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SOIL SCIENCE

Effects of Mulching on Soil Properties and Post Harvest Quality of Mango Cv. Himsagar Grown in New Alluvial Zone of West Bengal

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ABSTRACT

An experiment was conducted to study the effect of mulching on soil properties and post harvest quality of Himsagar mango grown in new alluvial zone of West Bengal at Central Research Farm, Gayeshpur, BCKV in a Randomized Block Design (RBD) with 3 replications during two consecutive years from 2013 to 2015. The results revealed that mulching with different materials on 15 years old mango tree cv. Himsagar having uniform growth and vigour, significantly increased the soil moisture content, available soil N, P and K, along with increase soil microbial population. Among the different mulching treatments, black polythene showed maximum soil moisture retention with improved soil properties. This treatment also exhibited maximum physico-chemical qualities of fruits followed by paddy straw and paddy husk. Black polythene mulch gave 80% marketable fruits on the 9th day of storage while control showed minimum storage life as evident from CO_2 evolution and total soluble solids content of fruit.

Highlights

- To study the effect of different mulches on the soil properties and microbial population in Himsagar mango at new alluvial zone of West Bengal.
- To study the post harvest quality attributes of Himsagar mango due to different mulching practices at new alluvial zone of West Bengal.

Keywords: Mulching, soil properties, microbial population, post harvest quality, *Mangifera indica* L.

Mango (*Mangifera indica* L.) is one the most luscious fruit since time immemorial in the tropical and subtropical region of the world and is native of South East Asia. It is designated as the 'King of Fruits' (Purseglove 1972) because of its excellent flavour, attractive fragrance, beautiful shades of colour and delicious taste with high nutritive value. India is the largest producer of mango but occupies only third position in the international trade. The total area under mango in India is 2.24 million hectares with the total production of 18.78 million metric tonnes. Average productivity of mango in India is 6.6 tonnes ha^{-1} (Anonymous 2016). Mango is the most important fruits of West Bengal covering about 93.50 thousand ha with an annual production of 4.31 lakh tons (Saxena 2015). In West Bengal, Himsagar mango is the choicest cultivar of mango but, very less information regarding the effect of mulches is available.

Mulches have a substantial impact on enhancing the sustainable yield and quality of fruit. It improves the physical and chemical qualities of the soil and availability of nutrient pool and biological qualities by increasing beneficial soil microbes (Dutta and Majumder 2009). Mulches impart manifold beneficial effect, like stabilization of soil temperature, reduced water loss through evaporation, resulting more stored soil moisture, which is utilized by the crop plants especially in the dry season (Shirgure *et al*. 2003). Mulches not only conserve soil moisture but along with modification of soil temperature also check the weed density (Kaur and Kaundal 2009), which ultimately increase the total and early yield (Pande *et al*. 2005). The practice of applying a layer of dead vegetative waste mulch on soil surface such as straw mulch and polyethylene mulches to conserve soil moisture has been prevalent for a very long time in many areas (Das *et al*. 2006). Polyethylene mulches (transparent and black) are not only completely resistant to water it also decreases the moisture losses and conserve soil particles over the surfaces (Tarara 2000). It also accelerates soil temperature as well (Ham *et al*. 1993). The secondary data also reported that increased self life and quality of fruits due to mulching (Kumar *et al.* 2008). For instant, the positive response of mulching on mango yield was also reported by Ghosh and Bauri (2003). Keeping in view, the present investigation was carried out to find out the effect of different mulching materials on the growth, yield, physico-chemical qualities and shelf-life of Himsagar mango fruits in new alluvial zone of West Bengal (India).

