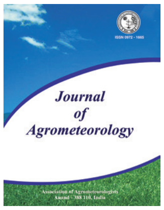

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Short Communication

Effect of anti-hail net installations on microclimate around apple plants in orchards of Himachal Pradesh

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In India, agricultural production is increasingly becoming vulnerable to climate variability. The changes can be attributed to the altered frequency, timing and magnitude of temperature as well as precipitation. Various weather events *viz.*, flash floods, hailstorms, droughts, heat waves etc. are causing extensive damage to crop and affecting productivity. The temperature in apple growing regions of Himachal Pradesh has shown increasing trends whereas precipitation showed decreasing trends (Rana *et al*. 2011). Hail is one of the most feared weather phenomena because it has the potential to destroy plants, trees, crops, animals and human life if strong enough. Even a short episode of hail can cause severe injury to crops, fruits trees both downgrading the quality of fruits and causing subsequent damage due to occurrence of disease like blight, moulds, rots, etc. It is difficult to quantify and identify the hail due to inhomogeneity in previous data available. During the year 2015, about 9381 million hectare land was affected due to hailstorm, out of which 0.067 million hectare land of Himachal Pradesh was affected by the hailstorm (Chattopadhyay *et al.,* 2017).

Changing climate have resulted in shifting of apple belt from lower to higher elevation areas, lower lying areas are no longer suitable to produce quality apple due to low chilling (Singh and Patel 2017). The ever-growing demand for quality fruit has forced, growers to experimenting with different mitigation measures to reduce apple damage. Anti-hail guns are also used as a measure to divert hail producing clouds but this method is not fully convenient and economic. On the other hand, anti-hail nets provide protection from hail damage and are also considered economical. Therefore, anti-hails nets are considered the best measure for hail damage mitigation so far.

Shade nets are extensively used by the apple growers to protect the apple fruits from hail damages as well as radiation damages, as excessive solar radiation causes fruit physiological disorders resulting in huge economic loss for the growers (Rackson and Schrader, 2012). Anti-hail nets change the microclimate of orchards and hence modify the physicochemical and sensory characteristics of fruits (Bosco *et al.,* 2015). Protective netting modifies the microclimatic factors such as light intensity and quality, canopy temperature, relative humidity, and soil temperature in the orchard. For apple production, it is very important to select the right type of netting according to the growing environment. Protective netting acts as a barrier for light and wind passes through it, and it directly alters the canopy and soil temperature. Maximum air temperature under hail net decreases up to 3 degrees and wind speed was decreased by 30-50% under net (Peano *et al*., 2001). Two degree reduction in daily temperature can be seen under the nets as compared to uncovered plot (Tanny *et al.,* 2009). Similarly Middleton *et al* (2002) observed decrease in the wind speed within an orchard from about 40-50 per cent and increase in humidity by 10-15 per cent. On the other hand, protective netting also changes the quality of light passing, altering light diffusion, reflectance, transmittance and absorbance (Basile *et al.,* 2008). In the present study, the change in microclimatic conditions in apple orchards having anti hail net has been studied and analyzed.

The study was carried out in areas where anti hail nets are installed to protect Apple fruit from hail damages. Three locations, *viz.,* Theog, Rohru and Mashobra were selected (Fig 1). A preliminary survey was conducted at six locations to identify the hail hit areas in Shimla district (Table 1). It was observed that Theog, Mashobra and Rohru received 5 hail days during April and May followed by Narkanda which witnessed 4 number of hail events followed by Kotgarh which received 3 hail days. Minimum hail days were observed at Rampur and Nankhari (2 each). The white nets with 10-20 per cent shade effects were used to protect the orchard in the present study. Apple orchards in each site with hail nets and without hail nets were selected. Temperature, humidity,

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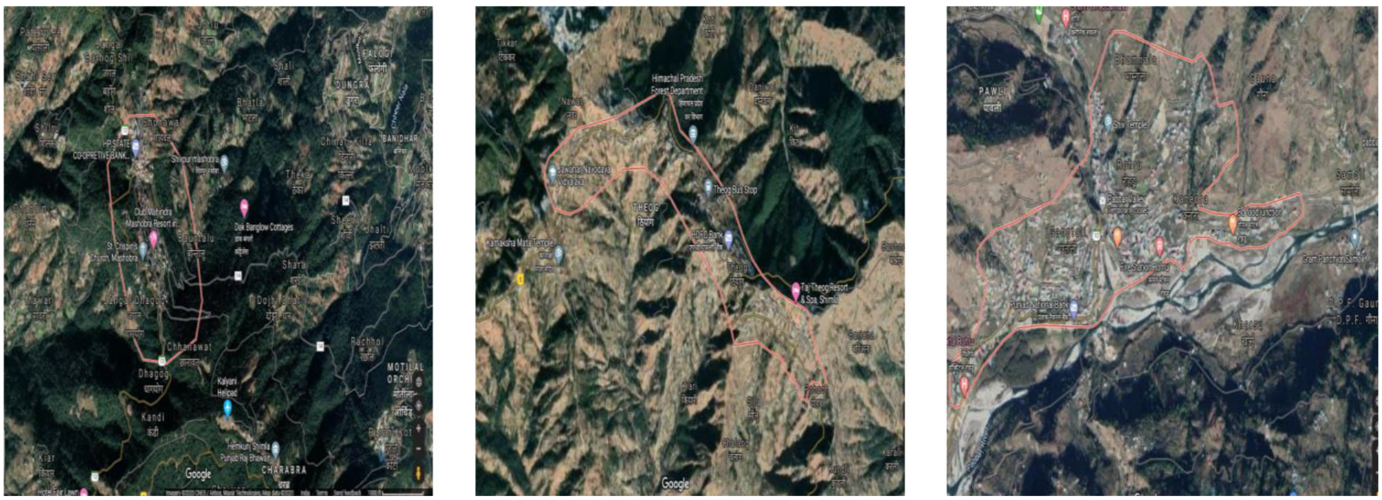
Table 1: Hailstorm events with duration (minutes) at different places in Shimla district

