Efficacy of mulching for sustainable weed management in persimmon (*Diospyros kaki*) cv Hachiya

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ABSTRACT

This study investigated the impact of various mulching materials on weed suppression, yield and fruit quality of six-year-old Hachiya persimmon trees (*Diospyros kaki*) from April to October. The experiment was conducted in a randomized block design with three replications, testing grass mulch, black polyethylene, silver polyethylene, red polyethylene, nylon mulch, coir mulch and a no-mulch control. Mulching significantly influenced fruit set, fruit drop and fruit yield. Significantly higher fruit set (83.55 and 82.63% respectively) was recorded with black and silver polytethlene mulch. Fruit drop was lowest under black polyethylene mulch (47.50%) and nylon mulch mat (48.31%). Fruit yield was maximized under black polyethylene (14.48 kg/tree) and nylon mulch mat (14.31 kg/tree). Black polyethylene mulch and nylon mulch mat also resulted in the longest (84.31 and 84.19 mm) and heaviest fruits (265.56 and 265.44 g/fruit). Fruit quality was enhanced, with red and black polyethylene mulches showing highest TSS (14.53 and 14.37 °Brix) and reducing sugars. Significant weed suppression was observed with mulching. Black polyethylene mulch exhibited the highest weed control efficiency (99.75%), followed by nylon (99.06%), silver (98.72%) and red polyethylene mulch (98.69%). No weed growth was observed at later stages under black and nylon mulches. The observed improvements in yield and quality are attributed to enhanced soil moisture conservation, weed suppression, favourable microclimatic conditions and altered light environments created by the mulches. These findings support the use of mulching as a sustainable and effective orchard management technique for Hachiya persimmon.

Keywords: Persimmon; mulching; weed control; fruit quality; fruit yield; fruit set; fruit drop

INTRODUCTION

Weeds have been a persistent challenge for farmers since agriculture began, often representing one of the biggest costs in crop production. Despite this, their impact is frequently underestimated compared to other farm pests. In fact, weeds are responsible for more crop yield losses than insects, diseases or other pests combined. In India, for instance, weeds account for an estimated 37 per cent of total annual agricultural losses, outstripping insects (29%), diseases (22%) and other pests (12%) (Yaduraju et al 2006). These unwanted plants are hidden threats, competing fiercely with crops for vital resources like nutrients, water, sunlight and growing space. They can also host harmful pests and pathogens, release chemicals that inhibit crop growth (allelopathy) and ultimately reduce both the quantity and quality of the harvest. Historically, conventional farming has heavily relied on synthetic herbicides for weed control, with these chemicals making up over half of all pesticide use in developed nations' agriculture (Dayan et al 2011). However, growing environmental concerns and the rise of organic farming have highlighted the need for alternative weed management strategies, especially in orchards (Goh et al 2001).

The continuous use of the same herbicides can also lead to shifts in weed populations and foster herbicide resistance. As organic and eco-friendly farming systems gain popularity, non-chemical weed control methods are attracting more interest, with mulching standing out as a particularly effective practice. Beyond just suppressing weeds, mulching offers several agronomic benefits. It helps retain soil moisture, boosts soil organic content and improves soil structure and nutrient dynamics. Mulches also act as a barrier against extreme temperatures, regulating soil temperature by reducing it 2-10°C during hot months and increasing it 2-6°C in colder periods (Lamont 2005, Noor-ul-Ain et al 2022). In persimmon orchards, the dense canopy and large leaves can significantly reduce light penetration, particularly to the lower parts of the tree, resulting in smaller, less colourful fruits. To address this, reflective or bicoloured mulches can be used. These materials bounce sunlight back into the tree canopy, improving light interception and positively influencing crucial fruit quality attributes like size and coloration. Surprisingly, despite these potential benefits, the influence of various mulching materials on soil properties, moisture retention and their relationship with crop productivity in persimmon cultivation hasn't been thoroughly investigated. This study was designed to explore the hypothesis that mulching could offer several beneficial effects in persimmon orchards, ultimately boosting both yield and fruit quality. An experiment was conducted using different types of mulches to generate meaningful insights into their advantages for persimmon production. This was aimed at supporting more sustainable and effective orchard management techniques. Specifically, the focus was placed on assessing how different mulch treatments impacted weed suppression and the overall quality of persimmon fruit.

