Original Research Article

Influence of Weed Management Approaches on Weed Density and Weed Control Efficiency in Apple Nursery

ABSTRACT

Aims: The study aimed to evaluate the effect of different weed management approaches on weed density and weed control efficiency in apple nurseries.
Study design: The experimental design used was Randomized Complete Block Design with seven treatments, each in three replications.
Place and Duration of Study: The experiment was laid out 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 - 6cm 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. Observations on weed flora, weed density, weed dry weight and weed control efficiency were 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: Black polyethylene (200 micron) was found to be the most effective weed management practice for minimizing weed density with high control efficiency in apple nurseries.

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) is an inter-specific hybrid and designated as *M.* 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 species of origin 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 a leading producer with an area of 0.165 m ha and a production of 1,882 mMT [5]

and only two important states, Jammu & Kashmir and Himachal Pradesh account for 92% of India's total production and about 85% of total acreage of apple.

Grafted plants before being transplanted to orchard locations, it requires adequate care and management in the nursery for at least one year. Weed control is a serious issue for fruit nursery growers, because of losses from weed infestation frequently out numbers the losses from other types of agricultural pests. The nursery plants are delicate and vulnerable to weed evasion, especially in their early stages of development, presence of those 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. Weed attacks indirectly affect the emergence of harmful insects and diseases, 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. Present study was carried out with the objectives of studying the influence of weed management approaches on weed flora, weed density and weed control efficiency in apple nursery.

2. MATERIAL AND METHODS

2.1 Experimental site

The experiment 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 M-9 T337 rootstock was used as plant materials under 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 respective treatment plots.

2.4 Experimental Design

The experiment was laid out with seven weed management treatments in Randomized complete block design where each treatment was replicated thrice.

2.5 Data collection

2.5.1 Weed flora

The weed flora appeared in the experimental field were identified and then classified into two groups i.e., 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. The quadrants of 1 m^2 were randomly drawn in each plot and weeds present in sampled quadrant 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 weed dry weight 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 ^{o}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 weed control efficiency of the treatment plot was recorded on 1st week of April, May and June, mid-July and 1st week of September. It was worked out on the basis of weed dry weight of the treatment plot and weedy check plot as per the formula suggested by 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 recorded on various parameters were statistically analyzed at a 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-T339 rootstock were identified and grouped as monocots and dicots. The details of different weeds found in experimental field are 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.

Table 1: Predominant weed species in apple nursery cv. Silver Spur on M9-T339 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*

Weed control methods resulted in significant effect on weed density in apple nursery as recorded in the 1st week of April, May and June, mid-July and 1st week of September, 2020 (Table 1). On the 1st week of April, black polyethylene mulched plots resulted no weeds in the field while minimum weed density (1 weed m^{-2}) in 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}).

The weed density of 2.67 m^{-2} was noted due to pendimethalin treatment and it was at par with the weed density observed in case of pendimethalin + manual weeding. Highest weed density (7.00 m^{-2}) was recorded with manual weeding. In the 1st week of June, Black polyethylene mulch recorded lowest weed density (4.33 m^{-2}) which was at par to the treatment Paddy straw mulch with the weed density of 6.33 m^{-2} (Table 1). The effect of paddy straw mulch also found was 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 exhibited a weed density of 41.67 m^{-2} and weedy check showed a very high weed density of 65.00 m^{-2}. In the 1st week of July, almost similar results were noted as observed in the 1st week of June (Table 1). Black polyethylene mulch resulted 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 1). 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 were noted as observed in mid-July. Black polyethylene mulch recorded lowest weed density (14.00 m^{-2}) and it was at par to 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 2: Effect of weed management practices on weed density in apple nursery cv. Silver Spur on M9-T339 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.*

