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Influence of fruit bagging on physical quality of mango (*Mangifera indica* L.) under high density planting

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Abstract
The present study was carried out at Regional Horticultural Research Station, ASPEE Collegeof Horticulture and Forestry, Navsari Agricultural University, Navsari from January 2018 to July 2018 in Sonpari variety. The experiment was laid out in Randomized Block Design with factorial concept and repeated thrice with twenty-one treatment combination. The experiment consisted of three planting distance (D) *viz*., 5 m × 5 m (D_1), 3 m × 3 m (D_2) and 3 m × 2 m (D_3) and seven fruit bagging materials (B) *viz*., control (B_1) newspaper bag (B_2), brown paper bag (B_3), transparent PP bag (B_4), butter paper bag (B_5), muslin cloth bag (B_6) and non-woven bag (B_7). The fruits were bagged at egg stage (55-60 days after fruit set). The result of present investigation revealed that maximum per cent fruit retention, marketable fruit and minimum fruit fly infestation were recorded in the planting distance of 5 m× 5 m. While maximum fruit weight, fruit length, fruit diameter, fruit volume, pulp weight, stone weight and minimum damage fruits (sun burned or bruised) and anthracnose infected fruits were observed in planting distance of 3 m× 3 m. Maximum fruit firmness and shelf-life at ambient temperature was recorded in planting distance of 3 m× 2 m. Among fruit bagging treatments, maximum per cent fruit retention, fruit firmness, marketable fruits shelf-life and minimum damaged fruits was noticed in fruits bagged with newspaper bag. Fruit fly incidence and anthracnose infestation was not observed in newspaper bag, butter paper bag and muslin cloth bag. While, maximum fruit weight, fruit length, fruit diameter, fruit volume, pulp weight, stone weight was found in fruits bagged with muslin cloth bag and newspaper bags. The interaction between D_2B_6 (3 m × 3 m distance and fruit bagging with muslin cloth bag) recorded maximum fruit volume followed D_2B_2 (3 m × 3 m distance and fruit bagging with newspaper bag). While, minimum damaged fruits and maximum marketable fruits were noted in D_1 (5 m × 5 m) and fruits bagged with B_2 (newspaper bag). The highest BCR (3.25) was recorded in the combination of D_1B_2 (5 m× 5 m and fruits covered with newspaper bag) followed by D_2B_2 (3 m × 3 m and fruits bagged with newspaper bag) with benefit cost ratio of 3.23. Owing to the results obtained during this study, it is inferred that fruits bagged with newspaper bag with planting distance of 5 m × 5 m was found better for enhancing the physical quality of mango fruit cv. Sonpari.

Keywords: Mango, planting distance, bagging materials, physical properties, fruit-fly, Anthracnose, economics

Introduction
Mango (*Mangifera indica* L.) belongs to family Anacardiaceae has been grown in India since long and is considered as "King of Fruits". It is one of the choicest and most ancient fruits known to mankind. India is the major producer and exporter of mangoes in the world. The productivity of mango in India is comparatively less than other mango producing countries. The low productivity of mango is mainly due to low plant population per hectare, improper orchard management practices, pests and diseases problems *etc*. Therefore, high density plantation and management is necessary to deal with these unfavorable situations of low productivity which gives higher yield at less cost with more resilience to climatic stresses along with maintain export quality of fruits. High density planting (HDP) is one of the technology for mango cultivation worldwide to increase productivity without affecting the quality of fruits. It has the potential to yield 200 per cent more produce than that of the traditional method (Singh, 2017) [34].

Climatic abbreviation such as sudden rise in temperature, humidity and unseasonal rain are the main problems in recent years. Such adverse climate not only affects the external appearance of the fruit but also aggravate the pest and diseases incidence. Thus, to prevent the losses caused by biotic and abiotic factors several good agricultural practices (GAP) are becoming popular throughout the world (Sharma, 2009) [31]. Among them, pre-harvest fruit bagging emerged as an effective method.

It was known to originate in Japan and Korea. Countries such as Mexico, Chile and Argentina do not import fruits unless they were bagged (Sharma *et al.*, 2014) [32]. Bagging not only improves the visual quality of fruits but also improves the internal quality of fruits by promoting skin colouration and reducing blemishes by change micro-environment. Hence an experiment was undertaken to study the influence on fruit bagging on quality of fruits.

