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Soil moisture study under drip irrigated cabbage (*Brassica oleracea* L. var. capitata) in sandy loam soil

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■ **ABSTRACT :** Field experiment was conducted at Plasticulture Farm, CTAE, Udaipur, Rajasthan during *Rabi* season of 2012-2013 and 2013-2014 on sandy loam soil to study the moisture distribution pattern of sandy loam soil under the drip irrigated cabbage at various irrigation and fertigation levels. The experiments were laid out in Factorial Randomized Block Design with ten treatments which included three irrigation levels 100, 80 and 60% of evapotranspiration (ET) along with three fertigation levels, *viz.*, 100, 75 and 50% of recommended dose of fertilizer and one control (Surface irrigation at 1.0 IW/CPE ratio + 100% RDF through farmer's practice) and were replicated thrice. Observations revealed that highest yield (340.73 q ha^{-1}) was recorded with the treatment combination of drip irrigation with 80 % ET and fertigation @ 75 % RDF. The crops treated with 80 per cent ET experienced that the moisture content was maintained near to field capacity at the root zone of the crop. The vertical and radial spread of water in the soil increased with the amount of irrigation. In all the treatments, the soil moisture distribution along the vertical direction increased and laterally it was decreased.

■ **KEY WORDS :** Drip irrigation, Fertigation, Soil moisture distribution, Cabbage

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In drip irrigation systems, water is applied in small amounts but at frequent intervals to the crop. Generally, water is applied in the root zone of the crop, because of which the surface runoff and deep percolation below the effective root zone are avoided. The aim of this method is to maximize the water and fertilizer use efficiency. In drip irrigation, water movement and its distribution in the soil depends upon numerous factors such as the soil type, rate of infiltration, hydraulic conductivity, rate of emitter discharge, quantity of water applied, antecedent soil moisture content, depth of water table and certain climatic factors. The rate of applying water in drip irrigation is an important factor which governs moisture distribution in soil profile. A high rate may cause deep percolation loss whereas a very low rate may contribute to evaporation losses. Irrigation frequency and rate of water application in drip system not only decide the size of the wetted soil surface, but also determine the geometry of the wetted zone.

Cabbage (*Brassica oleracea* L. var. capitata) is one of the most popular winter vegetables grown and the second most important cole crop after cauliflower. It is enriched in vitamins A and C. Due to lack of information on irrigation management techniques, the average yield of the crop in Rajasthan is very low because of either excess or deficit soil moisture. The crop is generally grown with surface irrigation, which has low application efficiency. Many farmers in the state are now becoming interested in growing the crop with drip irrigation. The government is also offering financial assistance to farmers who use this technique, especially for fruit and vegetable crops. However, some farmers in the state are reluctant to adopt drip technology due to lack of information on irrigation scheduling techniques. Also, not much information on crop water requirements of cabbage by drip irrigation is available. Hence, the present study was undertaken to examine the soil moisture distribution pattern under different irrigation schedules by drip irrigation and suggest the most efficient irrigation schedule that would attain the highest yield.

METHODOLOGY

The field experiment was conducted at Plasticulture Farm, CTAE, Udaipur, Rajasthan during winter season of 2012-13 and 2013-14. The field is located at 24°35' North latitude, 73°44' East longitude with an altitude of 582.17 m above mean sea level. The mean annual rainfall is 637 mm and mean temperature is 31°C. The soil of the experimental field was sandy loam with soil pH 7.76, EC 1.19 dS/m, organic carbon 0.32%, field capacity 20.70 %, permanent wilting point 6.8%, bulk density 1.52 g/ cm^3 and basic infiltration rate 1.8 cm/ hr.

The experiment was laid out in a Factorial Randomized Block Design with ten treatment combinations comprised of 3 levels of drip irrigation viz; 100%, 80% and 60% ET and 3 levels of fertilizer application *viz*., 100%, 75% and 50% of recommended dose of fertilizer through fertigation and one control (Surface irrigation at 1.0 IW/CPE ratio + 100% RDF through farmer's practice) which were replicated thrice. Pan evaporation method as suggested by (Mane *et al*., 2006) was used for estimating volume of water for 100 per cent ET and then the 80 and 60 per cent ET values were obtained.

$$V = \frac{CA \times PE \times Pc \times Kc \times WA}{Eu}$$

where,

V = Volume of water required for 100% ET (l/day/ plant)

CA = Crop area (m^2)

PE = Maximum pan evaporation (mm/day)

P_C = Pan co-efficient

K_C = Crop co-efficient

WA = Wetted area and

E_U is emission uniformity (in decimal).