MATERIAL and METHODS

This research was conducted from April to October on six-year-old Hachiya persimmon trees (*Diospyros kaki*), a pollination-constant astringent type, which were spaced at 5 m x 5 m and trained under an open-center system. Twenty one uniformly vigorous and similarly sized trees were selected and consistent cultural practices were maintained throughout the study period. Tree basins were prepared in February and treatments were randomly applied in mid-March. The selected trees were subjected to various mulching treatments: T_1 (Grass mulch), T_2 (Black polyethylene), T_3 (Silver polyethylene), T_4 (Red polyethylene), T_5 (Nylon mulch), T_6 (Coir mulch) and T_7 (No mulch). Each treatment was replicated thrice in a randomized block design. Standard protocols were followed for documenting observations related to flowering, fruit development and quality characteristics (Anon 1980). Weed count was determined through the quadrant method at 30-day intervals and expressed as total weeds per square meter. The fresh and dry weed weights were recorded at 30-day intervals up to October following the application of treatments. Fresh weight was measured using a digital weighing balance and subsequently, weeds were dried in a hot air oven at 65±2°C for 48 hours before being reweighed for final dry weight. The data on dry and fresh weight of weeds were calculated in grams per square meter.

Weed control efficiency was calculated using the formula:

$$\text{Weed control efficiency (\%)} = \frac{\text{Weed dry matter in untreated plot} - \text{Weed dry matter in treated plot}}{\text{Weed dry matter in untreated plot}} \times 100$$

The weed population in each treatment was determined by following the quadrant method. The collected data were statistically analyzed in accordance with the method described by Panse and Sukhatme (1984) and treatment effects were evaluated using a 5 per cent level of significance to determine statistical differences.

RESULTS and DISCUSSION

The data presented in Table 1 demonstrate that mulching significantly influenced fruit set, fruit drop and fruit yield in persimmon cultivar Hachiya. A significantly higher fruit set of 83.55 and 82.63 per cent was recorded with black and silver polyethylene mulch respectively, with these treatments being at par, as against 76.30 per cent in the control. The highest fruit drop was observed in the control (70.35%) and the lowest (47.50 and 48.31%) was noted under black polyethylene mulch and nylon mulch mat respectively, with these two treatments being at par. Fruit yield was maximized under black polyethylene (14.48 kg/tree) and nylon mulch mat (14.31 kg/tree), with these treatments being at par and a minimum yield was observed in the control (9.55 kg/tree).

Thus persimmon yield in Hachiya was significantly improved by mulching through increased fruit set and reduced fruit drop. Black polyethylene mulch and nylon mulch mat were particularly effective,

Table 1. Influence of mulching on fruit set, fruit drop and yield of persimmon

Treatment	Fruit set (%)	Fruit drop (%)	Fruit yield (kg/tree)
T_1: Grass mulch	78.68 (62.48)	56.87 (48.93)	12.42
T_2: Black polythene mulch	83.55 (66.06)	47.50 (43.55)	14.48
T_3: Silver polythene mulch	82.63 (65.35)	54.49 (47.55)	12.95
T_4: Red polythene mulch	80.31 (63.63)	52.07 (46.17)	13.58
T_5: Nylon mulch mat	81.12 (64.22)	48.31 (44.01)	14.31
T_6: Coir mulch	78.66 (62.46)	57.07 (49.04)	12.15
T_7: Control	76.30 (60.85)	70.35 (56.99)	9.55
$CD_{0.05}$	1.10	0.71	0.53

Angular transformed values within parentheses

both demonstrating significantly higher fruit set and lower fruit drop, ultimately leading to maximized fruit yield. The observed reduction in fruit drop under black polyethylene mulch and nylon mulch mat could be attributed to their superior ability to suppress weed growth and conserve soil moisture, which collectively contributed to enhanced flower retention. Highest fruit set and lowest fruit drop in guava cv L-49 following the application of black polyethylene mulch were reported by Das et al (2010). Similar results were reported by Singh et al (2009) in mango, Warade et al (2009) in pomegranate and Rui (2005) in sweet cherry.

