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Growth, productivity, leaf nutrient contents and water-use efficiency of kiwifruit (*Actinidia deliciosa*) under drip and basin irrigation system

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ABSTRACT

A field trial was conducted during 2005–07 to study the comparative performance of drip irrigation and conventional basin irrigation on growth, yield and fruit quality and water-use efficiency in kiwifruit (*Actinidia deliciosa* Chev.). Five Irrigation treatments, viz drip irrigation with 'V' volume, 0.8 'V' volume and 0.6 'V' volume of water and basin irrigation at 80% of field capacity and with 'V' volume of water were given to 18-year-old kiwifruit vines. The result revealed that drip irrigation with 'V' volume of water gave significantly higher vine growth (165.70 cm), fruit size (67.65 mm length and 45.75 mm breadth) and weight (71.45 g) compared with other levels of drip and basin irrigation. Leaf nutrients contents (2.97% N, 0.26% P, 2.21% K and 0.91% Mg) were significantly higher in drip irrigation with 'V' volume of water. However, water-use efficiency was found highest in drip irrigation with 0.6 'V' volume of water, besides saving of 25.32% water in drip irrigation with 'V' volume of water yielded 16.25% more fruits of better size and quality as compared to basin irrigation. The vines irrigated with 'V' volume of water with drip method registered 23.01% increase in shoot growth, 16.52% increase in yield and 13.25% increase in fruit weight over conventional basin method of irrigation.

Key words: Drip irrigation, yield, water-use efficiency, kiwifruit

Kiwifruit (*Actinidia deliciosa* Chev.) is the most recent fruit crop being successfully grown in low and mid hills of the north-western Himalayas. Kiwifruit is a boon to the farmers of the mid and low hills due to very high economic returns per unit area. Its anatomical features like low resistance to water flow, extensive canopy foliage and long growing season characterized it a water-consumptive plants. Due to less and erratic distribution of rainfall, the vines remain under water stress, especially during critical periods of fruit growth and development, thus causes reduction in the size and yield of fruits. Besides this, water resources are also limited and available water must be utilized efficiently through efficient method of irrigation for sustainable fruit production of kiwifruit. Therefore, the present investigations were conducted to study the efficacy of drip irrigation over the conventional basin method of irrigation.

MATERIALS AND METHODS

A field experiment was conducted on 18-year-old 'Allison' kiwifruit vines of cultivar planted at 4 m × 6 m distance and trained on T bar system at Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan during 2005–07. The soil was clay loam with *p*H 6.8, organic carbon 1.80% and available N, P, K was 285, 25, 210 kg/ha, respectively. The moisture content retained by the soil at field capacity was 20.60%. The experiment was laid out in a randomized block design with 5 irrigation treatments, viz T_1 drip irrigation with 'V' volume of water, T_2 drip irrigation with 0.8 'V' volume of water, T_3 drip irrigation with 0.6 'V' volume of water, T_4 basin irrigation at 80% of field capacity and T_5 basin irrigation with 'V' volume of water. Each treatment was replicated 5 times having one vine per replication. In drip method, irrigation was based on the evaporation of class 'A' pan evaporimeter and 'V' volume required for irrigation was computed by using equation

$$V = – [Ep \times Kc \times Kp \times (Sp \times Sr \times Wp) \times N – Re (Sp \times Sr \times Wp)]$$

where V, volume of water (litres/vine); Ep, mean pan evaporation (mm/day); Kc, crop co-efficient; Kp, pan factor; Sp, spacing plant-to-plant (m); Sr, spacing between rows (m); Wp, wetting area (%); N, number of days in the month; Re, effective rainfall (mm); Σ, total of the year. The data on the evaporation (Ep) and effective rainfall were recorded daily in the orchard. The crop factor (Kc) value for different methods was computed based on the existing relative

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humidity and wind velocity. The effective rainfall was calculated by balance sheet method from the actual rainfall received. The pan factor value was 0.70 as suggested for USDA class 'A' pan. In basin method of irrigation, measured quantity of irrigation water was applied to the vines to bring the soil moisture from 80% of field capacity and cumulated evapo-transpiration in these days was compensated by applying irrigation after 3 days. The quantity of water applied with basin method was calculated with the formulae:

Total quantity of water to be applied per vine (l) = A × d where A, basin area to be irrigated (m^2); d, depth of irrigation water (mm).