The pan co-efficient value was 0.75 as suggested for USDA class A pan and the crop co-efficient (Kc) for various growth stages was considered as suggested by Allen *et al.* (2000). To determined the emission uniformity co-efficient of drippers. The discharge of the emitter was measured by selecting the first, 1/3rd point, 2/3rd point and the last point. The constant operating pressure of 0.25 kg/cm^2 was measured throughout the period of application. The emission uniformity was evaluated by the equation as suggested by Keller and Karmeli (1974).

$$EUf = \left[\frac{qn}{qa}\right] x\,100$$

where,

EU_f = Field emission uniformity (%),

q_n = The average of lowest 1/4 of the emitter flow rate (l/h) and

q_a = The average of all emitters flow rate (l/h).

Four weeks old healthy seedlings of cabbage var. "Fieldman" were transplanted at crop spacing of 50 cm x 30 cm. The inline lateral were laid in between the two rows of crop and emitters with discharge rate of 1.86 lph and 30 cm apart from each other (one emitter for two plants). One common irrigation was applied first as pre transplanting irrigation for the purpose of proper establishment of crop in all the treatments. For drip irrigation treatments, the irrigation was scheduled daily and the required quantity of water to be applied was computed every day as explained in the previous section. For surface irrigation it was scheduled at 1.0 IW/CPE ratio with 50 mm depth. The daily pan evaporation from USWB Class A pan evaporimeter was summed up and when cumulative pan evaporation (CPE) attained the value of 50 mm, the water was carried out to the plots through the PVC pipe. The fertilizer recommendations for cabbage for this region is 150:80:75 kg NPK ha^{-1}. In drip irrigated plots, the entire quantity of P as per treatment and the half amount of recommended dose of N and K was applied as basal dose at the time of transplanting. The rest half amount of N and K were applied treatment wise through drip fertigation in twelve equal splits at 5 days interval starting from 30 DAT. However, in case of surface irrigated plots, the entire quantity of recommended dose of P, K and 50 per cent N per hectare was applied through single super phosphate, muriate of potash and urea, respectively. Remaining 50 per cent N through urea was applied in two equal split at 30 DAT and 60 DAT. Soil moisture distribution pattern under the different treatments, profile soil sample were drawn using screw auger from all the irrigation treatments at radial distance and vertical depth of 0-10 cm, 10-20 cm and 20-30 cm from emitter source after 24 and 48 hours of irrigation. The moisture content was determined through gravimetric method.

The data on yield collected from the experiment was analysed statistically using the analysis of variance procedure, appropriate for the Factorial Randomized Block Design. The test of significance was carried out at 5 per cent level.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of drip irrigation levels on moisture distribution pattern in soil :

The drip irrigation was scheduled with the computed quantity of water daily as per the treatment schedule of 100, 80 and 60 per cent ET. The data on moisture distribution after 24 and 48 hours of irrigation with different irrigation levels (60, 80 and 100% ET) are presented in Table 1. It is seen from the table that after 24 hours of irrigation with 100 per cent ET, the moisture content in horizontal distance at the dripper emission point was higher and it decreased as the distance increased from the dripper. While, the moisture content in the vertical direction was increased with the depth. The moisture content after 24 hours of irrigation near the dripper point (at 10 cm) was 19.12 per cent and decreased to 16.57 per cent at 30 cm radial distance, which increased to 20.65 per cent at 30 cm vertical depth. The similar trend for moisture content was also observed after 48 hours of irrigation. The moisture content after 48 hours of irrigation near the dripper point (at 10 cm) was 15.54 per cent and decreased to 13.58 per cent at 30 cm radial distance, which increased to 17.02 per cent at 30 cm vertical depth. After 24 hours of irrigation with 80 per cent ET, the moisture content in horizontal direction at the emission point was higher and decreased as the distance increased from the dripper while, in contrast the moisture in the vertical distance increased with depth. The moisture content near dripper point (at 10 cm) was 18.57 per cent and decreased to 16.09 per cent at 30 cm radial distance and increased to 19.88 per cent at 30 cm vertical depth. The similar trend for moisture content was also observed after 48 hours of irrigation. The moisture after 48 hours of irrigation near the dripper point (at 10 cm) was 15.36 per cent and decreased to 13.43 per cent at 30 cm radial distance, which increased to 16.69 per cent at 30 cm vertical depth. After 24 hours of irrigation with 60 per cent ET, the moisture content in horizontal direction at the emission point was higher and decreased as the distance increased from the dripper while, the moisture in the vertical direction found to increased with depth. The moisture content near dripper point (at 10 cm) was 17.24 per cent and decreased to

