DOI : 10.5958/0974-0112.2019.00035.5

Indian J. Hort. 76(2), June 2019: 226-232

Response of orchard floor management treatments to soil hydrothermal regimes in nectarine

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ABSTRACT

Being the second important stone fruit crop of Himachal Pradesh, nectarine still requires a great improvisation in floor management. Keeping this objective, a two year study was conducted with various orchard floor management practices on eight year old 'Snow Queen' nectarine trees during 2014 and 2015. The experiment was laid out in Randomized Block Design, having seven treatments including control and replicated four times. Among all treatments soil hydrothermal regimes were maintained effectively under grass mulch and black polythene mulch. Grass mulch recorded maximum increase in annual shoot growth (148.25 cm), per cent increase in trunk girth (11.49 %), per cent increase in tree height (14.46 %) and per cent increase in tree volume (40.84 %). Maximum fruit set (74.38 %) and fruit yield (26.09 kg/tree) was recorded under nylon mulch mat while minimum fruit drop (16.37 %) under grass mulch. Bicolour polythene mulch recorded fruit size (56.90 mm), fruit weight (100.97 g), fruit volume (102.94 cc), pulp to stone ratio (14.65), TSS (12.91 ºBrix), total sugars (9.58 %) and reducing sugars (4.10 %) along with maximum proportion (82.25 %) of "A" grade fruits.

Key words: *Prunus persica* var. *nucipersica*, fruiting, quality, weed.

INTRODUCTION

Nectarine [*Prunus persica* (L.) Batsch var. *nucipersica*] is one of the important and emerging potential stone fruit crop of Himachal Pradesh. The lack of skin fuzz makes it more reddish than those of peaches, providing to fruit plum-like appearance. It can be cultivated all over the state except, dry and cold region of Lahaul and Spiti and Kinnaur districts. However, mid hill zone, especially Rajgarh and Kullu valley areas are the main centers of nectarine cultivation because of highly congenial agro climatic conditions for its successful cultivation. In Himachal Pradesh, among stone fruits, peach/nectarine ranks next only to plum with an area and production of 5090 ha and 7262 MT, respectively (Anonymous, 1). However, no separate area and production data is available on the commercial level of nectarine.

Snow Queen is the most important cultivar of nectarine grown in the state. It's fruit is mid- season maturing (ripen in first fortnight of June), attractive bright red colour on cream white background, white fleshed, sweet, juicy and possessing excellent flavour. It has high commercial value and has shown promise in the recent past for cultivation in mid hills of Himachal Pradesh.

Nectarine orchards in Himachal Pradesh are established on the undulating land, susceptible to soil erosion and run-off losses having rain-fed conditions. The erratic rainfall, moisture stress during critical stages of growth and development affect fruit quality (small size and low weight) adversely consequently fetch low prices in the market. There is a need to overcome this problem by standardizing suitable orchard floor management practices for improving fruit quality and productivity. Effective orchard soil management play pivotal role to profitable and sustainable fruit production as it controls weeds, conserves soil moisture, prevents soil erosion, maintains soil organic matter and structure, improves water infiltration and nutrient retention and thereby enhances the fruit quality (Derr, 7; Meena *et al.,* 14). Proper orchard floor management makes the long-term conservation of soil fertility and favourable soil physical conditions especially important from horticultural, economic and environmental perspectives (Merwin, 16) Since these management practices affect the growth, yield and fruit quality through its effect on the availability of nutrients, soil microbial population and moisture, the present studies were conducted to standardize these practices for the adoption in the agro-climatic conditions of Himachal Pradesh.

MATERIALS AND METHODS

The experiment was laid out at an elevation of 1250 m above mean sea level which lies under the sub-temperate, sub-humid mid-hill agro climatic zone II of Himachal Pradesh during the years 2014 and 2015. The average rainfall and temperature

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was recorded 84.20, 77.00 mm and 16.76, 17.31 ºC, respectively during the present course of study (From 1st January- 30th June). Eight-year old trees of nectarine 'Snow Queen' of uniform vigour were selected which were planted at 5 × 5m spacing and trained as open centre system.