MATERIALS AND METHODS

The experiment was conducted at the Central Research Farm, New alluvial zone of Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal during 2013 to 2015. The mean annual rainfall is 1,750 mm, out of which 80-90% is normally received from June to September. Soil at the experiment site was sandy clay loam (sand 64.8%, silt 10.4%, and clay 24.8%) with a pH of 6.9 and contained organic carbon of 0.63%, available nitrogen 271.00 kg ha^{-1}, phosphorus 28.21 kg ha^{-1} and potassium 210.00 kg ha^{-1} (Das *et al*. 2015). The experiment was conducted in a fifteen year aged well managed healthy mango orchard cv. Himsagar having uniform growth and vigour spaced at 10m x 10m apart. All the experimental trees received uniform cultural practices and were fertilized through organic means like bio-fertilizer, vermicompost an FYM. Plant protection measure was also done through organic sources. The experiment was laid out in a Randomized Block Design (RBD) with 3 replications having following five treatments viz. T_1 – Black polythene (gauge, 50 micron), T_2 – Paddy husk, T_3 – Paddy straw, T_4 – Dry banana leaves, T_5 – Dry mango leaves, and T_6 – Unmulched (Control). The different mulches were applied around the tree basin during the flower bud differentiation stage (March). 5 cm thick layer of paddy husk and paddy straw were spread on the tree basin covering 1 m^2 area of tree circumference. Plastic mulches were applied by covering the basin of each plant. The sides of plastic mulches were covered with soil in order to avoid removal of the applied materials by wind blow. The mature fruits were harvested and brought to the laboratory for physico-chemical analysis and observing the storage life of fruits. Soil moisture content at 50-75 cm depth was determined gravimetrically at weekly intervals. Observations of fruit physical parameters like fruit size (length and diameter) with the help of Vernier Calipers, fruit weight, with the help of digital weighing balance was based on random 10 fruit samples. Biochemical fruit quality was determined from the juice extracted from 10 fruits. The TSS was estimated using digital refractometer (ATAGO, RX 5000, Tokyo, Japan) and expressed as ^{o}Brix. Titratable acidity was determined by titrating 5 ml of juice against 0.1 N NaOH and expressed as %. Total sugar (%) was determined following the standard methods as described by Ranganna (2003). The β carotene of fruit pulp was estimated by spectrophotometric method as per Davies (1976) and expressed in mg/100 g of fruit pulp. It is calculated using the equation:

$$\beta \text{ carotene (mg/100g)} = \frac{\text{Concentration of carotene in solution as read from the standard curve } (\mu g/ml) \times \text{Final volume} \times \text{Dilution} \times 100}{\text{Weight of the sample (g)} \times 1000}$$

Soil nutrients were also estimated by the methods as N (Black, 1965), P_2O_5 (Jackson, 1960) and K_2O (Piper, 1956). To estimate the number of soil bacteria, sample was taken from 10-15 cm depth and bacterial counts were calculated on the basis of serial 10 fold dilution technique, using the pour plate methods and replicate of 10 gm soil samples, and an appropriate dilution as described by Johnson and Curl, (1972). Soil bacterial population expressed as Colony forming units per g of soil (cfu/g) that calculated using the equation of James (1978).

$$\text{Colony forming unit}\left(\frac{\text{CFU}}{\text{gm}}\text{soil}\right) = \frac{\text{No. of colonies} \times \text{dilution factor}}{\text{Volume of inoculum}}$$

Mature fruits were stored at ambient room temperature (35-38 °C) and 84-89% RH and storage life was studied at three days intervals up to ninth day. During storage, CO_2 evolution, total soluble solids and percentage of marketable fruits were determined. CO_2 evolution of fruits were determined by titration of residual $Ba(OH)_2$ in the solution with standardized $^{N}/_{10}$ HCl as described by (Mitra *et al*. 1971). The data were analysed statistically by the analysis of variance as suggested by Goon *et al*., (2001).

RESULTS AND DISCUSSION

Soil properties and microbial population

Perusual of data revealed that different mulches significantly increased the soil moisture content from 3.40% to 13.14%. Black polythene mulch demonstrated maximum (13.14%) soil moisture content followed by paddy straw (11.00%) and paddy husk (10.21%) while the least was observed in unmulched (control) plants (3.40 %) (Table 1). High moisture retention ability of plastic mulches could be due to less evaporation from soil. The water vapors that evaporate from the soil surface further trapped in the plastic and dropped again into the upper soil surface which increases soil moisture content in the root zone (Noman Khan *et al.* 2016). Such an improvement in soil hydrothermal regime with mulching was also reported on several other tropical species such as guava cv. L-49 (Dutta and Majumder 2009), mango fruits cv. Himsagar (Ghosh and Bauri 2003). The soil mineral contents (N, P and K) were also influenced by the application of different mulches, black polythene mulch proved very effective and had the highest content of available soil mineral contents viz. Nitrogen (192.32 Kg ha^{-1}), Phosphorus (48.11 Kg ha^{-1}) and Potassium (280.11 Kg ha^{-1}) followed by paddy straw and paddy husk while the least available N (170.11 Kg ha^{-1}), P (30.29 Kg ha^{-1}) and K (203.22 Kg ha^{-1}) was found in control treatments. Higher available nutrient pool in the soil under polythene mulch was the result of mineralization of organic matter. Similar result was also obtained by Dutta and Majumder (2009) in guava. Soil microbial population was also influenced by different mulches. Highest soil microbial population was observed in paddy straw (2.5×10^6 $cfug^{-1}$ soil bacteria) followed by black polythene mulch (2.4×10^6 $cfug^{-1}$ soil bacteria) while least recorded in control treatment (1.8×10^5 $cfug^{-1}$ soil bacteria) (Table 1). Micro-organism is an important component of soil environment (Arshad and Frankenberger 1992). There larger number is indicative of better soil health (Barea *et al*. 1976) and improved nutrient availability to plant and the fruits. Organic mulch are efficient in reduction of nitrates leaching, improve soil physical properties, prevent erosion, supply organic matter, regulate temperature and water retention, improve nitrogen balance, take part in nutrient cycle as well as increase the biological activity (Hooks and Johnson 2003; Muhammad *et al*. 2009; Sarolia and Bhardwaj 2012). Increased macronutrient uptake with the application of biofertilizer and mulching was also reported in mango (Dutta & Kundu 2012) and Litchi (Anubha *et al*. 2013).

