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Effect of Weed Management Approaches on Weed Density and Weed Control Efficiency in Apple Nursery Plants Grafted on Clonal Rootstock

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AUH, AA, AK, FAK, SAM and BAA designed the study. Authors AUH and AA managed the literature searches. Author AUH wrote the protocol and wrote the first draft of the manuscript. Authors AUH, AA and AK managed the experimental materials and data recording. Author SAM performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study aimed to evaluate the influence of different weed management approaches on weed density and weed control efficiency in apple nurseries.
Study Design: The experimental method used in this study was a Randomized Complete Block Design with seven treatments, each replicated three times.

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Place and Duration of Study: The experiment was set up at the Experimental Farm, Division of Fruit Science, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Campus, Srinagar, Jammu and Kashmir, India during the year 2020.
Methodology: Seven weed management treatments i.e. manual weeding, pendimethalin @ 1 kg a.i. ha^{-1}, pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding, paddy straw mulch – 6 cm thick, black polyethylene mulch - 200 micron, weed-free and weedy check were tested in apple nursery. Apple cv. Silver Spur grafted on M-9 T337 was used as plant material for the study. Weed flora, density, dry weight, and weed control efficiency were all observed and recorded.
Results: Among different weed management approaches tested, black polyethylene mulch (200 micron) resulted in the lowest weed density and weed dry weight, and the highest weed control efficiency followed by paddy straw mulch (6 cm thick) and pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding.
Conclusion: In apple nurseries on clonal rootstock M9-T337, black polyethylene (200 micron) was determined to be the most effective weed control strategy for reducing weed density while increasing overall control efficiency.

Keywords: Apple nursery; weed management; weed density; weed control efficiency.

1. INTRODUCTION

Apples are one of the most popular and most adapted fruit crops in the temperate regions of the world. It belongs to family *Rosaceae* (sub-family Pomoideae) and it is an inter-specific hybrid designated as *Malus* x *domestica* [1]. Although the origin and ancestry of the *M.* x *domestica* hybrid complex is controversial, *Malus sieversii* (Ledeb.) Roem has been proposed as the leading origin species for today's cultivated apples [2]. It is widely grown in the temperate or highlands of the tropics of all continents except Antarctica [2]. Apples are cultivated in an area of 4,717 mha and have an annual production of 87,236 mMT worldwide [3]. Commercial apple production is mainly concentrated in countries and regions with a strong comparative advantage in apple production and marketing. In India, it is cultivated in an area of about 0.31 mha with a total production of 2,316 mMT, mainly in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Arunachal Pradesh and Nagaland [4]. Jammu & Kashmir is the leading producer with 0.165 m ha area and 1,882 mMT production [5] and only two important states, Jammu & Kashmir and Himachal Pradesh account for about 92% of India's total production and about 85% of total acreage of apple.

Grafted plants before being transplanted to orchard locations, requires adequate care and management in the nursery for at least one year. Weed control is a serious issue for fruit nursery growers, because losses due to weed infestation frequently exceed losses caused by other types of agricultural pests. The nursery plants are delicate and vulnerable to weed invasion, especially during their early stages of development, as the presence of the unsown plant species interferes with the growth of nursery saplings. Inadequate weed control in young nurseries causes inadequate plant growth and development, resulting in inferior planting material. Between weed and nursery plants, competition for water, light, nutrients, and interference with other operational factors are significant. Weeds can also interfere with cultural practices in nursery viz. budding, grafting, thinning, sprays etc. Weeds indirectly support the emergence of harmful insects and diseases, thereby impeding the growth and development of young seedlings, resulting in poor quality seedlings.

In India, the majority of farmers rely on human resources for physical weed control because they are unaware of herbicide use and subsequent crop sequelae [6]. The goal in managing weeds in fruit nursery is to optimize resource use efficiency for nursery plants by suppressing weed competition during critical periods of plant growth. This concept is the critical weed-free period when it is most important to control weeds to prevent competition with growing saplings. The critical weed-free period for temperate fruit nursery of Kashmir valley is the spring-summer during May, June and July. Weed management in fruit nurseries is normally achieved by a variety of methods around the world, either mechanically through specific cultivation practices or with the application of herbicides; however, the traditional hand weeding approach is the most common in

India, particularly in the Kashmir. The current study sought to investigate the impact of weed management practises on weed flora, weed density, and weed control efficiency in an apple nursery.

