Indian J. Hort. 67(4), December 2010: 463-469

Effect of *in-situ* moisture conservation on morphology, physiology and production of olives under rainfed conditions

Karan Singh and N. Sharma*
Department of Fruit Science, Dr Y.S. Parmar University of Horticulture and Forestry,
Nauni, Solan 173 230

ABSTRACT

A field experiment on effect of *in-situ* moisture conservation techniques, *viz.* T_1-V-ditch; T_2-cresent bund with open catchments pits; T_3- trench system and T_4- traditional basin system was installed in a rain-fed olive cultivars Leccino and Cipressino grove in the Experimental Orchard of Fruit Science, University of Horticulture and Forestry, Solan, Himachal Pradesh. Among different soil working techniques, crescent bund with open catchment pits conserved higher soil moisture content at all the observation dates. Blooming intensity, per cent perfect flower and fruit set were also recorded significantly higher in trees under crescent bund with open catchment pits. Higher increase in summer flush growth was observed in the tree under crescent bund with open catchment pits due to higher moisture availability. However, the extent of leaf rolling, leaf yellowing and shoot tip bending were highest under traditional tree basins, which, was however, reduced to the maximum extent in trees under crescent bund with open catchment pits system. Physiolological characteristics, such as photosynthetic rate, stomatal conductance, and transpiration rate and leaf water potential were higher in the tree under crescent bund with open catchments pits. These results suggest that, soil working technique-crescent bund with open catchment pit can be employed to conserve more soil moisture in rain-fed conditions for improving growth and production of olives.

Key words: *Olea europaea,* moisture conservation, growth, yield efficiency.

INTRODUCTION

The olive (*Olea europaea* L.) is an evergreen tree but requires chilling for fruiting. It is mostly grown for oil, which is extracted from its fruits. Olive oil possesses numerous biological and medicinal values. The leading olive producing countries of the world includes Italy, Spain, Greece, Portugal and Turkey. In India olive cultivation is restricted to the states of Jammu and Kashmir, Himachal Pradesh and Uttrakhand. In Himachal Pradesh, olives are grown on a limited scale in Kullu, Shimla, Solan and Sirmour districts. Flower bud differentiation is the major concern of olive growers of monsoon type climate and the yield is often irregular and uneconomical (Bartolini and Feabbri, 3). The trees suffer acute moisture stress at their critical stage of growth and development during November-December and April-June due to erratic and uneven rains under rain fed conditions of the state. It therefore becomes imperative to conserve every drop of rain water in the field using *in-situ* moisture conservation techniques to enhance soil moisture storage and to produce optimum flowering and fruit set by improving their morphological and physiological status. Present studies were therefore, undertaken with an objective to evaluate the morphological and physiological status and productivity potentials of olive through conserving soil moisture under rain fed conditions with the aid of suitable soil working techniques under the tree basins.

MATERIALS AND METHODS

The present experiments were conducted on olive cultivars Leccino and Cipressino during 2007 and 2008 in the experimental orchard, Department of Fruit Science, University of Horticulture and Forestry, Solan, Himachal Pradesh, under rain-fed conditions. For this study, 18-year-old uniform trees planted at 6 m × 6 m spacing were selected. Soil at the experimental site was silty loam having 6.02 pH, 0.697 dSm^{-1} EC, 1.60% organic carbon content, 4.79% permanent wilting point, 21.06% field capacity, and 0.99 g cm^{-3} bulk density. Four soil working techniques employed were T_1-V-ditch (Nagarin, 0.45 m × 0.30 m), T_2-Cresent bund (height: 0.3 m) with open catchments pits (3 no., 0.5 m × 0.5 m), T_3- trench system (L × B × D- 3.0 × 0.5 m × 0.5 m), T_4- traditional basins (2 m radius). All the treatments were replicated four times with one tree per replication in a randomized block design. Soil moisture readings (%) were taken with the help of AquaPro soil moisture profiler at 15-day intervals from January 1 to July 1, at 30 cm depth (in 2007) and at 30 and 60 cm depth (in 2008) of the access

*Corresponding author's E-mail: nsharma.sol@gmail.com

tubes fitted 1 m away from the trunk at two locations per tree basin. The data on morphological parameters *viz.*, shoot growth measure in cm and leaf yellowing (%), leaf rolling (%) and shoot tip bending (%) were observed in the field at the cessation of summer flush in August. Simultaneously, 50 fully expended leaves from the middle of the current season's growth of each experimental tree were collected randomly and their area (cm^2) was determined using LiCor 3100 leaf area meter. Blooming intensity (%) was worked out as per method suggested by Westwood (10). For ascertaining proportion of perfect flowers, twenty five inflorescences were sampled from all the sides of the experimental trees. The individual flowers of these inflorescences were carefully examined to determine their sex. These flowers were then categorized into two groups *viz.*, perfect and staminate on the basis of presence or absence of a fully developed and functional pistil. Results on the proportion of perfect flowers were expressed in percentage.

