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Water distribution, application efficiency and growth of young apple plants under drip irrigation in mid-Himalayas

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ABSTRACT

The soil water distribution in both 0-0.15 and 0.15-0.30 m depths was uniform under drip irrigation and decreased as soil depth and distance from drippers increased. The matric suction under this system did not vary rapidly and remained near 41-45 kPa, whereas, in basin flooding it varied rapidly from 33 to 77 kPa. Root growth and distribution was not influenced by any of the treatment. The favourable and uniform distribution of soil water under drip irrigation was reflected in the plant growth as shoot growth and trunk girth were highest. The increase in shoot growth and trunk girth under drip irrigation over rainfed conditions was 92 and 12 per cent, respectively. Whereas, under basin flooding the increase in shoots growth and trunk girth was 32 and 6 per cent only. Water application efficiency of drip irrigation system over basin flooding was found to be 44 per cent. Hence, drip system of irrigation can be a very effective and efficient method of water application for apple orchards of mid-Himalayas.

Key words: Basin flooding, apple, irrigation, water use efficiency, root distribution.

INTRODUCTION

Drip irrigation system is characterized by localized frequent application of small volume of water and such regimes restrict the fluctuations in soil water potential with in a narrow range which maintains a favourable soil water regime, leading to very high yields of crops (Bresler, 1; Shirgure *et al*., 11; Morales-Garcia *et al*., 9). Plant growth is restricted both at very low and high content of soil water. A close relationship of soil water distribution with vegetative growth has been recorded by several workers in stone and pome fruits (Goode and Ingram, 6).

Drip irrigation can be a promising technology especially for apple (*Malus domestica*) which occupies a significant place in the horticultural wealth of hilly regions of mid-Himalayas. Owing to uneven and erratic distribution of rainfall, apple plants in these areas remain under moisture stress during most part of the year. Moreover, undulating topography, shallow soil depth, poor water retentivity and availability of soil water are the major constraints towards increasing its production in hills. The present investigation was therefore, conducted with young apple plants to assess the effect of drip irrigation on soil water distribution, application efficiency and growth by comparing with conventional (basin flooding) system and traditional (rain-fed) conditions.

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MATERIALS AND METHODS

A field experiment on young apple plants (2-year-old) under drip irrigation was conducted at the research farm of the University of Horticulture and Forestry, Solan. The experimental soil (0-0.45 m) was gravely loam in texture (gravel 55%. sand 42%, silt 30%, clay 26%). The surface (0-0.15m) layer had pH, organic carbon, bulk density and available water (33-1500 k Pa) 7.3, 8.9 g kg^{-1}, 1.27 Mgm^{-3} and 0.16 kg kg^{-1}, respectively. The corresponding values for sub surface (0.15-0.30 m) depth were 7.3, 5.8 g kg^{-1}, 1.30 Mg m^{-3} and 0.16 kg kg^{-1}, respectively. The treatments replicated six times in a randomized block design were rainfed condition (Io), basin flooding (Ibf) and drip irrigation (Id). Drip irrigation was given, with the help of three tab type turbulent emitters (discharge 2.5 l h^{-1}) placed at a distance of 0.30 m from tree trunk having 120^0 angle (unpublished data). Soil water (both in Id and Ibf) was maintained at near field capacity which corresponds with tension of 30 to 40 k Pa by the tensiometers. The quantum of water used under Id and If was 48.3 and 191.3 cm per year, which comes to about 4.3 and 9.8 l per plant per day, respectively.

Tensiometers were installed at 0.15 and 0.30 m depths in duplicate to monitor changes in soil water suction with time. Changes in water content at 0.15 m interval upto 0.30 m depth were determined gravimetrically at weekly interval. Representative soil samples for determination of water content under Io and Ibf were collected from the basin and in Id from two places, i.e. corresponding to emitter location i.e. at 0.30 m from tree trunk and at 0.25 m away from emitters (0.55 m away from tree trunk). Root distribution (horizontal and vertical) was studied by profile trench method (Ghosh, 5; Bhom, 3). Plant growth (shoot length and trunk girth) was recorded to asses the effect of irrigation treatments.

