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CONTENTS

Effect of pre-harvest application of eco-friendly chemicals and fruit bagging on yield and fruit quality of mango

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ABSTRACT: The investigation was carried out at Horticultural Research Center, Patharchatta, G. B. Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand), during the year 2020-2021. The experiment was laid out in Randomized Block Design (RBD) with 12 treatments (T_1: Nimbecidine @ 0.4%, T_2: Kunapajala @ 10%, T_3: Starch @ 1%, T_4: Starch @ 2%, T_5: Mineral oil @ 0.5%, T_6: Mineral oil @ 1.0%, T_7: Starch @ 1 % + Mineral oil @ 0.5%, T_8: Sodium bicarbonate @ 1% + mineral oil @ 0.5%, T_9: Nutrients mixture (boric acid @ 0.2% + calcium nitrate @ 0.2% + zinc sulphate @ 0.2%), T_{10}: Fruit bagging (ordinary brown paper), T_{11}: Fruit bagging (organic / UV/ water resistant brown paper), T_{12}: Control) and the treatment were replicated thrice. The results of the study revealed that the treatment T_{11} (fruit bagging with organic / UV/ water resistant brown paper bags), was found to be most effective for increasing the yield (14.58 kg plant^{-1}, 19.43 tonnes hectare^{-1}), fruit weight (298.23g), shelf life (15.05 days), TSS (20.95 ºB), total sugars (16.86%), reducing sugar (5.20%) and total carotenoids (5.86 mg/ 100g). The net return (737027.2 Rs/ha) was also observed higher with the treatment T_{11}. Thus, fruit bagging with organic /UV / water resistant brown paper bags was found most effective for increasing the yield, shelf life, quality and net return in late maturing mango cv. Amrapali.

Key words: Eco-friendly, fruit bagging, mango, net return, quality, shelf life

Mango (*Mangifera indica* L.) is the most popular fruit crop, pantropical in nature, grown round the world. It is believed to be originated in South East Asia, Indo Burma region, in the foothills of the Himalayas (Mukherjee, 1951). The genus *Mangifera* belongs to the order Sapindales in the family Anacardiaceae characterized by the presence of resinous canals having somatic chromosome number 2n = 40 with genus consists of 69 species and most of them are restricted to Tropical Asia. Botanically, mango fruit is a fleshy drupe, containing an edible mesocarp. It is eulogized as Bathroom fruit, Pride of Hindustan and King of fruit in India. In India, fruit crops cover an area of 6.59 million hectares, with an annual production of 97.96 million tonnes and average productivity of 14.6 t/ha (Anonymous, 2019 a). Mangoes are grown on 2.29 million hectares, with an annual production of 21.37 million tonnes and average productivity of 8.7 t/ha. Andhra Pradesh, Uttar Pradesh, and Rajasthan are the top three mango producing states in terms of area and productivity (Anonymous, 2019 a). In Uttarakhand mango is grown in an area of 36914.46 ha with an annual production of 156792.50 metric tons and productivity of 4.25 t/ha (Anonymous, 2019 b). The Amrapali mango has gained status in recent years as a result of its desirable characteristics such as regular and prolific bearing as well as suitability for high density planting owing to its dwarf stature. Despite its popularity, this cultivar's production ability has not been fully exploited due to different problems such as heavy fruit drop, small & irregular size of fruits and blackening of fruits in North India due to late maturity and all of these have a negative impact on the cultivar's economic potential (Jakhar and Pathak, 2016). Such problems have a negative impact on the economic potential of Amrapali mango. Due to this, mango growers suffer significant financial losses. So, to mitigate these problems, pre-harvest fruit bagging, spray of nutrients, mineral oil, sodium bicarbonate, starch, kunapajala and neem oil, have been tried on the basis of previous research works. Therefore, considering the above facts and constraints, the experiment was undertaken to assess the effect of fruit bagging and eco-friendly chemicals on yield and quality of mango cv. Amrapali.

