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Comparative Analysis on Impact of Different Mulches on Growth and Yield Parameters of Mulberry under Rainfed Condition of Poonch District of Jammu and Kashmir

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Authors' contributions

This work was carried out in collaboration among all authors. Author SC designed the experiment and finalized the manuscript. Author PT conducted the field work and collected data. Author MAB collected the literature. Author JA helped in framing the manuscript. Author GRV provided the lab facilities and author AA statistically analysed the data. All authors read and approved the final manuscript.

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ABSTRACT

The current study was formulated to analyse the impact of different biodegradable and synthetic mulches on growth and yield parameters of mulberry plant. Among the selected parameters survival rate of mulberry plants was recorded to be maximum in T-2 i.e, paddy straw and husk as 95% followed by T-1 and T-3 i.e, Black polythene mulch and Green branches of tree respectively as 90% and least for Control i.e, without any mulch as 70%. Least population of weeds with minimum intensity was recorded in T-1 (05) followed by T-2 (08) and T-3 (10). Maximum weed flora with highest intensity of weeds was found in Control i.e, without any mulch (20). For the studied samples, maximum soil moisture percentage and moisture retention capacity (MRC) of 66.57 & 95.6% was recorded in T-1 followed by T-3 as 40.31 & 87% and T-2 as 16.36 & 91% and minimum in control as 13.43 & 85.56%. The pH was recorded as 6.1 in T-1 depicting the slightly acidic

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soiland could be viewed as the most appropriate soil pH for mulberry cultivation. Available NPK were recorded to be in the most ideal range for T-1 as 8.2, 1.3 and 9.6%. Maximum leaf size was recorded in T-1 as 126cm followed by T-2 and T-3 as 116cm and 110cm respectively and 105cm in control. Moisture percentage was recorded to be highest 76.23% followed by 74.61% and 54.16% for T-3, T-1 and T-2 respectively and 68.2% in control. Maximum MRC was observed in case of plants grown under Black polythene mulch (73.24%) and least in green branch mulch (61.39%). Therefore, it can be concluded that application of suitable bio-mulches in mulberry fields can reduce the dependency of chemical weedicides.

Keywords: Mulberry; soil; mulch; synthetic; organic; moisture; leaf.

1. INTRODUCTION

Mulberry sericulture involves the cultivation of mulberry to produce leaf, rearing of silkworm to convert leaf to cocoon, reeling of the cocoon to obtain silk yarn and the cocoon to obtain silk yarn and weaving to convert yarn to fabrics. Mulberry (*Morus alba* L.) the sole food of silkworm (*Bombyx mori* L.) is a perennial crop cultivated for more than 15-20 years in the same land and it is a prime constituent of sericulture industry. The continuous production of mulberry for a long time results in gradual reduction of leaf yield and quality [1].

The highly intensive mulberry cropping system causes depletion of nutrients in soil and excess usage of inorganic fertilizers as well as pesticides results in the deleterious effect on soil health [2]. Even though inorganic fertilizers and necessary nutrients to the soil; their regular use cause long term depletion of organic matter, soil compaction and degradation of overall soil quality [3]. Organic farming is considered to be an alternative agricultural practice to mitigate the adverse effects of various inorganic fertilizers to soil conditions. Mulberry (*Morus alba* L.) prefers almost neutral soil reaction for its luxuriant growth. Mulching has been proved very effective in conserving the soil moisture thereby leading to better yield in various crops. Mulch is a layer of material applied to the surface of soil. Mulch is a material (as straw or bark) spread over the ground especially to protect the roots of plants from heat or cold, to keep soil moist, and to control weeds. Materials that can be used on the soil surface mainly to prevent loss of water by evaporation to cut down weed growth, to reduce temperature fluctuations, and to promote soil productivity are all designated as 'Mulch'. Mulching creates micro-climate for the plant to grow and perform better in an area that has regulated moisture content, suitable temperature, humidity, carbon dioxide, and proper microbial activity within the soil [4]. Mulching technique is primarily used in the fields by farmers to reduce the weeds growth in the crops [5,6]. Mulching plays an important role in conserving moisture of soil by decreasing rate of evaporation and altering infiltration capacity of soil surface [7]. Therefore, keeping in view the importance of mulching in mulberry cultivation, the present experiment has been conducted to analyse the impact of different biodegradable and synthetic mulches on growth and yield parameters of mulberry plant.

2. MATERIALS AND METHODS

Considering the significance of mulching in mulberry cultivation and its impact on growth and yield parameters of mulberry the present study was carried out at Post Graduate Department of Sericulture, Poonch Campus, University of Jammu during the spring season, January to April-2022 in order to make recommendations on best mulch material for mulberry cultivation. The material used for current study was comprised of:

1. Synthetic mulches to be used: Black polythene Mulch (T-1) at Nursery bed
2. Organic mulches to be used: Paddy Straw and Husk (T-2) at Mulberry garden (Sapling Block-III) and Green branches of trees will be used (T-3) at Mulberry garden (Sapling Block-IV).
3. Control: mulberry sapling block-V under normal cultural practice (T-4) (Sapling Block-V).