Data in Table 2 depict that black polyethylene mulch and nylon mulch mat resulted in the longest fruits (84.31 and 84.19 mm) and the heaviest fruits (265.56 and 265.44 g/fruit), having maximum fruit volume (274.67 and 237.90 cc) respectively. These treatments were at par when compared to other treatments, while the smallest length fruits (79.13 mm) and lightest fruits (259.46 g/fruit) having minimum fruit volume (265.73 cc) were found in the control. However, the broadest fruits of 73.41 mm were recorded under black polyethylene mulch as compared to all other treatments and minimum breadth fruits were found in the control (69.17 cm).

The enhancement in fruit physical attributes such as size, weight and volume may be attributed to improved plant growth and development fostered by the favourable microclimatic conditions created by mulching. This environment likely promoted better nutrient absorption, thereby, supporting optimal fruit development. The consistent water availability provided by mulch stimulates continuous cell division and elongation, contributing to increased metabolite accumulation in the fruits (Sandhu and Bal 2014). Superior fruit physical traits in strawberry cultivar Chandler were reported by Bakshi et al (2014) when grown with black polyethylene mulch. Similar results were also documented by Meghwal and Kumar (2014) and Bal and Singh (2011) in ber cultivation.

Fruits obtained under red polyethylene mulch were at par with those under black polyethylene mulch for highest TSS (14.53 and 14.37 °Brix) and reducing sugars (5.41 and 5.23%) respectively, as compared to the lowest values of 12.76 °Brix and 4.20 per cent respectively in the control. Titratable acidity was minimum under red polyethylene mulch (0.21%), black polythene mulch (0.22%) and nylon mulch mat (0.22%), which were at par and maximum in the control (0.29%).

Red polyethylene mulch (7.90%), black polyethylene mulch (7.83%), nylon mulch mat (7.73%) and silver polyethylene mulch (7.65%) resulted in the highest total sugars and were at par. Minimum total sugars were recorded under the control (6.66%). No effect of mulching on the non-reducing sugars of fruits was observed.

This increase in fruit quality parameters may be attributed to improved hydrothermal conditions. These conditions potentially increase the concentration of ions within the cells, leading to elevated osmotic pressure and enhanced stomatal activity, which in turn might have influenced the conversion of starch to sugars, thereby, boosting sugar content in fruits (Bhat et al 2015). Additionally, the use of coloured reflective mulches, particularly red mulch, can alter the light environment by increasing the ratio of red to far-red wavelengths (R:FR) in the light reflected onto the plant canopy.

Table 2. Effect of different mulches on fruit quality traits of persimmon

Treatment	Fruit length (mm)	Fruit breadth (mm)	Fruit weight (g)	Fruit volume (cc)	TSS (°B)	Titratable acidity (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)
T_1: Grass mulch	81.80	70.97	262.70	270.58	13.56	0.25	7.52	4.59	2.79
T_2: Black polythene mulch	84.31	73.41	265.56	274.67	14.37	0.22	7.83	5.23	2.47
T_3: Silver polythene mulch	81.55	70.58	263.57	271.37	13.70	0.24	7.65	4.89	2.63
T_4: Red polythene mulch	83.52	70.12	264.03	272.34	14.53	0.21	7.90	5.41	2.36
T_5: Nylon mulch mat	84.19	72.33	265.44	273.90	14.17	0.22	7.73	4.98	2.61
T_6: Coir mulch	81.10	70.22	262.56	269.03	13.44	0.26	7.50	4.55	2.80
T_7: Control	79.13	69.17	259.46	265.73	12.76	0.29	6.66	4.20	2.34
$CD_{0.05}$	0.73	0.56	1.07	1.22	0.30	0.02	0.34	0.26	NS

These mulches absorb photosynthetically active radiation (PAR) while transmitting solar infrared radiation, resulting in improved photosynthetic efficiency (Sharma et al 2013). Moreover, as noted by Kasperbauer et al (2001), phytochromes absorb red and far-red light, initiating a cascade of biochemical processes in fruits that influence the levels of sugars and organic acids, potentially enhancing the sweetness and flavour of fruits grown under red mulch.