MATERIALS AND METHODS

The present study was conducted during 2020-2021 at Horticultural Research Centre, Patharchatta of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar on 8-year old trees of mango cv. Amrapali

planted at a spacing of 3×2.5 m. The growth and vigor of all the trees selected were nearly identical. Trees of mango cultivar Amrapali maintained under uniform agronomic and cultural practices were selected for the study. The soil of the experimental site has been classified as silty loam soil which is dark in colour with moderately high organic matter content, high fertility, cation exchange capacity, water holding capacity etc. Under bagging treatment, ordinary brown paper bags and organic/ UV/ water resistant brown paper bags of Diyaan Agritech (www.diyaanagritech.com) were used to cover the fruit. Almost all the fruits were bagged on the tree under bagging treatment. Bagging was done 45 days before harvesting and all chemical sprays were done 2 times (1st spray at 45 days before harvesting and 2nd spray at 20 days after 1st spray except in bagging treatment). Fruits of Amrapali were harvested randomly at their harvesting maturity. The bagged fruits were also collected from tree by opening the bags. Six (6) fruits were randomly selected from each tree under multiple replications were brought to the laboratory and put at room temperature for fruit quality analysis. Data were recorded on physical attributes such as yield ha^{-1}, fruit weight (weight of ten fruits was recorded with the help of electronic balance), colour of fruits (as per the reference of the Colour chart of Royal Horticultural Society), shelf life (days) and in chemical parameters TSS (with the help of hand refractometer), acidity, total sugars, reducing sugars, non-reducing sugars and ascorbic acid were determined by the methods as suggested by Ranganna (1986). Total carotenoid content was calculated by using spectrophotometer.

Statistical analysis

The data were statistically evaluated by the Randomized Block Design given by Snedecor and Cochran (1967). "F" test was used to determine the significance of variance among the treatments. Critical difference at 5 % level of significance was calculated and the mean value of the treatments was compared for all characters under study.

RESULTS AND DISCUSSION

The findings of the experiment (Table 1) revealed that the yield, colour, shelf-life, and net return of the fruit were significantly affected by the various treatments. In comparison to the control, the treatment T_{11} (bagging with UV/water resistant brown paper bags) recorded the higher fruit yield (11.62 kg $plant^{-1}$, 19.43 tonnes ha^{-1}), fruit weight (298.23 g), shelf life (15.05 days) and net return (737,027.20 Rs/ha) followed by the treatment T_{10} (fruit bagging with ordinary brown paper bag). In mango, Kireeti *et al*. (2016), Islam *et al*. (2017), Haldankar *et al*. (2015) and Mohapatra (2016) reported similar type of results. Sharma *et al*. (2014) found similar findings, stating that all bags, except the polythene bags, have longer shelf life for mango. The excellent and appealing yellow orange coloured fruits (yellow orange group 13 A) were seen with the treatment T_{11} (fruit bagging with organic/ UV/ water resistant brown paper bags), as shown in Table 1 and Fig 1. These findings are consistent with the findings of Tyasa *et al*. (1998) in litchi, who found that re-exposing fruits to light after bagging improves their light sensitivity and accelerates anthocyanin production. Mango fruits wrapped in two-layer paper bags showed skin colour shift from green to yellow (Watanawan *et al*., 2008). In terms of net return in mango cv. Amrapali, treatment T_{11} proved to be superior. The higher net return of 737,027.20 Rs/ ha, were obtained with the treatment T_{11} (fruit bagging with organic/ UV/ water resistant brown paper bags). This is certainly due to prevalence of ideal growing conditions for fruit growth and development, as well as no occurrence of diseases and insect pests in bagged fruits. These findings are similar to those of Amarante *et al*. (2002), who found that bagging of pear fruits with micro-perforated polythene bags 30 days after full bloom improved the Per centage of pears suitable for export purposes from 27.2 % to 63.2 % by improving fruit quality. However, lower net return/net return (-226,563.10 Rs/ha) was recorded with the treatment T_4 (starch @ 2%). Losses were also observed with the treatments of T_7 (starch @ 1% + mineral oil @ 0.5%) and T_6 (mineral oil @ 1.0%) and this is certainly due to high cost of chemicals.