The experiment comprised of seven treatments viz., clean cultivation (T_1), chemical weed control (glyphosate @ 5 ml/l) (T_2), grass mulch (12-15 cm thickness) (T_3), black polythene mulch (100 µ) (T_4), bicolour polythene mulch (100 µ) (T_5), nylon mulch mat (90 GSM) (T_6) and control (untreated) (T_7). Clean cultivation was done at monthly intervals while post-emergence application of glyphosate @ 5ml/l was given during the last week of March and second week of May around the tree basins. Different mulches were applied around the tree basins in second week of February.

The growth parameters like tree height, tree spread, tree volume, tree girth and annual shoot extension growth were recorded as per as standard procedure. For annual shoot growth ten shoots from the current season growth were randomly selected from all over the periphery of each tree. The length of these shoots was measured at the end of growing season for calculating average annual shoot growth during the investigation. For trunk girth, it was marked with yellow paint at 10 cm above the graft union before the start of experiment. The trunk girth was measured at this point once before the start of experiment and at the end of growing season. The tree spread was measured in meter (m) in two directions (East-West and North-South) once before the commencement of the experiment and again after the end of growing season at the point where the canopy spread was maximum. The tree height was measured from the soil surface to the top of a tree, once before the start of the experiment in January and again after the end of growing season. Total above ground volume of the each experimental tree was calculated from height and spread measurements (Westwood, 21).

Fruit set and fruit drop were recorded as per the method suggested by Westwood (21) and expressed in per cent while total fruit yield was taken by weighing total fruits on top pan balance and expressed in kg/tree.

The per cent fruit set was calculated as:

$$\text{Fruit set (\%)} = \frac{\text{Total number of fruits set on fruiting branch}}{\text{Total number of flowers on fruiting branch}} \times 100$$

The per cent fruit drop was calculated as:

$$\text{Fruit drop (\%)} = \frac{\text{Total number of fruits set on fruiting branch - Fruits retained at the time of harvest}}{\text{Total number of fruits set on fruiting branch}} \times 100$$

Graded yield was calculated by grading the fruits into three different grades as "A" grade (size > 50 mm), "B" grade (size between 45 to 49 mm) and "C" grade (size < 45 mm). Marketable yield under different grades was expressed as percentage of total yield.

After harvesting fruits were evaluated for both physical and bio-chemical traits. For fruit size ten randomly selected fruits from each experimental tree were recorded in terms of length and breadth with the help of digital Vernier Calliper (Mitutoyo, Japan). The average values of fruit length and breadth were expressed in millimetre (mm). Selected fruits were weighed on electronic top pan balance and the average fruit weight was expressed in gram per fruit (g/fruit). Volume of fruits was measured by water displacement method and expressed in cubic centimetre per fruit. For pulp to stone ratio, ten fresh fruits were weighed and the stone from these fruits were removed, washed under tap water, dried to remove excess water and finally weighed. The pulp to stone ratio was worked out by dividing the weight of fruit flesh (flesh weight = fruit weight - stone weight) by the weight of stone. The fruit firmness was determined by digital pressure tester (FHP-802) which recorded the pressure necessary for the plunger to penetrate the peeled flesh of nectarine fruits. Five fruits were tested from each tree and results were expressed in kg per cm^2. Bio-chemical analysis of fruit quality was done as per standard procedure described by AOAC (2).

Soil moisture content was determined by gravimetric method at fortnightly interval by taking soil sample at 15 cm and 30 cm depth. Soil sample were collected in Knee's moisture box which is made of aluminium and were dried on hot air oven for 48 hours at 105°C. Soil temperature was recorded at 15 days intervals with soil thermometers embedded at 10 cm and 15 cm depth at 8:30 am and 2:30 pm and mean of both the timings were recorded.

The two years data were pooled and statistically analyzed with the standard procedure as suggested by Gomez and Gomez (9). The level of significance for different variables was tested at 5 per cent value of significance.

