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Effect of irrigation levels and in situ moisture conservation on vegetative growth, flowering and fruiting characteristics of kiwifruit cv Allison

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ABSTRACT

The effect of different irrigation levels and in situ moisture conservation on vegetative growth, flowering and fruiting characteristics was investigated in kiwifruit cultivar Allison. The seven treatments viz irrigation at 80 per cent (T_1), 60 per cent (T_2) and 40 per cent field capacity (T_3), T_2 plus grass mulch (T_4) or black polythene (T_5) and T_3 plus grass mulch (T_6) or black polythene (T_7) were applied from March to October with three replications in randomized block design (RBD). The shoot growth, length of internodes, leaf area, bloom intensity, fruit set and fruit retention decreased with DI levels under T_2 and T_3 treatments. The treatment T_4 and T_5 maintained soil moisture level nearly to the level of T_1 and mitigated these water stress induced responses. However T_5 was better in this respect.

Keywords: Kiwifruit; deficit irrigation; shoot growth; leaf area; bloom intensity; fruit set; mulching; leaf yellowing; fruit yield

INTRODUCTION

The kiwifruit or Chinese gooseberry (*Actinidia deliciosa* Chev) is a deciduous fruit vine native to Yangtze valley of south and central China (Ferguson 1984). It is a dioecious vine bearing pistillate and staminate flowers separately and requires 700-800 chilling hours below 7°C and mild summer with temperature not exceeding 35°C. In India therefore it can be grown successfully in areas situated at elevation of 900-1800 m above mean sea level where the winters are cold, summers are warm and humid and receive well distributed annual rainfall of about 150 cm.

The fruit has an excellent table and keeping quality and acclaimed for its nutritive and medicinal values. Kiwifruit is a rich source of vitamin C, K, and E and provides dietary fiber and minerals like P, K and Ca. In Himachal Pradesh the area under its cultivation is 117 ha with annual production of 555 MT (Anon 2013).

In Himachal Pradesh however kiwifruit cultivation has extended to those areas where demand for water exceeds that of local resources. The problem of water limitation may prove to be a more critical constraint to temperate fruit productivity in future due to global environmental change. The use of different mulching materials is known to be beneficial for in situ moisture conservation during the drought period (Guleria 1986). Mulches also regulate soil temperature, prevent soil erosion and surface run-off of water and control the weeds. Organic mulch helps to prevent winter injury to crowns, promotes growth of the extensive fibrous kiwifruit root system and helps to control unwanted suckers. Hay and straw mulch materials are easily available and comparatively cheaper than other mulch materials. Organic mulch decomposes easily and adds manures to the field. However the black plastic mulch of 200-400 gauge with desired dimension has been in use commercially in different countries. Using black plastic mulch is advantageous as higher yields of better quality fruits are obtained (Sharma 2002). The plastic mulch can be recycled again but not hay or straw. The aim of in situ moisture conservation and deficit irrigation is to maintain water stress within a desirable range so that the physiological reactions of the vine can be harnessed to the benefit of the kiwifruit growers.

MATERIAL and METHODS

The present experiment was undertaken in the Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Solan, HP during the years 2011 and 2012. Twenty five year old uniform vines of kiwifruit cultivar Allison planted at 6 x 4 m spacing and trained on T-bar system were selected for this investigation. The seven irrigation treatments viz irrigation at 80 per cent (T_1), 60 per cent (T_2) and 40 per cent field capacity (FC) (T_3), T_2 plus grass mulch (T_4) or black polythene (T_5) and T_3 plus grass mulch (T_6) or black polythene (T_7) were applied from March to October and the mulching was applied in mid-March. These treatments were arranged in RBD with three replicates each of one kiwifruit vine.

The shoot growth and length of internodes were measured with the measuring tape at the end of growing period and expressed in centimeter (cm). The leaf area (cm^2) was determined by using leaf area meter Li-COR Model-3100. The leaf thickness (mm) was recorded by joining the surfaces of twenty five leaves together and then measuring it with the Digimatic Calliper (Mitutoyo, Japan). The observations on the leaf yellowing were recorded by counting the number of leaves that turned yellow on the five selected fruiting arms of each vine. Total number of leaves on the selected

branches was also counted and leaf yellowing was calculated by using the following formula and expressed in percentage.

$$\text{Leaf yellowing (\%)} = \frac{\text{Number of yellow leaves}}{\text{Total number of leaves}} \times 100$$

The number of flowers on four selected fruiting arms from each treated vine was counted and the cross sectional area of these fruiting arms was recorded in square centimeter. The bloom intensity was determined as per formula given below:

$$\text{Bloom intensity} = \frac{\text{Number of flowers per fruiting arm}}{\text{Cross sectional area of fruiting arm}} \times 100$$

The bloom intensity was expressed as number of flowers/cm^2 arm cross sectional area. The results were expressed in per cent. To study the percentage of fruit set and fruit retention ten fruiting arms of equal length were selected on each vine in all possible directions. The per cent fruit set was calculated as per formula given below:

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit set on the fruiting arm}}{\text{Total number of flowers present on the fruiting arm}} \times 100$$

The per cent fruit retention was calculated as per formula given below:

$$\text{Fruit retention (\%)} = \frac{\text{Number of fruits retained on the fruiting arm}}{\text{Total number of fruit set on the fruiting arm}} \times 100$$

The total yield of kiwifruit under different treatments was determined on the basis of total weight of fruits harvested from the vine under each treatment and average yield per vine was calculated. The yield was expressed in kilogram per vine (kg/vine).