All the treatments exhibited significant influence on chemical attributes of fruits (Table 2). The values of total sugar (16.86 %), reducing sugar (5.20 %),

Table 1: Effect of eco-friendly chemicals and fruit bagging on yield, colour, shelf-life and net return of mango cv. Amrapali

Treatment details		Fruit weight (g)	Fruit yield plant^{-1} (kg)	Fruit yield hectare^{-1} (tonnes)	Shelf life (Days)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Colour of fruits (Colour chart of Royal Horticultural Society)
T_1	Nimbecidine @ 0.4%	240.81^{c}	11.83^{cd}	15.77^{cd}	11.80^{bcd}	62,200	410,748.40^{de}	Yellow group 13A
T_2	Kunapajala @ 10%	281.78^{ab}	12.76^{bcd}	17.01^{bcd}	11.33^{cd}	46,520	463,619.10^{cd}	Yellow orange group 15 A
T_3	Starch @ 1%	245.39^{c}	12.30^{cd}	16.39^{cd}	12.67^{b}	380920	110,823.70^{h}	Yellow orange group 15 A
T_4	Starch @ 2%	246.61^{c}	12.31^{cd}	16.41^{cd}	11.93^{bc}	718840	-226,563.1^{k}	Yellow group 12A
T_5	Mineral oil @ 0.5%	277.70^{ab}	12.83^{bcd}	17.10^{bcd}	12.37^{bc}	330040	183,165.00^{g}	Yellow group 12B
T_6	Mineral oil @ 1.0%	280.57^{ab}	13.03^{bc}	17.37^{bc}	12.13^{bc}	617080	-96,143.60^{i}	Yellow group 13B
T_7	Starch @ 1% + mineral oil @ 0.5%	258.88^{bc}	12.60^{cd}	16.79^{cd}	12.07^{bc}	667960	-164,086.00^{j}	Yellow group 12B
T_8	Sodium bicarbonate @ 1% + mineral oil @ 0.5%	256.33^{bc}	12.42^{cd}	16.55^{cd}	11.67^{bcd}	132750	363,925.80^{e}	Yellow orange group 15B
T_9	Nutrient mixture(H_3BO_3 @ 0.2% + $Ca(NO_3)_2$ @ 0.2% + $ZnSO_4$ @ 0.2%)	295.53^{a}	14.03^{ab}	18.70^{ab}	12.67^{b}	79960	481,099.70^{c}	Yellow orange group 17B
T_{10}	Fruit bagging (ordinary brown paper)	275.85^{ab}	13.90^{ab}	18.53^{ab}	14.12^{a}	106984	634,341.80^{b}	Yellow orange group 17C
T_{11}	Fruit bagging (organic / UV/ water resistant brown paper)	298.23^{a}	14.58^{a}	19.43^{a}	15.05^{a}	234952	737,027.20^{a}	Yellow orange group 13 A
T_{12}	Control (water spray)	240.11^{c}	11.62^{d}	15.49^{d}	10.77^{d}	43000	266,700.30^{f}	Yellow group 12 C
	SE(m)±	10.06	0.44	0.59	0.38	-	18,447.52	-
	C.D. (5%)	29.71	1.30	1.74	1.12	-	54,453.86	-

Table 2: Effect of eco-friendly chemicals and fruit bagging on chemical characteristics of mango cv. Amrapali

