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Response of Chilli to Water and Nitrogen under Drip and Check-basin Methods of Irrigation

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Abstract: The effects of drip fertigation (100, 75 and 50% of recommended N, 180 kg ha^{-1}) and check-basin irrigation at 180 kg N ha^{-1} for chilli in respect of yield, water saving and water use efficiency (WUE) were studied on loamy sand soil. The highest yield (2.94 Mg ha^{-1}) was recorded under drip fertigation at 180 kg N ha^{-1}. However, conventional irrigation with 180 kg N ha^{-1} gave equivalent yield (1.94 Mg ha^{-1}) to drip fertigation at 90 kg N ha^{-1} (2.06 Mg ha^{-1}). Two year study revealed that drip fertigation at 180 kg N ha^{-1} provided 40% saving in water and 52% higher yield over check-basin method of irrigation. The WUE was the highest in drip fertigation at 180 kg N ha^{-1} (5.17 kg ha^{-1} mm^{-1}), followed by drip fertigation at 135 kg N ha^{-1} (4.90 kg ha^{-1} mm^{-1}).

Key words: Irrigation, nitrogen, chilli, drip fertigation, check-basin, WUE.

Chilli (*Capsicum annum* L.), a cash crop, is cultivated in approximately 50,000 ha area in Rajasthan, of which 26% area is cultivated only in Jodhpur with an annual production of 15-19 thousand ton. Indiscriminate use of water (30-35 irrigations) through conventional irrigation system, with only 50% application efficiency, is causing serious threat to available ground water resources. Minimising water use is thus the prime requirement of the region, where drip irrigation can play a vital role.

Application of fertilizer with the irrigation water applied by drippers and not with the water applied by other methods introduces inaccessible fertilizer effects, in addition to the irrigation frequency effects. Locally available P and K fertilizers, not being 100% soluble in water, cannot be applied through drip system, whereas, applying N fertilizer through a drip system has gained considerable impetus (Bar-Yosef, 1977; Keng *et al.*, 1979; Stark *et al.*, 1983). However, in these studies, single row planting for each drip line was employed. Since drip is an expensive technology, Singh (1978) minimised the installation cost by keeping one lateral (spaced 1.2 m apart) in between two rows. However, in this planting system, only 33% land is irrigated along the drip line. This further emphasised the need for efficient management of water and nitrogen with drip system.

The present study was conducted on chilli with the following objectives: (a) to evaluate drip and check-basin methods with respect to yield and WUE and (b) to compare the efficiency of N fertilizer application through drip with conventional application in check-basin.

Materials and Methods

The effects of drip fertigation and conventional irrigation on the yield and WUE (WUE) of chilli cv. Mathania were studied at Central Arid Zone Research Institute, Jodhpur, on a loamy sand soil with pH 8.1, organic carbon 0.22%, total N 0.03%, available phosphorus 16 kg ha^{-1} and available potassium 225 kg ha^{-1}. The soil (Typic Camborthid) had 85.2% sand, 8.1% silt, 5.5% clay, 20.7% (w/w) water holding capacity, 10.5% (w/w) field capacity; 3.4% (w/w) permanent wilting point (-15 bar tension) and 1.56 g cm^{-3} bulk density. Five treatments comprised of 4 nitrogen levels as drip fertigation: (i) 180 kg, (ii) 135 kg, (iii) 90 kg, (iv) without nitrogen along with 180 kg N ha^{-1} in check-basin method of irrigation, were arranged in randomised block design with four replications.

Nitrogen at 100, 75 and 50% of 180 kg ha^{-1} in equal splits was applied with water on alternate days beginning 15 days after sowing to 150 days old crop in drip system. In case of check-basin, it was applied in 3 equal splits at 15 and 60 days after planting and at 50% flowering stage. Single super phosphate and muriate of potash were applied as basal to supply P and K @ 70 and 60 kg ha^{-1}, respectively. Monthly means of daily maximum temperature, relative humidity, U.S. Class A pan evaporation and total rainfall per month are given in Table 1.

The commercial drip irrigation system (Drossbach, Germany) was used. Seventy five metre long laterals (drip line) were laid 1.5 m apart on the smooth and flat soil surface with 125 drippers, 0.6 m apart, on each lateral. In check-basin, a plot size of 10 x 12 m was maintained in each replication.

Three-week-old seedlings of chilli were planted with the onset of monsoon on 16 July 1993 and 30 July 1994. The spacing between rows was 26 cm (height of the perpendicular of a 30 cm equilateral triangle) in drip system and drip line was in the middle of twin rows. The distance between two row pairs was 1.24 m. In check-basin, spacing of 75 cm between rows and 30 cm between plants within a row was maintained.

