

Original Research Article

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Effect of Weed Management Strategies on Soil Nutrient Status of Apple (*Malus X Domestica*) under High Density Orchard System

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ABSTRACT

Weed management in high density orchards is a critical component for successful crop production. The present investigation was conducted in the Experimental fields of Division of Fruit Science, SKUAST, Kashmir during the year 2018 with the aim of standardizing the effect of various weed management strategies on soil moisture and nutrient availability. One year old trees of exotic apple cv. "Elstar" grafted on M-9 T337 rootstock, introduced by SKUAST-Kashmir from Holland in March 2017, were selected for experimentation. The thirteen treatments used were replicated thrice in Factorial Randomized Complete Block Design. Different weed management practices significantly influenced the soil temperature at 0-15 cm depth, highest being recorded under inorganic polyethylene mulches and lowest among organic mulches. Maximum mean soil temperature of 25.63 °C was recorded under T₃ (Unpunched black polyethylene mulch) which was statistically at par with T₂ (Punched black polyethylene mulch) (25.59 °C) and T₄ (Bi-colour polyethylene mulch) (25.38 °C). Minimum soil temperature (18.48 °C) was recorded under paddy straw mulch (T₅). Also the available nitrogen content of the soil was markedly influenced by various weed management practices during the year of study. Maximum available nitrogen content (323.78 Kg ha⁻¹) was recorded under paddy straw mulch (T₅) which was followed by T₁₂ (Oxyfluorfen followed by Glufosinate ammonium) (319.89 Kg ha⁻¹) and T₁₁ (Oxyfluorfen followed by Glyphosate) (316.83 Kg ha⁻¹). Minimum available nitrogen content (282.11 Kg ha⁻¹) was recorded under unweeded control. Available phosphorus content in soil was highest (22.22 Kg ha⁻¹) under paddy straw mulch (T₅) whereas minimum phosphorus content (19.12 Kg ha⁻¹) was recorded under unweeded control. Available potassium content was maximum (232.22 Kg ha⁻¹) in paddy straw mulch (T₅). Minimum potassium status (201.44 Kg ha⁻¹) in soil was recorded under unweeded control.

Keywords

Elstar, Organic mulch, Inorganic mulch, Herbicides and nutrients

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Introduction

Apple (*Malus × domestica* Borkh), known as the king of temperate fruits, is fourth among

the most widely produced fruits in the world after banana, orange and grapes. Jammu and Kashmir with the area of 1,64,742 hectares and production of 18,82,319 MT (2018-19) is

leading in both area and production in the country. The productivity of apple in India is very low as compared to developed countries like China, Italy, Spain, USA etc (FAOSTAT, 2018). The high-density planting system (HDP) is now being conceived as an alternative production system having a potential for improving productivity, increasing yield efficiency, reducing input cost, minimizing risks and maximizing returns. Weed management in high density orchards is a critical component for successful crop production. The primary goal of weed management is to optimize yield by minimizing the weed competition (Merwin, 2003). Because of shallow root system in HDPs the weeds cause heavy losses by competing with the main crop for water, nutrients and also provide potential breeding niche for various insects/pests and diseases. One of the disquieting challenges in fruit production is weed management and can be managed through various management strategies like manual, mechanical, cultural, biological and chemical control (Hira *et al.*, 2004). Nevertheless, manual weed control is not only laborious but is also highly expensive. In addition to this, annual and mechanical weeding can cause damage to the shallow root system in high density plantations. Thus, of late, manual and mechanical weed control methods are gradually being replaced by other alternatives such as the use of mulches and herbicides as these are easier, cheaper and less time consuming. These management strategies, except use of herbicides, not only suppress the growth and development of weeds but also improve soil conditions, structure and soil nutrient status and impart manifold beneficial effects, like, stabilization of soil temperature, reduced water loss through evaporation, increased water holding capacity of soil, and improvement in growth and yield (Shirgure *et al.*, 2003). The use of mulches for weed control is a well-established practice to

