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Effect of bagging and fungicide application on physical traits of mango (*Mangifera indica* L.)

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Abstract
In order to explore the impact of bagging and fungicide spraying on physical features of the Dashehri variety of mango under ambient conditions, a pre-harvest study was carried out in an experimental orchard and post-harvest laboratory of the department of Horticulture during 2014–15. Nine treatments were used in a Randomized Block Design. According to the findings, bagging fruits in brown paper with a foliar treatment of 0.05% carbendazim caused the greatest delay in ripening (3.04 days), which was followed by bagging fruits in brown paper without a foliar application of 0.05% carbendazim (2.76 days). The fruits treated with bagging of fruits by brown paper + foliar application of 0.05% carbendazim showed the highest levels of organoleptic quality, no skin shriveling, and minimal decay loss.

Keywords: Bagging, Physical traits, Carbendazim, Treatment, Maturity

Introduction
Mango is regarded as one of the most popular and well-liked fruits in the world because of its delicious taste, alluring flavor, lovely color, and exceptional nutritional content. Although the concentration of the bioactive chemicals in mango fruit varies due to genotypic diversity, climatic conditions, pre-harvest and postharvest interventions, they have therapeutic characteristics for human health. (Matheyambath *et al*., 2016) [9]. Mango is second only to banana in terms of total fruit output in India, but it is currently acknowledged as one of the most valued fruits on the global market. In India, the area under fruit cultivation is 7,216 thousand hectares, with an annual production of 88,977 MT and a productivity of 12.3 MT. Next to banana, India accounts for around 20.7% of mango production. As a climacteric fruit, it is perishable and has a shelf life of around one week under normal conditions. Various physiological and biochemical changes occur in fruits after harvest, causing quality to deteriorate and shelf life to be shortened. Other issues, such as incorrect harvesting, mismanagement, insufficient transportation, and storage, have all contributed to post-harvest losses. The storage potential, marketable life and quality of mango fruits are determined by the stage of maturity at which they are collected. Early harvesting results in low quality and inconsistent ripening, while late harvesting results in severely poor self-life. (Thompson, 1996) [19]. Techniques such as the use of carbendazim (Methyl 1H-benzimidazol-2-yl carbamate) and physical treatments such as bagging and harvesting of fruits with pedicle are often used to improve post-harvest quality and fruit ripening propensity. With the use of fungicides and fruit bagging, studies have been conducted to improve post-harvest quality and reduce spoiling losses of mango fruits. (Nair and Singh, 2003 and Mahajan *et al.*, 1996) [11, 7]. In Mango fruit pre-harvest bagging is done largely for physical protection from fruit flies, but it also improves fruit quality to some amount by boosting peel color and minimizing skin flaws by modifying the micro-environment of the fruit. (Sharma *et al*., 2013) [14]. Bagging can help prevent insect-pest outbreaks, disease incidence, mechanical and sunburn injuries, and bird damage. Mango post-harvest behavior was modified by fruit bagging, particularly water evaporation during storage. Post-harvest water loss studies are significant because variations in water loss might impact fruit physiology during ripening, resulting in early ethylene generation (Paull, 1999) [12]. Mango anthracnose disease is reduced when fruits are bagged in brown paper or news paper bags (Rahman *et al.*, 2017) [5]. It is a non-chemical, eco-friendly way for controlling post-harvest illnesses and fruit fly infestations. It also enhances fruit quality, organoleptic quality in terms of appearance, uniform colour, taste, flavor, and overall acceptance throughout ripening, as reported in mangoes, and extends shelf life (Hofman *et al*., 1997) [4].

These findings suggest that bagging may result in black spot-free, attractive, and high-quality fruit at harvest and ripening, resulting in increased exports and higher prices for mango producers. Furthermore, several wrappers such as polythene cellophane, tissue paper, and Pliofilm have been explored to extend mango storage life (Cheema, 1939, Mukherjee, 1956 and Singh, 1960) [1, 10, 13]. Keeping these facts in view, an investigation entitled "Effect of bagging on physical traits of mango *Mangifera indica* L.)" has been conducted at Horticultural Research Centre and Post-Harvest Technology Laboratory of Department of Horticulture, Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh was conducted in the year 2015.