RESULTS AND DISCUSSION

Under drip irrigation the water content corresponding to the location of emitters (at 0.30m) ranged from 0.19 to 0.24 kg kg^{-1} soil in surface (0- 0.15m) and from 0.185 to 0.23 kg kg^{-1} soil in subsurface (0.15-0.30 m) layers except rainy days (Fig. 1 & 2). The water content between two layers remained more or less same (only 1.5% variations) as a result matrix suction under Id treatment did not vary rapidly and remained between 41 to 45 kPa (Fig. 3). However, water contents under Ibf at surface varied from 0.15 to 0.255 kg kg^{-1} and from 0.21 to 0.255 kg kg^{-1} in sub surface layers with variations of about 6 % in both the layers. The periodic variations (about 10.5 %) in water content at surface layer were comparatively more under basin flooding (Ibf) which resulted matric suction values ranging from 33 to 77 kPa (Fig. 3). Which could be due to relatively higher evaporation supplemented by hydraulic gradients and water flux of higher magnitude (Ks= 0.15 x 10^{-4} ms^{-1}) which lengthened the transmission zone with relatively higher water content. Further, comparatively less volume of water (4.3 l day^{-1}) required for frequent application in Id than in Ibf might have resulted in hydraulic gradients and water flux of less magnitude with minimum fluctuations in matric suction (Fig. 3). Soil water content decreased with horizontal distance from the drippers. At 0.25 m away from the emitters water content ranged from 0.11 to 0.228 kg kg^{-1} in surface and from 0.11 to 0.215 kg kg^{-1} in subsurface layers. A variation of about 8% in water content was observed at 0.25m horizontal distance from the emitters as compared to the emitters location. Study further indicated that water content under drip irrigation tended to decrease as soil depth and distance from the drippers increased, whereas, in basin flooding reverses were observed for water distribution with depths. The water contents under rainfed conditions (Io), on the other hand, reduced to 0.09 to 0.1 kg kg^{-1} (9-10 %) during April to May and October to February months.

Root growth expressed as total length in different layers was not influenced significantly (Table 1). Generally, total root length was slightly higher under irrigation treatments i.e. 89.34 m and 88.2 m under Id and Ibf treatments, respectively than Io treatment (86.07 m). Vertical distribution of roots exhibited that a major

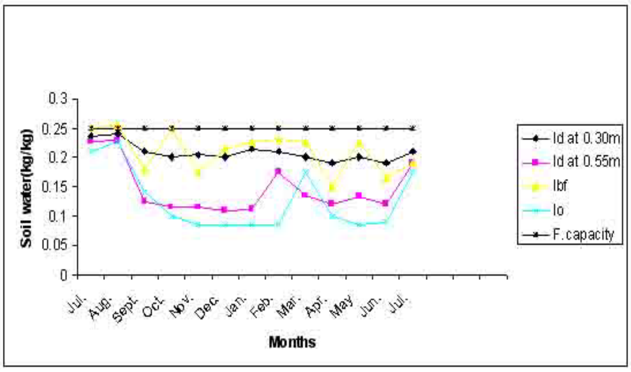

Fig. 1. Periodic variations in soil water content under different treatments at surface layer (0-0.15 m).

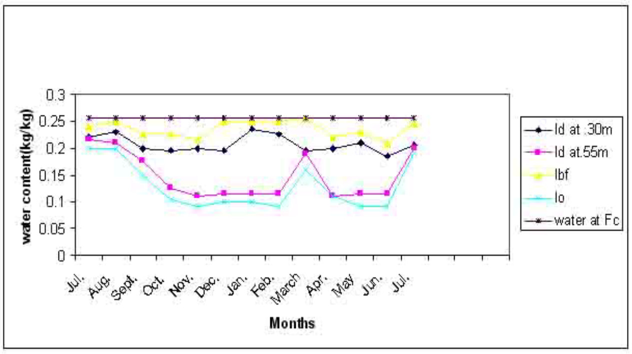

Fig. 2. Periodic variations in soil water content under different treatments at subsurface layer (0.15-0.30 m).