The graded yield was calculated on the basis of weight and the harvested fruits were classified into four grades viz A (>70 g), B (50-70 g), C (<40-50 g) and D (<40 g). The yield of different grades was expressed in percentage of the total yield.

RESULTS and DISCUSSION

Deficit irrigation resulted in a significant reduction in shoot growth, length of internodes and leaf area under irrigation at 60 per cent FC and irrigation at 40 per cent FC when compared to those under standard irrigation treatment at 80 per cent FC in the year 2011 (Table 1) and 2012 (Table 1). This reduction in shoot growth characteristics is in line with results reported in 'Pacific Rose™' apple (Zegbe and Behboudian 2008). The deficit irrigation might have decreased vegetative growth of kiwifruit vines as a result of reduced rate of photosynthesis, leaf nutrient status and hormones metabolism. Dry et al (2001) observed inhibition in shoot growth in PRD grapevines in parallel with a marked decrease in the concentration of cytokinin in shoots and roots. In fruit trees the continuous readily available soil moisture conditions during the growing period resulted in more total growth compared to the limited supply of moisture (Goode and Ingram 1971). Hsiao (1973) also reported that the soil moisture affects almost every aspect of plant growth and development by modifying morphological and biochemical characteristics. The mulching treatments moderated the influence of deficit irrigation on these parameters and the black polythene mulching was more effective as compared to grass mulching. Similar effect of mulching was also reported by Heiberg (1996) on shoot growth and Kirnak et al (2001) on length of internodes and Phadung et al (2005) on leaf area. The leaf thickness and leaf yellowing increased with deficit irrigation and decreased effectively with black polythene mulch treatment as the black polythene mulching at different stress levels resulted in better soil moisture conservation ability as compared to grass mulch. Kumar (2010) also reported that the drought stress resulted in increase in leaf thickness of olive. In olive different in situ moisture techniques also decreased the leaf yellowing as reported by Singh and Sharma (2010).

In the present investigation the bloom intensity, fruit set and fruit retention decreased under DI treatment during both the years 2011 and 2012 (Table 2) however irrigation applied at 40 per cent of field capacity had more adverse effects on these production parameters. The mulching treatment along with deficit irrigation at 60 per cent FC increased bloom intensity, fruit set and fruit retention almost near to the level of well irrigated vines however in this respect black polythene mulch gave better performance compared to the grass mulch. These findings are in line with the earlier reports that DI decreased flowering in 'Braburn' apple (Mills et al 1994) and 'Hosui' Asian pears (Caspari et al 1994). It has been observed earlier that mulching increases flowering (Singh et al 2005, Wang 2005, Singh et al 2009), fruit set and fruit retention (Thakur et al 1993, Singh et al 2009) in different fruit crops. Koshita and Takahara (2004) also observed that severe

Table 1. Effect of irrigation levels and mulching on shoot growth, length of internodes, leaf area, leaf thickness and leaf yellowing of kiwifruit cv Allison during 2011 and 2012

Treatment	Shoot growth	Length of internodes	Leaf area	Leaf thickness	Leaf yellowing
2011					
T_1: Irrigation at 80% of FC	291.5	8.38	158.3	0.410	22.5
T_2: Irrigation at 60% of FC	283.5	8.23	154.3	0.414	32.1
T_3: Irrigation at 40% of FC	275.0	7.86	152.0	0.490	46.1
T_4: Irrigation at 60% of FC + mulching with grass	288.6	8.32	156.2	0.413	36.3
T_5: Irrigation at 60% of FC + black polythene mulching	290.8	8.36	157.6	0.412	26.4
T_6: Irrigation at 40% of FC + mulching with grass	278.0	7.88	153.5	0.480	43.1
T_7: Irrigation at 40% of FC + black polythene mulching	280.0	7.91	154.0	0.470	39.7
$CD_{0.05}$	1.7	0.06	0.7	0.026	0.4
2012					
T_1: Irrigation at 80% of FC	290.0	8.35	156.0	0.417	23.0
T_2: Irrigation at 60% of FC	281.0	8.21	153.3	0.431	35.0
T_3: Irrigation at 40% of FC	274.6	7.84	151.1	0.520	48.0
T_4: Irrigation at 60% of FC + mulching with grass	287.0	8.32	156.0	0.420	35.5
T_5: Irrigation at 60% of FC + black polythene mulching	289.2	8.37	156.9	0.410	25.0
T_6: Irrigation at 40% of FC + mulching with grass	277.0	7.87	153.1	0.510	42.0
T_7: Irrigation at 40% of FC + black polythene mulching	279.3	7.90	153.2	0.480	38.0
$CD_{0.05}$	2.2	0.07	1.3	0.018	0.7