Treatment symbols	Treatment Details			Sugars			Ascorbic acid (mg/100g)	Total carotenoids (mg/100g)
		Total Soluble Solids (°B)	Titratable acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)		
T_1	Nimbecidine @ 0.4%	18.56^{de}	0.22^{ab}	14.79^{de}	3.53^{cd}	10.70^{bcd}	36.29^{de}	5.09^{efg}
T_2	Kunapajala @ 10%	18.94^{bcde}	0.21^{abc}	14.07^{ef}	3.46^{cd}	10.08^{cd}	37.77^{cd}	5.67^{ab}
T_3	Starch @ 1%	18.86^{bcde}	0.22^{ab}	14.86^{cd}	3.66^{bcd}	10.64^{bcd}	37.59^{cde}	5.48^{bcd}
T_4	Starch @ 2%	18.84^{e}	0.22^{ab}	15.30^{bcd}	3.69^{bcd}	11.03^{ab}	35.83^{de}	5.59^{abc}
T_5	Mineral oil @ 0.5%	19.82^{abcd}	0.19^{d}	15.72^{b}	3.36^{d}	11.74^{a}	39.77^{abc}	5.17^{def}
T_6	Mineral oil @ 1.0%	20.03^{ab}	0.19^{d}	15.65^{b}	3.47^{cd}	11.57^{a}	39.38^{bc}	5.32^{cde}
T_7	Starch @ 1% + mineral oil @ 0.5%	18.65^{cde}	0.22^{ab}	14.83^{cd}	3.61^{bcd}	10.66^{bcd}	37.80^{cd}	4.86^{fg}
T_8	Sodium bicarbonate @ 1% + mineral oil @ 0.5%	18.47^{e}	0.23^{a}	14.72^{de}	3.85^{bc}	10.33^{bcd}	35.35^{e}	5.05^{efg}
T_9	Nutrient mixture(H_3BO_3 @ 0.2% + $Ca(NO_3)_2$ @ 0.2% + $ZnSO_4$ @ 0.2%)	20.71^{a}	0.18^{d}	15.77^{b}	4.03^{b}	11.14^{ab}	42.01^{a}	5.74^{ab}
T_{10}	Fruit bagging (ordinary brown paper)	19.84^{abc}	0.20^{bcd}	15.55^{bc}	4.06^{b}	10.91^{abc}	39.10^{bc}	5.44^{bcd}
T_{11}	Fruit bagging (organic / UV/ water resistant brown paper)	20.95^{a}	0.19^{d}	16.86^{a}	5.20^{a}	11.07^{ab}	41.31^{ab}	5.86^{a}
T_{12}	Control (water spray)	18.49^{e}	0.23^{a}	13.87^{f}	3.35^{d}	9.99^{d}	35.08^{e}	4.82^{g}
	SE(m)±	0.43	0.01	0.25	0.16	0.29	0.82	0.11
	C.D. (5%)	1.27	0.02	0.74	0.47	0.86	2.41	0.33