Depth of irrigation water for each application was calculated by the following formula:

$$d = Pw \times Bd \times D$$

where Pw, moisture percentage to be raised; Bd, bulk density of the soil (1.27 g/cm^2); D, depth of root zone to be moistened (45 cm).

After harvest fruit yield, yield of different grades of fruit and physico-chemical analysis of fruits were done with the standard procedure of AOAC (1990). The total water requirement under different irrigation treatment was calculated from the irrigation water applied plus effective rainfall received during the period of study. Water-use efficiency was calculated by dividing the total fruit yield by total water used in cm during the crop growth. Leaf samples (leaf blade + petiole) were collected from the middle portion of current season's growth of fruiting shoot in August for nutrient estimation. After digestion of leaf samples, total nitrogen was determined on Kjeltec Auto analyzer 2300, P by Vandomolybdate phosphoric yellow colour method as suggested by Koeing and Johnson (1942) and K was determined with the help of flame photometer. For estimation of Mg leaf samples were digested in diacid mixture containing nitric acid and perchloric acid in the ratio of 4: 1 (Jackson 1967). The total Mg was determined on ECIL atomic absorption spectrophotometer. The data obtained were statistically analyzed in accordance with the method described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The vine growth and vigour were significantly influenced by drip irrigation regimes (Table 1). The highest shoot growth (165.70 cm), increase in trunk girth (2.70 cm) and leaf area (136.80 cm^2) were recorded in vines irrigated with 'V' volume of water through drip method which was higher than those vines irrigated with 'V' volume of water through basin method. The increased vegetative growth under drip irrigation with 'V' volume of water may be attributed to better and continuous availability of water to the vines. Soil moisture content remained nearly at the field capacity throughout the growing period under drip irrigation treatment, therefore, higher soil moisture may have accounted for better growth and vigour of vines. These results are in accordance with the findings of Bonany and Camps (1998) in apple (*Malus domestica*). The vines irrigated with less amount of water, ie with 0.6 'V' volume of water through drip, attained less growth in terms of annual shoot growth,(134.60 cm), trunk girth (1.50 cm) and leaf area (123.30 cm^2). Under this treatment, the soil moisture depleted to the level at which it was not readily available to the vines and water stress conditions develop in the soil, particularly during the active growing period. These water stress conditions resulted in the reduction of uptake of nutrients and may interfere in cell division and cell enlargement, thereby reduced stem elongation. Monastra *et al.* (1997) also reported reduction in vegetative growth of kiwifruit vines under water stress conditions.

A comparison of different levels of irrigation indicated maximum fruit yield (69.40 kg/vine) and yield of 'A' grade fruit (32.30 kg/vine) with 'V' volume of water through drip which was significantly higher as compared to those produced by the vines irrigated with 0.6 'V' volume of water and basin method of irrigation. Increased yield under drip irrigation with 'V' volume of water might have resulted due to better utilization of water. Better size and weight of fruits in vine subjected under drip irrigation with 'V' volume of water in the present study might have accounted for higher total yield and yield of 'A' grade fruits (Table 2). In basin irrigation with 'V' volume, same amount of water was applied as in case of drip irrigation with 'V' volume of water but the total yield (63.35 kg/vine) and yield of 'A' grade fruits (23.80 kg/vine) were comparatively less. Basin irrigation not only resulted in wastage of water in deep percolation below the root zone but also causes leaching of available nutrients, thereby, making less availability of water and nutrient for

Table 1 Effect of drip and basin irrigation on annual shoot growth, trunk girth and leaf area of kiwifruit