Materials and Methods

The present experiment was carried out at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during the year 2017-18. The experiment was laid out in Randomized Block Design with factorial concept and repeated thrice with twenty-one treatment combinations. The experiment consisted of three planting distance (D) *viz.*, 5 m × 5 m (D_1), 3 m × 3 m (D_2) and 3 m × 2 m (D_3) and seven fruit bagging materials (B) *viz.*, control (B_1) newspaper bag (B_2), brown paper bag (B_3), transparent PP bag (B_4), butter paper bag (B_5), muslin cloth bag (B_6) and non woven bag (B_7). All fruits at egg stage (55-60 days after fruit set) were bagged and tied with the help of plastic thread to the fruit stalk. Six perforations of 4 mm diameter were made at the bottom of all the bags except muslin cloth and non woven bags for proper ventilation. The observations *viz.* fruit retention (%), days required for harvesting after bagging and various physical parameters were recorded.

The fruits which retained up to harvest were counted and fruit retention was worked out in percentage as per the formula given below,

$$\text{Fruit retention (\%)} = \frac{\text{Total no. of fruits at the time of bagging} - \text{Total number of fruits drop}}{\text{Total no. of fruits at the time of bagging}} \times 100$$

The weight of fruit, pulp and stone were recorded by electronic balance and expressed in gram. The length and diameter of fruit was measured using digital Vernier caliper and expressed in centimeter. Fruit volume was measured by water displacement method and expressed in centimeter cube (cm3). Fruit firmness was measured with the help of penetrometer and expressed in kg cm^{-2}. The shelf-life was noted when the fruits reach up to eating stage and expressed in days. The statistical analysis of data was carried out as per the method prescribed by Panse and Sukhatme (1985) [24]. The standard error of mean (S. Em.) was worked out and the critical difference (C. D.) at 5 per cent was calculated whenever the results were found significant.

Fruit retention

Data presented in Table 1 indicate that planting distance and bagging materials had a significant effect on fruit retention. Significantly maximum fruit retention (70.37 %) was observed in D_1 (5 m × 5 m) and less fruit retention in closer spacing which might be due to greater competition among the developing fruits (Singh, 2003) [33]. Similar result on fruit retention was reported by Brar and Bal (2010) [6] in guava. It is evident from the data that significantly higher fruit retention (70.15 %) was found in B_2 (newspaper bag), statistically at par with the B_3 (brown paper bag) and B_5 (butter paper bag) which might be due to that the micro-climate surrounding the fruits change favorably by these bag materials (Mohapatra, 2016) [21]. Bagging of fruits alters the microenvironment inside the bag (Sharma *et al.* 2014) [32]. The minimum fruit retention (60.95 %) was noted in B_1 (control). The interaction between planting distance and bagging materials were found non-significant.

Days required for harvesting after bagging

Planting distance as well as different bagging materials was significantly altered the days required for harvesting after fruit bagging which was described in Table 1. An early harvesting of fruit after bagging (56.95 days) was recorded in D_1 (5 m × 5 m), which was statistically at par with D_2 (3 m × 3 m) which might be due to higher solar radiation penetration and canopy temperature. These results are in close conformity with those found by Sarrwy *et al.* (2012) [30] in banana and Brar and Bal (2010) [6] in guava. The obtained results are also in accordance with those reported by Chattopadhyay *et al.* (1985) [7] and Abdallah *et al.* (2010) [2] in banana who found that close space took the longest time from flowering to harvest as compared to plants cultivated at wide spacing. Significantly, minimum days after harvesting (51.67 days) observed in B_1 (control), which was statistically at par with the B_4 (transparent PP bag) being 53.56 days required for harvest. It might be due to light and air play important role in growth and development of plant organ. The control fruits are exposed to natural light and air whereas the bagged fruits intercept the light. Control fruits are at par with polythene bag which might be due to development of higher temperature inside the bag (Mohapatra, 2016) [21]. Delay in maturity was observed in newspaper bag and brown paper bag. It might be due to less warmer condition inside these bags as compared to control. Similar results were reported by Mingire *et al.* (2017) [19], Haldankar *et al.* (2015) [13] in mango, Abbasi *et al.* (2014) [1] in guava and Debnath and Mitra (2008) [9] in litchi. The interaction effect between planting distance and bagging materials were found non-significant with respect to days required for harvesting after bagging.

