MAUSAM, **73**, 4 (October 2022), 941-948

MAUSAM

DOI: https://doi.org/10.54302/mausam.v73i4.3215
Homepage: https://mausamjournal.imd.gov.in/index.php/MAUSAM

UDC No. 634.13 : 631.436 : 551.571 (540.15)

Mulching effects on soil temperature and yield of pear [Pyrus pyrifoila (Burm.) Nakai] in humid subtropical climate of Punjab

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(*Received 7 October 2021, Accepted 27 April 2022*)

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सार – **भारत के उत्तर पश्चिमी क्षेत्र के उपोष्णकटिबंधीय भाग की मिट्टी के तापमान और नाशपाती पैदावार पर मल्च सामग्री के प्रभाव का अध्ययन दो वर्षों** 2018 **और** 2019 **के लिए किया गया । भिन्न-भिन्न प्रकार के मल्च जैसे: धान का पुआल मल्च** (Psm), **सफेद पॉलिथीन मल्च** (Wpm) **और काली पॉलिथीन मल्च** (BPM) **अप्रैल के दूसरे सप्ताह के दौरान 'पत्थरनाख' नाशपाती के पेड़ों की छतरियों के नीचे लगाया गया। भिन्न-भिन्न मल्च सामग्री के सापेक्ष प्रभावों की तुलना करने के लिए वेडी चेक (नियंत्रण) और हाथों से निराई किए गए भूखंडों को रखा गया। समय अंतराल और वर्षों के बीच, मिट्टी का उच्च तापमान डब्ल्यूपीएम मल्च के साथ उसके बाद बीपीएम के साथ देखा गया, जबकि मिट्टी का सबसे कम तापमान पीएसएम के साथ दर्ज किया गया। डब्ल्यूपीएम अभिक्रिया ने दोनों वर्षों में जांच के दौरान** $16^{वें}$ **से** $28^{वें}$ **मानक मौसम विज्ञान सप्ताह** (एसएमडब्ल्यू) **तक मिट्टी के गर्म होने का प्रभाव दिखाया। भिन्न-भिन्न प्रकार के मल्चों ने पत्थरनाख नाशपाती के फलों की उपज और उसकी गुणवत्ता को महत्वपूर्ण रूप से प्रभावित किया। अधिकतम फलों का वजन** (2018 **में** 152.8 **ग्राम और** 2019 **में** 159.4 **ग्राम**) **और फलों की उपज** (2018 **में** 135.3 **किलोग्राम/पेड़ और** 2019 **में** 145.2 **किलोग्राम/पेड़**) **पीएसएम में देखा गया, जबकि न्यूनतम नियंत्रण में वेडी चेक** (2018 **में** 145.3 **ग्राम और** 2019 **में** 148.7 **ग्राम**) (2018 **में** 120.5 **किलोग्राम/पेड़ और** 2019 **में** 126.8 **किलोग्राम/पेड़**) **था। पत्थरनाख नाशपाती के फलों के आकार और उपज में वृद्धि के लिए** Psm **का उपयोग फलोद्यान तल प्रबंधन अभ्यास के रूप में किया जा सकता है।**

ABSTRACT. The effect of mulch materials on soil temperature and yield attributes in pear under subtropics of North Western region of India were studied for two years 2018 and 2019. The different mulches viz. paddy straw mulch (PSM), white polythene mulch (WPM) and black polythene mulch (BPM) were applied underneath the canopies of the 'Patharnakh' pear trees during the second week of April. The weedy check (control) and manual weeding plots were maintained to compare the relative effects of different mulch materials. Among the time intervals and years, the higher soil temperature was observed with the WPM mulch followed by BPM while the lowest soil temperature was recorded with PSM. The WPM treatment showed soil warming effect from the 16^{th} to 28^{th} standard meteorological week (SMW) during both years of investigation. Different mulches significantly influenced the fruit yield and quality attributes of the Patharnakh pear. The maximum fruit weight (152.8 g in 2018 and 159.4 g in 2019) and fruit yield (135.3 kg/tree in 2018 and 145.2 kg/tree in 2019) were observed in PSM, while minimum in control as weedy check (145.3 g in 2018 and 148.7 g in 2019) (120.5 kg/tree in 2018 and 126.8 kg/tree in 2019). PSM can be used as orchard floor management practice to improve fruit size and yield in Patharnakh pear.