The data generated from observations was subjected to statistical analysis by using statistical tools like ANOVA (Analysis of Variance) on SPSS (Statistical Package For Social Sciences) software for drawing conclusions and validation of results.

3. RESULTS AND DISCUSSION

3.1 Survival Rate and Sprouting Percentage

In current study, survival rate of the cuttings and saplings under different treatments (Fig. 1) along with the control had been calculated by the formula.

> Survival rate = No. of cuttings/saplings survived × 100 / Total no. of cuttings/ saplings planted

The Survival rate of mulberry plants under different treatments of mulches is given below in the Table 1 and maximum survival rate was recorded for T-2 i.e, mulberry saplings provided with mulch of paddy straw and husk is 95% followed by T-1 and T-3 Black polythene and Green branches respectively as 90% and least 70% for control i.e, without any mulch.In the present study, T-1exhibited maximum sprouting percentage 98% followed by T-2 as 78% and least by control as 70% as given in Table 1. Earlier also Chopra, M. and Koul, B. (2020) reported similar observations with polythene sheet mulch and recorded maximum survivability of about 90% for the nursery bed provided with thin sheet of polythene. Prosdocimi et al., [7] too reported the best results of survival percentage for mulberry nursery provided with black polythene sheet. Sprouting percentage was recorded as 70-80% in mulberry as earlier observed by Wani et al., [5], Khan et al., [8] and Chanotra et al. [9].

3.2 Colour of the Newly Developed Leaf and Shoot

Although colour is a genetic phenomenon but can be influenced to a greater extent by Genotype × Environment (GxE) interaction. For the studied treatments all the studied plants under various treatments exhibited light green colour for newly developed leaves and light green to brown or grey (Table 2) for shoots that progressively turned darker in shade with maturity (Fig. 2). The current observations lies in close conformity with the earlier reports of Chaudhary and Iqbal [10] and Mirazalva et al., [11], who emphasised the pronounced effect of agro-climatic conditions for growth and development of mulberry.

3.3 Time / Duration of Sprouting and Onset of Inflorescence

Sprouting is a genetic characteristic that starts with the bulb swelling. Buds in mulberry varies greatly from species to species. The sprouting involves various stages such as bulb swelling, bud formation and bud opening. The time taken to complete all the stage could be regarded as sprouting duration. The details regarding sprouting duration of the studied genotypes have been presented in Table 3 and Figs. 3, 4. Inflorescence in mulberry has been observed to start along with the bud sprouting i.e., 13 January to April end that later mature as ripened fruit (Fig. 5). However Mirazalva et al., [11] demonstrated the effect of agro-climatic conditions on sprouting behaviour of mulberry and reported maximum sprouting of 70-80% under optimum environmental conditions of approximately 20-25°C and 60-70% RH. They suggested the more pronounced effect of climatic conditions than the cultural practices like mulching.

3.4 Types and Intensity of Weed Flora Development in T1, T2, T3 and Control

Different types and intensity of weed flora numbers (Nos.) in different treatments (T-1, T-2, T-3 and control) is given below in Tables 4 to 7. The observation recorded with least intensity of weeds including common plants like Hemp, Rhubarb, Mallow, Pricklylettuce and clover. The results were found to be in close conformity with the findings of Sakthivel, N [12] who suggested that the black polythene as best mulching material for weed control as compared to other treatments.

3.5 Soil Moisture Percentage and MRC

The soil moisture percentage was calculated by the formula:

> Soil moisture percentage (%) = Fresh weight (FW) - Dry weight (DW) × 100 / Fresh weight (FW)

Hence, for the studied samples with different mulches maximum soil moisture percentage of 66.57% was recorded in T_1 followed by T3 as 40.31%, T_2 as 16.36% and Control as 13.43%. Maximum moisture retention value for soil sample was recorded for T1 (Black polythene mulch) as 95.6% followed by T-2 (Paddy straw and husk) as 91% and T-3 (Green branches of

tree) as 87% and Control (without any mulch) as 85.56% was recorded with least moisture retention capacity value of soil sample (Fig. 6). Soil moisture percentage and MRC was recorded to be highest in T-1 as 66.57% and 74.0% resp. followed by T-3 as 40.31% and 87% as 13.43%. A similar experiment was conducted by Sakthivel, N. [12] and Chakraborty et al., [13] who utilized both organic and inorganic mulches and reported soil moisture percentage to be significantly higher in mulched treatment i.e, Black and minimum value was recorded in Control polythene mulch as compared to un-mulched treatment.