Table 1 : Variation in moisture content (%) from emitter with different level of irrigation after 24 and 48 hours of irrigation

Soil Depth (cm)	Radial distance from dripper (cm) — After 24 hours of irrigation: 10	20	30	After 48 hours of irrigation: 10	20	30
Drip irrigation at 100 per cent ET						
0-10	19.12	17.53	16.57	15.54	15.28	13.58
10-20	19.38	18.85	17.21	16.33	15.82	14.99
20-30	20.65	19.47	17.64	17.02	16.66	15.00
Drip irrigation at 80 per cent ET						
0-10	18.57	17.56	16.09	15.36	15.02	13.43
10-20	19.22	17.93	16.81	16.01	15.49	14.63
20-30	19.88	18.62	17.33	16.69	16.24	14.75
Drip irrigation at 60 per cent ET						
0-10	17.24	16.76	14.95	13.88	12.87	11.27
10-20	18.05	17.16	15.85	14.26	13.27	11.54
20-30	18.67	17.88	16.68	15.30	14.57	12.42

14.95 per cent at 30 cm radial distance and increased to 18.67 per cent at 30 cm vertical depth. The similar trend was observed after 48 hours of irrigation. The moisture content after 48 hours of irrigation near the dripper point (at 10 cm) was 13.88 per cent and decreased to 11.27 per cent at 30 cm radial distance, which increased to 15.30 per cent at 30 cm vertical depth. The variation in moisture content in both the direction as influenced by different levels of irrigation for 24 and 48 hours after irrigation are shown in Fig.1 and 2. In both cases, the soil moisture content values observed is, respectively higher in case of 100 per cent and 80 per cent ET when compared with that of 60 per cent ET. Moisture content recorded after 24 hours of irrigation was near to field capacity (20.70 %) as compared to moisture content recorded after 48 hours of irrigation, so the irrigation was scheduled daily. Soil moisture content is more in higher depth (20-30 cm) and lower at the radial distance of 30 cm away from the emitter. It is observed from the Fig.1 and 2 that vertically downward, maximum soil moisture content increased along the depth, while laterally maximum soil moisture was found just below the drip source (0-10 cm) and decreased with distance from dripper. It may also be seen that in 100 per cent ET in which depth of water applied was highest among the irrigation level, the soil moisture content vertically downward were higher compared to lateral and in 60 per cent ET the moisture content was lowest compared to 80 and 100 per cent ET. The trend remains the same. Similar findings were also reported by Rajput and Patel (2006); Biswas *et al.* (2007); Shirahatti *et al.*(2007); Bansod and Patil (2008)' Mirjat *et al.* (2010) and Panigrahi *et al.* (2010).