Key words – Soil temperature, mulches, management practices, pear, fruit attributes.

1. Introduction

Pear [*Pyrus pyrifoila* (Burm.) Nakai] belong to temperate regions of the World, however, the low chill varieties can be cultivated in the sub-tropics of North Western India. In Punjab state, pear is the fourth most important crop after citrus, guava and mango and presently grown over an area of 3501 hectare and productivity of 23.39 tons ha^{-1} (Anonymous, 2020). The fruit development period in pear coincides with summer months characterized by high air temperature and low humidity which consequently affect the fruit yield and quality. The high evapotranspiration during April to June months results in rapid soil moisture loss affecting the fruit growth, development, yield and quality (Brar *et al.*, 2017).

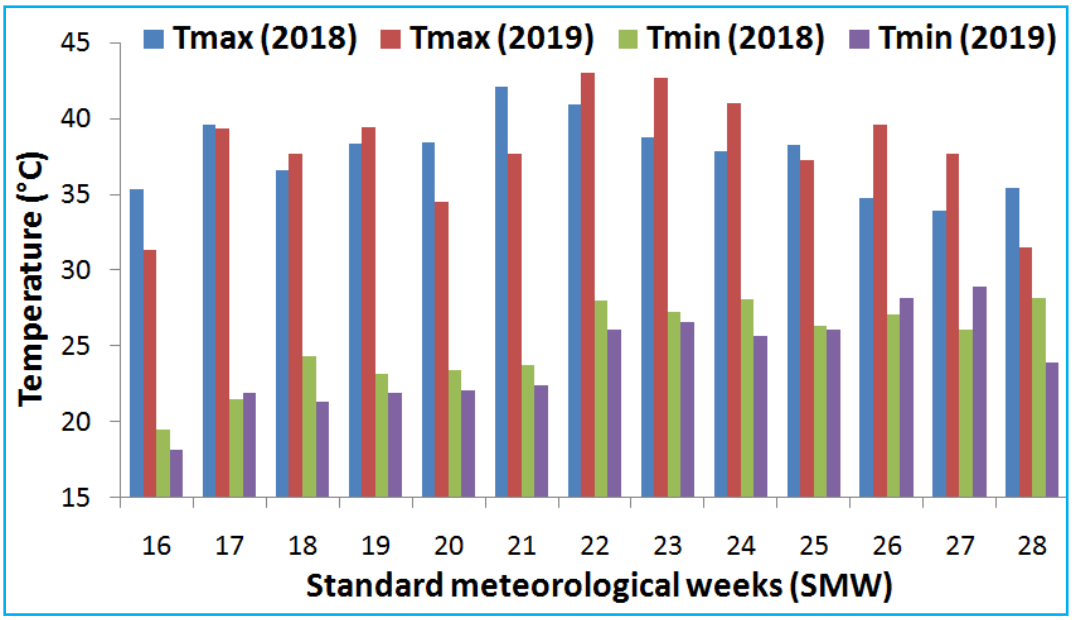

Fig. 1. Weekly average minimum and maximum temperature during study year of 2018 and 2019

Soil temperature is linked to crop growth and has an impact on plant activities and microbial diversity in the soil. Because of the decreased water viscosity at low temperatures, water intake is inhibited and photosynthesis is slowed. Cold circumstances impede the growth of roots and shoots by inhibiting cell reduplication and hence slowing overall growth. Crop growth is influenced by soil temperature, which in turn influences the quantity and diversity of soil microbial communities that allow temperate crops to grow at low soil temperatures (Sabri *et al.*, 2018).

