha^{-1}) was recorded with drip irrigation at 0.5×Epan, however statistically same with drip irrigation at 1.0×Epan, but significantly higher than check basin method of irrigation. The drip irrigation at 0.5×Epan resulted increase in red pepper yield to the tune of 37.3% over check basin method of irrigation. The graded doses of nitrogen did not influence the red pepper yield significantly. The highest yields with drip irrigation may be attributed mainly owing to good vegetative growth in terms of higher plant height, more branches, fruit size and higher fruit weight than check basin method of irrigation (Table 2). This may be because of frequent and consistent application of water in the vicinity of roots, which provides a good soil moisture regime in the crop root zone throughout the life period of crop. As the plant height and number of branches increased, new nodes for flower and fruit development appeared resulting in an increase in total yield. These results are in conformity with Antony and Singandhupe (2004). Manunatha *et al.* (2001), Shirgure *et al.* (2001), Cetin and Bilgel (2002) and Tiwari *et al.* (2003) who also reported beneficial effect of drip irrigation on growth and yield of different vegetables. The check basin method of irrigation not only resulted in wastage of water in deep percolation below root zone, but also sets a chain of undesirable reaction such as leaching of available plant nutrients and consequently development of soil problem and poor aeration resulting in reduced crop yield. These results are in conformity with Gutal *et al.* (1990), who observed higher red pepper yield under drip irrigation as compared to surface irrigation.

The interaction effect of irrigation treatments and varied nitrogen doses on red pepper yield was also found significant. The perusal of data in Table 3 revealed that when recommended level of nitrogen was applied through drip irrigation at 1.0×Epan, a significantly higher red pepper 255.0 q ha^{-1} was obtained as compared to 216.1 q ha^{-1} in check basin method of irrigation. It further revealed that when half quantity of recommended nitrogen was applied through drip irrigation at 0.5×Epan, the red pepper yield increased by 40.2% over check basin method of irrigation. The data further elucidated that under check basin method of irrigation, the decrease in N dose from the recommended level resulted an significant reduction in pepper yield, while in drip irrigated crop, the red pepper yield was found statistically same at all the level of nitrogen which revealed that there is substantial saving of nitrogen when the crop was drip irrigated as compared to check basin method of irrigation.

Water and nitrogen use efficiency: The total water expenses and Agronomic Efficiency of Nitrogen (AEN) at various levels of water supply is reported in Table 2. The maximum amount of irrigation water was applied in case of surface irrigation at 1.0×Epan (940 mm) while the minimum

Table 2: Effect of treatments on different parameters of hot red pepper (Mean of 2 years)

Treatments	Plant height (cm)	Branches/ plant	Length of fruit (cm)	Weight of fruit (g)	Yield (q ha^{-1})	Irrigation water applied (mm)	NUE (q kg^{-1} N)	WUE (q ha^{-1} mm^{-1})	Root length (m)
Irrigation treatments									
DI 0.5×Epan	61.30	8.55	6.72	2.89	274.09	389	3.94	0.704	36.3
DI 1.0×Epan	62.50	8.67	6.65	2.88	264.30	686	3.83	0.385	24.1
Check basin	52.80	5.11	6.18	2.50	199.60	940	2.84	0.212	18.4
LSD (0.05)	0.77	0.62	0.06	0.03	13.90		0.2	0.017	5.5
Nitrogen doses									
50% of recommended	55.80	6.89	6.32	2.74	241.20	672	4.82	0.425	26.9
75% of recommended	59.40	7.55	6.59	2.77	247.30	672	3.30	0.438	26.3
100% of recommended	61.40	7.89	6.63	2.77	249.50	672	2.49	0.438	26.3
LSD (0.05)	1.49	0.61	0.10	0.03	NS	-	0.17	NS	NS

DI: Drip irrigation, q = Quintal, NS = Non Significant

Table 3: Interaction effect of irrigation treatments and varied levels of nitrogen on red pepper yield in q ha^{-1} (Mean of two years)

	Nitrogen levels		
Irrigation treatments	50% of recommended N	75% of recommended N	100% of recommended N
DI 0.5×Epan	267.03	277.8	277.4
DI 1.0×Epan	266.00	272.0	255.0
Check basin	190.50	192.1	216.1
LSD (0.05)	18.10		

was with drip irrigation at 0.5×Epan (389 mm). The WUE increased from 0.212 to 0.385 q ha^{-1} mm in drip irrigation as compared to check basin method of irrigation when it was applied at 1.0 Epan. Drip irrigation at 0.5×Epan registered much higher water use efficiency as compared to 1.0×Epan when the water was applied either through drip or check basin method of irrigation. The highest water use efficiency obtained with drip irrigation at 0.5×Epan was owing to more yields of red pepper along with considerable saving of irrigation water compared to check basin method of irrigation. The results corroborated with those of Manjunatha *et al.* (2001), Cetin and Bilgel (2002) and Tiwari *et al.* (2003). The AEN at drip irrigation of 0.5×Epan and 1.0×Epan remained statistically same, however increased significantly over check basin method of irrigation. Further irrespective of irrigation treatments, the nitrogen use efficiency increased with the decrease in application of nitrogen. Lesser NUE at higher level of nitrogen dose indicated that excessive N application may shift the balance between vegetative and reproductive growth toward excessive vegetative development, thus delaying crop maturity and reducing red pepper yield.

