

Influence of Different Mulch Materials on Soil Parameters and Weed Control in Guava (*Psidium guajava* L.) cv. VNR Bihi under Tarai Region of Uttarakhand

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Authors' contributions

This work was carried out in collaboration among all authors. Author RS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VPS and RKJ' managed the analyses of the study. Author RK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The impact of different mulches on soil properties and weed control efficiency on Six-year-old guava cv. VNR Bihi orchard was studied during the year 2018-19. The experiment was laid out in randomized block design (RBD) using twelve treatments each replicated thrice. Different mulching treatments showed non-significant effect on soil pH, electrical conductivity and soil organic carbon. However, this effect was found significant with respect to available N, P and K content where mulching with plastic film of silver-black colour (T₄) showed maximum increase (5.75, 2.76 and 1.48 Kg ha⁻¹, respectively). Highest average weekly temperature (23.70°C) was obtained in the plots mulched with transparent film without herbicide application (T₆). Maximum weed control was found under black plastic mulch (T₅) which registered minimum weed population (10.50 m⁻²), fresh weight (7.17 g m⁻²) and dry weight (2.48 g m⁻²). The experimental results revealed that application of mulches is one of the easiest and cheapest methods for

orchard soil management which can be successfully employed for improving physico-chemical properties of soil with efficient weed control.

Keywords: Mulching; orchard soil management; soil heat flux; weed control.

1. INTRODUCTION

Guava is one of the major fruit crops of tropical and sub-tropical regions commonly grown throughout the world. It is easily available at reasonable price thus also known as 'The Apple of the Tropics' or 'Poor Man's Fruit'. Due to its hardy nature, the trees have high adaptability to wide range of edaphic and climatic conditions. It is a prolific bearer and can give high economic returns even without much care. It is fifth most important fruit crop of India occupying 2.65 per cent of total area under fruit cultivation. The area under guava is estimated to be 2.65 lakh hectares with an estimated annual production of 40.54 lakh tonnes.

In Uttarakhand, area under commercial guava cultivation is only 3620 ha with annual production of 20,370 metric tonnes with a very low productivity (5.62 MT/ha) which is almost one-third of the national guava productivity. The main cause behind low productivity is poor orchard management practices which results into biotic and abiotic stresses in fruit crops. This high stress adversely affects the growth and productivity of fruit crops [1]. Weeds also compromise crop productivity through competition for resources including water, nutrients and light [2]. Under such situations, floor management through application of mulches is one of the cheapest available options for guava. According to Jack et al. [3], the english word mulch probably derived from the German word 'Molsch' meaning 'soft to decay'. Mulches are also known as the grower's first line of defense in providing ideal conditions for plants with highly cost efficient. The other well-known effects of this practice are regulation of soil temperature, improvement of soil aeration, control of weed population, increase in organic matter content (organic mulch) and also increase the activity of soil microbes [4]. It exerts decisive effects on nutrient use efficiency, earliness, yield and quality of the crop [1,5]. The advantage of mulching lies in its effect on soil environment modification. The greatest benefit from plastic mulch is that the soil temperature in the planting bed is raised, promoting faster crop development and earlier harvest. Fertilizer loss by leaching is less beneath the mulch, so that fertilizers are optimally used and not wasted. The soil under plastic mulch remains loose and friable

and roots access to adequate oxygen is not compromised and microbial activity is enhanced [6]. Weed management is the least cared part among the various orchard management practices in India. It is thought as trees are much larger than weed plants hence these do not affect the tree growth and productivity. But the fact is that most of the fruit trees have root systems that do not compete well with other plants [1]. The commonly used mulching materials in fruit orchards include pruned materials from fruit trees, fallen leaves, paddy straw, saw dust, hay etc. However, use of synthetic mulches which include plastic film and LDPE film (biodegradable types) are becoming more popular.

As per the literature available it was observed that there is no comparative efficiency study of organic, plastic and biodegradable mulching on soil parameters and weed control in guava under *tarai* conditions of Uttarakhand. Therefore, an experiment was planned with the objective to find out the influence of different mulch materials on soil parameters and weed control in guava.