The observations on the fruit set were recorded two weeks after petal fall and then were again confirmed two weeks later so as to allow sufficient time for the abscission of unfertilized parthenocarpic fruits. The final fruit set was then computed by using the following formula as suggested by Westwood (10). Total number of fruit set was counted from five randomly selected branches of each experimental tree. The number of fruits dropped from these branches between the time of fruit set and harvest/maturity was recorded at monthly intervals and computed as per cent fruit drop. Yield and yield efficiency were calculated in kg/ tree and kg/cm limb circumference, respectively. Observations on physiological parameters like photosynthetic rate (µmol $m^{-2}s^{-1}$), stomatal conductance (mol $m^{-2}s^{-1}$) and transpiration rate (m mol $m^{-2}s^{-1}$) were taken with LiCor 6200 photosynthetic system and leaf water potential was observed by the "Pressure Bomb" apparatus and expressed in –bar. Two years data were pooled analyzed as per method described by Gomez and Gomez (5), and different correlations with moisture contents at 60 cm soil depth were computed by Pearson's co-efficient of correlation method.

RESULTS AND DISCUSSION

Soil moisture contents (Figs. 1 & 2) under the tree basins fluctuated greatly with dry spells and erratic rainfall cycles (68, 4, 107, 25, 20, 85, & 110 mm rainfall in January, February, March, April, May, June & July 2007, respectively and corresponding figures for 2008 were 25, 31, 0, 39, 95, 260 & 120 mm, respectively) during the course of investigation. However during all the observation dates, higher soil moisture was retained under the treatment of crescent bund with open catchment pit showing significantly more mean

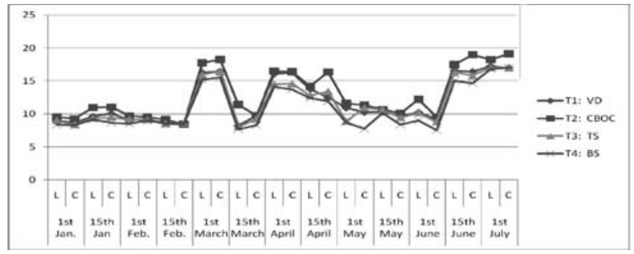

Fig. 1. Soil moisture status (30 cm) under different rain water harvesting techniques in olive (2007).

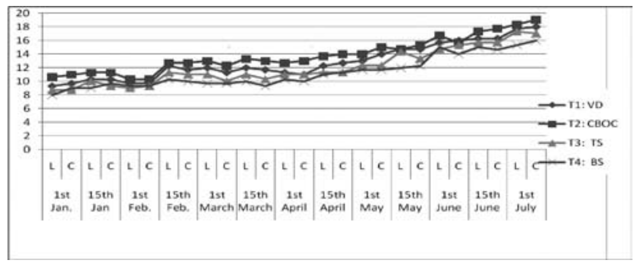

Fig. 2. Soil moisture status (30 cm) under different rain water harvesting techniques in olives (2008).

values of 13.01% soil moisture at 30 cm depth in 2007 and 13.80 and 15.25% at 30 and 60cm depth, respectively in 2008, in comparison to the traditional basin system, averaging 10.89% soil moisture at 30cm depth in 2007 and 11.25 and 12.05% soil moisture soil moisture at 30 and 60 cm depth, respectively during 2008 (Table 1). In our experiment, soil working technique CBOP might have prevented rain water runoff from the tree catchment area and consequently conserved more soil moisture under tree basins, during the study period.