Materials and Methods

During 2014-15, the Department of Horticulture's experimental orchard and post-harvest laboratory were used to evaluate the influence of bagging and fungicide spraying on physical attributes of Dashehari mango under ambient condition. The experiment was arranged in Randomized block design. Twenty years old trees of mango were selected for conducting the experiment. A representative sample of five fruits for 09 treatments with three replications comprising of 135 fruits randomly selected. The physiologically matured treated fruits with uniform size and specific gravity (1.00) were harvested in the morning hours. There were a total of 15 fruits per treatment. The treatment details are as follows:

T_1: Control (Fresh water) +no bagging
T_2: Bagging with brown paper+ no foliar application of carbendazim (0.05%)
T_3: Bagging with brown paper + foliar application of carbendazim (0.05%)
T_4: Bagging with white paper+ no foliar application of carbendazim (0.05%)
T_5: Bagging with white paper + foliar application of carbendazim (0.05%)
T_6: Bagging with newspaper + no foliar application of carbendazim (0.05%)
T_7: Bagging with newspaper +foliar application of carbendazim (0.05%)
T_8: Bagging with transparent polythene+ no foliar application of carbendazim (0.05%)
T_9: Bagging with transparent polythene + foliar application of carbendazim (0.05%)

The data collected for all parameters was statistically evaluated using analysis of variance, as recommended by (Fisher, 1958).

Results and Discussion

Table 1: Effect of pre-harvest bagging and fungicide application on physical attributes of mango

S. No.	Treatments	Days to Fruit Ripening		Skin Shriveling		Organoleptic quality		Decay Loss		Shelf-Life	
		Mean	±SE	Mean	±SE	Mean	±SE	Mean	±SE	Mean	±SE
1.	T_1 - Control (Fresh water) + no bagging	5.233	0.073	2.500	0.058	2.500	0.173	50.00	.774	5.500	0.289
2.	T_2 - Bagging with brown paper+ no foliar application of carbendazim (0.05%)	8.000	0.200	0.000	0.000	4.733	0.088	0.00	0.000	8.200	0.300
3.	T_3 -Bagging with brown paper + foliar application of carbendazim (0.05%)	8.277	0.112	0.000	0.000	4.900	0.058	0.00	0.000	9.000	0.577
4.	T_4 -Bagging with white paper+ no foliar application of carbendazim (0.05%)	7.250	0.087	1.700	0.058	4.000	0.115	13.00	3.512	7.500	0.500
5.	T_5 -Bagging with white paper + foliar application of carbendazim (0.05%)	7.500	0.058	1.400	1.400	4.200	0.231	6.67	6.667	8.000	0.577
6.	T_6 -Bagging with newspaper + no foliar application of carbendazim (0.05%)	6.573	0.087	2.300	0.058	3.600	0.100	30.00	5.774	6.000	0.500
7.	T_7 -Bagging with newspaper +foliar application of carbendazim (0.05%)	6.697	0.028	2.100	0.058	3.833	0.033	20.00	5.774	6.30	0.404
8.	T_8 -Bagging with transparent polythene+ no foliar application of carbendazim (0.05%)	4.620	0.069	3.000	0.173	2.600	0.115	40.00	5.774	2.500	0.153
9.	T_9 -Bagging with transparent polythene + foliar application of carbendazim (0.05%)	4.717	0.142	2.800	0.058	2.800	0.115	33.33	6.667	3.000	0.289
	C.D	0.316		0.233		0.378		16.325		1.257	
	SE(d)	0.148		0.109		0.177		7.635		0.588	

The results on days to fruit ripening revealed that treatments had a positive effect on boosting and delaying mango maturity (Table 1). The treatments ranged in terms of the time necessary for the fruits to ripen. Bagging with brown paper with or without foliar application of carbendazim (0.05%) was the most efficient pre-harvest therapy in delaying ripening when compared to other treatments. Both the bagging and carbendazim delay the metabolic activity of fruits during ripening (Halfarce and Barden, 1979) [3]. The recent study's results on skin shrivelling found that skin shriveling was comparatively less with bagging (brown paper) + carbendazim (0.05%) as compared to control fruits during ripening. The reduction in skin shriveling percentage and improvement in fruit marketability by the pre-harvest application of carbendazim and other chemicals has also been advocated by Anjum and Ali, 2014 [20], who observed shriveled free skin fruit with chemical treatments. The organoleptic quality of fruits includes different characteristics such as peel colour, shine, flesh colour, texture, taste and flavour. In the present findings, the pre harvest bagging + fungicide application influenced the organoleptic quality of mango fruits during ambient storage. Fruits bagged with brown paper + (0.05%) carbendazim application had superior organoleptic quality with highest score (4.9) against control which obtained lowest score (2.50). The finding of present study also confirmed the results of Jakhar and Pathak, 2014 [6], in Amrapali mango who reported that fruits treated with CaCl2 @2% + K2SO4@1% + bagging (brown paper) was