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 under between black polyethylene and paddy straw much (Table 1). 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 the weed density but not at a level of black polyethylene mulch (200 micron) and paddy straw much (6 cm thick). There was almost complete of weeds under black polyethylene much during early period of plant growth. Complete absence of sunlight coupled with the physical barrier provided by the black polyethylene sheet to the emerging weeds are obvious reason for biennial results on controlling weed density. The systemic herbicide pendimethalin applied as pre-emergent in this study is used to suppress annual grasses and certain broad leaf weeds by inhibiting root and shoot growth of germinating weeds as the primary mode of action of pendimethalin is to prevent cell division and elongation in susceptible species. The significant control of weeds by mulching and herbicidal treatments observed in the present studies were also in conformity with the 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 weeks 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 noted zero and it was at par with paddy straw mulch (0.40 g m^{-2}) while weedy check exhibited highest weed dry weight (3.05 g m^{-2}). Second highest weed density was noted in manual weeding 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 and found at par with each other. 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 2). Keeping aside the weed free check treatment which resulted weed density of 32.21 g m^{-2}, the significantly highest weed dry weight (19.54 g m^{-2}) was recorded in manual weeding as

compared to others treatments. In 1st week of June, the lowest weed dry weight (5.73 g m^{-2}) was again recorded due to T_5 (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 2). 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 comparatively low 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}.

Table 3: Effect of weed management practices on weed dry weight in apple nursery cv. Silver Spur on M9-T339 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±	0.59	0.31	0.30	0.34	0.26
C.D(P≤0.05)	0.19	0.97	0.89	1.04	0.78

**Values in parentheses are square root transformation*

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). Keeping aside the 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 measure on weed dry weight recorded in 1st week of September were similar to the findings recorded in mid-July (Table 2). 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.

Different weed management measures had a significant effect on weed control efficiency on all the dates of observation (Table 3). Weed free treatment has showed 100 % weed control efficiency at all the dates of observations noted as the results of no weeds were kept in field throughout the crop season. At 1st date of observation (1st week of April), the highest weed control efficiency (100%) was noted under treatment black polyethylene mulch which was significantly superior over rest of the treatments (Table 3). manual weeding resulted in lowest weed control efficiency (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. In 1st week of May, the treatment black polyethylene mulch recorded highest weed control efficiency (91.63%), although it was at par with 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 at 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 3). 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}.

Table 4: Effect of weed management practices on weed control efficiency in apple nursery cv. Silver Spur on M9-T339 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±	3.96	4.67	3.81	4.03	3.53
C.D(P≤0.05)	0.19	0.19	0.19	0.19	0.19

**Values in parentheses are square root transformation*

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 3). The weed control efficiency of pendimethalin @ 1 kg a.i. ha^{-1} treatment was lowest (28.78 %). In 1st week of September, black polyethylene mulch resulted in highest weed control efficiency (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 lowest among different weed management practices.

Manual weeding, mulching and herbicide treatments in present study influenced the weed dry weight and weed control efficiency significantly as recorded at first weeks of April, May, and June, mid-July, and the first week of September (Table 3). Among the mulching treatments, lowest dry weight and highest weed control efficiency was observed under black polyethylene mulch on all five dates of observation, it was followed by treatment paddy straw mulch and both of these were statistically at par with each other on all dates of observation except for the first observation in weed control efficiency where black polyethylene mulch

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recorded 100% weed control efficiency as compared to Paddy straw mulch which recorded 86.77% weed control efficiency. 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 results were in line with the investigations 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 with black polyethylene mulching can be due to the complete lack of sunlight combined with the physical barriers that polyethylene sheets provide to the emerging weeds. The action of herbicides that suppress weed growth is caused by a lack of photosynthesis, the formation of secondary plant toxic substances, altered reactions associated with protective carotenoids, and weed starvation due to the involvement of photo-oxidative pigments [23].

4. CONCLUSION

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. Black polyethylene (200 micron) found to be most effective weed management practice for minimizing weed density with high control efficiency in apple nursery.

CONSENT

Not Applicable

ETHICAL APPROVAL

Not applicable

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. 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.

REFERENCES

1. Korban SS, Skirvin RM. Nomenclature of the cultivated apple. *HortSci.* 1984;19:177-180.
2. Luby JJ. Taxonomic Classification and Brief History. In: Ferree DC, Warrington IJ (Eds.) Apples: Botany, Production and Uses; Cambridge: CABI Publishing; 2003. DOI: https://doi.org/10.1079/9780851995922.0031.
3. FAOSTAT. Food and Agricultural Organization. Statistical Database on World Fruit Production; 2017. Available: https://www.fao.org.