A manipulation of soil micro-climate through orchard management practices such as mulch is highly successful adaptive approach (Panging *et al.*, 2019). Covering of soil surface or mulching the base of the tree with suitable materials can maintain or improve the physical properties of soil, sustain soil microclimate favorable for plant growth and development of fruits under extreme weather conditions. Mulches are known to conserve soil moisture, regulate soil temperature, improve soil aeration, suppress the weed flora, increase organic matter content and improve soil micro-organism activity (Tyagi *et al*., 2018).

In addition, organic mulches are effective in reducing nitrate leaching, improve physical properties of soil, preventing soil erosion, the addition of organic matter, regulation of temperature, improvement in water retention, nitrogen balance as well as microbial activities in soil (Muhammad *et al.*, 2009).

The plastic mulch significantly reduces evapotranspiration loss of water from soil and also regulates soil temperature which provides favourble conditions for the functioning of roots even under low temperature conditions (Fan *et al*., 2016; Iqbal *et al.*, 2020). Regulated soil temperature under water hyacinth mulch resulted in increment in leaf area index, biomass production and ultimate tuber yield of the potato as compared to other mulches (Panging *et al*., 2019).

Mulching is an extremely efficient non-chemical weed management approach that also has the added benefits of conserving soil moisture, increasing soil organic matter, and improving soil structure and nutritional status (Downer, 2009). To manage weeds, organic waste products such as cereal straw, weeds, aquatic weeds, manure, compost, bark, and composted municipal trash have been successfully employed as mulch. The application of black polythene, grass and straw mulch increases mandarin output, according to Abouziena *et al*., (2008). Joolka *et al.*, (2008) used black polythene mulch to achieve maximum fruit size, greatest SSC and lowest acidity in delicious apple while researching the effects of various weed management strategies. Mohanty *et al.*, (2002) found that mulching had no influence on the SSC of mandarin fruits, but that the black polythene treatment had the lowest acidity and the un-weeded treatment had the highest.

Till date, no literature was documented on effect of mulching on soil temperature regime and production of