2. MATERIALS AND METHODS

The experiment was conducted on six-year-old guava trees cv. VNR Bihi planted in medium high density planting system (5 m x 3 m) at Horticulture Research Centre, Patharchatta, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, situated at 29 °N latitude, 79.3 °E longitudes and 243.94 m above mean sea level in the tarai region of Himalayas with humid subtropical climate. The annual rainfall is about 145 cm, which has a lot of variations throughout the year. The temperature variation is very large as summer holding maximum temperature of around 42-43 °C while in winter it falls heavily to 2-4 °C. The average relative humidity is measured to be 67 %. The meteorological observations which were recorded on weekly basis during the period of experimentation (from April, 2019 to January, 2020) with respect to weather parameters viz., minimum and maximum temperature, relative humidity, pan evaporation, rainfall and sunshine hours are presented in Fig. 1. The soil of the experimental field is silt-loam having pH of 5.78-5.82 and an electrical conductivity in the range of

0.89-0.95 dSm⁻¹. The experiment was laid out in randomized block design (RBD) using twelve treatments each replicated thrice. Different mulch treatments were plastic film of red-black colour (T₁), plastic film of white-black colour (T₂), plastic film of yellow-black colour (T₃), plastic film of silver-black colour (T₄), plastic film of black colour (T₅), transparent film without herbicide application (T₆), transparent film with herbicide application (T₇), biodegradable film of white-black colour (T₈), biodegradable film of silver-black colour (T₉), organic material i.e. paddy straw (T₁₀), organic material i.e. *Kans* grass (T₁₁) and no-mulch i.e. control (T₀). The paddy straw mulch and dry *Kans* grass @ 16 Kg and 17 Kg per square metre, respectively were applied uniformly on the bunds of tress to a height of 15 cm. All plastic and biodegradable mulches of width 1.2 m and thickness 100 micron were used and dual colour mulches with black on lower side and respective colours on the upper side of the sheet were applied to the base of trees.

The imposition of the treatments was done in the month of April, 2019 and the observations were recorded twice i.e. before imposition and after completion of the experiment. To assess the fertility status of soil, representative soil samples

(0-30 cm depth) from each plot of experimental site was collected, composited and air dried. The samples were powdered using a wooden mortar-pastle and passed through 2 mm plastic sieve and were analyzed for pH and EC in soil:water suspension (1:2) using glass electrode and conductivity meter [7]. Organic carbon was determined by the Walkley and Black's method as described by Black [8]. Available nitrogen was determined by using alkaline potassium permanganate method [9] using auto nitrogen analyzer. Available phosphorus was determined by Olsen et al. [10] method using 0.5 M NaHCO₃ solution adjusted at pH 8.5 using spectrophotometer. Available potassium was determined using 1N neutral ammonium acetate method [11] using flame photometer. The soil temperature was measured using thermometer to a depth of 10 cm at weekly intervals. The weed density was estimated using a quadrat (1 x 1 m) placed randomly in all the replications of each treatment and control. The fresh weight of weeds was recorded as such and dry weight of weeds was recorded by drying the weeds of each treatment in hot air oven at 65 °C temperature. The fresh and dry weight of weeds were expressed in g/m².