Uniform water, amounting to 40 mm, was given for the establishment of seedlings in drip as well as check-basin before the commencement of regular irrigation schedule. The regular irrigation schedule began 10 days after transplanting of seedlings in both the years. In drip system the number of hours of operation ranged from 0.5 to 2, depending on amount of daily class A pan evaporation. The flow rate of emitter was 2 L h^{-1}. The amount of water applied was 68% (0.8 crop coefficient x 0.85 crop canopy) of class A pan evaporation (E). The water applied was measured by a meter fitted into the drip assembly. In check-basin, irrigation was scheduled at weekly intervals and water was computed at 0.8 of cumulative pan evaporation in a week. The application efficiency was 95 and 65% in drip and check-basin system, respectively. Computed water was applied daily in drip and at weekly intervals in check-basin, excluding effective rainy day periods. The depth of water ranged from 1.5 mm day^{-1} in January to 6.8 mm day^{-1} in August in drip system, while in check-basin, depth of water varied from 25 mm $week^{-1}$ in January to 77 mm $week^{-1}$ in August. The total number of irrigations were 25 in 1993-94 and 21 in 1994-95. The irrigation was stopped 175 days after planting in both the systems. Red chillies were harvested every 20-25

Table 1. Monthly means of daily maximum temperature (Tmax), relative humidity (RH mean), class A pan evaporation and rainfall during experimental period

Month	Tmax (°C)		RH mean (%)		Evaporation (mm day^{-1})		Rainfall (mm month^{-1})	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
July	36.6	34.1	72	79	6.5	5.4	90	80
August	36.5	31.9	61	83	8.5	3.9	–	146
September	35.5	32.6	60	70	5.9	5.0	47.4	97.2
October	36.7	26.3	44	44	6.4	5.7	–	–
November	32.9	32.3	38	44	4.6	4.0	–	–
December	28.7	26.9	41	54	3.7	3.0	–	–
January	25.8	23.3	52	51	3.2	2.7	23.6	1.8

days starting with 120 DAP in 4 pickings. The chillies were dried with the help of a solar drier and weighed.

Results and Discussion

Weather conditions and water use

The season 1993-94 experienced low rainfall and hence it was drier than the season 1994-95 (Table 1). The water applied through irrigation was less (Table 2) during 1994-95 owing to low evaporation rate. Water use by crop in drip irrigation was comparatively less than that in check-basin because of high application efficiency (95%) and irrigation schedules based on canopy area basis (85%). Low application efficiency (65%), combined with water applied on whole area basis, resulted in higher water use in check-basin. Thus, drip irrigation resulted in 40% saving in water over check-basin. On medium deep vertisol, drip irrigation with 50% wetted area provided 53% water saving in chilli (Bankar and Pampattiwar, 1995) as vertisols retain moisture for longer period. In sandy soils with hot arid climate, water saving beyond 40% seems impossible.

The benefits of drip fertigation decreased with decreasing N levels during both the seasons (Table 3). Drip fertigation at 180 kg N ha^{-1} provided the highest yield in both the seasons, followed by drip fertigation at 75% of 180 kg N ha^{-1}, respectively. A considerable increase in yield with drip over surface irrigation was recorded in chilli (Bankar and Pampattiwar, 1995) and in cucurbits (Singh and Singh, 1978). Daily drip fertigation, maintaining higher soil moisture content (Singh, 1978) and nutrient in available form in the rooting

Table 2. Seasonal rainfall and water applied (mm) under conventional and drip irrigation

Irrigation system	1993-94			1994-95		
	Rainfall	Irrigated	Total	Rainfall	Irrigated	Total
Check-basin	161	1080*	1241	325	802*	1127
Drip	161	651	812	325	489	814

* Number of irrigations: 25 in 1993-94; 21 in 1994-95.

Table 3. Effect of check-basin and drip fertigation on yield and WUE with added irrigation water

Treatment	Yield (Mg ha^{-1})			WUE (kg ha mm^{-1})		
	1993-94	1994-95	Mean	1993-94	1994-95	Mean
Check-basin + 180 kg N ha^{-1}	2.00	1.86	1.93	1.82	2.27	2.05
Drip + 180 kg N ha^{-1}	3.27	2.60	2.94	5.02	5.32	5.17
Drip + 135 kg N ha^{-1}	3.16	2.42	2.79	4.85	4.95	4.90
Drip + 90 kg N ha^{-1}	2.24	1.88	2.06	3.44	3.84	3.64
Drip + 0 kg N ha^{-1}	1.18	1.10	1.14	1.81	2.25	2.03
LSD (0.05)	0.16	0.12	–	–	–	–

volume (Singh *et al.*, 1989), might be responsible for higher chilli production than that in check-basin. drip fertigation at 50% of 180 kg N ha^{-1} provided yield at par with check-basin fertilized at 180 kg N ha^{-1} during 1994-95. Depletion of moisture below 50% of availability limit before each irrigation, and low availability of nutrient in the rooting zone, might have caused reduction in yield.

Water use efficiency

WUE in terms of harvested yield per unit of added irrigation water (Table 3) was the highest with drip fertigation at 180 kg N ha^{-1} and it declined with decreasing N application during both the seasons. Check-basin resulted in low WUE; though water applied was more. It suggests that check-basin is less efficient. On the other hand, drip irrigation has shown the good potential to increase yield and WUE of this crop.

The maximum yield increase of 52% due to drip fertigation over check-basin obtained in present study is much below the 100% increase reported by Goldberg and Shmueli (1970) in arid climate of Israel. But, they used a soil less suited to furrow irrigation; however, soils under our climatic conditions are also favourable for conventional irrigation. The over-all performance of drip fertigation depends upon the usefulness of the methods to be replaced under a given set of growing conditions.

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