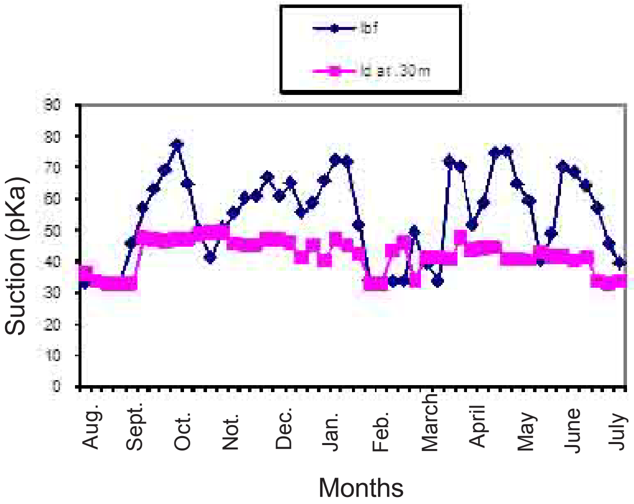

Fig. 3. Periodic variations in matric suction under basin flooding (Ibt) and drip irrigation (Id) at surface layer.

portion (85%) under all treatments was confined in 0.30 m layer. The results are in agreement with the findings of Babuk (1) who also found most of the roots in 0-0.40 m layer in two years old trees of a number of apple cultivars. The unaltered root distribution pattern under drip irrigation system is contrary to the result of Proebsting *et al*. (10) and Levin *et al*. (7) who observed restricted root development in trickle irrigated apple trees under arid conditions. Under the present conditions high rainfall which might have fully recharged the soil profile with good quality of water, contrasted to those in arid region could account for many differences in root distribution.

Horizontal root distribution decreased as the distance from tree trunk increased and in 0.15-0.50 m zone comparatively higher root length (60.75 m) was recorded in Id over Ibf (57.80 m) and Io (57.49 m). This could be attributed to better nutrient availability (Malik *et al*.,8), readily available moisture and favourable air water environment due to frequent application of small volume of water without any disturbance to soil system.

As the drip irrigation favourably influenced soil water distribution (Fig.1-3) and nutrient availability (Malik *et al*., 8) significant increase in plant growth (shoot extension and trunk girth) was observed in Id (0.48 and 0.13m) over Ibf (0.33 and 0.12 m) and Io (0.25 and 0.12m), respectively (Table 2). In Id and Ibf average shoot extension increased by 92 and 32% over Io, respectively. The corresponding percentages for trunk girth were 12 and 6, respectively. Under drip irrigation an increase of 10 to 33% in shoot length and 9 to 33% trunk girth has also been recorded (Gargley and Faragley, 4) in apple plants. The periodic increase in shoot growth indicated an increase of 0.24, 0.31 and 0.49 m under Io, Ibf and Id, respectively during the period from April to June indicating it to be a period of active growth (Table 2). In order to obtain better growth and to maintain trees in healthy condition, trees should not encounter any soil moisture stress during this period.

The water used in drip irrigation was 44% of that of basin flooding. Thus the drip irrigation effected the saving of 56% of irrigation water compared to basin flooding. Earlier Malik *et al*. (8) working on plum and apricot under

Table 1. Effect of irrigation treatments on root length of apple.