2. MATERIAL AND METHODS

2.1 Experimental Site

The present investigation was conducted in the Experimental Field of the Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir (SKUAST-K), Shalimar Campus, Srinagar, Jammu and Kashmir (India) during the year 2020.

2.2 Plant Materials

Apple cv. Silver Spur grafted on M9-T337 rootstock was used as plant materials for this study.

2.3 Treatments and Its Application

The treatments included: manual weeding (T_1), pendimethalin (T_2), pendimethalin + manual weeding (T_3), paddy straw mulch - 6cm thick (T_4), black polyethylene mulch (T_5), weed free (T_6) and weedy check (T_7). The paddy straw mulch (6 cm thick) and black polyethylene mulch (200 micron) were applied around the plants in each treatment plot to completely cover the soil with the mulch. On March 15, pendimethalin @ 1 kg a.i. Ha1) was applied as a pre-emergence herbicide in the respective treatment plots.

2.4 Experimental Design

With seven weed management treatments, each with three replicates, the experiment was set up in a Randomized Complete Block Design.

2.5 Data Collection

2.5.1 Weed flora

The weed flora found in the experimental field during experimentation was identified and categorised into two classes: monocots and dicots weeds.

2.5.2 Weed density

The weed density in each treatment plot was recorded on 1st week of April, May and June, mid-July and 1st week of September. Quadrats of 1 m^2 were randomly drawn in each plot and weeds present in a sampled quadrat were counted. The number of weeds noted in each treatment plot was expressed as weed density in terms of number per m^2 area.

2.5.3 Weed dry weight

The dry weight of weeds in each treatment plot was recorded on 1st week of April, May and June, mid-July and 1st week of September. The weeds in the quadrat of 1 m^{-2} area in each treatment plots were removed from ground. The samples were air-dried at ambient room conditions; followed by oven drying at 65°C to achieve complete moisture removal from samples and the weed dry weight values were expressed in g.

2.5.4 Weed control efficiency

The treatment's weed control efficiency was recorded on 1st week of April, May and June, mid-July and 1st week of September. It was computed using the treatment plot's weed dry weight and the weedy check plot's weed dry weight according to Kondap and Upadhyay [7] and values were expressed in percentage.

$$WCE\ (\%) = \frac{(DWC - DWT)}{DWC} \times 100$$

Where,

WCE = Weed Control Efficiency
DWC = Dry weight of weeds from control plot
DWT = Dry weight of weeds from treated plot

2.6 Data Analysis

The data collected on different aspects were analyzed at 5% significance level according to Panse and Sukhatme's standard method [8].

3. RESULTS AND DISCUSSION

The predominant weed flora in the experimental field of apple nursery cv. Silver Spur on M9-T337 rootstock were recognised and classified into monocots and dicots. The information on the different weeds found in experimental field is presented in Table 1. *Setaria glauca, Digitaria sanguinalis, Cynadon dactylon, Sorghum helepense were m*ajor monocot weeds observed in apple nursery. Major dicot weeds recorded were *Anthemis cotula, Capsella ursa-pastoris,*

Taraxacum officinalis, Plantago major, Convolvulus arvensis, Amaranthus viridis, Solanum nigrum, Portulaca oleraceae, Trifolium repens, Polygonum tubulosum and Cyperus rotundus. The occurrence of weeds observed in present study is in congruence with Hussain et al. [9], Nazir et al. [10] and Din et al. [11] as they observed similar weed flora in Kashmir conditions.

In an apple nursery, weed management measures had a considerable impact on weed density as recorded in the 1st week of April, May and June, mid-July and 1st week of September, 2020 (Table 2). On the 1st week of April, black polyethylene mulched plots recorded no weed while the minimum weed density (1 weed m^{-2}) was recorded in the paddy straw mulch. The results noted with paddy straw mulch were at par with the values observed under black polyethylene mulch), pendimethalin + manual weeding (2.33 m^{-2}) and pendimethalin (2.67 m^{-2}).