The data shown in Fig 1 unveil the significant influence of different mulch materials on weed population, weed fresh weight, dry weight and weed control efficiency in a persimmon orchard. The control exhibited the maximum weed population in comparison to all treatments applied.

The maximum weed count was observed at 180 days after mulch application in the control, whereas, the minimum was noted under black polyethylene mulch at all time intervals. However, no weed growth was observed at 150, 180 and 210 days after the application of black and nylon mulches in the persimmon orchard. Similarly, maximum fresh and dry weight of weeds was recorded in the control, with maximum values of 270.12 and 64.72 g per m^2 obtained at 150 and 180 days interval respectively.

Among all applied treatments, weed count, fresh and dry weight followed the trend as $T_2 > T_5 > T_3 > T_4 > T_6 > T_1 > T_7$. A similar trend was followed in terms of weed control efficiency, with black polyethylene mulch exhibiting a statistically highest mean value of 99.75 per cent weed control efficiency, followed by nylon (99.06%), silver (98.72%) and red polyethylene mulch (98.69%), whereas, the minimum was observed in grass mulch (78.72%).

Improved weed suppression observed with inorganic mulches can be attributed to their ability to block sunlight, thereby, acting as a physical barrier that hinders the photosynthetic activity of both annual and perennial weeds beneath the mulch layer. This reduction in light availability likely inhibits weed emergence and growth. Additionally, the rise in soil temperature associated with plastic mulches may contribute to weed control by impairing the viability of weed seeds, as previously noted by Antill (1989), who found that elevated soil temperatures under mulch destroyed weed seed embryos in apple orchards. Moreover, mulching may create predominantly anaerobic soil conditions, which are unfavourable for weed development, thereby, significantly lowering weed density (Iqbal et al 2016).

These results are consistent with earlier studies conducted on various fruit crops, such as ber cv Umran (Brar et al 2020), apple (Din et al 2020) and pomegranate cv Bhagwa (Kaushal et al 2020), who reported minimal weed growth and enhanced weed control under black polyethylene mulch.

CONCLUSION

This study conclusively demonstrates the significant positive impact of mulching on the productivity and quality of Hachiya persimmon trees.