Treatment	Vertical distribution				Horizontal distribution		
	Depth (m)				Horizontal distance (m)		
	0-0.15	0.15-0.30	0.30-0.45	Mean	0.15-0.50	0.50-0.85	Mean
Io	38.99	32.38	14.70	28.69	57.49	28.58	43.04
Ibf	40.37	32.88	14.95	29.40	57.80	30.42	44.13
Id	41.09	33.13	15.12	29.78	60.75	28.59	44.67

CD (P = 0.05)
Irrigation = NS, Vertical distribution = 0.89
Irrigation x Vertical distribution = NS
NS = Not significant Irrigation x Horizontal

CD (P = 0.05)
Irrigation =NS, Horizontal distribution =1.54
Distribution = 2.67

Table 2. Effect of irrigation treatments on shoot growth and trunk girth of apple.

Treatment	Shoot growth (m)						Trunk girth (m)	
	April	May	June	July	August	Mean	At beginning	At the end
Io	0.03	0.17	0.27	0.36	0.40	0.25	0.098	0.117
Ibf	0.03	0.24	0.34	0.49	0.54	0.33 (32)	0.100	0.124 (5.6)
Id	0.04	0.34	0.53	0.70	0.77	0.48 (92)	0.102	0.131 (12)

CD (P = 0.05)
Irrigation = 0.004, Time = 0.006
Time x Irrigation = 0.010

CD (P = 0.05)
Irrigation = 0.005

Figures in parentheses indicate per cent increase over Io same soil and climatic conditions have found that water applied under drip irrigation was 35 and 40%, respectively as compared to basin flooding method of irrigation.

Drip irrigation system by using 2.28 times less volume of water than basin flooding resulted uniform moisture distribution in 0 - 0.30 m soil layer. This system without disturbing the root distribution pattern resulted in better vegetative growth (shoot growth and trunk girth) of apple plants. Drip irrigation, therefore, can be a very effective and efficient method of water application for apple orchards established on light textured soils and water scarcity areas of mid- Himalayas.

REFERENCES

1. Babuk, V.I. 1971. The effect of tree age on the development of the root system, growth, productivity of apple tree (in Russian). *Trudy Kishinev. Sel Kokh. Inst.* **81**: 70-76.
2. Bresler, E. 1977. Trickle-Drip irrigation. Principles and application to soil water management. *Adv. Agron*. **29**: 343-93.
3. Bohm, W. 1978. Methods of Studying Root Systems. Springer-Verlag, Berlin, p.188.
4. Gargely, I. and Farago, M. 1985. Autumn irrigation in Jonathan apple orchards. Kertgazelasag, **17**: 9-14.
5. Ghosh, S.P. 1974. Some aspects of root systems of sweet orange, guava and mango. *Punjab Hort. J*. **14**: 34-38.
6. Goode, J. E. and Ingram, J. 1971. The effect of irrigation on the growth, cropping and nutrition of Cox's Orange Pippin apple trees. *J. Hort. Sci.* **46**: 195-208.
7. Levin, I., Assaf, R. and Bravdo, B.A. 1979. Soil moisture and root distribution in an apple orchard irrigated by trickler. *Plant Soil* **228**: 31-40.
8. Malik, R.S., Bhardwaj, S.K., Sharma, I.P. and Bhandari, A.R. 1992. *Proc. National Seminar on Emerging Trends in Temperate Fruit Production in India*, pp.191.
9. Morales-Garcia, Dagobiet, Stewart, Katrine A., Philippe Seguin and Chandra Madramootoo 2010. Saline drip irrigation and polyethylene mulch on yield and water use efficiency of bell peppers. *Int. J. Veg. Sci.* **16**: 3-16.
10. Proebsting, E.L., Middleton, J.E. and Roberts, S. 1977. Altered fruiting and growth characteristics of Delicious apple associated with irrigation method. *HortSci.* **12**: 349-50.
11. Shirgure, P.S., Srivastava, A.K. and Singh Shyam, 2004. Growth, yield and quality of acid lime under pan evaporation based drip irrigation scheduling. *Indian J. Soil Cons*. **32**: 32-35.

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