Root characteristics: The data on root length (Table 2) revealed that, varied level of nitrogen did not influence the root length significantly, but significantly influenced by irrigation treatments. A cursory examination of data revealed that root length increased gradually at lower levels of irrigation in drip treatment. The root length in check basin method of irrigation was found minimum (18.4 m). Drip irrigated plants received water once in two days, whereas water applied at larger intervals in surface irrigated crops. Osmotic adjustment and prolonging root cell expansion (Sharp *et al*., 1990) had been described as a cause for increased root length in mildly stressed plants than well watered plants (Jupp and Newman, 1987), so at lower level of drip irrigation, root length was maximum (36.3 m), because, though the crop received water once in two days, the amount of water applied was less. In surface irrigation, due to larger interval between irrigation, this treatment suffered maximum water stress as compared to other treatments. This severe water stress has stopped the root elongation, as evident from less root length in the data.

REFERENCES

Alvino, A., M. Centritto and F. De Lorenzi, 1994. Photosynthesis response of sunlit and shade pepper leaves at different positions in the canopy under two water regimes. Aust. J. Plant Physiol., 21: 377-391.

Antony, E. and R.B. Singandhupe, 2004. Impact of drip and surface on growth, yield and WUE of capsicum (*Capsicum annum* L.). Agric. Water Manage., 65: 121-132.

Bhella, H.S., 1988. Tomato response of trickle irrigation and black polyethylene mulch. J. Am. Soc. Hortic. Sci., 113: 543-546.

Bouwer, H., 2000. Integrated water management emerging issue and challenges. Agric. Water Manage., 45: 217-228.

Cetin, O. and L. Bilgel, 2002. Effect of different irrigation methods on shedding and yield of cotton. Agric. Water Manage., 54: 1-15.

Dimitrov, Z. and A. Ovtcharrova, 1995. The productivity of pepper and tomatoes in case of insufficient water supply. In: Proc. of ICID special technical session on the role of advanced technologiesin irrigation and drainage system, Vol. 1 ft 9.1-ft9.5.

Gomez, A.K. and A.A. Gomez, 1984. Statistical Procedure for Agricultural Research. Wiley, New York.

Gutal, G.B., S.S. Jadhav, R.L. Takte and V.M. Solunkhe, 1990. Response of chilli crop to drip irrigation. In: Proc. Int. Agric. Eng. Conf. Exhi. Held at Bangkok, Thailand, pp: 845-846.

Habib, R., 1988. Total root length as estimated from small sub samples. Plants Soil, 108: 267-274.

Jaimez, R.E., O. Vielma, F. Rade and C. Garcia-Nunez, 2000. Effect of water deficit on the dynamics of flowering and fruit production in *Capsicum chinese* Jacq in a tropical semiarid region of Venezuela. J. Agron. Crop Sci., 185: 113-119.

Jupp, A.P. and E.I. Newman, 1987. Morphological and anatomical effect of severe drought on roots of *Lolium perenne* (L.) New Phytol., 105: 393-402.

Manjunatha, M.V., K.N. Shukla, K.K. Singh, P.K. Singh and H. Chauhan, 2001. Response of micro irrigation on various vegetables. In: Proc. of Int. Conf. Micro Sprinkler Irrigation System, Held During 8-10 Feb, 2000 at Jalgaon, Maharashtra, India, pp: 398-402.

Mohammad, M.J., 2004. Utilization of applied nitrogen and irrigation water by drip fertigated squash as determined by nuclear and traditional techniques. Nutri. Cycl. Agroecosyst., 68: 1-11.

Raina, J.N., B.C. Thakur and A.R. Bhandai, 1998. Effect of drip irrigation and plastic mulch on yield, water use efficiency and benefit: Cost ratio of pea cultivation. J. Ind. Soc. Soil Sci., 46: 567-569.

Sharp, R.E., T.C. Hsiao and W.K. Silk, 1990. Growth of maize primary root at low water potential. II. Role of growth and deposition of hexoses and potassium in osmotic adjustment. Plant Physiol., 93: 1337-346.

Shirgure, P.S., A.K. Srivastava and Singh Shyam, 2001. Effect of drip, microjet and basin irrigation method on growth, soil and leaf nutrient change in acid lime. Ind. J. Soil Conserv., 29: 229-234.

Singh, V.Y., N.L. Joshi, D.V. Singh and A. Saxena, 1999. Response of chilli to water and nitrogen under drip and check basin method of irrigation. Ann. Arid Zone, 38: 9-13.

Sivanappan, R.K. and O. PadmaKumari, 1980. Drip irrigation. Tamilnadhu Agricultural University, Coimbatore, India. SVNP Report, pp: 15.

Tiwari, K.N., Singh Ajai and P.K. Mal 2003. Effect of drip irrigation on yield of cabbage (*Brassica oleraceae* L. var. capitata) under mulch and nonmulch conditions. Agric. Water Manage., 58: 19-28.

Tumbare, A.D. and S. Bhoite, 2002. Effect of solid soluble fertilizer applied through fertigation on growth and yield of chilli (*Capsicum annum*). Ind. J. Agric. Sci., 72: 109-111.