Fig. 1. Mulberry nursery with Black Polythene mulch (T-1), Paddy Straw & Husk (T-2), Green Branches Mulch (T-3) & Control (T-4) without any mulch

Fig. 2. Colour of mature mulberry leaves

Table 1. Data of various agronomical traits of mulberry plant under different mulch treatments

S. No	Treatments	Survival percentage	Sprouting percentage (%)	Date of sprouting	Fresh weight (W1) g	Second weight (W2) g	Dry weight (W3) g	Moisture percentage (%)	Moisture loss percentage (%)	MRC (%)	Soil ph	N (%)	P (%)	K (%)	Size of leaf cm^2	Actual leaf area	Area of largest Glossy leaf cm^2
01.	T-1: Black polythene mulch	90	98	20th January 2022	216	200	72.2	66.57	25.92	95.6	6.1	8.2	1.3	9.6	126	74	82.4
02.	T-2:Paddy straw and Husk	95	78	13th January 2022	121	110	101.2	16.36	9.0	91	5.4	8.6	1.60	1.4	116	66	86
03.	T-3:Green branches of tree	90	73	13th January 2022	128	90	76.4	40.31	13.02	87	5.6	7.9	4.32	3.71	110	44	63.5
04	T-4: Control: without mulch	70	70	25th January 2022	134	120	116	13.43	10.44	85.56	7.9	5.4	0.24	2.16	105	40	28.6
Mean		86.25	79.75														
S.D		11.08	12.60														
S.E		5.54	6.303														

Table 2. Data of various morphological parameters of mulberry plant under different mulch treatments

S. No	Treatments	Colour of newly developed leaf	Shoot colour	Young leaf colour	Mature leaf colour	Leaf shape	Leaf Base	Leaf margins	Leaf texture
01.	T-1: Black polythene mulch	Light green	Green	Light green	Dark green	Ovate	Cordate	Serrated	Succulent
02.	T-2:Paddy straw and Husk	Light green	Green	Light green	Dark green	Ovate	Cordate	Serrated	Succulent
03.	T-3:Green branches of tree	Light green	Green	Light green	Dark green	Ovate	Cordate	Serrated	Succulent
04	T-4: Control: without mulch	Light green	Brown or grey	Light green	Dark green	Ovate	Truncate	Serrated	Coarse

Table 3. Time /Duration of sprouting

S. no	Stage	Initiation	Completion
01	Bulb swelling	13 January	25 January
02	Bud formation	26 January	15 March
03	Bud opening	15 March	25 March
04	Leaf formation	25 March	10 April

Total time taken/Duration: 13 January to 10 April, i.e, 70 days

Fig. 3. Stages of bud sprouting in cuttings under T-1

Fig. 4. Stages of bud sprouting in saplings under T-2

Fig. 5. Onset of inflorescence in T-1, T-2, T-3 & Control

3.6 Soil pH

The pH was recorded to be in ideal range of 6.1 for T-1 and moderately acidic in T-2 and T-3 with pH value of 5.4 and 5.6 respectively. Whereas, slightly alkaline with pH of 7.9 in control. The soil pH values of mulched soils and control is given below in Table 1 (Fig. 7). The soil samples of the treated plots were studied and pH was recorded as 6.1 for T-1 and moderately acidic in T-2 and T-3 with pH value of 5.4 and 5.6 respectively. Whereas, slightly alkaline with pH of 7.9 in control. The results on pH value of the treated soil samples lies in close conformity with the earlier reports of Gangawa et al. [14], Faber et al. [15] and Gosh and Bauri [16].

3.7 Nutrient Content: Nitrogen, Phosphorous & Potassium (NPK)

The treated and un-treated soil with mulches is also studied to NPK content and values of

available NPK were recorded to be in the most ideal range (Fig. 8) for T-1 as 8.2, 1.3 and 9.6 per cent (Table 1). Thus, depicted the suitability of black polythene mulch over the other treatments. Moreover, the treated and un-treated soil with mulches is also studied to NPK content and values of available NPK were recorded to be in the most ideal range for T-1 as 8.2, 1.3 and 9.6%. Thus, depicted the suitability of black polythene mulch over the other treatments. The results on chemical studies for NPK value of the treated soil samples lies in close conformity with the earlier reports of Chaudhary and Iqbal [10], Mirazalva et al. [11], Gao et al. [17] and Kaur & Bons [18].

3.8 Colour and size of Mature Leaf

Generally mulberry leaves are of light green when young and dark green in colour on full maturity i.e. 70 day old leaf (Fig. 9). The colour of leaf under different treatments of mulching along with control is given in the Table 1. For determination of leaf size, the space formula of length × Width was applied and the maximum leaf size was recorded in case ofT-1 as 126cm^2 and minimum in case of Control as 105cm^2 (Fig. 10). Details of the different leaf size are described in Table 1. The result finds enough validation by the results presented by Chanotra et al. [9].