A weed density of 2.67 m^{-2} was noted for pendimethalin treatment and it was at par with the weed density observed in case of pendimethalin + manual weeding. The highest weed density (7.00 m^{-2}) was recorded in manual weeding. In the 1st week of May, black polyethylene mulch recorded the lowest weed density (4.33 m^{-2}) which was at par with the paddy straw mulch treatment with a weed density of 6.33 m^{-2} (Table 1). The effect of paddy straw mulch was found to be at par with pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding (8.67 m^{-2}), and pendimethalin @ 1 kg a.i. ha^{-1} (9.67 m^{-2}). Manual weeding treatment exhibited a weed density of 41.67 m^{-2} while the weedy check showed a very high weed density of 65.00 m^{-2}. In the mid July, almost similar results were noted as observed in the 1st week of June (Table 2). Black polyethylene mulch resulted in the lowest weed density (9.00 m^{-2}) which was at par to the treatment paddy straw mulch. Weed density in paddy straw mulch was 14.00 m^{-2} which was at par with pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding (17.67 m^{-2}), and manual weeding (30.00 m^{-2}). Pendimethalin @ 1 kg a.i. ha^{-1} exhibited a weed density of 21.33 m^{-2} and weedy check showed a very high weed density of 97.00 m^{-2}.

In mid-July, Black polyethylene mulch recorded lowest weed density (17.33 m^{-2}) which was at par to the T_4 i.e. paddy straw mulch (Table 2). Weed density in paddy straw mulch was 26.00 m^{-2} which was at par with pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding (28.67 m^{-2}), and manual weeding (31.33 m^{-2}). Pendimethalin @ 1 kg a.i. ha^{-1} treatment exhibited a weed density of 94.33 m^{-2} while weedy check showed a very high weed density of 139.00 m^{-2}. In first week of September, similar effect of weed control measures on weed density was noted as observed in mid-July. Black polyethylene mulch recorded lowest weed density (14.00 m^{-2}) and it was at par with the paddy straw mulch. Weed density in paddy straw mulch was 21.67 m^{-2} which was at par with pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding (31.33 m^{-2}), and manual weeding (31.33 m^{-2}). Pendimethalin @ 1 kg a.i. ha^{-1} treatment exhibited a weed density of 87.67 m^{-2} while weedy check showed a very high weed density of 119.67 m^{-2}.

Table 1. Predominant weed species in apple nursery cv. Silver Spur on M9-T337 rootstock

Botanical Name	Family	English Name	Local Name
Monocot Weeds			
Setaria glauca	Poaceae	Foxtail	*Shaol gasa*
Digitaria sanguinalis	Poaceae	Hairy crab grass	-
Cynadon dactylon	Poaceae	Bermuda grass	*Dramun*
Sorghum helepense	Poaceae	Johnson grass	*Druham*
Dicot Weeds			
Anthemis cotula	Compositae	May weed	*Gur gassa*
Capsella bursa-pastoris	Brassicaceae	Shepherd's purse	*Kralamond*
Taraxacum officinalis	Asteraceae	Dandelion	*Maidan hand*
Plantago major	Plantaginaceae	Broadleaf plantain	*Veuth Gulla*
Convolvulus arvensis	Convolvulaceae	Field bindweed	*Thrier*
Amaranthus viridis	Amaranthaceae	Amaranth	*Lisa*
Solanum nigrum	Solanaceae	Black nightshade	*Kambai*
Portulaca oleraceae	Portulaceae	Common purslane	*Nunnar*
Trifolium repens	Fabaceae	White clover	*Trupater*
Polygonum tubulosum	Polygonaceae	Knotgrass	-
Cyperus rotundus	Cyperaceae	Nut sedge	*Zab*

Table 2. Effect of weed management practices on weed density in apple nursery cv. Silver Spur on M9-T337 rootstock