improve plant performance. Mulching plays an important role in the conservation of soil moisture (Hira *et al.*, 2004) during dry periods besides offering the advantage like suppression of weed growth (Kaur and Kaundal, 2009), reducing water runoff and soil erosion, provide cover for rodents that damage tree roots and trunks, improve water and fertilizer use efficiency (Salaria, 2009). Various materials of plant origin like straw, saw dust, wood chips, shredded paper (Rowley *et al.*, 2011), hay, crop residues and synthetic material like polyethylene plastic (Camposeo and Vivaldi, 2011), woven polypropylene fabric (Rozpara *et al.*, 2008), non-woven polyacrylic fabric (Camposeo and Vivaldi, 2011) have been extensively used as soil mulch in fruit orchards. Also new fabrics are being developed with white colour on top (to reflect light and heat) and black on bottom to suppress weeds (Makus, 2007). However, complete elimination of weed competition in orchards is possible with residual herbicides (Merwin, 2003). Herbicides are the most important weed control tools for alleviating the infestation of weeds and getting higher yield as reported by Ashiq *et al.*, (2007). Herbicidal weed control seems indispensable and has proved efficient in controlling weeds (Kahramanoglu and Uygur, 2010) and hence presently about two-third, by volume, of the pesticides used worldwide in agricultural production are herbicides. Herbicides are observed to be highly effective and economical in fruit orchard besides giving the satisfactory level of weed control when applied as pre-emergent or post-emergent. It also offers several advantages such as longevity of treatment, stimulation of plant growth, effective weed control, easily executed, are relatively cheap, and ensure high yielding of trees (Harrington *et al.*, 2005). Keeping in view the above facts, the present study was carried out in high density apple blocks with the objective of standardizing the effect of various weed

management strategies on soil temperature and soil nutrient availability.

Materials and Methods

Experimental site and climatic conditions

The present investigation entitled “Effect of Weed Management Strategies on Soil Nutrient Status of Apple Under High Density Orchard System” was carried out in the experimental fields of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir, Shalimar, Srinagar, Jammu & Kashmir during the year 2018. The experimental site is located at 34.1⁰ North latitude and 74.9⁰ East longitude. During the experimentation period, the average maximum temperature recorded was 25.3⁰C and the average minimum temperature recorded was 10.9⁰C. The total precipitation of 800.8 mm was received during 2018.

Soil

Before the start of the experiment, composite sample of the soil from 0-15 cm depth from all the replications was collected. The procedure followed for the analysis of soil for various chemical characteristics and the results obtained are given in Table 1.

Planting material

One year old trees of exotic apple cv. “Elstar, spaced 1 x 3 m (3333 trees /ha), grafted on M-9 T337 rootstock and introduced by SKUAST-Kashmir from Holland in March 2017 were selected for experimentation. The trees of uniform size, vigour and bearing capacity were selected for experiment. All the trees under study received uniform cultural practices during the year as per the package of practices of SKUAST-Kashmir. Treatments and replications were randomly assigned with a single plot size.

Experimental details

Thirteen treatments comprising of various organic and inorganic mulches and also pre and post emergent herbicides were laid out in Randomized complete block design (RCBD), with each treatment replicated thrice. The mulches were applied during the last the last week of March. The commercial formulations of pre and post- emergent herbicides were sprayed with high volume Knapsack sprayer. Pre-emergent herbicide was applied during the first week of March, whereas post-emergent herbicides were applied during mid-June. The details of the pre and post emergent herbicides used are given in Table 2.

Active ingredient (a.i.)

It is a part of chemical formulation which is directly responsible for herbicidal effect. Thus, the commercial herbicide is made up of two parts i.e. the effective part and the inert part. Since all the recommendations are made on the basis of a.i., herbicides quantity was calculated with following formula:

$$\text{Weight of herbicide required (Kg ha}^{-1}\text{ or L ha}^{-1}\text{)} = \frac{\text{Dose of chemical required}}{\text{Active Ingredient \% in chemical Product}} \times 100$$

Soil temperature (°C)

Soil temperature (°C) of each experimental treatment was recorded at depth of 0-15 cm with the help of soil thermometer. First reading was taken on 1st May and subsequent readings at 30 days intervals. Final reading was recorded at the time of harvesting.

Soil pH

Soil pH was determined in 1:2.5 soil: water suspension using pH meter with glass electrode as described by Jackson (1973).

Available nitrogen (Kg ha⁻¹)

Available nitrogen was determined by alkaline potassium permanganate distillation method as described by Subbiah and Asija (1956).

Available phosphorus (Kg ha⁻¹)

Available phosphorus content of the soil was determined by Olsen method using 0.5 N sodium bicarbonate at pH 8.5 (Olsen *et al.*, 1954).