RESULTS AND DISSCUSSION

The perusal of data in Table 1 revealed that orchard floor management treatments had a significant effect on all the growth parameters of 'Snow Queen' nectarine during the present course of study. Maximum shoot growth (148.25 cm), increase in trunk girth (11.49 %), tree height increment (14.46 %) and tree volume increment (40.84%) was recorded under grass mulch (T_3). Whereas, in case of tree

Table 1. Effect of orchard floor management practices on tree growth in 'Snow Queen' nectarine.

Treatments	Annual shoot growth (cm)	Trunk girth (% increase)	% Increase in tree height	% Increase in tree spread		% Increase in tree volume
				E-W	N-S	
T_1	136.50	10.76 (3.43)	11.30 (3.51)	12.03 (3.60)	11.34 (3.51)	33.91 (35.59)
T_2	139.50	11.09 (3.48)	11.58 (3.55)	12.09 (3.62)	11.32 (3.51)	34.15 (35.73)
T_3	148.25	11.49 (3.53)	14.46 (3.93)	13.28 (3.78)	13.11 (3.76)	40.84 (39.70)
T_4	142.25	11.15 (3.49)	13.72 (3.84)	13.39 (3.79)	12.52 (3.68)	40.49 (39.50)
T_5	142.00	10.95 (3.46)	13.81 (3.85)	13.15 (3.76)	12.37 (3.66)	37.08 (37.49)
T_6	144.25	11.23 (3.50)	14.00 (3.87)	12.43 (3.66)	13.62 (3.82)	39.08 (38.67)
T_7	122.00	8.96 (3.16)	9.57 (3.25)	9.44 (3.23)	10.28 (3.36)	28.61 (32.31)
$CD_{0.05}$	13.17	0.14	0.13	0.15	0.13	1.83

Values in the parentheses are square root transformed values for trunk girth and tree height, while arc sine for tree volume.

spread, maximum increment of 13.39 % (E-W) and 13.62 % (N-S) was recorded under black polythene mulch (T_4) and nylon mulch mat (T_6), respectively. The minimum value for these parameters was recorded under control (T_7).

The influence of organic and inorganic mulches was more pronounced as compared to other treatments in respect of tree growth parameters (Table 1). This may be efficient to better hydrothermal regimes under grass mulch (Fig. 1 and 2) which makes the optimum conditions in terms of soil moisture and nutrient availability for better tree growth as compared to all other treatments. Similarly, Bhardwaj and Kumar (3) observed that adequate moisture in the soil is vital for physiological processes in plants, nutrient solubility as well as availability in soil solution, which in turn makes better uptake of nutrients. The results of present studies are in accordance with the findings of Bhat (4) in apricot cv. New Castle, Das *et al.* (6) in guava cv. L-49 and Singh *et al*. (20) in aonla cv. NA-7.