4. NHB. Indian Horticulture Database (2018-19), National Horticulture Board, Ministry of Agriculture and Farmer Welfare, Government of India, Gurugram; 2019. Available: https://www.nhb.gov.in.
5. Anonymous. Area and Production of Major Horticultural Crops in Jammu and Kashmir. Directorate of Horticulture, Kashmir, J&K; 2019. Retrieved from: http://hortikashmir.gov.in.
6. Mishra JS, Rao AN, Singh VP, Kumar R. Weed management in major field crops. In: Advances in Weed Management, Indian Society of Agronomy: New Delhi; 2016.
7. Kondap SM, Upadhyay UC. A practical manual on weed control. New Delhi: Oxford and IBH Publishing Company; 1985.
8. Panse VG, Sukhatme PV. Statistical Method for Agricultural workers; New Delhi: ICAR; 1985.
9. Hussain S, Sharma MK, Tundup P, Ali M, Hussain S, Bashir D. Effect of orchard floor management practices on growth, yield and quality attributes of apple cv. Royal Delicious. *Int. J. Pure Appl. Biosci.* 2017;5(3):944-952. DOI: http://dx.doi.org/10.18782/2320-7051.3087.
10. Nazir A, Bahar FA, Rashid Z, Fayaz S, Bhat TA, Ahmad O. Weed dynamics of Baby Corn (*Zea mays* L.) as influenced by different weed management practices under the temperate conditions of Kashmir valley. *Bull. Environ. Pharmacol. Life Sci.* 2019;8:99-103.
11. Din S, Wani RA, Pandit AH, Majid I, Nisar S, Nisar F, Farooq T, Jan S, Sheikh Q, Angmoo T. Effect of weed management strategies on weed count and yield attributes of apple (*Malus* x *domestica*) under high density orchard system. *Intl. J. Chem. Studies.* 2020;8(4):1117-1121.
12. Rana MR. Effect of certain nursery management practices on growth of nursery plants of apple. M.Sc. Thesis submitted to Dr. Y.S. Parmar University of Horticulture and Forestry, Solan; 1998.
13. Dalal MR, Pandit AH, Wani WM, Mir MA, Bhat KM, Malik AR. Effects of different weed control measures on weed population and growth parameters of apple nursery plants. *Acta Hortic.* 2011;903:1017-1021. DOI: https://doi.org/10.17660/ActaHortic.2011.903.143.
14. Kaur K, Kaundal GS. Efficacy of herbicides, mulching and sod cover on control of weeds in plum orchards. *Indian J. Weed Sci.* 2009;41(1&2): 110-112.
15. Sharma S, Sharma DP. Weed management in stone fruit nectarine orchard with inorganic mulches and herbicides. *Indian J. Weed Sci.* 2019;51(1):45-49. DOI: https://doi.org//10.5958/0974-8164.2019.00010.8.
16. Black AL, Greb DW. Nitrate accumulation in soil covered with plastic mulch. Agronomy Journal 1962;59:366. DOI: https://doi.org/10.2134/agronj1962.00021962005400040031x.
17. Atkinson D, White GC. Soil management with herbicides, the response of soils and plants. In: Proceedings; British Crop Protection Congress; 1976.
18. Srivastava RP, Misra RS, Pandey VS, Pathak RK. Effect of various mulches on the soil temperature and moisture, weed density, survival and growth of apple grafts. *Prog. Hort.* 1973;5(3):27-42.
19. Kaundal GS, Singh S, Chanana YR, Grewal SS, Singh S. Effect of glyphosate and plastic mulch on weed control in peach orchard. *J. Res. Punjab Agric. Univ.* 1995;32(1):32-38.
20. Buban T, Lakatos T, Helmeczi B, Dorgo E, Papp J, Mezo M, Jakab I, Merwin I.. Ground cover management systems by limited use of herbicides in young apple orchards. *Novenyvedelem.* 1997;33(9):445-452.
21. Shylla B, Chauhan JS, Sharma U. Effect of orchard floor management practices on weed control, growth and cropping of Santa Rosa plum. In: Proceedings of the International Conference on World Perspective on Short Rotation Forestry for

Industrial and Rural Development; Solan: Dr. YS Parmar University of Horticulture and Forestry; 2003.
22. Kour A, Gupta N, Brar SK. Integrated weed management practices in guava nursery. *Journal of Pharmacog. Phytochem.* 2019;8(2):982-985.
23. Ashton FM, Crafts AS. Mode of action of herbicides. New York: John Willey and Sons; 1981.