Physical parameters and shelf-life

Fruit weight, fruit length, fruit diameter, pulp weight and stone weight was significantly maximum in the planting distance of D_2 (3 m × 3 m). It might be due to good enough canopy size and less number of fruits (sink) which leads to less partitioning of the sources among the limited number of sink. Among all the bags used for fruit bagging, B_6 (muslin cloth bag) was found best for increasing fruit weight, fruit length, fruit diameter, pulp weight and stone weight and it was at par with B_2 (newspaper bag) and B_5 (butter paper bag). Which might be due to microclimate created by these bags had congenial effect on fruit growth (Mingire *et al.*, 2017) [19]. These results are analogous with the earlier findings of Haldankar *et al.* (2015) [13] in mango and Mondal *et al.* (2015) [22] in guava. The interaction between planting distance and bagging materials were found non-significant (Table 2).

Table 1: Effect of planting distance and bagging materials on fruit retention and days required for harvesting after bagging of mango cv. Sonpari

Treatments	Fruit retention	Days required for harvesting after bagging
Planting distance (D)		
D_1 (5 m × 5 m)	70.37 (88.54)	56.95
D_2 (3 m × 3 m)	64.39 (81.00)	57.62
D_3 (3 m × 2 m)	62.96 (79.06)	59.33
S.Em.±	0.65	0.67
C.D. at 5 %	1.86	1.90
Bagging materials(B)		
B_1: Control	60.95(76.01)	51.67
B_2: Newspaper bag	70.15(88.23)	63.00
B_3: Brown paper bag	67.55(84.98)	65.67
B_4: Transparent PP bag	63.66(80.19)	53.56
B_5: Butter paper bag	67.47(85.12)	57.67
B_6: Muslin cloth bag	65.37(82.09)	59.56
B_7: Non woven bag	66.21(83.47)	54.67
S.Em.±	0.99	1.02
C.D. at 5 %	2.84	2.91
Interaction effect (D × B)		
S.Em.±	1.72	1.76
C.D. at 5 %	NS	NS
C.V. %	4.53	5.26

Table 2: Effect of planting distance and bagging materials on physical parameters and shelf-life of mango fruit

Treatments	Fruit weight (cm)	Fruit length (cm)	Fruit diameter (cm)	Pulp weight (g)	Stone weight (g)	Fruit firmness (kg cm-2)	Shelf-life (Days)
Planting distance (D)							
D_1 (5 m × 5 m)	324.36	10.28	8.15	143.40	47.31	3.51	15.17
D_2 (3 m × 3 m)	406.78	11.44	8.78	175.89	54.85	3.93	16.40
D_3 (3 m × 2 m)	403.30	11.30	8.59	170.17	54.51	4.00	16.69
S.Em.±	6.23	0.15	0.10	3.72	0.95	0.06	0.22
C.D. at 5 %	7.81	0.42	0.28	10.62	2.72	0.16	0.64
Bagging materials(B)							
B_1: Control	379.57	10.36	8.25	159.16	49.95	3.38	14.11
B_2: Newspaper bag	391.93	12.01	8.79	175.57	54.21	4.18	18.22
B_3: Brown paper bag	367.58	10.54	8.32	155.65	50.78	3.89	16.28
B_4: Transparent PP bag	371.32	9.95	8.42	161.13	51.39	3.43	13.94
B_5: Butter paper bag	382.53	11.60	8.53	166.05	53.31	3.95	16.11
B_6: Muslin cloth bag	407.34	12.24	8.93	176.56	55.99	4.04	18.11
B_7: Non woven bag	346.75	10.36	8.29	147.95	49.94	3.83	15.83
S.Em.±	9.52	0.23	0.15	5.68	1.46	0.09	0.34
C.D. at 5 %	7.21	0.64	0.43	16.23	4.17	0.25	0.98
Interaction effect (D × B)							
S.Em.±	16.49	0.39	0.26	9.84	2.53	0.15	0.59
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS
C.V. %	7.55	6.17	5.31	10.44	8.38	6.94	6.39