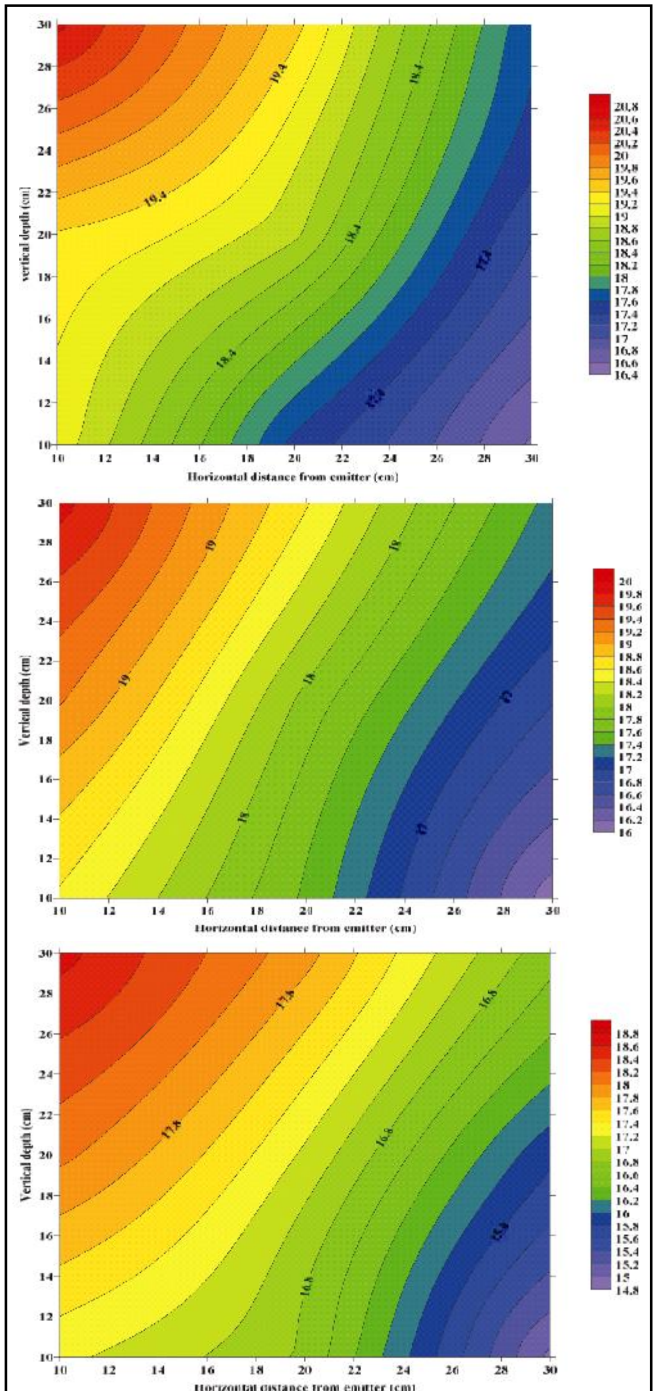

Fig. 1 : Soil moisture distribution in 100, 80 and 60 per cent ET after 24 hour of irrigation

Effect of irrigation and fertigation levels on the yield:

Irrigation and fertigation levels had a pronounced effect on cabbage yield (Table 2). Among drip irrigation experimented I_2 (drip irrigation at 80% ET) registered the highest yield (318.39 q ha^{-1}) and it was found superior over I_1 (291.71 q ha^{-1}) and I_3 (271.69 q ha^{-1}). This might be due to the optimum use of irrigation water. Among different fertigation levels, the highest yield (314.18 q ha^{-1}) was observed in F_2 (fertigation at 75% recommended dose of fertilizer) and was superior over F_1 (299.90 q ha^{-1}) and F_3 (267.71 q ha^{-1}). The highest yield might be due to the application of optimum fertilizer required by the crop. The influence of irrigation and fertilizer levels reflected on the yield of cabbage, the maximum yield of 340.73 q ha^{-1} was recorded in treatment drip irrigation at 80% ET with fertigation at 75% of