Table 1: Effect of mulching on soil properties and microbial population

Treatment	Soil moisture (%) at 50-75 cm depth	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Soil microbial population ($cfug^{-1}$ soil)
Black polythene	13.14	192.32	48.11	280.11	2.4×10^6
Paddy husk	10.21	180.11	40.11	270.32	2.0×10^6
Paddy straw	11.00	183.11	38.12	260.11	2.5×10^6
Dry banana leaves	10.11	179.11	36.72	258.12	1.8×10^5
Dry mango leaves	9.22	178.12	34.11	248.11	1.9×10^5
Unmulched (control)	3.40	170.11	30.29	203.22	1.8×10^5
SEm±	0.37	1.11	0.92	0.74	—
CD (P=0.05)	1.11	3.40	2.79	2.19	—

Yield and Fruit Quality

The data pertaining to the positive influence of different mulches on yield and fruit quality parameters such as fruit weight, fruit length and diameter, yield and bio-chemical composition of fruit was founded with application of black polythene mulch followed by paddy husk and paddy straw. Among the different mulches black polythene mulch showed maximum fruit weight (263.42 g), fruit length/diameter (8.72/7.92 cm), and yield (271.41 no./tree) followed by Paddy husk in relation to fruit weight (250.11g), fruit length/diameter (8.41/7.66cm) and yield (243.72 no./tree) while unmulched (control) gave the minimum values (Table 2). Such beneficial effect of mulching was also observed by Borthakur and Bhattacharya (1992) in guava who reported that the polyethylene treatment significantly increase the growth of plants which subsequently increase the fruit physical characters. Bhusan and Panda (2015) also reported that black polythene mulching significantly increased the TSS, reducing sugar, total sugar, reduce acidity and effectively decrease physiological loss in weight of mango cv. Amrapali. Results of our current study are also in close conformity with the findings of Kulkarni and Yewale (2012) in mango cv. Keshar.

Like physical characters, bio-chemical composition of fruits was also influenced by different mulching methods. Black polythene mulch showed maximum total soluble solids (19.20 °brix), total sugar (14.75%) and β-carotene (6741 μg/100g) with minimum (0.17%) acidity of fruits. Increase in fruit quality with mulching might be due to the effect of leaf potassium and an increased rate of photosynthesis which cumulatively improved the fruit quality. The maximum formation of sugars with ripening of fruits is evident as disappearance of starch as reported by Joshi and Roy (1985). Increased sugars might be due to slow hydrolysis of starch to sugars and the gradual build up of sugars during ripening (Kulkarni and Yewale 2012). Our findings corroborate with the results obtained by Dutta and Majumder (2009) in Guava, Singh *et al.* (2010) in aonla and Bhusan *et al.* (2015) in mango.

Respiration and Marketability

The respiration rate of fruit varied with the different mulching treatments (Fig. 1).