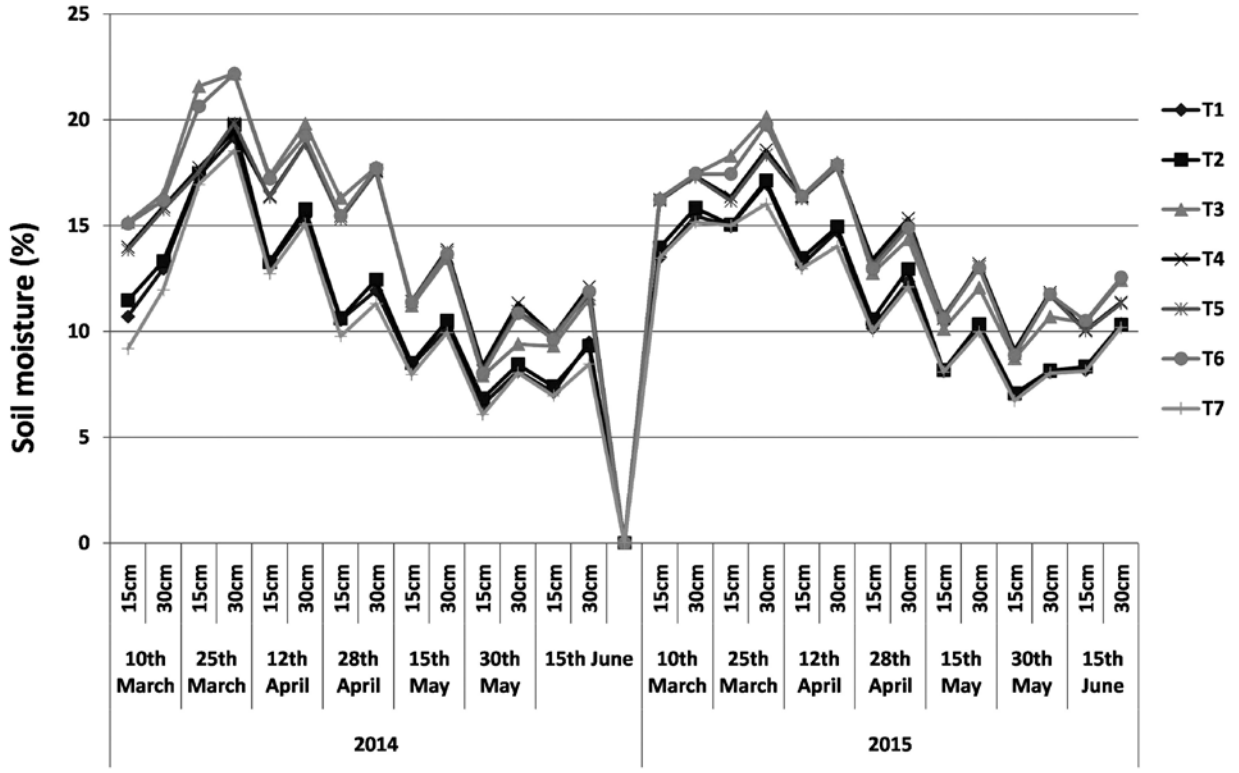

Fig. 1. Effect of orchard floor management treatments on per cent soil moisture content at 15 and 30 cm depth in 'Snow Queen' nectarine.