3.9 Actual Leaf Area (By Graph Method)

In the current experiment different values of leaf area was recorded in different treatments (T1, T2 and T3 and in control) and Actual leaf area was calculated by graph method. The maximum leaf area was recorded for mulberry plant growing under black polythene mulch as 74 cm^2 followed by T-2 as 66 cm^2 and least in T4 Control as 40 cm^2 (Fig. 11). The result finds enough validation by the results presented by Khan et al., [8] and Chanotra et al. [9].

3.10 Leaf Shape, Base, Margins and Largest Glossy Leaf

In present study the ovate type of leaf shape was recorded for all the treatments and control exhibited ovate, cordate leaf base whereas, control the wild tree reported truncate leaf base with serrated leaf margins having smooth texture. The maximum leaf area was recorded in plants under T_2 as 86 cm^2 and minimum in wild tree as 28.6 cm^2 (Fig. 12). The result lies in close conformity with that of the results presented by Chanotra et al. [9].

Table 4. Types of weed flora and intensity of weeds in Treatment-1 (Black polythene mulch)

S. No	Name of the weeds	Scientific name	Intensity (Nos.)
01	Hemp	*Cannabis ruderculis*	5
02	Rhubarb	*Rheum rhabarbarum*	1
03	Mallow	*Malva parviflora*	5
04	Prickly lettuce	*Lactuca serriola*	3
05	Clover	*Trifolium repens*	4
Mean			3.60
S.D			1.673
S.E			.748

Table 5. Types of weeds and intensity of weeds in Treatment-2 (Paddy straw and Husk)

S. no.	Name of the weeds	Scientific name	Intensity (Nos.)
01	Clover	*Trifolium repens*	10
02	Hemp	*Cannabis ruderculis*	10
03	Mallow	*Malva parviflora*	8
04	Dallis grass	*Paspalum dalatatum*	20
05	Couch grass	*Elymus repens*	15
06	Dock or curled Dock	*Rumex crispus*	16
07	Carrot grass	*Parthenium hysterophorus*	15
08	Indian goose grass	*Eleusine indica*	25
Mean			14.87
S.D			5.66
S.E			2.003

Table 6. Types of weeds and intensity of weeds in Treatment-3 (Green branches of trees)

S. no	Name of the weeds	Scientific name	Intensity (Nos)
01	Mallow	*Malva parviflora*	8
02	Couch grass	*Elymus repens*	20
03	Cleavers	*Gallium aparine*	20
04	Carrot grass	*Parthenium hysterophorus*	25
05	Couch grass	*Elymus repens*	20
06	Dallis grass	*Paspalum dalatatum*	25
07	Clover	*Trifolium repens*	12
08	Hemp	*Cannabis ruderculis*	15
09	Dock or curled Dock	*Rumex crispus*	15
10	Indian goose grass	*Eleusine indica*	20
Mean			18.00
S.D			5.45
S.E			1.72