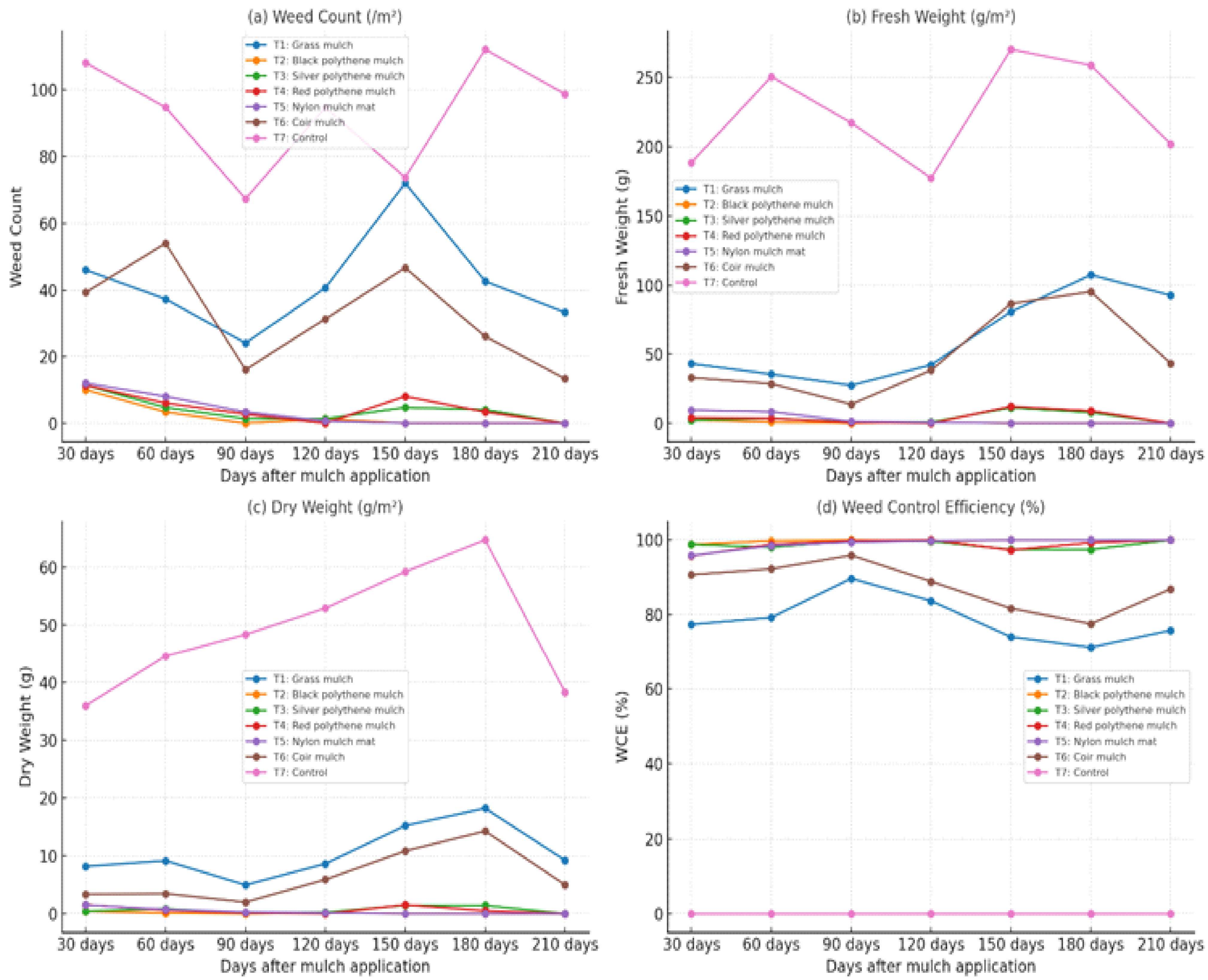

Fig 1. Influence of different mulches on weed dynamic and weed control efficiency over time in persimmon cv Hachiya

The strategic application of mulches, particularly black polyethylene and nylon mulch mats, was found to considerably improve fruit set and reduce fruit drop, leading directly to higher overall fruit yields. These benefits are primarily attributed to the superior weed suppression and enhanced soil moisture conservation provided by these materials, which collectively foster a more conducive environment for flower retention and optimal fruit development. Furthermore, mulching was observed to enhance various fruit physical attributes, including fruit length, weight, volume and breadth and to improve key quality parameters such as total soluble solids and total sugars. These improvements are linked to the favourable microclimatic conditions and altered light environments created by the mulches, which promote efficient nutrient absorption and metabolic processes within the fruits. Critically, the study highlighted the exceptional weed control efficiency offered by inorganic mulches, with black polythene mulch providing nearly complete suppression. This is achieved by blocking sunlight and potentially creating unfavourable soil temperature and anaerobic conditions for weed growth. In summary, the implementation of mulching, particularly with black polythene or nylon mulch mats, is strongly recommended for sustainable and effective orchard management in Hachiya persimmon cultivation. This practice not only provides excellent weed control but also significantly enhances fruit yield and quality, thereby, contributing to more productive and environmentally friendly persimmon production systems.

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