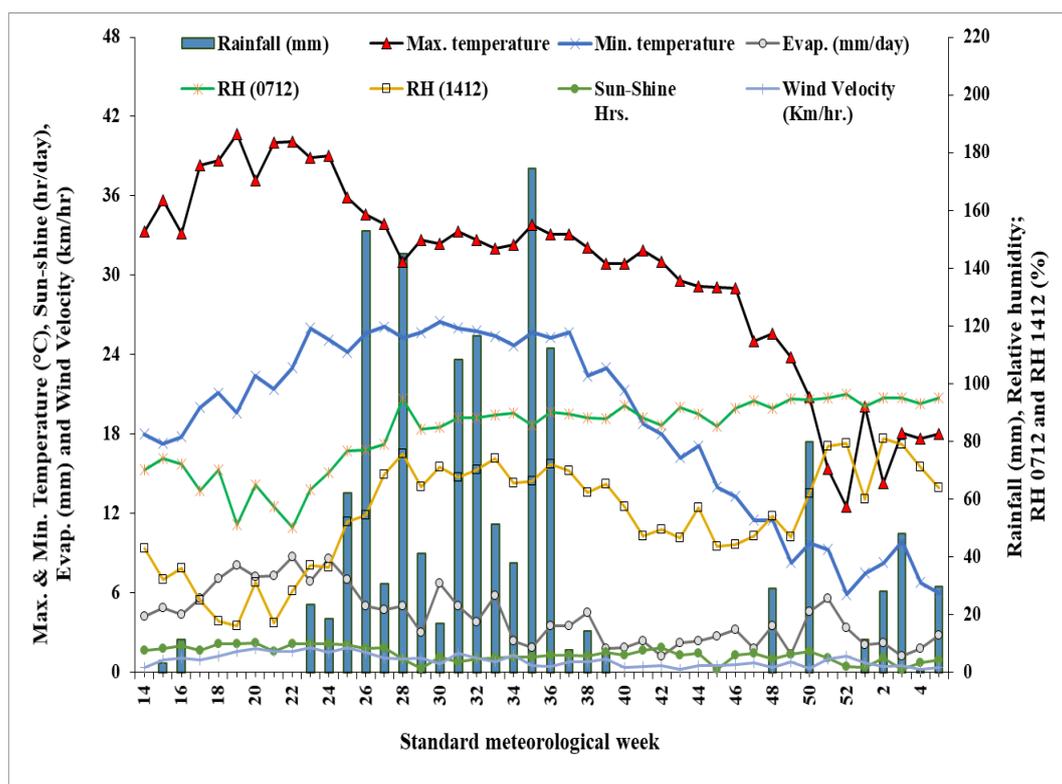


Fig. 1. Standard meteorological week's average weather data of 2019-20 at G. B. Pant University of Agriculture and Technology, Pantnagar, 263145 (Uttarakhand)

3. RESULTS AND DISCUSSION

3.1 Soil pH and Electrical Conductivity

There was no significant change observed in soil pH and electrical conductivity (EC) in any of the treatments throughout the experiment period (Table 1). However, maximum change (-0.04) in pH value was found in treatment mulched with T₁₁ (organic material i.e. *Kans* grass) followed by control which showed increase in pH value (0.03) on positive side. However there were no significant differences between these values exhibited on the other hand very meagre change after the experiment. The slight reduction in pH value due to organic mulching (T₁₀ and T₁₁) might be due to the release of organic acids and this decrease was proportional to the depth of mulching [12]. Mulching reduced the accumulation of salt at surface soil by minimizing the loss of water through evaporation, hence showed non-significant variation in pH change. The present findings were similar with the results of Mukherjee et al. [13] in ber, Kotur [14] in guava and Singh et al. [15] in mango. On the other hand, soil EC values were slightly higher under all mulches and the probable cause of this might be due to higher moisture content under mulched treatments [16]. The similar observations have also been made by Singh et al. [17] in ber and Garg et al. [18] in guava.

3.2 Soil Organic Carbon

No significant differences were experienced among the mulching treatments with respect to soil organic carbon at the initial stage (before

imposition of the treatments) as well as after the final harvest (Table 1). But treatments having organic mulches showed a higher change as compared to other treatments while, control was having minimum change in organic carbon content. This might be due to soil covering with different mulches improved the environmental condition for soil micro-organisms by inhibiting drastic variation in humidity and temperature as well as by increasing organic matter as a source of nutrition thus, resulted in high organic carbon content [19]. Maximum increase in organic carbon content in organic mulches might be due to increased accumulation of starch and lignin compounds which affected the soil organic carbon [20]. This result is in close agreement with the findings of Mandal and Chattopadhyay [21] in custard apple, Das et al. [22] in guava and Kumar and Hassan [23] in apple.

3.3 Available Nitrogen, Phosphorous and Potassium

Different mulch treatments had significant effect on available N, P and K of the experimental plot (Table 2). Mulching under T₄ recorded maximum increase (5.75, 2.76 and 1.48 Kg ha⁻¹, respectively) in available N, P and K followed by T₉ (5.65, 2.65 and 1.45 Kg ha⁻¹, respectively) and T₁₀ (5.52, 2.61 and 1.35 Kg ha⁻¹, respectively) whereas, minimum values (-3.28, -2.28 and -0.85 Kg ha⁻¹, respectively) for N, P, K were observed in T₀. All the mulching treatments positively influenced the values as available N, P, and K were higher after the harvesting (final value) than before the commencement of experiment (initial value) except in control (T₀).