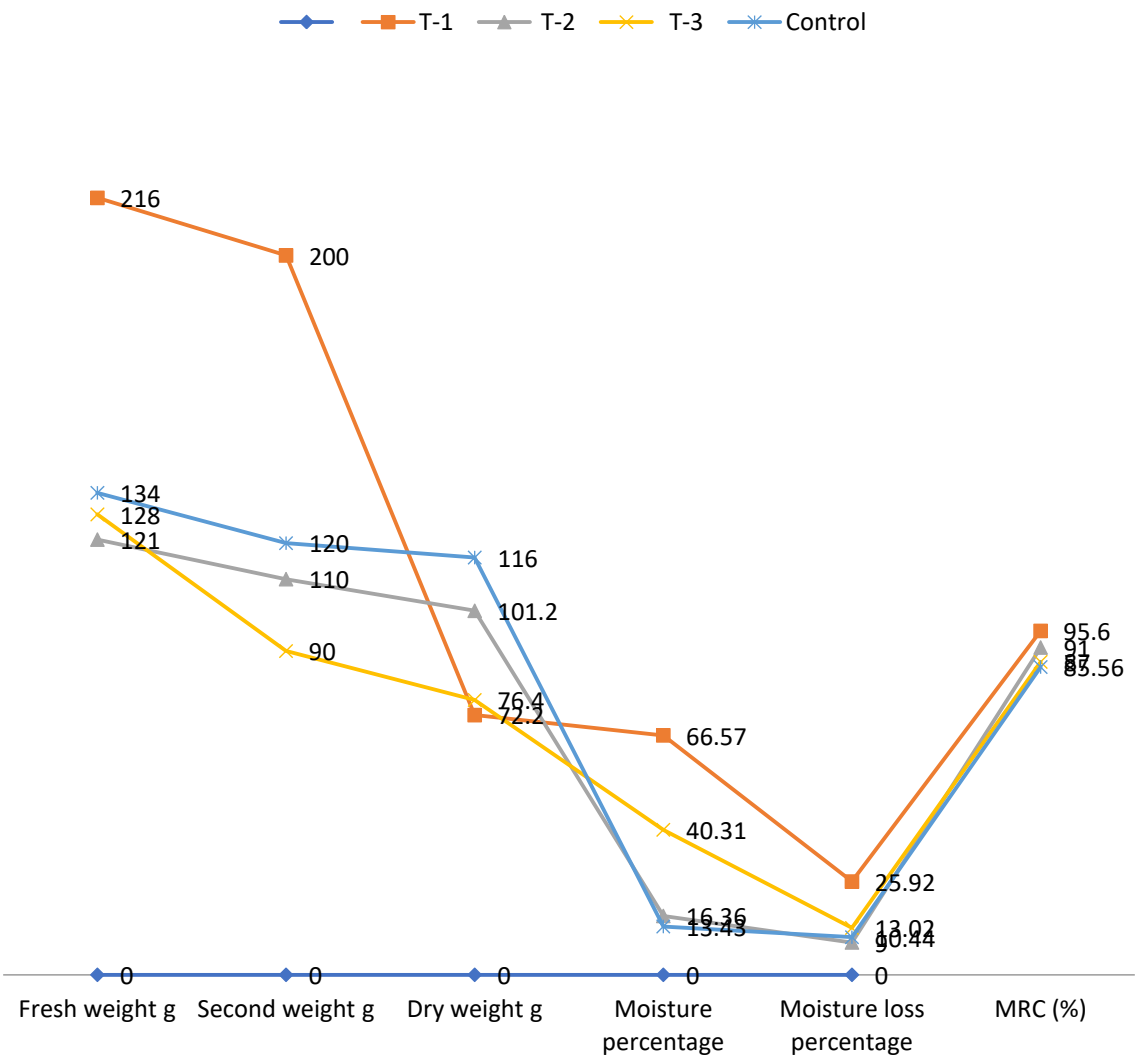

Fig. 6. Soil moisture percentage of T-1, T-2, T-3 and Control

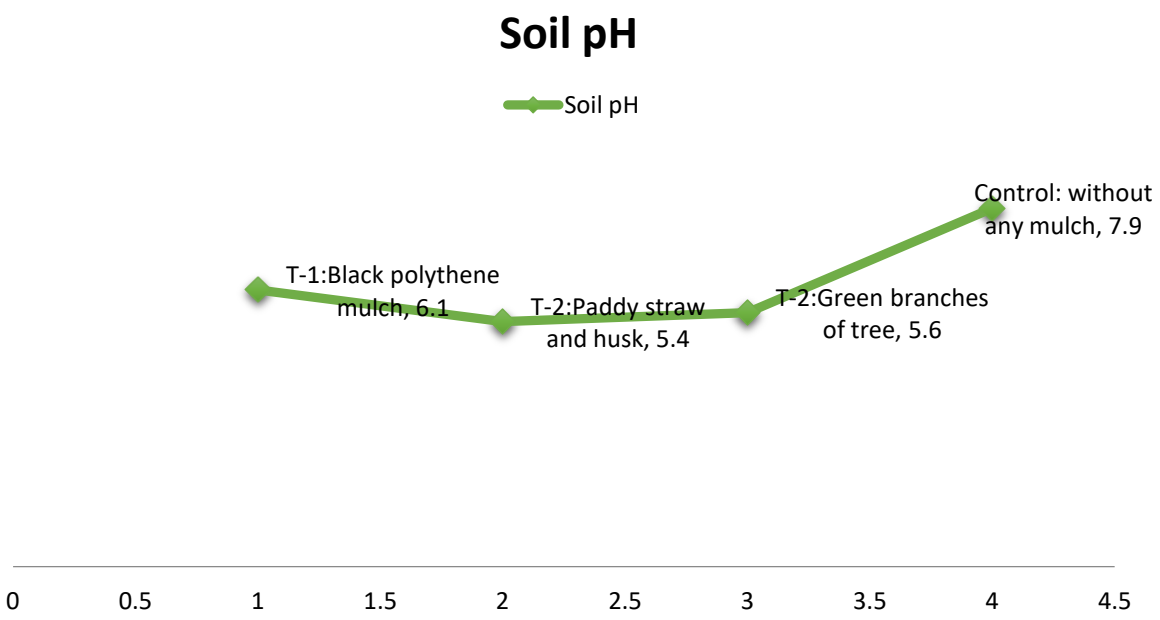

Fig. 7. Soil pH in T1, T2, T3 and Control

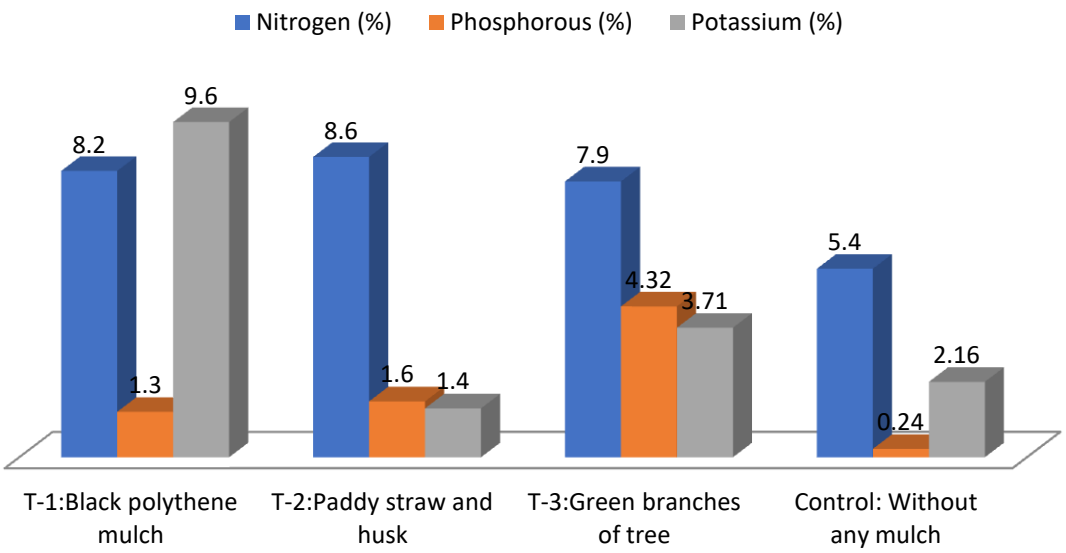

Fig. 8. NPK content in T1, T2, T3 and Control