Treatment	Weed density (No. of weeds m^{-2})				
	1st week of April	1st week of May	1st week of June	Mid July	1st week of September
T_1: Manual weeding	7.00 (2.82)	41.67 (6.53)	21.33 (4.71)	31.33 (5.67)	30.00 (5.56)
T_2: Pendimethalin @1 kg a.i. ha^{-1}	2.67 (1.88)	9.67 (3.25)	34.67 (5.96)	94.33 (9.76)	87.67 (9.41)
T_3: Pendimethalin @1 kg a.i. ha^{-1} + manual weeding	2.33 (1.82)	8.67 (3.10)	17.67 (4.32)	28.67 (5.44)	31.33 (5.68)
T_4: Paddy straw mulch (6 cm thick)	1.00 (1.38)	6.33 (2.70)	14.00 (3.87)	26.00 (5.19)	21.67 (4.75)
T_5: Black polyethylene mulch (200 micron)	0.00 (1.00)	4.33 (2.31)	9.00 (3.14)	17.33 (4.27)	14.00 (3.86)
T_6: Weed free	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1,.00)	0.00 (1.00)
T_7: Weedy check	8.00 (3.00)	65.00 (8.12)	97.00 (9.90)	139.00 (11.83)	119.67 (10.98)
SEm±	0.17	0.28	0.32	0.40	0.31
C.D(P≤0.05)	0.55	0.84	0.97	1.12	0.95

**Values in parentheses are square root transformation*

Table 3. Effect of weed management practices on weed dry weight in apple nursery cv. Silver Spur on M9-T337 rootstock

Treatment	Weed dry weight (g m^{-2})				
	1st week of April	1st week of May	1st week of June	Mid July	1st week of September
T_1: Manual weeding	2.00 (1.73)	19.54 (4.53)	11.58 (3.53)	14.32 (3.91)	12.52 (3.67)
T_2: Pendimethalin @1 kg a.i. ha^{-1}	0.99 (1.41)	4.59 (2.36)	19.51 (4.52)	58.23 (7.69)	51.45 (7.24)
T_3: Pendimethalin @1 kg a.i. ha^{-1} + manual weeding	0.92 (1.38)	4.28 (2.28)	9.99 (3.30)	17.29 (4.28)	13.18 (3.75)
T_4: Paddy straw mulch (6 cm thick)	0.40 (1.18)	3.43 (2.10)	7.37 (2.88)	17.04 (4.24)	10.88 (3.43)
T_5: Black polyethylene mulch (200 micron)	0.00 (1.00)	2.70 (1.92)	5.73 (2.58)	13.09 (3.75)	8.41 (3.06)
T_6: Weed free	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
T_7: Weedy check	3.05 (2.01)	32.21 (5.76)	53.93 (7.41)	81.77 (9.10)	70.31 (8.44)
SEm±	0.19	0.31	0.30	0.34	0.26
C.D(P≤0.05)	0.59	0.97	0.89	1.04	0.78

**Values in parentheses are square root transformation*

Table 4. Effect of weed management practices on weed control efficiency in apple nursery cv. Silver Spur on M9-T337 rootstock

Treatment	Weed control efficiency (%)				
	1st week of April	1st week of May	1st week of June	Mid July	1st week of September
T_1: Manual weeding	34.53 (35.87)	39.33 (38.80)	78.52 (62.45)	82.49 (65.28)	82.19 (65.07)
T_2: Pendimethalin @1 kg a.i. ha^{-1}	67.65 (55.39)	85.73 (67.83)	63.81 (53.02	28.78 (32.32)	26.82 (31.15)
T_3: Pendimethalin @1 kg a.i. ha^{-1} + manual weeding	69.94 (56.76)	86.72 (68.85)	81.47 (64.59)	78.85 (62.60)	81.25 (64.40)
T_4: Paddy straw mulch (6 cm thick)	86.77 (72.61)	89.34 (70.96)	86.32 (68.36)	79.15 (62.82)	84.52 (66.93)
T_5: Black polyethylene mulch (200 micron)	100.00 (90.00)	91.63 (73.18)	89.38 (71.05)	83.98 (66.40)	88.03 (69.77)
T_6: Weed free	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
T_7: Weedy check	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)	0.00 (0.57)
SEm±	1.59	1.87	1.52	1.61	1.41
C.D(P≤0.05)	3.96	4.67	3.81	4.03	3.53