Date / places	April 4, 2019	April 21, 2019	May 1, 2019	May 10, 2019	May 11, 2019	May 12, 2019	June 6, 2019	June 14, 2019
Theog	1-2	15-20	<1	10-13	Nil	3-4	Minor	Nil
Mashobra	Nil	1-2	1-2	3-5	Nil	1-2	Nil	1-2
Kotkhai	Nil	20-22	Nil	5-6	Nil	Nil	3-4	nil
Rohru	1-2	18-20	Nil	5-6	Nil	Nil	1-2	2-3
Rampur	Nil	Minor	Nil	Nil	3-4	Nil	Nil	<1
Kotgarh	Nil	3-4	Nil	Nil	4-6	Nil	<1	Nil
Narkanda	Nil	20-22	1-2	2-3	Nil	2-4	Nil	Nil
Nankhari	Minor	5-10	Nil	Nil	Nil	4-5	Nil	Nil



(a) (b) (c)

Fig. 1 : Selected areas for apple orchards, (a) Mashobra, (b) Theog and (c) Rohru

light penetration, soil temperature and soil moisture were recorded at different sites with net and without net between 11 am to 12 noon hours. Relative humidity and temperature data were recorded in orchards with nets and without nets using thermo-hygrometer. Light penetration was recorded by using Lux meter. Soil temperature was taken by using soil thermometer at 30 cm depth. Soil moisture upto 30 cm depth was calculated by using the gravimetric method.

The microclimatic conditions varied significantly under net and without net (Table 2) at all the three locations. Significant decrease in air and soil temperature and light penetration was observed under the anti-hail nets. A significant decrease in air temperature was recorded under the hail nets. The mean temperatures recorded at all locations under the hail nets and without net were 21.6^{o}C and 24.3^{o}C, respectively. This indicated that temperature under the hail net was 11.11 per cent less as compared to plot without net. Similar observations were recorded by Tanny *et al.,* (2009) observed a decrease in temperature by 2^{o}C under the hail nets. The reduction in temperature might be due to less light penetration under the hail nets and hence, decreasing the overall temperature under the nets.

Mean light penetration under the net was recorded 329.66 μmol m^{-2} s^{-1} and without net it was observed of 487.33 μmol m^{-2} s^{-1}. The light penetration under hail net was 32.35 per cent less as compared to plot without net. The above results are supported by the findings of Peano *et al*. (2001), they observed that nets installation can reduced the incident solar radiation by 25 per cent. Decrease in light penetration may be due to the barrier created by hail nets. Similar to the air temperature, soil temperature under hail nets was found to be lower whereas significant amount of increase in soil moisture was observed under the hail nets. Mean soil temperature with net was 23.7^{0}C, which was significantly lower than the mean soil temperature without net i.e. 26.3^{0}C. A significant decrease of 9.88 per cent in soil temperature was observed under net. The decrease in soil temperature was attributed to reduction in the amount of light reaching the ground through shade net and hence, resulting in decrease in soil temperature. Similar results were also observed by Kalcsists *et al.,* (2018), and observed 20 per cent increase in soil moisture up to the depth of 0-30 cm.

Mean relativity humidity under the net was observed 43 per cent and without net humidity was 37 per cent. A significant decrease of 15 per cent was observed in humidity under the nets, decrease in atmospheric humidity under shade net as compared to open condition might be due to considerable decrease of wind speed within the orchard. The above results are supported by the findings of Middleton *et al.* (2002) who reported 10-15 percent increase in air humidity along with 40-50 per cent decrease in wind speed within an orchard with shade net as a whole.

A significant increase of 7.91 per cent was observed

Table 2: Microclimatic parameters around selected apple orchard with net and without net

Parameters	Temperature (°C)		Light penetration (µmol m^{-2} s^{-1})		Soil temperature (°C)		Humidity (%)		Soil moisture (%)		Apple yield (kg)	
Location	Under net	Without net	Under net	Without net	Under Net	Without net	Under net	Without net	Under net	Without net	Under net	Without net
Theog	22.0	23.8	342.00	487.00	24.1	27.5	43	36	37.05	33.25	5,880	4,732
Rohru	22.8	27.0	409.00	620.00	25.0	27.0	37	32	35.20	33.21	3,808	2,968
Mashobra	20.0	22.0	238.00	355.00	21.6	24.9	50	43	42.93	39.60	7,952	7,868
Mean	21.6	24.3	329.66	487.33	23.7	26.3	43	37	38.39	35.33	17,640	15.568
CD: 0.05	0.71		27.21		1.07		0.50		2.14		-	
Difference (%)	11.11		32.35		9.88		15		7.91		11.77	

in soil moisture content under the nets as compared to orchards without nets. Mean soil moisture under net was 38.39 per cent whereas mean soil moisture without net was 35.35 per cent. Increase in soil moisture content might be due to reduction in amount of solar radiation reaching the ground. Apple yield in all the three selected sites under the hail nets was higher than orchard without anti hail net. Total apple yield from all three selected locations was 17,640 kg under the net and 15,568 were extracted from orchards without net, an increase of 11.77 per cent (Table 2). Meena *et al.,* (2014) also observed 22.1 per cent more yield of spinach under the nets.

The present study revealed that the microclimatic conditions varied significantly under the hail nets. A significant alteration in microclimatic parameters is caused due to hail nets as hail nets decreases the total incident solar radiation therefore altering all the other environmental factors like temperature, humidity, light and soil moisture, under net yield had higher value than without nets.

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