Summer flush shoot extension growth was significantly higher (18.45 cm) in the trees under CBOC, followed by the trees under V-ditch and lowest growth was observed in trees under traditional basin system (Table 2). It was also observed that cultivar Cipressino was more vigorous than Leccino, irrespective of treatments. Highest vigour was recorded in the former cultivar under CBOC, which was however statistically at par with the cultivar Leccino under CBOC and the same cultivar trees under V-ditch. In the study, soil moisture exhibited a positive and highly significant correlation with shoot growth (Tables 6 & 7) and it seems that olive trees maintained better flush growth under CBOC because of higher soil moisture status (Figs. 1, 2 & 3). Similarly, conservation of soil moisture increased growth of plum (Sharma and Kathiravan, 9) and apple (Joolka *et al.*, 7) in earlier studies.

Under water stress conditions, olive trees usually exhibits leaf yellowing and leaf rolling symptoms. During the course of investigation, it was observed that

Table 1. Mean moisture (January to July) contents in 2007 and 2008.

Treatment	Mean moisture at 30 cm (2007)			Mean moisture 2008 at 30 cm (2008)			Mean moisture at 60 cm (2008)		
	Leccino	Cipressino	Mean	Leccino	Cipressino	Mean	Leccino	Cipressino	Mean
VD	11.97	11.86	11.92	12.81	12.85	12.83	14.30	14.32	14.31
CBOC	13.05	12.96	13.01	13.74	13.86	13.80	15.12	15.38	15.25
TS	11.57	11.64	11.61	12.12	11.88	12.00	13.68	13.46	13.57
BS	11.06	10.71	10.89	11.27	11.23	11.25	12.11	11.99	12.05
$CD_{0.05}$									
	Treatment		0.01			0.02			0.75
	Variety		0.01			0.02			0.53
	T × V		0.01			0.01			1.07
Mean	11.91	11.79		12.48	12.45		14.04	13.80	

Table 2. Morphological parameters in olive as affected by different *in-situ* moisture conservation techniques.

Treatment	Growth (cm)			Leaf area (cm^2)			Leaf yellowing (%)			Leaf rolling (%)			Shoot tip bending (%)		
	Leccino	Cip-ressino	Mean	Leccino	Cip-ressino	Mean	Leccino	Cip-ressino	Mean	Leccino	Cip-ressino	Mean	Leccino	Cip-ressino	Mean
VD	17.05	18.33	17.47	5.94	4.43	5.43	2.37	2.77	2.57	2.57	2.71	2.64	4.30	3.78	3.84
CBOC	18.46	18.48	18.45	5.97	4.97	5.46	2.03	3.11	2.56	2.44	2.57	2.50	4.40	3.51	3.75
TS	17.96	17.68	17.82	5.95	4.94	5.44	2.80	2.98	2.91	3.55	2.93	3.25	3.75	4.80	4.27
BS	15.29	14.93	15.11	5.92	4.92	5.42	3.55	3.52	3.54	3.20	3.80	3.50	5.07	4.86	4.97
$CD_{0.05}$															
		Treatment	0.51			0.02			0.01			0.02			0.02
		Variety	0.36			0.02			0.01			0.01			0.01
		T × V	0.50			0.02			0.01			0.01			0.01
Mean	17.19	17.36		5.94	4.94		2.69	3.10		2.94	3.00		4.03	4.31	

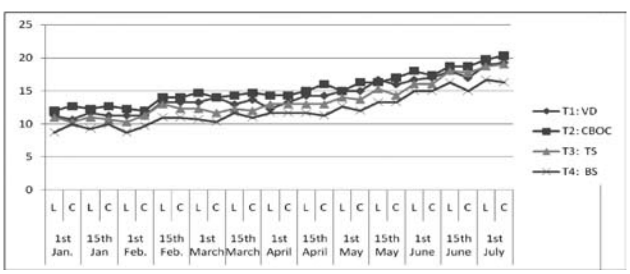

Fig. 3. Soil moisture status (60 cm) under different rain water harvesting techniques in olives (2008).

leaves yellowing (Table 2) was significantly higher in the trees under the treatment of BS (3.54%) and lower in the trees under CBOC (2.56%) system. Similarly, leaf rolling (3.50%) and shoot tip bending (4.97%) were significantly higher in tree grown under BS, whereas; lowest values of these parameters (2.50% leaf rolling & 3.75 % shoot tip bending) were noticed in the trees under CBOC system (Table 2). It however, noticed that cultivars differed in showing shoot tip bending, which was significantly higher in Cipressino than Leccino. In this study, these physiological disorders, except leaf yellowing in 2008 had highly significant negative correlation with soil moisture contents (Tables 6 & 7) and probably soil working technique CBOC seems to have reduced these symptoms by maintaining higher soil moisture contents and photosynthetic rates (Table 4). Leaf area (Table 2) was largest (5.46 cm^2) under the treatment of CBOC and smallest in trees grown under traditional basin system maintaining least soil moisture level. Earlier, leaf area has been shown to be significantly negatively affected by water stress (Abo-Taleb *et al.*, 1).