Table 1. Effect of different mulches on soil pH, EC and organic carbon

Symbols	Soil pH			Soil EC (dSm ⁻¹)			Organic carbon (%)		
	Initial value	Final value	Change	Initial value	Final value	Change	Initial value	Final value	Change
T ₁	5.81	5.80	-0.01	0.92	0.94	0.02	0.618	0.616	-0.002
T ₂	5.80	5.81	0.01	0.95	0.98	0.03	0.625	0.626	0.001
T ₃	5.81	5.80	-0.01	0.91	0.93	0.02	0.657	0.658	0.001
T ₄	5.80	5.79	-0.01	0.89	0.93	0.04	0.613	0.614	0.001
T ₅	5.81	5.82	0.01	0.90	0.93	0.03	0.634	0.624	-0.01
T ₆	5.80	5.78	-0.02	0.93	0.95	0.02	0.585	0.583	-0.002
T ₇	5.82	5.81	-0.01	0.89	0.91	0.02	0.654	0.652	-0.002
T ₈	5.82	5.81	-0.01	0.90	0.92	0.02	0.615	0.616	0.001
T ₉	5.82	5.80	-0.02	0.93	0.95	0.02	0.594	0.595	0.001
T ₁₀	5.81	5.78	-0.03	0.92	0.95	0.03	0.666	0.669	0.003
T ₁₁	5.82	5.78	-0.04	0.94	0.96	0.02	0.584	0.586	0.002
T ₀	5.80	5.83	0.03	0.90	0.91	0.01	0.646	0.641	-0.005
CD (P=0.05)	NS	NS	-	NS	NS	-	NS	NS	-

The increased status of available N, P and K in soil under different mulches may be due to increased microbial activity by maintaining the favourable temperature which could have stimulated the nitrification process, decomposition of humic substances and also minimized the nutrient losses through weeds [24]. Consistent with the above findings, Mukherjee et al. [13] in ber, Dutta and Majumder [25] in guava and Singh et al. [15] in mango also reported higher available N, P and K through mulching when compared with unmulched control.

3.4 Soil Temperature

Overall perusal of the experimental data pertaining to soil temperature (Fig. 2) exhibited that the maximum mean soil temperature was observed (23.70 °C) in T₆. This might be due to the characteristic nature of transparent mulch sheet which absorbed most ultraviolet, visible and infrared wavelength of incoming solar radiation which created similar effect as in case of greenhouse, by which soil temperature has been increased [16,26,27]. Plastic as well as biodegradable films of black and silver-black colour were considerably effective in increasing soil temperature better than organic mulches due to a greater net radiation under the mulch as black surface is good absorber of heat [28,29] compared to other coloured mulches and soil heat flux would be greater under these mulches. The colour of mulch sheet determined the degree

of soil warming. Light-coloured (clear/transparent, silver) mulches maintained higher values of soil temperature (2.5-2.9 °C) as compared to dark coloured (black, red, yellow, blue etc.) mulches which enhanced the soil temperature in the range of 1.4-2.1 °C [30].

3.5 Weed Parameters

The treatment under T₆ (Transparent film without herbicide application) registered maximum number of weeds (140.63 m⁻²) and highest fresh and dry weight of weeds (83.34 and 31.54 g m⁻², respectively). The maximum weed control was found under T₄ and it was also experienced that the mulches with black underside exhibited lesser weed count with no significant differences with treatment mulched with plastic film of black colour except the treatment having mulching with plastic film of white-black colour. Possible reasons of this could be the fact that mulching reduced the weed population by inhibiting light to photosynthetic portion of weeds [31]. Various organic, biodegradable and inorganic mulches, which were of different nature and kind, differed considerably in weed controlling ability. In the present study, black and other coloured plastic as well as biodegradable mulches having lower side black in colour were found to be most effective in controlling weeds due to complete inhibition of sunlight, which was essential for photosynthesis and also acted as physical barrier for newly emerging weeds at all stages of growth [32].

Table 2. Effect of different mulches on change in available nitrogen, phosphorous and potassium contents of soil

Symbols	Available N (Kg/ha)			Available P (Kg/ha)			Available K (Kg/ha)		
	Initial value	Final value	Change	Initial value	Final value	Change	Initial value	Final value	Change
T ₁	184.84	190.07	5.23	154.78	157.08	2.3	7.65	8.89	1.24
T ₂	183.78	189.08	5.3	155.24	157.42	2.18	7.61	8.76	1.15
T ₃	183.00	188.10	5.1	154.37	156.47	2.1	7.64	8.91	1.27
T ₄	184.72	190.47	5.75	153.76	156.52	2.76	7.65	9.13	1.48
T ₅	184.75	190.35	5.6	153.80	156.30	2.5	7.59	8.94	1.35
T ₆	183.10	184.45	1.35	153.83	155.15	1.32	7.72	8.08	0.36
T ₇	183.34	184.62	1.28	155.05	156.25	1.2	7.59	7.91	0.32
T ₈	184.22	189.92	5.7	154.63	157.25	2.62	7.70	9.08	1.38
T ₉	185.22	190.87	5.65	153.91	156.56	2.65	7.61	9.06	1.45
T ₁₀	183.39	188.91	5.52	156.19	158.80	2.61	7.72	9.07	1.35
T ₁₁	185.12	190.22	5.1	154.25	156.83	2.58	7.72	8.77	1.05
T ₀	183.66	180.38	-3.28	154.87	152.59	-2.28	7.64	6.79	-0.85
SEm ±	-	2.86	-	-	1.20	-	-	0.16	-
CD (P=0.05)	NS	8.22	-	NS	3.38	-	NS	0.47	-