**Values in parentheses are square root transformation*

Black polyethylene mulch effectively minimized the weed density although, paddy straw much (6 cm thick) was equally effective as there was no significant difference in the weed density recorded for the two treatments (Table 2). Manual weeding at first weeks of April, May, and June, mid-July, and the first week of September alone or in combination of pendimethalin at 1 kg a.i. ha^{-1}, also suppressed weed density but not at much as black polyethylene mulch (200 micron) and paddy straw much (6 cm thick). There was almost complete absence of weeds under black polyethylene mulch during early period of plant growth. The obvious reason for this result is the complete lack of sunlight combined with the physical barrier offered by the black polyethylene sheet to the developing weeds. Pendimethalin, a systemic herbicide utilised as a pre-emergent in this study, is used to control annual grasses and some broad leaf weeds. Its principal mode of action is to hinder cell division and elongation in sensitive species thereby limiting root and shoot growth of germinating weeds. The considerable weed control seen in the current trials by mulching and herbicidal treatments was likewise consistent with findings of Rana [12], Dalal et al. [13], Kour et al. [14] and Sharma and Sharma [15]. Suppression of weed growth and improved nutrient and water availability through mulch may explain the improved nursery growth characteristics in current experiments [16]. Improved root development may be due to a better root environment caused by mulching and herbicide mitigation effects on soil temperature and moisture, resulting in increased nutrient absorption [17].

Weed control measures exhibited a significant impact on weed dry weight in apple nursery as observed during the first week of April, May, and June, mid-July, and the first week of September, 2020 (Table 2). At 1st week of April, there were no weeds in black polyethylene mulch, the weed dry weight was zero and it was at par with paddy straw mulch (0.40 g m^{-2}) while weedy check exhibited the highest weed dry weight (3.05 g m^{-2}). The second highest weed density was noted in manual weeding plot with weed density of 1.73 g m^{-2} followed by pendimethalin @ 1 kg a.i. ha^{-1} (1.41 g m^{-2}) and pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding (1.38 g m^{-2}). The treatments pendimethalin @ 1 kg a.i. ha^{-1} and Pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding recorded a weed dry weight of 0.99 g m^{-2} and 0.92 g m^{-2}, respectively, which was not significantly different. In 1st week of May, among different weed control methods, lowest weed dry weight (2.70 g m^{-2}) was recorded in black polyethylene mulch, followed by paddy straw mulch (3.43 g m^{-2}), pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding (4.28 g m^{-2}) and pendimethalin @ 1 kg a.i. ha^{-1} (4.59 g m^{-2}) (Table 3). Keeping aside the weed free check treatment which resulted weed density of 32.21 g m^{-2}, the highest weed dry weight (19.54 g m^{-2}) was recorded in manual weeding. In 1st week of June, the lowest weed dry weight (5.73 g m^{-2}) was again recorded in black polyethylene mulch, however, it was at par with paddy straw mulch and pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding with the weed dry weight of 7.37 and 9.99 g m^{-2}, respectively (Table 3). Among various weed management approaches tested, significantly highest weed density of 19.51 g m^{-2} was recorded with pendimethalin @1 kg a.i. ha^{-1} and manual weeding resulted lower weed dry weight (11.58 g m^{-2}) than pendimethalin @ 1 kg a.i. ha^{-1} treatment. Weedy check resulted in highest weed dry weight of 53.93 g m^{-2}.

On 4th date of observation (mid-July), weed dry weight (13.09 g m^{-2}) was lowest in black polyethylene mulch, although it was at par with paddy straw mulch (17.04 g m^{-2}), pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding (17.29 g m^{-2}) and manual weeding) (14.32 g m^{-2}) (Table 2). Other than weed free check treatment which resulted weed density of 81.77 g m^{-2}, the significantly highest weed dry weight (58.23 g m^{-2}) was recorded in pendimethalin @ 1 kg a.i. ha^{-1}. The effects of weed density on weed dry weight recorded in 1st week of September were similar to the findings recorded in mid-July (Table 3). The lowest weed dry weight (8.41 g m^{-2}) was noted in black polyethylene mulch although it was at par with paddy straw mulch (10.88 g m^{-2}), pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding (13.18 g m^{-2}), and manual weeding (12.52 g m^{-2}). Weed dry weight in pendimethalin @ 1 kg a.i. ha^{-1} was 51.45 g m^{-2} while it was 70.31 g m^{-2} in case of weedy check.