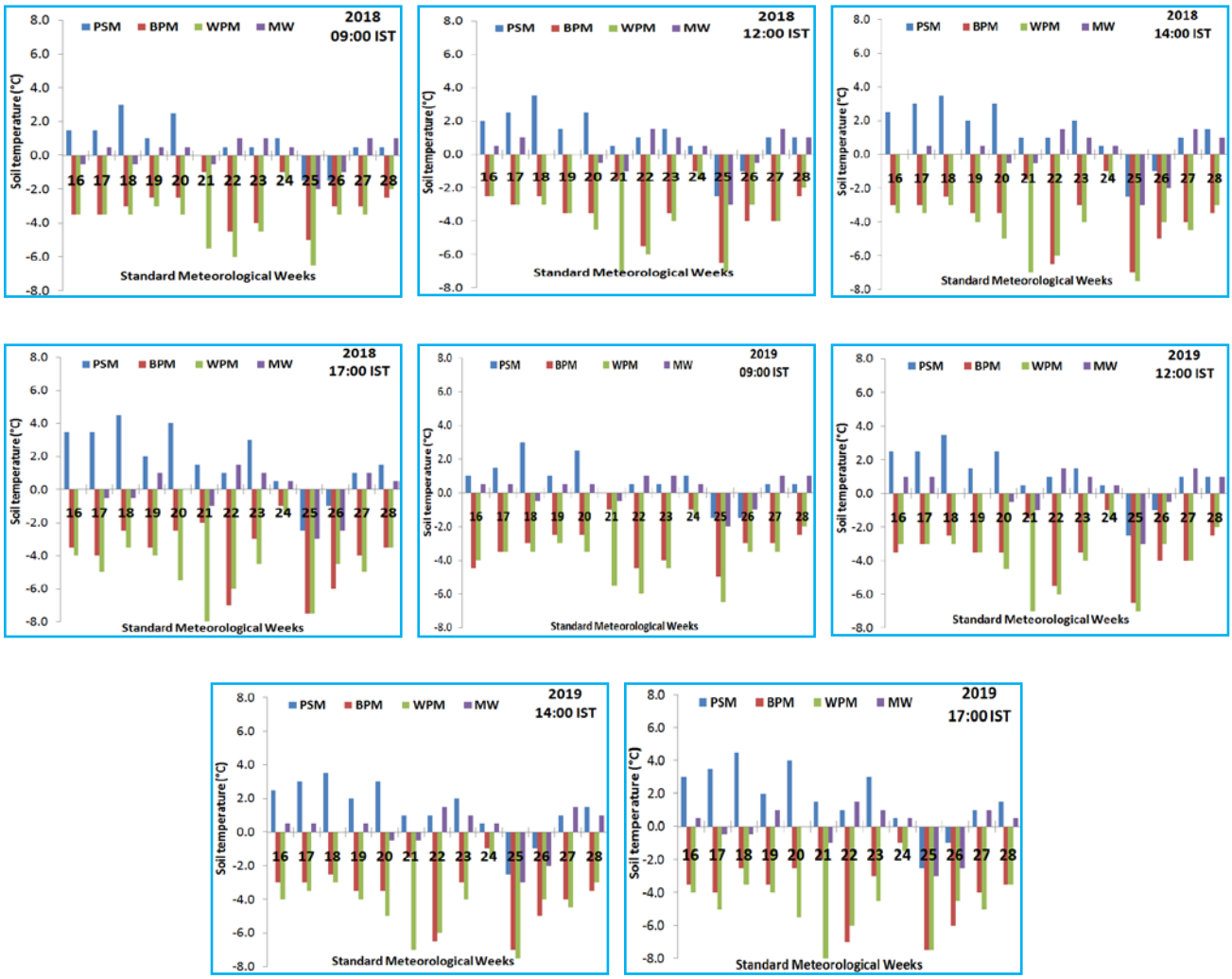

Fig. 2. The weekly soil temperature deviations under different mulching treatments in Pear orchard over weedy check treatment as control (from mid April to mid July) during study year of 2019

sub tropical pear, so the current study was conducted to evaluate the effects of various mulches on soil temperature and pear yield.

2. Data and methodology

2.1. *Weather and Climate of the study region*

The experimental site is located at 30.9 °N 75.85 °E at Punjab Agricultural University, Ludhiana with an elevation of 244 amsl. The climate of this region features a relatively dry monsoon-influenced the humid sub-tropical climate This location records an average annual temperature is 23.3 °C and receives ~760.8 mm of rainfall annually majority during the July to September months. The driest month is November, the warmest month of the year is June, with an average temperature of 32.0 °C. January is the coldest month of the year having 11.9 °C average temperature.

Weather data in Fig. 1 illustrated that the minimum and maximum temperatures varied from 19.0 - 28.0 °C and 34.0 - 42.0 °C during the year 2018 and from 18.0 - 29.0 °C and 32.0 - 43.0 °C during 2019, respectively**.** During the first year of study, the highest value of maximum temperature was observed in the 21st SMW followed by the 22nd SMW, while in year 2019, it was observed in the 22nd SMW. Similarly, during the year 2018, the higher value of the minimum temperature was noticed in the 28th SMW followed by the 24th SMW, while during 2019, it was observed during the 27th SMW followed by the 26th SMW. Overall, from 16th to 28th