Blooming intensity was significantly higher (0.53%) in the trees under the treatment of CBOC than all other moisture conservation treatments and lowest blooming intensity (0.45%) was observed in the trees under traditional basin system (Table 3). The count of perfect flowers was also found higher in trees under the treatment of CBOC (47.06%), which in this respect was however, statistically at par with the trees under V-ditch system (46.57%). Consequently, fruit set (Table

3) was significantly higher in trees under the treatment of CBOC (4.20%) and V-ditch system (4.02%) than the trees under control (2.88%). Cultivar Leccino had significantly higher blooming intensity and perfect flowers than Cipressino. However in respect of fruit set, both the cultivars were statistically at par with each other. In this study, a positive correlation was observed between soil moisture contents and fruit set. Fruit drop (Table 3) was highest the tree maintained with traditional basin system (77.35%), and lowest in the trees under CBOC system (65.53 %). However, the fruit yield was highest (3.39 kg/tree) in the tree under CBOC, followed by those under V-ditch system. Lowest yield (1.98 kg/tree) was observed in trees maintained with traditional basins. Likewise, highest yield efficiency (0.05 kg/limb circumference) was observed in trees under CBOC system, closely followed by those under VD system. Lowest yield efficiency (0.03 kg/limb circumference) was found in the tree under BS system. Fruit drop showed negative correlation, whereas yield exhibited positive correlation with soil moisture (Tables 6 & 7) in both the cultivars. During the course of study, better soil moisture regimes under the treatments of CBOC system might have helped in improving flowering, flower quality and fruiting in olive. Furthermore, increased fruit yield under CBOC can also be attributed to higher photosynthetic rates (Table 5). In recent studies, better soil moisture regimes under *in situ* water conservation with mulches resulted in increased yield in plum (Sharma and Kathiravan, 9) and apple (Joolka *et al.*, 7). The results are also in line with those of Arora and Mohan (2) who observed decreased fruit drop and increased fruit yield with V-shaped micro-catchment with full polythene cover in lemon cv. Eureka Round.

Fruits from the trees under CBOC system were larger in size (21.30 m × 14.19 m) and heavier in weight (2.71 g) while those from the trees under traditional basin system were smaller in size and lowest in weight (Table 4). In this study, more availability of water and increased photosynthetic rate might have increased fruit size and weight in trees under CBOC (Figs. 1, 2 & 3; Table 5). The results are in accordance with those of Gucci (6), who observed that better soil moisture management increased fruit size, pulp-to-stone ratio, and yield in olive. Photosynthetic rate (Table 5) was significantly higher (20.33 μmol $m^{-2}s^{-1}$) in tree under the treatment of CBOC in comparison to other treatments and minimum photosynthetic rate was observed in the tree under the traditional basin system (11.28 μ mol $m^{-2}s^{-1}$). Likewise, transpiration rate (Table 5) was significantly higher in the trees under CBOC system (0.040 m mol $m^{-1}s^{-1}$), followed by VD system and lowest transpiration rate was observed under traditional basin system (0.028 m mol $m^{-2}s^{-1}$). Stomata conductance (Table 5) was also found maximum in the trees under CBOC system (2.19 mol $m^{-2}s^{-1}$) and minimum under traditional basin system (1.30 mol $m^{-2}s^{-1}$). Leaf water potential (Table 5) was least negative in trees under CBOC system (-12.55 bar) and most negative in trees under traditional basin system -15.68 bar). However, leaf water potential between both cultivars was observed statistically at par. with other. In this study, higher stomatal conductance in the trees under CBOC pits system can be attributed to better soil moisture and trees' internal water regimes and consequently, transpiration and photosynthetic rates might have increased. Kumar *et al.* (8) reported that the soil moisture conservation practices in coconut palm basins prolonged the availability of soil moisture in the root zone and due to this the net photosynthesis, water use efficiency, and number of physiologically functional leaves in the crown were increased markedly. Earlier, good positive relationships have been found between stomatal conductance and both leaf water potential and soil moisture in field-grown olive trees under water deficit (Giorio *et al.*, 4). These studies revealed that soil working technique- crescent bund with open catchment pit can be employed to conserve more soil moisture,

Table 3. Effect of different systems of *in situ* moisture conservation on flowering, fruit set and fruit drop in olives.