Fig. 9. Mature leaf colour of mulberry leaf of mulberry under T1, T2, T3 and Control

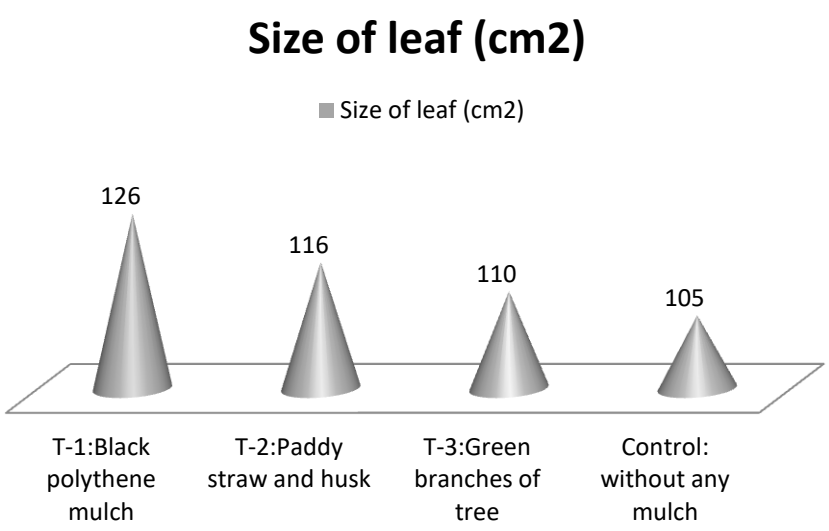

Fig. 10. Leaf size of mulberry plant grown in different mulching treatments and control

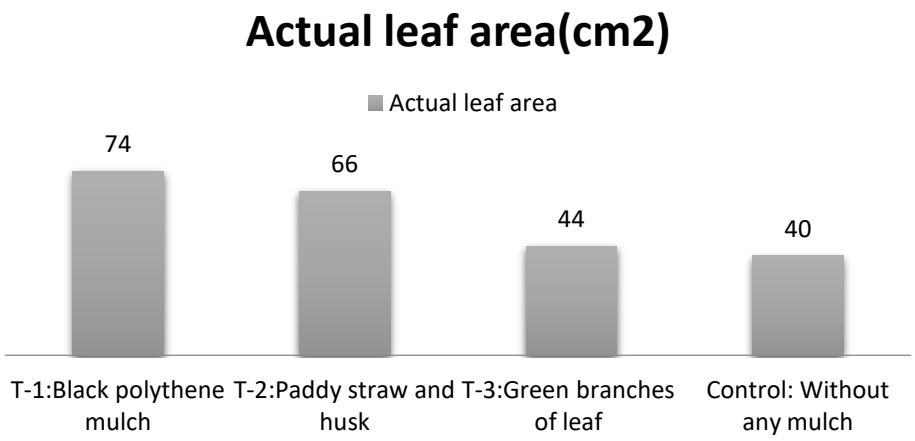

Fig. 11. Actual leaf area of mulberry plant grown in different mulching treatments and control