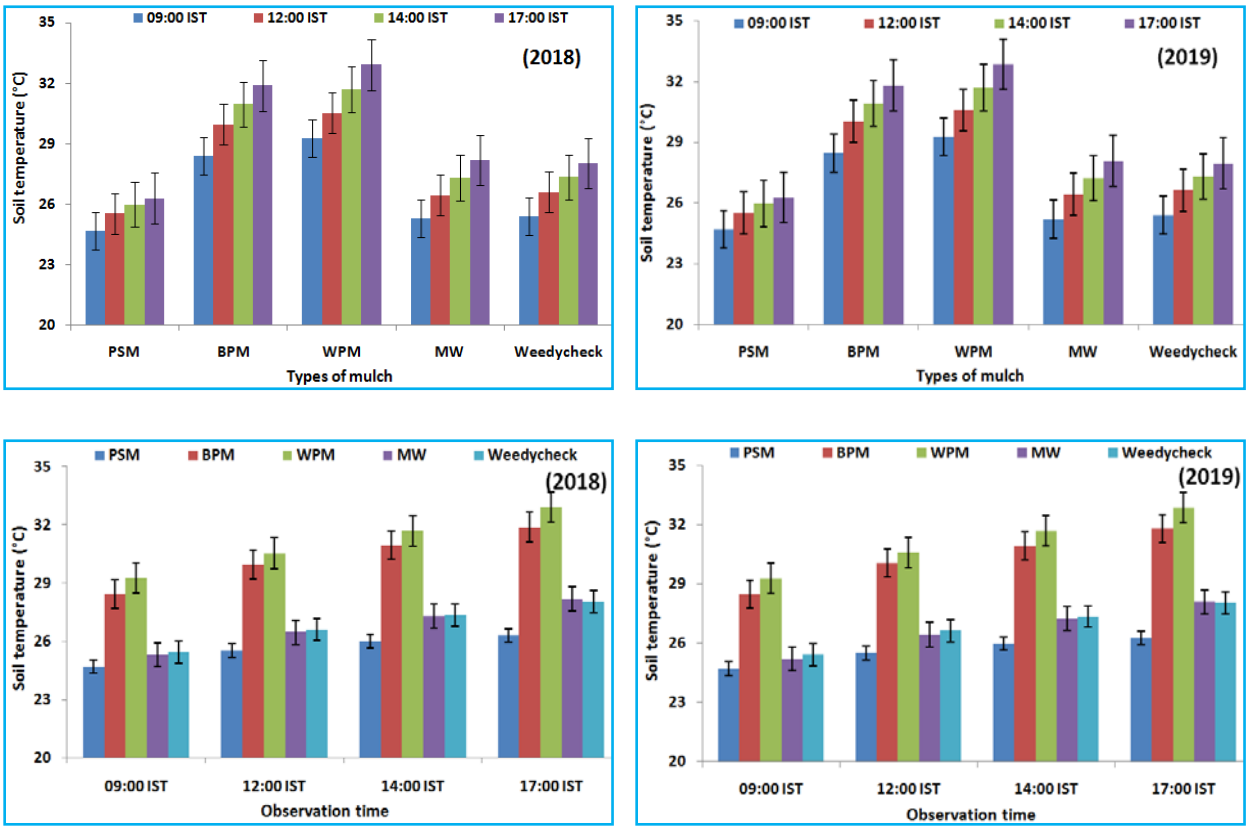

Fig. 3. Average soil temperature variations in respect to time intervals as well as different mulching treatments in Pear orchard for two consecutive years of 2018 and 2019

SMW, the higher average maximum temperature was recorded during 2018, while the higher minimum temperature was observed in 2019.

2.2. *Experimental details*

In the present study the different types of mulches such as paddy straw mulch (PSM), white polythene mulch (WPM) and black polythene mulch (BPM) were applied underneath the canopies of the 'Patharnakh' pear trees. Before application of mulches soil surface was kept weed free with manual hoeing. The mulches were applied in the second week of the April after the application of the second dose of inorganic fertilizers. The dried paddy straw was spread in the form of a 10 cm thick layer @ 5.5 tons /acre. The white (30µ thickness) and black (100µ thickness) polythene mulches were also applied as in the case of paddy straw mulching. The experiment was laid out in a randomized block design with three replications having three trees under each replication. The weedy check (control) and manual weeding (MW) plots were kept to compare the relative effects of different mulch materials.

2.3. *Soil temperature data*

Soil temperature was recorded at weekly interval from mid-April to mid-July (16^{th} to 28^{th} SMW) during both the study years. Soil temperature observations were recorded at 0900, 1200, 1430 and 1700 IST hours at 10 cm soil depth. However, minimum and maximum temperature was recorded from agro-meteorological observatory of the university which is located within 500m of study location.