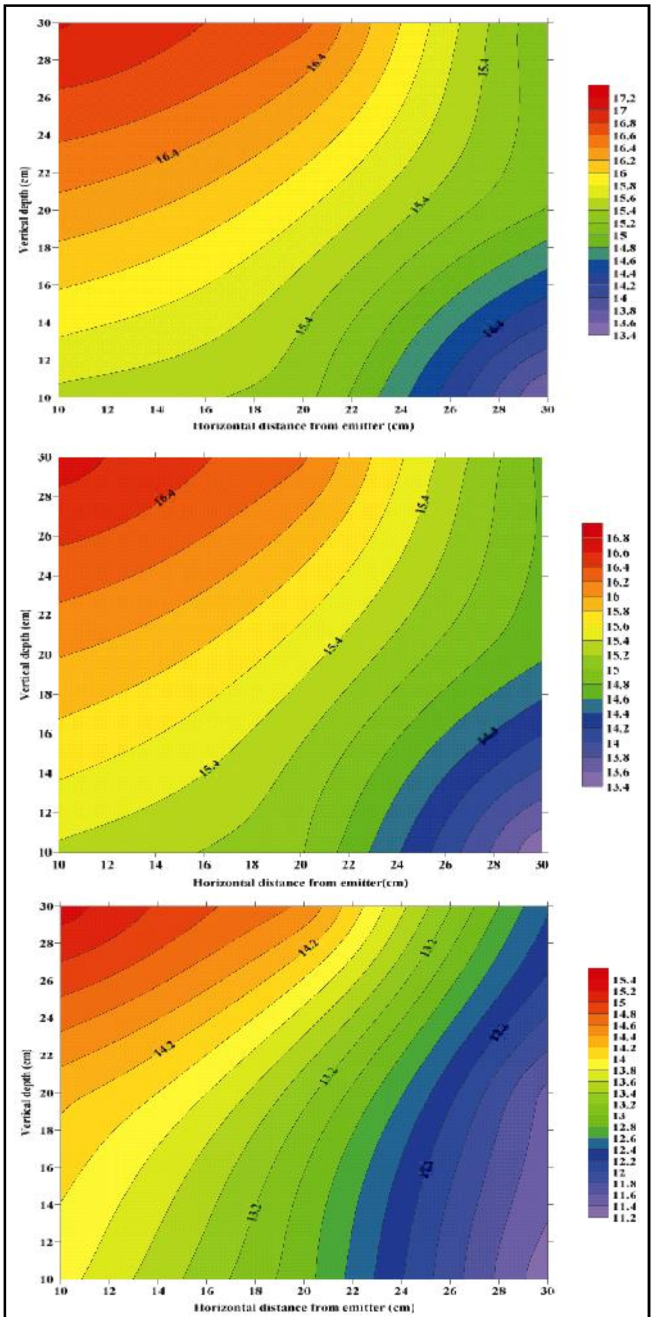

Fig. 2 : Soil moisture distribution in 100, 80 and 60 per cent ET after 48 hour of irrigation

recommended dose of fertilizer compared to other treatments. With respect to control vs rest analysis, the drip mean showed significantly superior over surface control. Similar results were also reported by Gupta *et al*. (2009); Chatterjee (2010) and Vijayakumar *et al.* (2010).

The crop with 100 per cent ET experienced excess moisture which deleteriously affected the soil aeration, root growth and ultimately resulted in lower yield of the crop as compared to 80 per cent. The excess moisture tends to leach down the nutrients beyond the root zone and the root also was not effective to absorb the available nutrients which might have affected the growth and yield of the crops under excess moisture. The crops treated with 80 per cent ET experienced that the moisture content was maintained near to field capacity, the roots tend to absorb more water and nutrients to satisfy the crop need, which might have resulted in higher yield as compared to other level (Ramah *et al.*, 2011).

Table 2 : Effect of different treatments on yield (t/ha) of cabbage (pooled data of two year)

Irrigation	Fertilizer level			Mean (I)
	F_1	F_2	F_3	
I_1	302.45	312.80	259.88	291.71
I_2	319.47	340.73	294.96	318.39
I_3	277.78	289.01	248.28	271.69
Mean (F)	299.90	314.18	267.71	293.93
Control				190.14
Source	I	F	IF	Control *vs* Rest
C.D. (P=0.05)	3.23	3.23	5.60	5.90

Conclusion :

The moisture content was higher in the plots treated with drip irrigation at 100 per cent ET. In drip irrigation with 80 per cent ET, the moisture content was maintained nearer the field capacity throughout the crop period. The soil moisture distribution under all drip fertigation treatments indicated that it increased along the vertical direction and decreased along the radial direction. It is concluded that in water scarcity area, one should go for drip irrigation with 80 per cent ET level along with fertigation @ 75 % RDF to obtain higher yield of cabbage. This level of irrigation and fertigation would be sufficient to meet the crop demand for cabbage crop.

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