Treatment	Shoot growth (cm)	Increase in trunk girth (cm)	Leaf area (cm^2)
T_1 (drip irrigation with 'V' volume of water)	165.70	2.70	136.80
T_2 (drip irrigation with 0.8 'V' volume of water)	150.60	2.20	131.90
T_3 (drip irrigation with 0.6 'V' volume of water)	134.60	1.50	123.30
T_4 (basin irrigation at 80% of FC)	134.70	2.10	128.10
T_5 (basin irrigation with 'V' volume of water)	148.20	1.90	130.50
SEm ±	9.62	0.34	3.06
CD (P= 0.05)	20.39	0.72	6.49

Table 2 Effect of drip and basin irrigation on yield and yield of different grade fruits and yield efficiency of kiwifruit

Treatment	'A' grade (kg/vine)	'B' grade (kg/vine)	'C' grade (kg/vine)	Total yield (kg/vine)	Fruit weight (g)	Fruit size (mm)	
						Length (mm)	Diameter (mm)
T_1 (drip irrigation with 'V' volume of water)	32.30	23.70	13.40	69.40	71.45	67.65	45.75
T_2 (drip irrigation with 0.8 'V' volume of water)	27.50	23.40	14.10	65.00	69.27	65.97	43.34
T_3 (drip irrigation with 0.6 'V' volume of water)	15.70	16.60	20.70	53.00	61.06	59.45	38.65
T_4 (basin irrigation at 80% of FC)	18.30	24.30	16.96	59.56	63.09	62.75	40.60
T_5 (basin irrigation with 'V' volume of water)	23.80	21.60	17.95	63.35	67.32	63.76	41.84
SEm ±	2.52	2.38	2.14	3.09	1.78	1.73	1.25
CD (P= 0.05)	5.35	5.06	4.54	6.57	3.78	3.76	2.67

Table 3 Effect of drip and basin irrigation on leaf nutrient status, total water requirement and water-use efficiency of kiwifruit

Treatment	Leaf nutrient status (%)				Irrigation water applied (cm)	Effective rainfall (cm)	Total water requirement	Water-use efficiency (kg/vine/cm)
	N	P	K	Mg				
T_1 (drip irrigation with 'V' volume of water)	2.97	0.26	2.21	0.97	98.28	15.08	113.36	0.71
T_2 (drip irrigation with 0.8 'V' volume of water)	2.83	0.24	2.09	0.77	78.62	27.05	105.68	0.83
T_3 (drip irrigation with 0.6 'V' volume of water)	2.12	0.23	2.08	0.82	58.97	34.45	93.42	0.90
T_4 (basin irrigation at 80% of FC)	2.46	0.23	1.76	0.83	131.61	21.27	152.88	0.45
T_5 (basin irrigation with 'V' volume of water)	2.66	0.20	2.11	0.07	98.28	15.08	113.36	0.64
SEm ±	0.21	0.02	0.10	0.06				
CD (P = 0.05)	0.46	0.04	0.22	0.13				

fruit growth and development. The lowest fruit yield (53.10 kg/vine) and yield of 'A' grade fruits (15.70 kg/vine) under 0.6 'V' volume of water through drip was due to poor fruit set, heavy fruit drop and smaller size of fruits.

The results revealed that drip irrigation significantly increased fruit size and weight as compared to basin method of irrigation. The maximum fruit size in terms of length and breadth (67.65 mm and 45.75 mm) and weight (71.45 g) were registered with 'V' volume of water through drip irrigation. This, perhaps, is due to better and continuous availability of water and nutrients to vines subjected under drip irrigation with V volume of water. Srinivas *et al.* (1999) also noticed significant increase in berry size and bunch weight of grapes under drip irrigation with increased rate of irrigation. The minimum fruit size (59.45 mm length and 38.65 mm breadth) and weight (61.06 g) were recorded with 0.6 'V' volume of water. The inadequate soil moisture during the growing season under 0.6 'V' volume drip irrigation treatment, resulted in smaller fruit size and weight as the fruit size in kiwifruit is directly related to the availability of soil moisture