significantly superior in improving the organoleptic quality against control which obtained lowest score. Previously, workers observed that fruit bagging can increase fruit quality by maintaining fruit appearance and preferring consistent colour of the fruit, as documented in apples and mangos. (Hofman *et al*., 1997; Paull ER) [4, 12] and grape (Signes *et al*., 2012) [15]. In the current investigation, carbendazim-treated fruits had superior organoleptic quality, presumably due to its involvement in delaying the metabolic activity of fruits during ripening (Halfarce and Barden, 1979) [3]. The proportion of decay loss in the current study was greatly reduced under ambient conditions due to pre-harvest bagging and fungicide spraying. The most successful treatments for lowering the percentage of fruit deterioration loss under ambient conditions included bagging the fruits in brown paper and adding carbendazim (0.05%). The results of the study are in line with findings of Jakhar and Pathak, 2014 [6] who reported that pre-harvest bagging of fruits by brown paper + chemical had minimum black spotted fruits. The findings obtained on fruit decay in the present study also confirmed the findings of Thompson, 1987 [18] who observed that pre-harvest spray of fungicide reduced the post-harvest diseases in mango. The data recorded on shelf-life of mango indicated that the pre-harvest bagging (brown paper) + carbendazim (0.05%) increases the shelf life of mango more than 3 days as compare to control. The finding of present study was supported by Hofman *et al*., 1997 [4], who suggested that the bagging prolongs the shelf-life in mangoes. Bagged fruits were found to have a better shelf life which is an important criterion for exportable mango (Islam *et al*., 2017) [5]. The pre-harvest bagging in mango fruit prolonged the shelf life of fruit at ambient temperature (Mathooko *et al*., 2011) [8].

Table 2: Effect of pre-harvest bagging and fungicide application on Skin and Pulp colour of mango

S. No	Treatments	Skin Colour	Pulp Colour
1.	T_1 - Control (Fresh water) + no bagging	Green	Whitish Yellow
2.	T_2 - Bagging with brown paper+ no foliar application of carbendazim (0.05%)	Yellow	Yellowish Red
3.	T_3 -Bagging with brown paper + foliar application of carbendazim (0.05%)	Yellow	Yellowish Red
4.	T_4 -Bagging with white paper+ no foliar application of carbendazim (0.05%)	Yellowish Green	Yellow
5.	T_5 -Bagging with white paper + foliar application of carbendazim (0.05%)	Yellowish Green	Yellow
6.	T_6 -Bagging with newspaper + no foliar application of carbendazim (0.05%)	Greenish Yellow+ Black spots	Yellowish White + Black Spot
7.	T_7 -Bagging with newspaper +foliar application of carbendazim (0.05%)	Yellowish Green+ Black spots	Yellowish White
8.	T_8 -Bagging with transparent polythene+ no foliar application of carbendazim (0.05%)	Yellow + Black spot	Yellow + Black spot
9.	T_9 -Bagging with transparent polythene + foliar application of carbendazim (0.05%)	Yellow + Black spots	Yellow + Black spot

Mango fruit skin color is a crucial marketing factor since it increases the commodity's appeal and increases sales. In comparison with other treatments, bagging (brown paper) + 0.05% carbendazim significantly induced yellow skin colour (Table 2). Due to the well-known fungicidal and cytokinin characteristics of carbendazim, treatments in the current study that contained it performed better at preserving yellow skin color than those that did not. Because of the reduced rate of respiration and transpiration caused by the carbendazim treatment, the fruits, vegetables, and other produce were less susceptible to microbial decay brought on by fungi (Desai *et al.*, 2012) [21]. The fruits with pre-harvest bagging with brown paper ensure attractive coloration of fruits as reported by CISH, Lucknow (2011). Pulp color is a crucial characteristic because it indicates the fruit's quality. Results from the current study demonstrated that all pre-harvest treatments considerably enhanced pulp color compared to the control. At ripening, the fruits packaged with brown paper + 0.05% carbendazim treatment had reddish red pulp as opposed to the control fruits, which had whitish yellow pulp (Table 2). Carbendazim-treated fruits showed better pulp color and organoleptic quality in the current investigation, which could be attributed to its involvement in delaying fruit metabolic activity during ripening **(**Halfarce and Barden, 1979) [3].

Conclusion

Based on the data, it is concluded that pre-harvest bagging of mangoes with brown paper with or without 0.05% carbendazim application was significant in improving mango post-harvest quality. This treatment was applied prior to harvest and increased fruit quality in terms of days to fruit ripening, fruit appearance, pulp color, organoleptic quality, decay loss, and shelf life. The current study also found that pre-harvest bagging of fruits in clear polythene with or without 0.05% carbendazim resulted in the greatest improvement in ripening. The increased shelf-life of fruits provided by this treatment is significant since it alleviates farmer concerns. As a result, mango dealers and growers are advised to use a combination of pre-harvest treatment with bagging (brown paper) + 0.05% carbendazim.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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