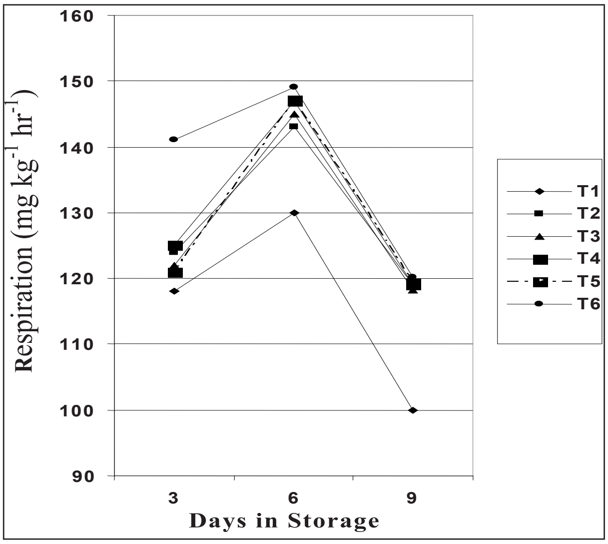

Fig. 1: Effect of mulching on respiration of fruit

Fruits treated with black polythene mulch showed less evolution of CO_2 compared to other mulching

Table 2: Effect of mulching on physico-chemical characters of mango fruit

Treatment	Fruit Weight (g)	Fruit length / diameter (cm)	Yield (No./tree)	TSS (⁰brix)	Total Sugar (%)	Acidity (%)	β carotene (μg/100g)
Black polythene	263.42	8.72/7.92	271.41	19.20	14.75	0.17	6741
Paddy husk	250.11	8.41/7.66	243.72	18.40	13.72	0.17	5747
Paddy straw	248.13	8.00/7.00	240.72	17.40	11.92	0.24	5811
Dry banana leaves	249.32	8.11/7.00	231.44	17.10	11.44	0.21	5011
Dry mango leaves	243.18	7.62/7.00	220.44	17.00	11.00	0.20	4922
Unmulched (control)	222.11	7.11/6.97	192.72	16.00	10.92	0.27	4719
SEm±	1.03	0.71/0.31	1.14	0.41	0.77	0.07	1.94
CD (P=0.05)	3.01	2.11/0.91	3.42	1.23	2.31	0.24	5.82

methods. Maximum evolution of CO_2 was noted in control fruits. A similar observation was noted by Singh *et al*. (2004) in mango. Black polythene mulch showed greater total soluble solids content of fruit at different days of storage. In the present study fruit marketability was also affected significantly by the mulching. Maximum amount of marketable fruit 80% with (16.20 ^{0}brix) total soluble solids on the 9th day of storage were obtained from black polythene mulch, while a negligible amount (30%) was obtained from unmulched plants (control). This may be due to a low rate of respiration during storage in the black polythene mulch treatment (Fig. 2).

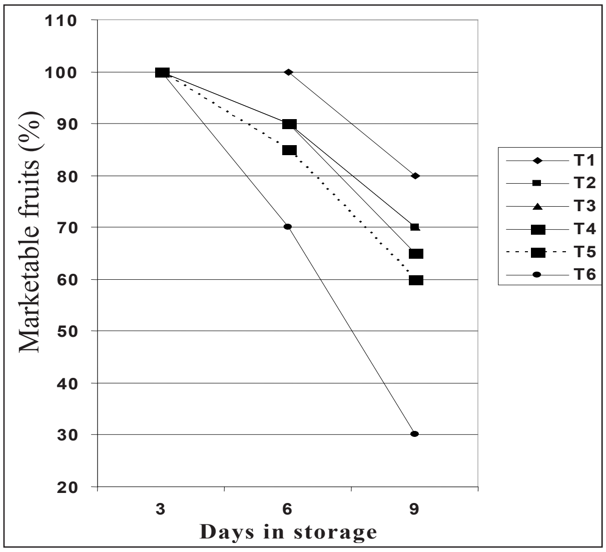

Fig. 2: Percentage of marketable fruits at different days of storage

Similar results with black polythene mulch giving 89% marketable fruit on the ninth day of storage as evident from CO_2 evolution and soluble solid content of fruit was reported by Dutta and Majumder (2009) in guava. Polythene mulching was found effective for improving fruit marketability, reducing decay percentage and reducing physiological loss in weight of the fruit during storage in Mango cv. Amrapali as reported by Bhusan *et al.* (2015), Bhusan and Panda (2015) and Singh *et al*. (2012) in mango cv. Dashehari.

CONCLUSION

Mulching is beneficial for improving fruit quality of mango along with the improvement in biological properties of orchard soil, thus also resulted in increased yield of fruits. Among the different mulches used, black polythene mulch proved to be most effective in improving the fruit physico-chemical parameters of fruit and biological attributes of soil and also helps in increasing the shelf-life of fruit during storage having good marketable quality. Therefore, this technology can be transmitted to the mango growers for commercial adoption to suit to their economic condition, traders and consumers.

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