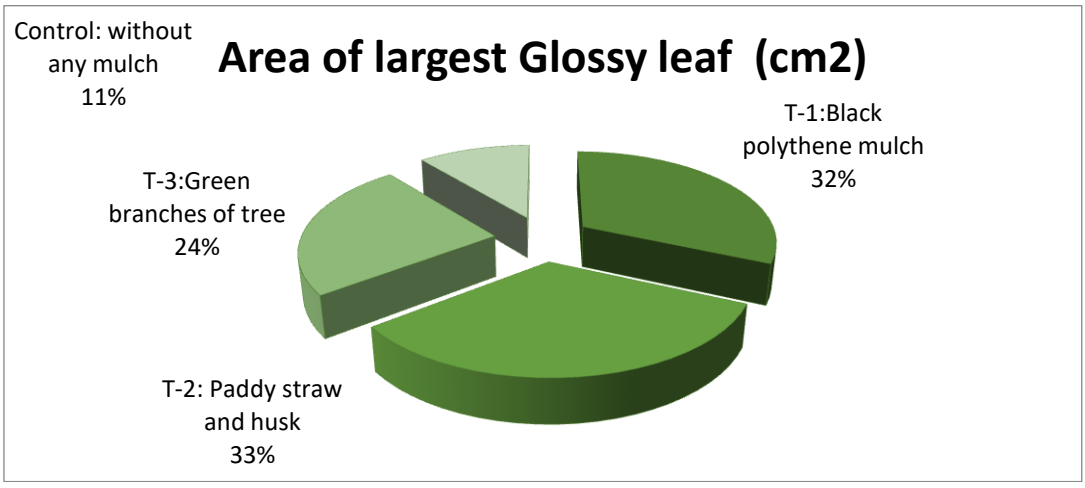

Fig. 12. Area of leaf calculated by largest Glossy leaf method in all treatments

Table 7. Types of weeds and intensity of weeds in Control (without any mulch)

S. no	Name of the weeds	Scientific name	Intensity (Nos.)
01	Cheeseweed	*Malva parviflora*	60
02	Milk weed	*Euphorbia peplus*	25
03	Cape weed	*Arctotheca calendula*	26
04	Sweet clover	*Melilotus indicus*	50
05	Onion weed	*Allium triquetrum*	25
06	Carrot grass	*Parthenium hysterophorus*	30
07	Hemp	*Cannabis ruderculis*	20
08	Dock or curled dock	*Rumex crispus*	15
09	Purslane	*Portulaca oleracea*	20
10	Prickly lettuce	*Lactuca serriola*	30
11	Clover	*Trifolium repens*	35
12.	Cleavers	*Gallium aparine*	36
13	Shepherd's purse	*Capsella bursa-pastroris*	25
14	Couch grass	*Elymus repens*	60
15	Creeping wood sorrel	*Oxalis corniculata*	20
16	Indian goose grass	*Eleusine indica*	85
17	Reed canary grass	*Phalaris arundinacea*	30
18	Chick weed	*Stellaria media*	15
19	Black night shade	*Solanum nigrum*	10
20	Speed well	*Veronica hederifolia*	35
Mean			32.60
S.D			18.377
S.E			4.109

3.11 Fresh, Dry Weight, Moisture Percentage and MRC

10 mature leaves of mulberry plants under different treatments were randomly harvested and weighed for fresh leaf weight on electronic weighing balance. Maximum fresh weight was recorded in plants with green mulches as 10.1g followed by T_2 as 7.2g, T_1 as 7.1g and least in wild (Control) as 6.1g. The same leaves were then oven dried for 6 hours at 60°C for obtaining values of Dry weight. Maximum Dry weight for 10 leaves was recorded in T_2 as 3.3g followed by T_3 as 2.4g, T_1 as 1.8g and minimum of 1.2g in T-4 control i.e, wild tree. After taking the fresh and dry weight of leaves, the moisture percentage was calculated by using the formula:

Moisture percentage = Fresh weight – Dry Weight × 100 / Fresh weight

The values for moisture percentage for different treatments was recorded to be highest as 76.23% followed by 74.64% and 54.16% for T_3, T_1 and T_2 respectively. Whereas, the wild tree selected as Control was recorded with moisture percentage of 68.2 per cent (Table 1).

MRC of the different mulberry varieties were determined by using the following formula:

$$\text{Moisture \%} = \frac{W1 - W3}{W1} \times 100$$

$$\text{Moisture loss \%} = \frac{W1 - W2}{W1} \times 100$$

W1 – Fresh weight of leaves
W2 – Second weight of leaves
W3 – Dried weight of leaves

Moisture Retention Capacity = 100 – Moisture loss %

For the studied leaf samples, maximum moisture retention capacity was observed in case of plants grown under Black polythene mulch as T_1 as 73.24% and least in green branches mulch T_3 as 61.39% (Fig. 13). For T-1 the fresh weight of leaves was recorded as 7.1g and the moisture percentage as 74.64% and MRC after 6 hour was recorded as 73.24%, the highest value. These findings lies in close line with the early observations of Sahida et al. [2] who reported the maximum moisture content in mulched treatments as compared to control.