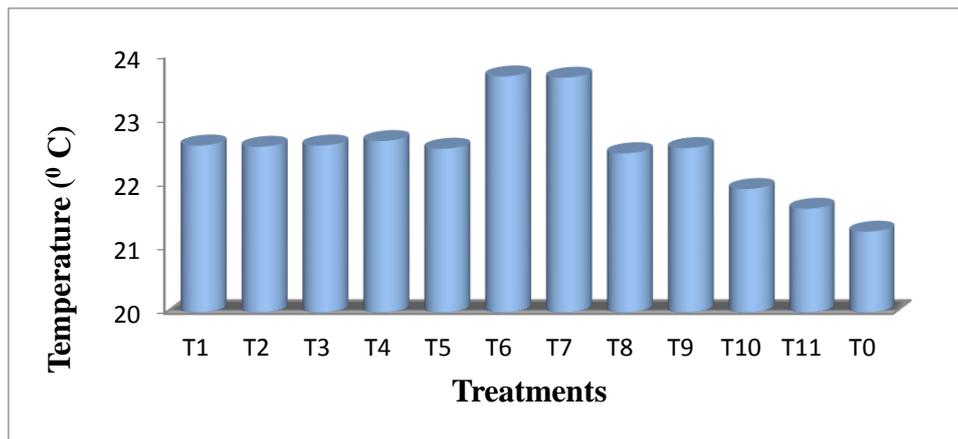


Fig 2. Effect of different mulches on mean soil temperature

Table 3. Effect of different mulches on weed parameters

Symbols	Weed count per m ²		Fresh weight of weeds (g m ⁻²)		Dry weight of weeds (g m ⁻²)	
	Initial value	Final value	Initial value	Final value	Initial value	Final value
T ₁	33.67	14.54	23.01	9.93	7.94	3.43
T ₂	31.33	18.88	21.41	12.90	7.39	4.45
T ₃	32.67	15.62	22.32	10.67	7.71	3.69
T ₄	33.33	11.20	22.77	7.65	7.86	2.64
T ₅	30.67	10.50	20.96	7.17	7.24	2.48
T ₆	39.33	140.63	26.87	83.34	9.28	31.54
T ₇	32.67	127.44	22.32	76.46	7.71	27.28
T ₈	33.33	20.35	22.77	13.90	7.86	4.80
T ₉	33.33	12.74	22.77	8.70	7.86	3.01
T ₁₀	34.33	68.32	23.46	46.68	8.10	16.12
T ₁₁	38.67	94.94	26.42	64.87	9.12	22.40
T ₀	31.33	109.42	21.41	68.76	7.39	25.82
SEm ±	-	2.65	-	1.15	-	0.46
CD (P=0.05)	NS	7.86	NS	3.38	NS	1.30

Among organic mulches, paddy straw mulch was reported to suppress considerable weed growth that made a continuous and compact layer on the soil surface, whereas, in *Kans* grass mulched plants, the weeds were more in number as compared to paddy straw mulch because of better penetration of sunlight, while, maximum weed count in control might be due to unrestricted availability of solar radiation [33].

4. CONCLUSION

Keeping in view the overall results, it can be inferred that all the mulching treatments (either organic or inorganic) were effective in improving soil nutrient status and controlling weeds in guava orchard cv. VNR Bihi but the film of silver-

black colour (plastic or biodegradable) was found to be most effective among all the treatments. Plastic mulching has proved to be most effective but it results in polyethylene residues that contaminate the cultivable land and also contribute to the massive worldwide plastic pollution, a serious environmental concern. This limitation of plastic mulching can be overcome by the use of biodegradable mulches which have the tendency to break down over a period of time and hence, a promising alternative to alleviate polyethylene pollution.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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