Treatment	Blooming intensity (%)			Perfect flower (%)			Fruit set (%)			Fruit drop (%)		
	Leccino	Cipressino	mean	Leccino	Cipressino	Mean	Leccino	Cipressino	mean	Leccino	Cipressino	Mean
VD	0.53	0.47	0.50	47.14	46.01	46.57	4.00	4.04	4.02	71.65	72.71	72.18
CBOC	0.56	0.49	0.53	47.80	46.31	47.06	4.40	4.00	4.20	65.16	65.90	65.53
TS	0.53	0.46	0.49	46.40	45.64	46.02	3.97	3.38	3.68	71.87	72.57	72.22
BS	0.48	0.43	0.45	45.00	44.11	44.55	3.06	2.70	2.88	77.45	77.25	77.35
$CD_{0.05}$												
T		0.02			0.57			0.91				1.10
V		0.01			0.40			0.64				0.78
T × V		0.02			0.58			0.90				1.09
Mean	0.53	0.46		46.59	45.52		3.85	3.53			71.53	72.11

Table 4. Fruiting in olive as affected by different *in situ* moisture conservation techniques.

Treatment	Yield (kg/tree)			Yield efficiency			Fruit length (mm)			Fruit breadth (mm)			Fruit weight (gm)		
	Leccino	Cipressino	Mean	Leccino	Cipressino	Mean	Leccino	Cipressino	Mean	Leccino	Cipressino	Mean	Leccino	Cipressino	Mean
VD	2.68	2.53	2.60	0.04	0.03	0.04	22.33	20.16	21.25	14.16	14.17	14.17	2.71	2.62	2.67
BOC	3.52	3.25	3.39	0.05	0.04	0.05	22.43	20.18	21.30	14.20	14.18	14.19	2.75	2.67	2.71
TS	2.60	2.47	2.53	0.04	0.04	0.04	22.38	20.17	21.27	14.16	14.17	14.17	2.71	2.64	2.67
BS	2.04	1.92	1.98	0.03	0.03	0.03	22.38	20.16	21.27	14.15	14.15	14.15	2.70	2.61	2.66
$CD_{0.05}$															
Treatment			0.26			0.003			0.03			0.02			0.02
Variety			0.18			0.002			0.02			0.01			0.01
T × V			0.26			0.003			0.02			0.02			0.02
Mean	2.71	2.54		0.04	0.04		22.38	20.17		14.17	14.17		2.72	2.64	

Table 5. Physiological parameters as affected by different *in situ* moisture conservation techniques.

Treatment	Photosynthetic rate (μmol $m^{-2}s^{-1}$)			Transpiration rate (mmol $m^{-2}s^{-1}$)			Stomatal conductance (mol $m^{-2}s^{-1}$)			Leaf water potential (-bar)		
	Leccino	Cipressino	Mean	Leccino	Cipressino	Mean	Leccino	Cip-ressino	Mean	Leccino	Cip-ressino	Mean
VD	13.82	5.38	14.77	0.038	0.024	0.037	2.15	1.20	2.03	13.99	6.00	13.83
CBOC	21.08	16.06	20.33	0.041	0.037	0.040	2.33	1.92	2.19	11.74	13.27	12.55
TS	11.68	19.23	13.40	0.036	0.036	0.034	1.95	2.01	1.68	13.99	14.07	14.02
BS	11.53	12.32	11.28	0.028	0.028	0.028	1.29	1.37	1.30	15.74	14.65	15.68
Mean	12.14	11.35		0.036	0.030		1.93	1.33		13.86	14.84	
	Treatment		0.02			0.001			0.08			0.02
	Variety		0.01			0.002			0.06			0.01
	T × V		0.01			0.001			0.08			0.01
$CD_{0.05}$												

Table 6. Correlation of moisture with shoot growth, fruit set, fruit drop, yield, leaf yellowing, leaf rolling and shoot bending under different in situ moisture systems in olive cultivar Leccino (2008).