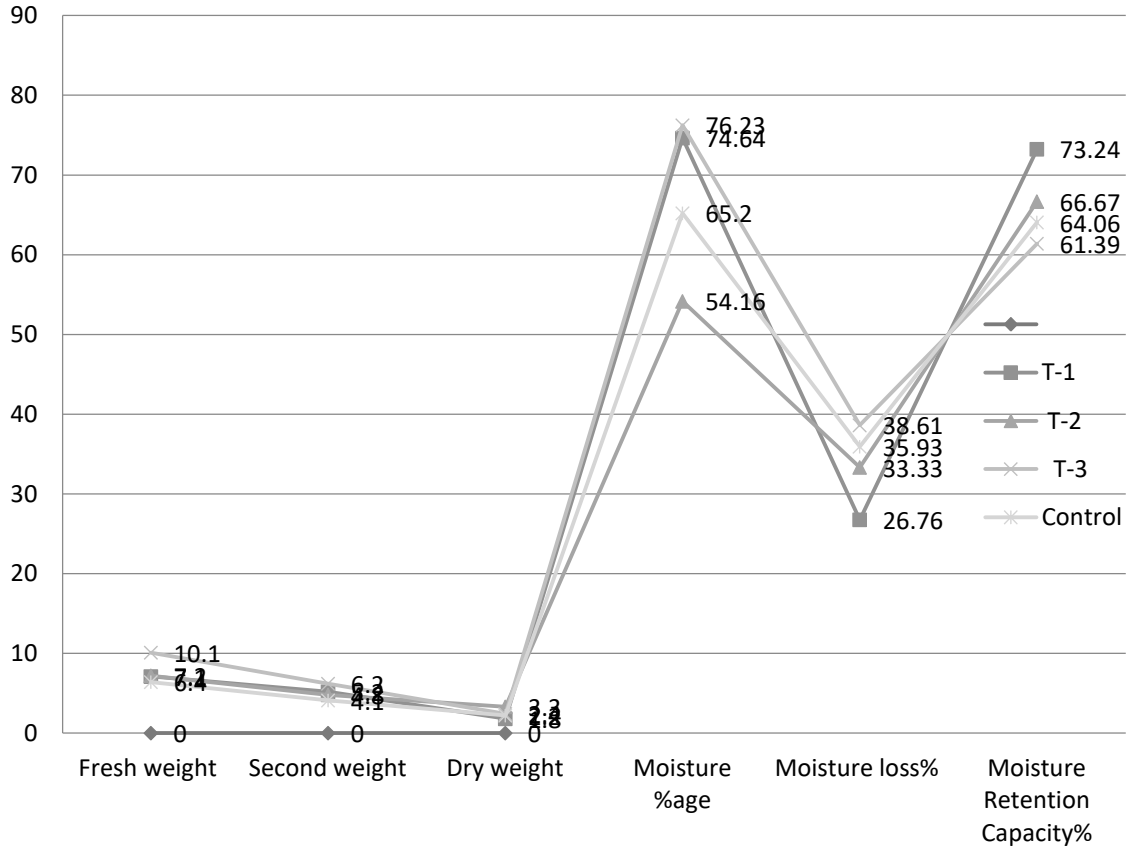

Fig. 13. Fresh & dry leaf weight & moisture percentage & MRC of mulberry leaf in all treatments

4. CONCLUSION

On the basis of current results it can be concluded that mulching could be considered as a viable option for conserving the moisture and its synergistic response to the applied inputs. Mulch acts as a barrier which effectively blocks the transport of vapours out of soil and alters the net radiation at the soil surface which checks soil evaporation, moderate soil temperature, modify crop microclimate, suppress weed growth, improve soil physical, chemical and biological properties and check the direct beating action of rains lead to soil erosion control. In the current experiment, Black Polythene Mulch was recorded with most superior results in terms of physical and chemical prosperities of the soil having, most ideal pH with value 6.1 and NPK values as 8.2, 1.3 and 9.6%. Moreover, minimum weed flora with least intensity was recorded for the mulberry plot provided with Black polythene mulch (T-1). Whereas, the plot without any mulch (Control) was recorded with comparatively poor performance and very dense weed intensity. Therefore, on the basis of current findings, Black Polythene sheet is recommended as the most ideal synthetic mulch to achieve the expected foliage yield in mulberry. Application of suitable mulches in mulberry fields can reduce the dependency of chemical weedicides for wed control as mulches proved to be suitable bio-tools for limiting the weed growth. The results of current experiment could further be utilized for developing suitable package of practices and cultural operations for mulberry cultivation under rainfed conditions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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