water stress (-1.5 to -2.0 MPa) resulted in 1/3rd reduction in flowering percentage than that of moderate water stress (-0.5 to -1.0 MPa) in trees of Satsuma mandarin which was attributed to the enhanced levels of GA by severe water stress in leaves. Singh and Sharma (2010) reported that soil moisture content had a positive correlation with fruit

set and negative correlation of fruit drop in olives grown under rainfed conditions. In the present study decreased photosynthetic rate and internal water regime and increased ABA level in water stressed vines might have lead to decreased fruit set and fruit retention.

The fruit yield decreased with DI treatment, the total yield (Table 2) and A and B grade fruit yield (Table 3) whereas inferior grade C and D fruit yield increased linearly with the decrease in the supply of water. However the irrigation applied at 60 per cent of field capacity along with mulching treatments resulted in increased total fruit yield as well as superior grade fruit yield near to the level of well irrigated vines.

Higher total fruit yield and superior grade fruit yield in well irrigated vines and vines given irrigation at 60 per cent of field capacity along with mulching treatments can be attributed to increased bloom intensity, fruit set, fruit retention (Table 2), fruit size and weight. These results are in accordance with the findings of Sharma and Kathiravan (2009) and Li et al (2011) who observed increased yield with better soil moisture regimes under in situ water conservation with mulches in different fruit crops. Mulching creates more mesic root environment and reduces the environmental stress thus helping in increased fruit size and yield (Moore-Gordon et al 1997).

Table 2. Effect of irrigation levels and mulching on bloom intensity, fruit set, fruit retention and total yield of kiwifruit cv Allison during 2011 and 2012

Treatment	Bloom intensity		Fruit set		Fruit retention		Total fruit yield	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1: Irrigation at 80% of FC	0.66	0.64	86.7	85.6	85.5	84.4	67.0	66.0
T_2: Irrigation at 60% of FC	0.63	0.62	80.4	85.2	73.5	71.5	63.0	62.4
T_3: Irrigation at 40% of FC	0.60	0.61	78.4	81.5	65.5	70.7	52.0	50.0
T_4: Irrigation at 60% of FC + mulching with grass	0.64	0.62	81.4	85.3	78.0	79.1	65.4	63.7
T_5: Irrigation at 60% of FC + black polythene mulching	0.65	0.64	83.6	85.4	81.4	81.8	66.8	65.8
T_6: Irrigation at 40% of FC + mulching with grass	0.61	0.62	79.1	82.3	78.6	77.3	53.0	54.0
T_7: Irrigation at 40% of FC + black polythene mulching	0.62	0.63	79.9	83.0	79.7	78.4	55.3	56.0
$CD_{0.05}$	0.01	0.01	0.7	0.9	0.2	0.1	0.8	0.9

Table 3. Effect of irrigation levels and mulching on graded fruit yield of kiwifruit cv Allison during 2011 and 2012

Treatment	Grade							
	A		B		C		D	
	2011	2012	2011	2012	2011	2012	2011	2012
T_1: Irrigation at 80% of FC	27.5	27.0	37.5	37.5	26.0	25.6	9.0	9.9
T_2: Irrigation at 60% of FC	22.9	21.0	33.3	32.0	28.0	30.0	15.8	17.0
T_3: Irrigation at 40% of FC	13.0	12.0	29.8	30.0	34.0	33.5	23.2	24.5
T_4: Irrigation at 60% of FC + mulching with grass	24.8	25.0	35.2	35.0	27.0	26.9	13.0	13.1
T_5: Irrigation at 60% of FC + black polythene mulching	25.5	26.2	36.4	37.2	26.5	26.4	11.6	10.2
T_6: Irrigation at 40% of FC + mulching with grass	15.0	16.0	30.4	30.3	32.2	32.0	22.4	21.7
T_7: Irrigation at 40% of FC + black polythene mulching	17.0	18.0	31.6	31.5	30.8	30.7	20.6	19.8
$CD_{0.05}$	0.8	1.5	0.5	0.9	0.9	0.7	0.7	0.4

CONCLUSION

The study suggests that under moderate water stress condition the use of black plastic mulch may be beneficial as it helped to conserve moisture under DI regime and resulted in almost similar response in terms of vegetative growth and production attributes when compared to those in well irrigated vines. It may also reduce the high irrigation requirement of kiwifruit in areas where sufficient water is not available.

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