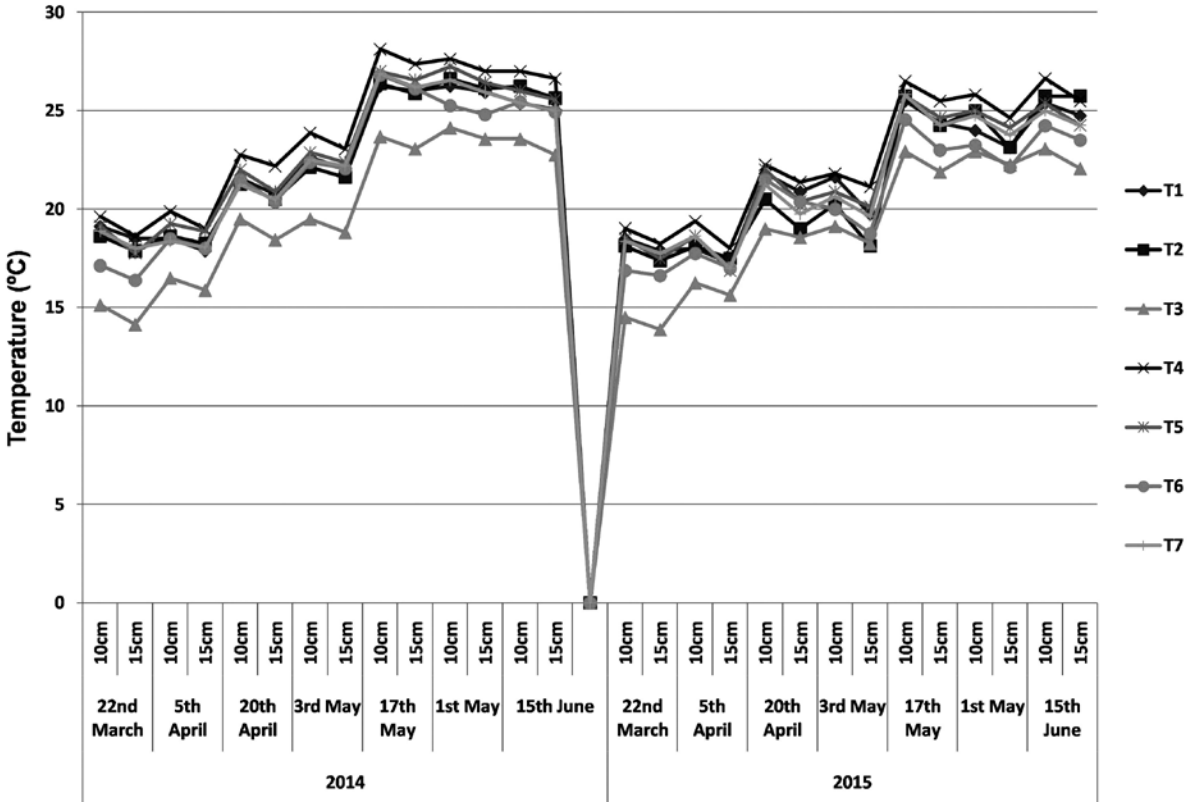

Fig. 2. Effect of orchard floor management treatments on soil temperature at 10 and 15 cm depth in 'Snow Queen' nectarine.

In terms of cropping, the pooled data of both the years indicate that different mulches had a significant influence on fruit set and fruit drop which ultimately resulted in increased yield as well as proportion of "A" grade fruits compared to unmulched treatments (Table 2 and 3). Among different mulches nylon mulch mat recorded highest fruit set (74.38 %) leading to maximum fruit yield (26.09 kg/tree). However, fruit drop was lowest (16.37%) under grass mulch (T_3) but it was statistically at par with nylon mulch mat (T_6). While, the minimum fruit set (67.70 %) and maximum fruit drop (26.37 %) was recorded under control leading to lowest fruit yield (15.15 kg/tree). However, maximum proportion of "A" grade fruits (82.25 %) was recorded under bicolour polythene mulch (T_5) and minimum proportion (45.66 %) under control (T_7).

Maximum fruit set and minimum fruit drop under nylon mulch mat may be due to its better efficiency of moisture retention and weed control which in turns increased the flower primordia, carbohydrates and nutrients essential to promote flowering, fruit set and control fruit drop in plants which ultimately lead to increase the yield. Highest yield under nylon mulch mat might be due to increased flowering, fruit set and lesser fruit drop (Table 2). The results of present studies confirmed the findings of Meena *et al.* (15) and Frimanslund (8) who postulated that often increased yields are preceded by significantly increased flowering. The maximum proportion of "A" grade fruits of 'Snow Queen' nectarine under bicolour polythene mulch were attributed to reflective

Table 2. Effect of orchard floor management practices on fruit cropping traits in 'Snow Queen' nectarine.

Treatments	Fruit set (%)	Fruit drop (%)	Total fruit yield (kg/tree)
T_1	69.99 (56.79)	22.93 (4.89)	21.08
T_2	69.43 (56.43)	21.61 (4.75)	21.94
T_3	73.66 (59.11)	16.37 (4.16)	23.75
T_4	71.92 (58.00)	17.74 (4.32)	24.31
T_5	70.40 (57.02)	18.90 (4.46)	20.70
T_6	74.38 (59.59)	16.42 (4.17)	26.09
T_7	67.70 (55.36)	26.37 (5.23)	15.15
$CD_{0.05}$	1.31	0.11	1.27

Values in the parentheses are arc sine and square root transformed values for per cent fruit set and fruit drop, respectively.

property of bicolour polythene mulch to reflect back the light in tree canopy which resulted in increase in photosynthesis and ultimately results in higher proportion of "A" grade fruits. Beside this, good hydrothermal regimes (Fig. 1 and 2) under bicolour polythene mulch also contributed towards higher proportion of "A" grade fruits. These results are in accordance with the findings of Posada *et al.* (17) and Shiukhy *et al.* (19) in strawberry that bicolour mulches improved the graded yield.

The scrutiny of data in Table 3, 4 and 5 unveiled that orchard floor management treatments had a significant effect on all the fruit quality parameters except fruit firmness, acidity and ascorbic acid content of 'Snow Queen' nectarine during the present course of study.