Available potassium (Kg ha⁻¹)

Available potassium was extracted with neutral 1 N ammonium acetate at 1:5 soil to extract ratio and the content of potassium was estimated by Flame photometer (Jackson, 1973).

Statistical analysis

The data recorded under study was subjected to standard statistical analysis as followed by Gomez and Gomez (1984) using the statistical software (SAS), according to randomized complete block design. The treatment effects were tested at 5 per cent level of significance.

Results and Discussion

The data presented in Table 3 indicate that different weed management practices significantly influenced the soil temperature at 0-15 cm depth, highest being recorded under inorganic polyethylene mulches and lowest among organic mulches. Maximum mean soil temperature of 25.63 °C was recorded under T₃ (Unpunched black polyethylene mulch) which was statistically at par with T₂ (Punched black polyethylene mulch) (25.59 °C) and T₄ (Bi-colour polyethylene mulch) (25.38 °C). Further investigation of data revealed that treatments

T₈ (Oxyfluorfen), T₁₂ (Oxyfluorfen followed by Glufosinate ammonium), T₁₀ (Glufosinate ammonium), T₉ (Glyphosate) and T₁₁ (Oxyfluorfen followed by Glyphosate) were statistically at par for their effect on soil temperature. Minimum soil temperature (18.48 °C) was recorded under paddy straw mulch (T₅). Among different days after treatments of observation, maximum soil temperature (23.37 °C) was recorded on 90 days and 120 days. However minimum soil temperature was recorded on 30 days (19.75 °C). Among treatments and days after treatments interaction, maximum soil temperature (27.43 °C) was recorded under unpunched black polyethylene mulch on 90 days, which was statistically at par with T₂ on 90 and 120 days and also with T₃ on 120 days. An increase in soil temperature, under inorganic mulches (black polythene and bi-coloured polythene mulch), may be attributed to the fact that these mulches absorb more radiation from Sun and thus transmit more heat to the upper layer of soil as compared to other organic mulches. These results are in accordance with the findings of Ramakrishna *et al.*, (2006), Sharma and Kathiravan (2009), Liu *et al.*, (2014) and Hussain *et al.*, (2018), who reported higher temperature under polythene mulches as compared to other organic mulches, herbicide treated soil and bare soils in various fruit crops.

The decrease in soil temperature under organic mulches may be due to the fact that organic mulches, generally, insulate the orchard soil against heat and have low thermal conductivity and thus reduce the heat flux, acting as a coolant besides retarding diurnal and internal temperature fluctuations (Greenham, 1953; Engel, 1960). Organic matter mulch treatments decreased the peak temperature of orchard soil in the summer and increased the minimum soil temperature in the fall.

Table.1 Chemical characteristic of experimental orchard soil

Particular	Content	Method followed
Soil pH	6.54	1:25 soil: water suspension using pH meter with glass electrode (Jackson, 1973)
Available Nitrogen (Kg ha ⁻¹)	289.26	Alkaline potassium permanganate distillation method (Subbiah and Asija, 1956)
Available phosphorus (Kg ha ⁻¹)	20.54	Olsen's method (Jackson, 1973).
Available potassium (Kg ha ⁻¹)	210.86	Neutral normal ammonium acetate method (Jackson, 1973)

Table.2 Details of the herbicides used in present studies

Common Name	Trade Name	a.i.	IUPAC Name	Manufacturer
Oxyflourfen	Galigan	23.5% EC	2-Chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene	ADAMA India Private Limited
Glyphosate	Roundup	41% SL	2-(phosphonomethylamino) acetic acid	Monsanto India limited
Glufosinate Ammonium	Mera71	71% SG	2-amino-4-[hydroxyl(methyl)phospho-ryl] butanoic acid	Excel Crop Care Limited

Table.3 Effect of weed management strategies on soil temperature of apple cv. Elstar under high density orchard system