2.4. *Fruit attributes and analysis*

The fruit yield was recorded at the time of fruit harvest by multiplying the number of fruits per tree and average fruit weight. The average fruit weight was calculated by weighing 30 randomly selected fruits per plant and yield was calculated by weighing all the fruits from the plant. Total soluble solids (TSS) content was determined using a digital hand-held refractometer (Atago, Japan). Titratable acidity of the fruit was expressed as malic acid % measured by titrating the fruit juice against 0.1 N NaOH.

TABLE 1

Effect of different mulching materials on fruit yield and quality characteristics of pear (2018 & 2019)

Treatments	Fruit weight (g)		Fruit yield (kg/tree)		TSS (%)		Acidity (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
PSM	152.8	159.4	135.3	145.2	12.5	12.6	0.32	0.30
BPM	149.1	153.2	130.4	137.4	12.3	12.3	0.31	0.32
WPM	150.9	154.6	133.1	141.5	12.4	12.5	0.32	0.32
Manual weeding	147.4	151.5	128.7	135.9	12.1	12.0	0.34	0.33
Weedy check (Control)	145.3	148.7	120.5	126.8	12.0	12.1	0.33	0.34
CD at 5%	3.32	4.86	3.56	3.78	0.24	0.34	NS	NS

2.5. *Statistical analysis*

For each character, the experimental data were evaluated using the analysis of variance (ANOVA) approach as instructed for a split plot design. For testing the significance of difference between two treatment means, the critical differences (CD) were calculated at a 5% level of probability. Additionally, a simple regression analysis was performed between the pear yield attributes to quantify the relationship between them using replicated data of both the years and the number of observations was 30.

3. Results and discussion

3.1. *Effect of mulch materials on soil temperature*

During the both years of study, weekly soil temperature deviations under different mulching treatments in pear plot over weedy check treatment as control (from mid-April to mid-July) is shown in Fig. 2. Additionally, the average soil temperature variations with time intervals as well as different mulching treatments are demonstrated in Fig. 3.

Soil temperature variations of various mulches from 16^{th} to 28^{th} SMW ranged between 21.5 - 32.5 °C, 22.5 - 34.0 °C, 23.0 - 35.0 °C and 22.5 - 37.0 °C recorded at 0900 IST, 1200 IST, 1400 IST and 1500 IST, respectively. The weekly soil temperature exhibited a rising trend from 16^{th} SMW upto 25^{th} SMW and decreased thereafter during both the study years. Among the time intervals of soil temperatures, the maximum value of soil temperature was observed in WPM mulch treatment followed by BPM treatment, while the minimum soil temperature was recorded in PSM treatment. During the investigation period, the PSM mulch treatment maintained the lower soil temperature from 16^{th} to 28^{th} SMW over weedy check(control) and also with the other mulching treatments. Additionally, WPM mulching treatment showed soil warming effect from 16^{th} to 28^{th} SMW.

Subsequently, the weekly soil temperature variations under different mulching treatments in pear over weedy check during 2018 indicated cooler soil temperature effect with PSM mulch treatment than all mulching treatments. The maximum number of positive values of soil temperature deviations were found with PSM mulch treatment which indicated an cooling effect, while, negative values indicated warming effect (Fig. 2). Similarly, among various time observations during study years, the higher negative values were recorded in WPM mulching treatment followed by BPM treatment which indicated warming effect over weedy check. Amongst the study years, the value of soil temperature ranged from -2.5 to 4.5 °C, -7.5 to -1.0, °C -9.0 to -1.5 °C and -3.0 to 1.5 °C for the mulching treatments of PSM, BPM, WPM and MW, respectively over control (Fig. 2).