Pooled data among different mulches revealed that bicolour polythene mulch (T_5) recorded maximum fruit size (56.90 mm), fruit weight (100.97 g), fruit volume (102.94 cc) and pulp to stone ratio (14.65).

Table 3. Effect of orchard floor management practices on per cent pooled graded yield in 'Snow Queen' nectarine.

Treatments	A grade fruits (%)	B grade fruits (%)	C grade fruits (%)
T_1	58.33 (49.88)	26.91 (31.17)	13.71 (3.80)
T_2	59.99 (50.80)	24.83 (29.80)	13.95 (3.86)
T_3	63.68 (52.99)	23.26 (28.76)	13.32 (3.77)
T_4	66.86 (55.00)	22.46 (28.04)	11.01 (3.46)
T_5	82.25(65.68)	9.51 (17.52)	8.51 (3.03)
T_6	64.90 (53.72)	22.35 (28.13)	12.70 (3.69)
T_7	45.66 (42.49)	32.21 (34.52)	24.03 (5.00)
$CD_{0.05}$	3.09	2.28	0.28

Values in the parentheses are arc sine transformed values for A and B grade and square root for C grade fruits

Table 4. Effect of orchard floor management practices on physical fruit properties of 'Snow Queen' nectarine.

Treatments	Fruit size (mm)	Fruit weight (g)	Fruit volume (cc)	Pulp to stone ratio	Fruit firmness (kg/cm^2)
T_1	53.50	92.47	94.49	12.36	6.47
T_2	54.86	95.79	97.84	12.85	6.59
T_3	54.69	95.39	97.33	13.03	6.80
T_4	56.05	99.87	101.94	13.74	6.41
T_5	56.90	100.97	102.94	14.65	6.28
T_6	54.83	94.83	97.00	13.25	6.61
T_7	51.17	84.48	86.39	10.68	6.23
$CD_{0.05}$	1.57	2.47	2.49	0.79	NS

Table 5. Effect of orchard floor management practices on chemical fruit properties of 'Snow Queen' nectarine.

Treatments	TSS (ºBrix)	Acidity (%)	Total sugars (%)	Reducing sugars (%)	Ascorbic acid (mg/ 100g)
T_1	12.21	0.54	8.97	3.37	10.79
T_2	12.34	0.57	9.06	3.52	11.15
T_3	12.62	0.53	9.12	3.84	11.50
T_4	12.61	0.56	9.17	3.83	11.44
T_5	12.91	0.54	9.58	4.10	11.22
T_6	12.74	0.55	9.32	3.97	11.60
T_7	11.80	0.59	8.28	3.18	10.31
$CD_{0.05}$	0.65	NS	0.50	0.33	NS

While, minimum fruit size (51.17 mm), fruit weight (84.48 g), fruit volume (86.39 cc) and pulp to stone ratio (10.68) was recorded under control (T_7).

Pooled data among different mulches revealed that bicolour polythene mulch (T_5) recorded maximum fruit TSS (12.91 ºBrix), total sugars (9.58 %) and reducing sugars (4.10 %) while, minimum acidity (0.53 %) and maximum ascorbic acid content (11.22 mg/100g of fruit) was recorded under grass mulch (T_3) and nylon mulch mat (T_6), respectively. Whereas, minimum fruit TSS (11.80 ºBrix), total sugars (8.28 %), reducing sugars (3.18 %), ascorbic acid content (10.31 mg/100g of fruit) and maximum acidity (0.59 %) was recorded under control (T_7).

Maximum fruit quality under bicolour polythene mulches was due to their reflective nature which improved the photosynthetic activities of the canopy and accumulated more photosynthates which lead to increase in fruit quality parameters. Reflective mulches also change the micro-climatic condition of the tree by increasing the temperature which results in advanced ripening and more accumulation of total sugars. These observations are in conformity with the findings of Mark *et al*. (13) in pecan and XiangMing *et al.* (22) in peach, who also reported that reflective mulches improve the physical as well as biochemical quality of fruits.