Days after reference date (1 st April) Treatments	Soil temperature (°C)				
	30	60	90	120	Mean
T ₁ :Farmer's Practice (Hoeing at 45 days interval, 3 hoeing's starting from last week of March)	20.07	21.80	22.93	22.57	21.84
T ₂ :Black polyethylene mulch (Punched) - 200µ	21.83	26.33	27.30	26.90	25.59
T ₃ :Black polyethylene mulch (Unpunched) - 200 µ	21.87	26.33	27.43	26.90	25.63
T ₄ :Bi-Colour polyethylene mulch - 200 µ	22.67	25.70	26.87	26.30	25.38
T ₅ :Paddy Straw mulch - 10cm thickness	16.07	18.70	19.40	19.77	18.48
T ₆ :Forest Litter (Pine Needles) - 10cm thickness	16.73	18.40	18.90	19.97	18.50
T ₇ :Chopped lawn grass - 5cm thickness	17.50	18.70	19.03	18.97	18.55
T ₈ :Oxyflourfen @ 0.5 L ha ⁻¹ (Pre-emergence herbicide)	19.60	22.93	24.77	23.97	22.82
T ₉ :Glyphosate @ 2.0 L ha ⁻¹ (Post-emergence)	20.07	21.93	23.67	24.30	22.49
T ₁₀ :Glufosinate ammonium @ 0.84 Kg ha ⁻¹ (Post-emergence)	19.67	22.60	24.33	23.77	22.59
T ₁₁ :Oxyflourfen @ 0.5 L ha ⁻¹ (Pre-emergence herbicide) followed by Glyphosate @ 2.0 L ha ⁻¹ (Post-emergence)	19.73	21.87	23.43	23.83	22.22
T ₁₂ :Oxyflourfen @ 0.5 L ha ⁻¹ (Pre-emergence herbicide) followed by Glufosinate ammonium @ 0.84 Kg ha ⁻¹ (Post-emergence)	20.20	22.87	23.70	23.77	22.63
T ₁₃ :No Weeding (Control)	20.73	21.17	22.00	22.40	21.58
Mean	19.75	22.26	23.37	23.37	

C.D (≤0.05)

Treatments	:	0.623	
Days	:		0.346
Treatment x Days	:	1.246	

Table.4 Effect of weed management strategies on soil characteristics of apple cv. Elstar under high density orchard system

Treatments	pH	Nitrogen (Kg ha ⁻¹)	Phosphorus (Kg ha ⁻¹)	Potassium (Kg ha ⁻¹)
T ₁ :Farmer’s Practice (Hoeing at 45 days interval, 3 hoeing’s starting from last week of March)	6.48	291.76	19.56	209.37
T ₂ :Black polyethylene mulch (Punched) - 200µ	6.50	305.97	21.68	223.93
T ₃ :Black polyethylene mulch (Unpunched) - 200 µ	6.53	305.38	21.55	223.04
T ₄ :Bi-Colour polyethylene mulch - 200 µ	6.54	306.22	21.96	224.29
T ₅ :Paddy Straw mulch - 10cm thickness	6.54	323.78	22.22	232.22
T ₆ :Forest Litter (Pine Needles) - 10cm thickness	6.47	314.57	21.92	231.28
T ₇ :Chopped lawn grass - 5cm thickness	6.55	315.56	21.67	230.32
T ₈ :Oxyfluorfen @ 0.5 L ha ⁻¹ (Pre-emergence herbicide)	6.62	297.21	20.60	211.34
T ₉ :Glyphosate @ 2.0 L ha ⁻¹ (Post-emergence)	6.57	293.78	20.68	212.33
T ₁₀ :Glufosinate ammonium @ 0.84 Kg ha ⁻¹ (Post-emergence)	6.56	294.85	21.04	212.27
T ₁₁ :Oxyfluorfen @ 0.5 L ha ⁻¹ (Pre-emergence herbicide) followed by Glyphosate @ 2.0 L ha ⁻¹ (Post-emergence)	6.57	316.83	21.44	226.51
T ₁₂ :Oxyfluorfen @ 0.5 L ha ⁻¹ (Pre-emergence herbicide) followed by Glufosinate ammonium @ 0.84 Kg ha ⁻¹ (Post-emergence)	6.57	319.89	21.81	227.91
T ₁₃ :No Weeding (Control)	6.46	282.11	19.12	201.44
C.D.(p≤0.05)	NS	2.432	0.953	1.583