The average soil temperature variations in time intervals as well as different mulching treatments as demonstrated in Fig. 3, also indicated cooling effect with PSM mulching (24.7 to 26.3 °C) followed by MW treatment (25.3 to 28.2 °C) over weedy check (25.4 to 28.0 °C). The higher value of mean soil temperature under WPM mulching treatment (29.3 to 32.9 °C) indicated warming effect followed by MW (25.3 to 28.2 °C) in both years (Fig. 3). Mulches regulate soil micro-climate, primarily soil moisture and temperature (Fan *et al.*, 2016; Iqbal *et al*., 2020) and manage temperature fluctuations in addition to improvement in soil physical, chemical as well as biological characteristics. Likewise, plastic mulches also improve the hydrothermal conditions of soil (Hai *et al.*, 2015; Wang *et al.*, 2016). Lower soil temperature

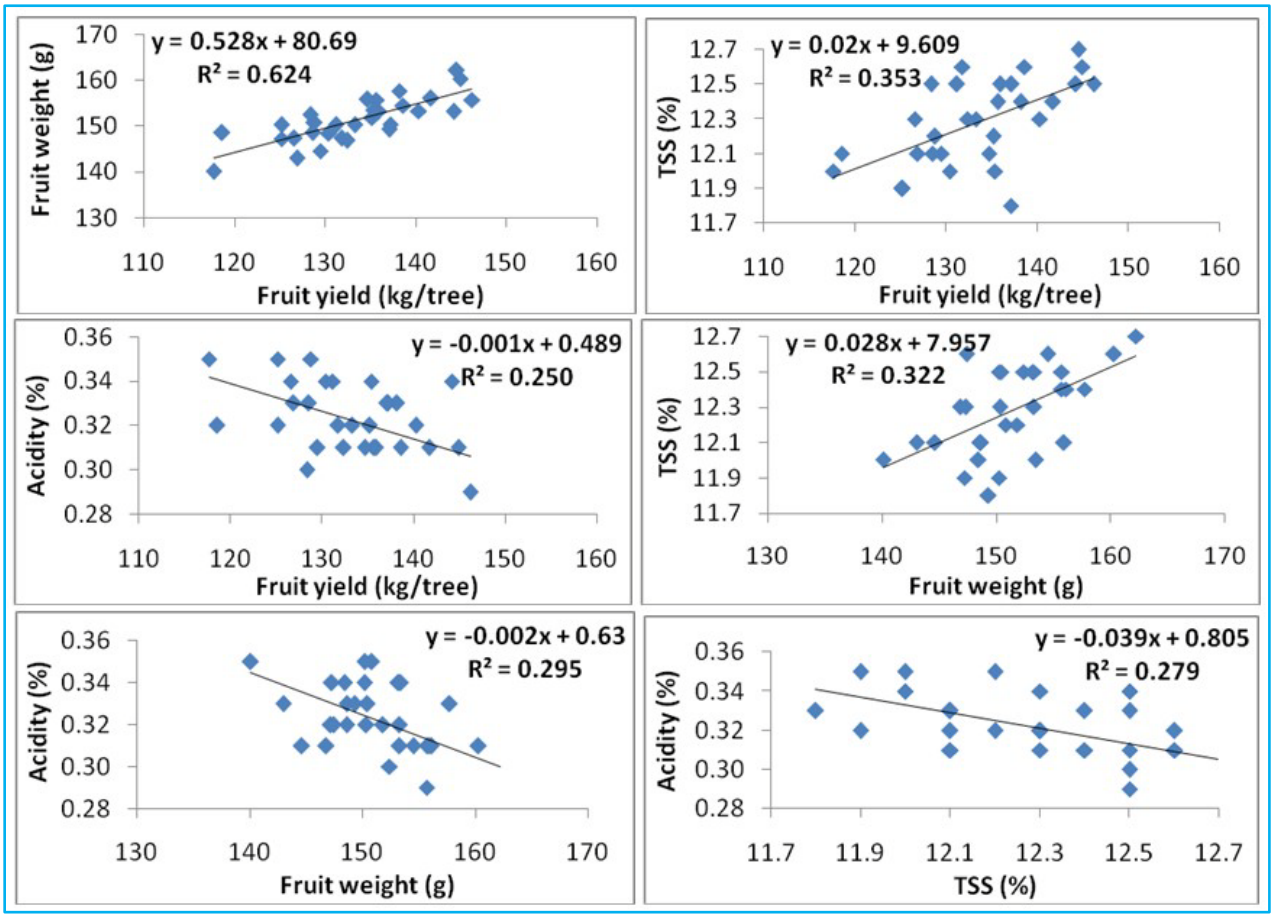

Fig. 4. Comparison between fruit yield *vs*. fruit weight, fruit yield *vs*. TSS, fruit yield *vs.* acidity, fruit weight *vs.* acidity, fruit weight *vs.* TSS and TSS *vs*. acidity as affected by different types of mulches during the study period of 2018 and 2019

during the entire season with combination of mulch and herbicide treatment than individual treatments of clean cultivation was reported by Rowley *et al*., (2011). Fourie and Freitag (2010) also reported a similar reduction in soil temperatures during summer and curtailing diurnal variation in soil temperature with the use of mulches in orchards.

3.2. *Effect of mulching materials on the fruit attributes*

It is evident from data in Table 1 that the different mulches significantly influenced the fruit quality parameters of the Patharnakh pear. The maximum average fruit weight (152.8 and 159.4 g) was observed in PSM followed by WPM (150.9 and 154.6 g) and the minimum fruit weight (145.3 and148.7 g) was recorded in control during years 2018 and 2019, respectively. Similarly, the maximum fruit yield was recorded from the trees with PSM as mulch (135.3 and 145.2 kg/tree) followed by 133.1 and 141.5 kg/tree under WPM as compared to fruit yield of 120.5 and 126.8 kg per tree in control treatment during the second year of study. The internal quality of pear fruits in terms of total soluble solids was better in PSM and WPM as compared to fruits obtained from control plants. Mulching enrich soil with the addition of essential nutrients and ultimately aid the plant growth and