Conservation of soil moisture has long been considered one of the most significant advantages of mulching in fruit trees. The periodic changes in soil moisture contents indicated that all mulches conserved sufficient soil moisture compared to unmulched treatments (Fig. 1). Among all the tested mulches (Fig. 1), grass mulch (T_3) maintained higher moisture contents ranged between 7.91 to 1.59 % at 0-15 cm and 9.41 to 22.20 % at 15-30 cm depth throughout the cropping season except in the month of May where, moisture was registered highest under

black polythene mulch (T_4) during 2014. Similar trend was observed during the year 2015, the values of moisture content ranged between 8.73 to 18.30 % at 0-15 cm and 10.70 to 20.14 % at 15-30 cm depth however, in the month of May, black polythene mulch (T_4) recorded higher moisture owing to less precipitation. The lowest soil moisture contents were recorded under control (T_7) during both the years. However, moisture content at 30 cm depth was higher as compare to 15 cm depth during entire course of study.

Higher moisture conservation under grass mulch may be due to greater infiltration capacity, while black polythene mulch conserved more moisture during drier period probably due to its condensation capacity which in turn reduced evaporation of water from the soil. The results are in line with Greenham (11) who stated that the general improvement in soil moisture status is likely a consequence of both improved infiltration capacity and reduced evaporation. Bhardwaj and Kumar (3) found that black polythene mulch acts as an insulating barrier, which checks evaporation from soil surface and conserves soil moisture. Similar findings were obtained by several researchers (Sharma and Kathiravan, 18; Kumar *et al.*, 12; Chandel *et al.*, 5) who reported comparatively higher soil moisture contents in different mulches over unmulched trees.

Soil temperature at different depths (10 and 15cm) was influenced appreciably by various orchard floor management treatments (Fig. 2). Maximum soil temperature was recorded under black polythene mulch (T_4) on all dates of observation, which ranged from 19.63 °C to 28.13 °C and 19.03 °C to 26.50 °C at 10 cm depth during the year 2014 and 2015, respectively. It followed the similar pattern at 15 cm depth as exhibited by 10 cm depth where, black polythene mulch (T_4) recorded the maximum soil temperature ranging from 18.63 °C to 27.38 °C in 2014 and 18.25 °C to 25.50 °C in 2015 on all dates except on 15th June wherein chemical weed control (T_2) recorded highest (25.75 °C) soil temperature, but it was found statistically at par with black polythene mulch (T_4) on this date.

High soil temperature under black polythene mulch (Fig. 2) may be attributed to the fact that it absorb more radiation from sun and thus transmit the absorbed radiation to the upper layer of soil (Sharma and Kathiravan, 18). The entrapment of long wave radiation from soil and reduction in conduction and convection loss also contributed in warming under black polythene mulch. The results of present study confirmed the findings of Sharma and Kathiravan (18) in 'Santa Rosa' plum. Lower soil temperature under bicolour polythene mulch than black polythene mulch may be due to its reflective nature (Sharma and Kathiravan, 18).

Minimum soil temperature was registered under grass mulch (T_3) at both the depths during both the years. It might be due to thick grass cover (12-15 cm thick) provided, thereby preventing atmospheric heat to reach the soil surface. Greenham (11) reported that organic mulches generally insulate the orchard soil and as a consequence lessen orchard soil temperature variability, reducing daily and annual temperature extremes. The mean soil temperatures beneath inorganic mulches in summer are frequently lower than under organic mulches (Gormley *et al.*, 10).

On the basis of the results obtained from present investigation, it is inferred that grass mulch and black polythene mulch were appreciably effective in conserving soil moisture. On the other hand grass mulch and nylon mulch mat markedly improved the growth and cropping, respectively, while bicolour polythene mulch lead significant increment in fruit quality parameters and proportion of "A" grade fruits. However, to meet the multiple objectives of maintaining adequate soil hydrothermal regimes, growth, yield and fruit quality bicolour polythene mulch was found to be the best treatment for nectarine production under rainfed conditions of Himachal Pradesh.

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Received : February, 2019; Revised : May, 2019;
Accepted : May, 2019