Fig.1 View of experimental field, Division of Fruit Science, SKUAST- Kashmir



As evident from the data presented in Table 4 different weed management practices had a non-significant effect on soil pH. The data presented in Table 4 reveals that the available nitrogen content of the soil was markedly

influenced by various weed management practices during the year of study. Maximum available nitrogen content (323.78 Kg ha⁻¹) was recorded under paddy straw mulch (T₅) which was followed by T₁₂ (Oxyfluorfen

followed by Glufosinate ammonium) (319.89 Kg ha⁻¹) and T₁₁ (Oxyfluorfen followed by Glyphosate) (316.83 Kg ha⁻¹). The minimum available nitrogen content (282.11 Kg ha⁻¹) was recorded under unweeded control. Similar observations were observed for phosphorus and potassium uptake. It is apparent from the data (Table 4) that available phosphorus content in soil was highest (22.22 Kg ha⁻¹) under paddy straw mulch (T₅). This maximum value was statistically at par with treatments T₄ (Bi-colour polyethylene mulch) (21.96 Kg ha⁻¹), T₆ (Forest litter) (21.92 Kg ha⁻¹), T₁₂ (Oxyfluorfen followed by Glufosinate ammonium) (21.81 Kg ha⁻¹), T₂ (Punched black polyethylene mulch) (21.68 Kg ha⁻¹), T₇ (Chopped lawn grass) (21.67 Kg ha⁻¹), T₃ (Unpunched black polyethylene mulch) (21.55 Kg ha⁻¹) and T₁₁ (Oxyfluorfen followed by Glyphosate) (21.44 Kg ha⁻¹). However, minimum phosphorus content (19.12 Kg ha⁻¹) was recorded under unweeded control. As evident from the data (Table 4) available potassium content was maximum (232.22 Kg ha⁻¹) in paddy straw mulch (T₅) which was statistically at par with T₆ (Forest litter) (231.28 Kg ha⁻¹). Minimum potassium status (201.44 Kg ha⁻¹) in soil was recorded under unweeded control (T₁₃). As evident from the data available potassium content was maximum.

In the present studies, various weed management treatments, increased the availability of all the macronutrients compared to unweeded control. The increase in available nutrients in soil solution may be due to reduced competition through effective weed control and increased organic carbon contents of the soil, leading to increased nutrient availability in soil solution and, also the humus, a resultant of organic carbon, decomposition, caused more release of cations from exchange complex of the soil. These findings are in accordance with Rao and Pathak (1998) who worked on aonla cv.

Francis under Faizabad conditions of Uttar Pradesh. Shylla *et al.*, (1998) who worked on plum cv. Santa Rosa under Solan conditions of Himachal Pradesh also reported that the use of herbicide resulted in higher available nitrogen content in soil than mulch and minimum available nitrogen content was registered in clean cultivation treatment. The present findings are also in accordance with the work of Atucha *et al.*, (2011), who worked on apple under New York conditions of USA and reported that maximum available nitrogen in soil was observed under pre-emergence herbicides treatment followed by post-emergence herbicides and minimum value of was in sod culture treatment. Application of glyphosate based herbicide increased the soil available phosphate by 127% compared to non treated plots (Berghausen *et al.*, 2015). Trimurtulu *et al.*, (2015) also reported increase of available phosphorus to the maximum of 31.0 Kg P₂O₅/ha by the used of herbicide oxyfluorfen. The results are in contradiction to the findings of Rao and Pathak (1998) in aonla cv. Francis and reported that highest available phosphorus content was observed in soil under control followed by rice husk and minimum in paddy straw mulch. Rao and Pathak (1998) and Meena *et al.*, (2015) who reported highest available potassium content in soil under paddy straw mulch in aonla. The higher available potassium content in tree basin was directly associated with rapid decomposition of organic mulches. Similar increase in available potassium in soil by use of herbicides for weed control was reported by Bhat (2004) and Sharma (2004) in plum, apricot and strawberry respectively.

From the present investigation it can be concluded that organic mulches act as insulators and helps in maintaining lower soil temperature besides conserving moisture. Also the adoption of various weed management practices, particularly use of

organic mulch and herbicides markedly increased the soil micronutrient content. Highest macronutrient content (N, P and K) was observed under paddy straw mulch but use of paddy straw mulch increase the chance of rodent infestation. Thus for reduction of nutrient loss through weed and ensuring nutrient utilization by main crop, application of pre-emergent herbicide (Oxyfluorfen @ 0.5 L ha⁻¹) followed by the application of post-emergent herbicide (Glufosinate ammonium @ 0.84 Kg ha⁻¹) can be used for effective controll of weeds in apple under high density orchard system in Kashmir conditions.

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