It is evident from Table 3 that different irrigation treatments significantly influenced the leaf nutrient content. The uptake of nutrient in leaves, in general, increased with the increase in frequency and quantity of irrigation water. The highest leaf nitrogen (2.97%), phosphorus (0.26%), potassium (2.21%), and Mg (0.91%) were observed in vines irrigated with 'V' volume of water through drip which was followed by drip irrigation with 0.8 'V' volume of water. The results also revealed that leaf nutrient content was lesser in the vines which were irrigated with 'V' volume of water through basin method than those irrigated with drip method with same amount of water.The possible explanation for the higher nutrient content in the vines subjected under higher soil moisture could be that the movement of mineral nutrients depends upon the mass flow of the soil solution driven by water uptake and diffusion co-efficient of the ion and water content of the soil. Movement of nutrients under high soil moisture is enhanced by the more movement along the soil particles and the increase in mass flow due to higher rate of transpiration as a result of stomata opening. Rana (1998) also support the present findings who found higher leaf nutrient content in kiwifruit vines subjected under higher soil moisture than those irrigated with less quantity of water.

The total water requirement was highest (152.88 cm) in basin irrigation at 80% field capacity, followed by (113.36 cm) in basin irrigation with 'V' volume of water treatment

(Table 3). In drip irrigation method, the lowest water requirement (93.42 cm) was recorded in drip irrigation with 0.6 'V' volume of water. Water requirement in drip irrigation with 'V' volume of water was equal to the basin irrigation with 'V' volume of water but the yield and fruit quality were higher under drip irrigation with 'V' volume of water. Water-use efficiency in terms of biomass production (yield) per unit of water consumed was also found to be influenced by different irrigation treatments. The increase in water-use efficiency appears to result both from reduced water losses by drip irrigation system and from more efficient plant use. The water-use efficiency of a drip irrigation system is also increased by the reduction of wetting area in the basin. The maximum water-use efficiency (0.90 kg/vine/cm) was recorded when vines were drip irrigated with 0.6 'V' volume of water somewhat closer water-use efficiency (0.83 kg/vine/cm) was recorded with 0.8 'V' volume of drip irrigation treatment. When lesser volume of water was applied a partial stomata closer can lead to decrease in transpiration and possibly increase of transpiration efficiency. The lowest water-use efficiency (0.45 kg/vine/cm) was recorded when vines were irrigated at 80% of field capacity with basin method, followed (0.64 kg/vine/cm) by basin irrigation with 'V' volume of water. The lower efficiency may be due to lesser water availability to plant resulting into lesser yield. Rolbiecki *et al*. (2004) also reported higher water-use efficiency for drip irrigation when half water rate was used only as compared to drip irrigation with full rate.

REFERENCES

A O A C. 1990. *Official Methods of Analysis of the Association of Analytical Chemists*, 1010pp. Benjamin Franklin Station Washington D C.

Bonany J and Camps F. 1998. Effect of different irrigation levels on apple fruit quality. *Acta Horticulturae* **466**: 47–52.

Jackson M L. 1967. *Soil Chemical Analysis*. Asia Publishing House, Bombay.

Koeing R A and Johnson R C R. 1942. Colorimetric determination of phosphorus in biological products. *Industrial Engineering Chemical Annals* **14**: 155–64.

Monastra F, Chiariotti A, Colorio G and Proietti G. 1997. Comparison of three irrigation systems of pergola trained kiwifruit orchard. *Acta Horticulturae* **448**: 335–40.

Rana R. 1998. 'Effect of different soil moisture regimes on growth, cropping, fruit quality and water relations of kiwifruit vines cv. Allison'. M Sc thesis, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan.

Rolbiecki S, Rolbiecki R, Rzekanowski and Dorkacz M. 2004. Effect of different irrigation regimes on growth and yield of Elsanta Strawberries planted on loose sandy soil. *Acta Horticulturae* **646**: 163–6.

Srinivas K, Shikhamany S D and Reddy N N. 1999. Yield and water use of Anab-e-Shahi grape (*Vitis vinifera*) vines under drip and basin irrigation. *Indian Journal of Agricultural Sciences* **69**(1): 21–3.