Parameter	Moisture	Flush growth	Fruit set	Fruit drop	Yield	Leaf yellowing	Leaf rolling	Shoot tip bending
Moisture	1.0000**							
Flush growth	0.9479**	1.0000**						
Fruit set	0.9792**	0.9203**	1.0000**					
Fruit drop	-0.9401**	-0.8678**	-0.9353**	1.0000**				
Yield	0.8881**	0.8416**	0.8671**	-0.8744**	1.0000**			
Leaf yellowing	-0.9595**	-0.9105**	-0.9428**	0.8214**	-0.7674*	1.0000**		
Leaf rolling	-0.9752**	-0.9272**	-0.9394**	0.8492**	-0.8099*	0.9925**	1.0000**	
Shoot tip bending	-0.9820**	-0.9392**	-0.9967**	0.9231**	-0.8780**	0.9502**	0.9482**	1.0000**

*,** Pearson's correlation coefficient at 5 and 1% significance levels, respectively.

Table 7. Correlation of moisture with shoot growth, fruit set, fruit drop, yield, leaf yellowing, leaf rolling and shoot tip bending under different *in situ* moisture systems in olive cultivar Cipressino (2008).

Parameter	Moisture	Flush growth	Fruit set	Fruit drop	Yield	Leaf yellowing	Leaf rolling	Shoot tip bending
Moisture	1.0000**							
Flush growth	0.9021**	1.0000**						
Fruit set	0.9448**	0.9682**	1.0000**					
Fruit drop	-0.9214**	-0.7510*	-0.7787*	1.0000**				
Yield	0.8109*	0.7387*	0.7372*	-0.7174*	1.0000**			
Leaf yellowing	-0.5411	-0.7863*	-0.6070	0.4774	-0.5411	1.0000**		
Leaf rolling	-0.9149**	-0.7725*	-0.9028**	0.7721*	-0.6909*	0.2286	1.0000**	
Shoot tip bending	-0.9499**	-0.9779**	-0.9472**	0.8499**	-0.8044*	0.7733*	0.7837*	1.0000**

*,** Pearson's correlation coefficient at 5 and 1% significance levels, respectively.

maintaining photosynthesis, improving growth, and production of olive in rain-fed conditions.

ACKNOWLEDGEMENT

The authors are grateful to Indian Council of Agricultural Research, New Delhi for financing the present research scheme under AP Cess funds.

REFERENCES

1. Abo-Taleb, S.A., Noaman, V.F. and El-Deen, S.S. 1998. Growth of pomegranate transplants as affected by different water regimes. *Annals Agri. Sci.-Oshtohor,* **36**: 1073-91.

2. Arora, Y.K. and Mohan, S.C. 1985. Water harvesting and water management for fruit crops in wasteland. *3rd National Workshop on Arid Zone Fruits,* pp. 104-12.

3. Bartolini, G. and Fabbri, A. 1994.The olive tree in monsoon climate. First result on the performance of 12 cultivars. *Acta Hort.* **356**: 119-22.

4. Giorio, P., Sorrentino, G. and d'Andria, R. 1999. Stomatal behaviour, leaf water status and photosynthetic response in field-grown olive trees under water deficit. *Env. Expt. Bot.* **42**: 95-104.

5. Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research,* John WIley and Son, New York.

6. Gucci, R. 2006. Implications of water relations on irrigation management of olive trees. *Italus Hortus* **13**: 61-70.

7. Joolka, N.K., Chand R. and Sharma, S. 2008. Impact of water conservation techniques and herbicidal treatments on yield and quality of Delicious apple under water stress conditions. *Indian J. Hort.* **65**: 12-15.

8. Kumar, S.N., Rajagopal, V., Thomas, S.T. and Cherian, V.K. 2006. Effect of conserved soil moisture on the source-sink relationship in coconut (*Cocos nucifera*) under different agro-climatic conditions in India. *Indian J. Agric. Sci.* **76**: 277-29.

9. Sharma, J.C. and Kathiravan, G. 2009. Effect of mulches on soil hydrothermal regimes and growth of plum in mid hill region of Himachal Pradesh. *Indian J. Hort.* **66**: 465-471.

10. Westwood, M.N. 1978. Growth and yield measurement. *Temperate Zone Pomology*. W.H. Freeman and Company, San Franscisco, USA, pp. 220-28.

Received: November, 2009; Revised: September, 2010; Accepted : October, 2010