crop (Kar 2003; Saikia *et al*., 2014). The acid content of fruits under different mulch treatment was not affected. Mulches influence on plant growth and development (Kumar and Lal, 2012) as these alter the physio-chemical properties of soil and also soil hydrothermal regime (Hedua and Kumar, 2002). The readily available soil moisture and optimum soil temperature conditions during fruit growth and development period improves fruit size specifically under PSM and WPM.

Subsequently, linear regression regarding comparison between fruit yield *vs*. fruit variables (like fruit yield *vs*. fruit weight, fruit yield *vs*. TSS, fruit yield

vs. acidity, fruit weight *vs*. acidity, fruit weight *vs*. TSS and TSS *vs*. acidity) as affected by different types of mulches during the study period of 2018 and 2019 is depicted in Fig. 4. The higher as well as positive value of R^2 (0.62) was found with fruit weight *vs.* fruit yield indicates an increment in fruit yield with the higher fruit weight during both the years of study. Similarly, a positive correlation with increasing trends were also found for TSS (%) *vs*. fruit yield (kg/tree) (R^2 = 0.35) and TSS (%) *vs*. fruit weight (g) (R^2 = 0.32), while, decreasing trends were noticed for acidity (%) *vs*. fruit yield (kg/tree), acidity (%) *vs*. fruit weight (g) and acidity (%) *vs*. TSS (%) having R^2 value of 0.25, 0.30 and 0.28, respectively (Fig. 4).

4. Conclusion

The minimum soil temperature was recorded in PSM mulch treatment during both years of study and maintained the lower soil temperature from 16th to 28th SMW over weedy check. The different mulches influenced the fruit yield and quality parameters of the Patharnakh pear fruit. The maximum fruit weight and fruit yield was observed in PSM and the internal quality of pear fruits in terms of TSS was better in PSM than the rest mulches. Overall, the readily available soil moisture and optimum soil temperature conditions during fruit growth and development period improves fruit size under PSM, hence it is recommended for further use in the study region.

Acknowledgements

The research supported by the Punjab Agricultural University, Ludhiana, Punjab is duly acknowledged. The contents and views expressed in this research article are the views of the authors and do not necessarily reflect the views of the organization they belong to.

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