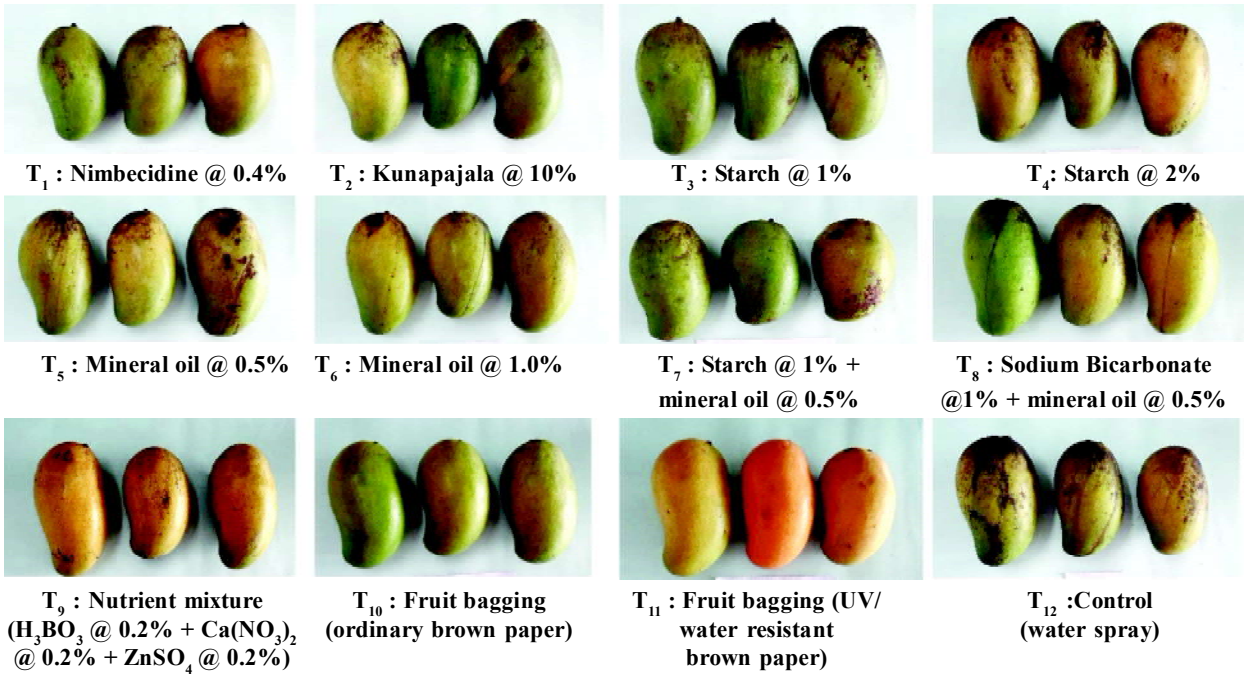

Fig 1: Glimpses of Amrapali mango fruits showing the effect of different treatments on fruit quality and colour at 9th day of harvest

total carotenoid content (5.86 mg/100 g) were found higher with the treatment T_{11} (fruit bagging with organic / UV/ water resistant brown paper bags). Maximum non reducing sugar (11.4 %) was observed with the treatment T_5 (mineral oil @ 0.5 %), while, minimum (9.99 %) with the treatment T_{12} (control). The maximum TSS content (20.95 °B) was recorded with the treatment of T_{11} (fruit bagging with organic/ UV/ water resistant brown paper bags) followed by T_9 (nutrient mixture (H_3BO_3 @ 0.2% + $Ca(NO_3)_2$ @ 0.2% + $ZnSO_4$ @ 0.2%). The variation observed in chemical composition of mango fruits probably due to bagging that can be attributed to the modified micro climate/ environment around fruit during its growth and development stages. These findings are in close agreement with those of Watanawan *et al*. (2008). The fruits of T_{11} and T_9 had more total soluble solids than the other treatments, in case of bagged fruit increase in TSS might be due to the higher temperature under the bags favoured the conversion of starch and other polysaccharides into sugars. On the other hand, an increase in TSS due to nutrient spray in fruit might be due to zinc which increases the synthesis of tryptophan that is a precursor of auxin. It plays a key role in protein synthesis, sugar metabolism and maintains the integral structure. Boron may be associated with the cell membrane where it could be complex with sugar molecules and facilitates its passage across the membrane that might be the reason of increased total soluble solids. Similarly, improvements in TSS due to nutrients spray had been reported by Panwar and Singh (2007) in mango. Bagging had a substantial impact on total sugar levels. Sucrose synthase is an enzyme that plays a major role in sucrose breakdown. During fruit growth, the activity of sucrose in bagged fruits increased and was greater than in unbagged fruits. These results are in conformity with the results of Harhash and Al-Obeed (2010) and Malshe and Parulekar (2017) in date palm and mango, respectively.

On the other hand, maximum titratable acidity per cent (0.23 %) was recorded with the treatment T_8 (sodium bicarbonate @ 1 % + mineral oil @ 0.5%) and treatment T_{12} (control), while minimum acidity (0.18 %) was observed with the treatment T_9 (nutrient mixture of H_3BO_3 @ 0.2 % + Ca $(NO_3)_2$ @ 0.2 % + $ZnSO_4$ @ 0.2 %). However, maximum ascorbic acid

content (42.01 mg $100g^{-1}$) was recorded with treatment T_9 (nutrients mixture (H_3BO_3 @ 0.2% + $Ca(NO_3)_2$ @ 0.2% + $ZnSO_4$ @ 0.2%) whereas, the minimum ascorbic acid (35.08 mg $100g^{-1}$) content was observed with treatment T_{12} (control).

CONCLUSION

It can be concluded that in late ripening mango cv. Amrapali, fruit bagging with organic/ UV/ water resistant brown paper bag is the most efficient method for enhancing colour (yellow-orange colour), shelf life, quality, fruit yield and net return.

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