On all of the observation dates, different weed management strategies had a substantial impact on weed control efficiency (Table 4). The treatment black polyethylene mulch had the best weed control efficacy (100%) during 1st week of April observations which was significantly superior over other treatments (Table 4). The weed control efficiency of manual weeding was the lowest (34.53%). The weed control efficiency of pendimethalin @ 1 kg a.i. ha^{-1}, pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding and paddy straw mulch) treatments was recorded 86.77,

69.94 and 67.65%, respectively. The black polyethylene mulch application had the best weed control efficacy (91.63%) in the first week of May too, despite the fact that it was comparable to paddy straw mulch (89.34%) and pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding (86.72%). The weed control efficiency of pendimethalin @ 1 kg a.i. ha^{-1} treatment was 85.73% and found to be par with pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding. Lowest weed control efficiency (39.33%) was recorded due to manual weeding treatment. On 1st June, the highest weed control efficiency (89.38%) was again recorded with black polyethylene mulch treatment and found at par with paddy straw mulch (86.32%) (Table 4). The weed control efficiency of 81.47% was noted in pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding treatment which was statistically at par with manual weeding (78.52%). The lowest weed control efficiency (63.81%) was recorded under pendimethalin @ 1 kg a.i. ha^{-1}.

In mid-July, the treatment black polyethylene mulch recorded highest weed control efficiency (83.98%) which was at par with paddy straw mulch (79.15%) and pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding (78.85%) and manual weeding (82.49%) (Table 4). The weed control efficiency of pendimethalin @ 1 kg a.i. ha^{-1} treatment was lowest (28.78%). In the first week of September, black polyethylene mulch provided the most effective weed control (88.03%), although it was at par with paddy straw mulch (84.52%). The pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding exhibited 81.25% weed control efficiency which was at par with T_4 and manual weeding (82.19%). The weed control efficiency of pendimethalin @ 1 kg a.i. ha^{-1} was 26.82% and it was found to be lowest among different weed management practices.

Manual weeding, mulching and herbicide treatments in the present study influenced the weed control efficiency significantly as recorded at first weeks of April, May, and June, mid-July, and the first week of September (Table 4). On all five observation days, black polyethylene mulch had the lowest dry weight and the best weed control efficacy of all the mulching treatments. Although it was statistically at par with paddy straw much on all dates of observation except for the first date of observation. On the first date of observation, weed control efficiency with black polyethylene mulch was 100% while it was 86.77% in paddy straw mulch. Lower weed dry weight and higher weed control efficiency under these are attributed to the facts that there was comparatively low weed density under these treatments as compared to weedy check and others. The highest weed dry weight and lowest weed control efficiency was observed under treatment weedy check. The present findings were consistent with reports of Rana [12], Dalal et al. [13], Srivastava et al., [18], Kaundal et al., [119], Buban et al., [20], Shylla et al., [21], and Kaur and Kaundal, [22]. Better weed control using black polyethylene mulching might be attributed to the complete lack of sunshine, as well as the physical barriers that polyethylene sheets provide to emerging weeds. Herbicides that reduce weed development work by inhibiting photosynthesis, causing the creation of secondary plant toxic compounds, altering processes related with protective carotenoids, and starving weeds owing to the involvement of photo-oxidative pigments [23].

4. CONCLUSION

Among the various weed management approaches examined for weed management in Siler Spur apple nursery plants grafted on M9-T337 clonal rootstock, black polyethylene mulch (200 micron) resulted the lowest weed density and weed dry weight, as well as the greatest weed control efficiency, followed by paddy straw mulch (6 cm thick) and pendimethalin @ 1 kg a.i. ha^{-1} + manual weeding. In conclusion, black polyethylene (200 micron) was determined to be the most effective weed management strategy for reducing weed density and maximizing weed control efficiency in apple nursery.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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