The data indicated that fruit firmness was significantly affected by planting distance as well as bagging materials (Table 2). Maximum fruit firmness (4.00 kg cm-2) was noted in distance 3 m × 2 m (D_2), which was at par with D_1 (3 m × 3 m). It is indicated in Table 2. A hypothesis for this result indicate that fruit trees at the closer spacing were more shaded and slowing down fruit ripening process (Pasa *et al.* 2015) [25]. It was maximum in mango fruits bagged with newspaper bag (4.18 kg cm-2), which was at par with B_6 (muslin cloth bag), B_5 (butter paper bag) and B_3 (brown paper bag). This might be due to less infestation of the fruits by fruit fly in these bags. Fruit fly damage is very common in mango which accelerates the softening of fruits as any physical injury can stimulate the production of ethylene and ultimately reduction of fruit firmness (Abbasi *et al.*, 2014) [1] in guava. It also might be due to bagging using paper bags maintained high relative humidity, hence reducing water loss (Chonhenchob *et al.*, 2010) [8] in mango. These findings are in agreement with those of Hudina and Stampar (2011) [15] in pear; Bentley and Viveros (1992) [5] in apple. With regard to fruit firmness, the interaction effect of planting distance and bagging materials remained non-significant.

Planting distance showed significant effect on shelf-life of mango fruit. Maximum shelf-life (16.69 days) was recorded in D_3 (3 m × 2 m), which was at par with D_2 (3 m × 3 m) *i.e.* 16.40 days. It might be due to minimum physiological loss in weight in closer spacing (Kumar *et al.*, 2017) [27] and also trees at the closer spacing were more shaded and slowing down fruit ripening (Pasa *et al.*, 2015) [25]. The observation recorded on shelf-life (days) of fruits significantly influenced by different bagging materials used for fruit bagging. Maximum shelf-life (18.22 days) was noted in fruits bagged with newspaper bag (B_2), which was at par with muslin cloth bag (B_6) *i.e.* 18.11 days. This might be due to bagging

modified the micro-environment near fruits especially in respect to temperature and relative humidity. The humidity was greater in newspaper bag. The longer shelf-life indicated that the effect of bagging persisted after ripening (Haldankar *et al*., 2015) [13] in mango. John and Scott (1989) [18] reported that banana bunch grown under double sealed cover had delayed ripening which extend the shelf life of fruits because in sealed bunch cover the O_2 concentration not low enough and the CO_2 concentration was not higher enough to block the action of C_2H_4. The results are in conformity with Mingire *et al.* (2017) [19], Mohapatra (2016) [21], Islam *et al.* (2017a) [16] and Islam *et al*. (2017b) [17] in mango and Samantaray (2015) [29] in banana (Table 2).

Fruit volume: Table 3 clearly indicate that Various planting distance significantly affect on fruit volume (cm3). The maximum fruit volume (388.36 cm3) was recorded in planting distance D_2 (3 m × 3 m), which was at par with D_3 (3 m × 2 m). It might be due to good enough canopy size and less number of fruits (sink) which leads to less partitioning of the sources among the limited number of sink.

Table 3: Effect of planting distance and bagging materials on fruit volume (cm^3) of mango cv. Sonpari

Fruit volume (cm^3)				
Planting Bagging distance materials	**D_1 5 m × 5 m**	**D_2 3 m × 3 m**	**D_3 3m× 2m**	**Mean (B)**
B_1: Control	321.22	366.94	391.78	359.98
B_2: Newspaper bag	325.56	403.22	390.00	372.93
B_3: Brown paper bag	272.22	386.94	397.22	352.13
B_4: Transparent PP bag	332.22	361.72	388.91	360.95
B_5: Butter paper bag	294.44	402.06	395.00	363.83
B_6: Muslin cloth bag	309.44	426.49	413.89	383.27
B_7: Non woven bag	305.89	371.11	327.78	334.93
Mean (D)	308.71	388.36	386.37	
	D	B	D × B	
S.Em.±	6.01	9.18	15.91	
C.D. at 5 %	17.18	26.24	45.46	
C.V. %	7.63			

Various types of bags were significantly altered the fruit volume of mango. The data indicated that significantly maximum fruit volume (383.27 cm3) in B_6 (muslin cloth bag) and it was at par with B_2 (newspaper bag), B_5 (butter paper bag) and B_4 (Transparent PP bag). Which might be due to microclimate created by these bags had congenial effect on fruit growth (Mingire *et al*., 2017) [19]. The results are in conformity with Saad *et al*., (2017) [28] in pomegranate.

The interaction between planting distance and bagging materials showed significant effect on mango fruit volume (cm3). Maximum fruit volume (426.49 cm3) was recorded in D_2B_6 (3 m × 3 m distance and fruit bagging with muslin cloth bag), which was at par with D_2B_2, D_2B_3, D_2B_5, D_3B_1, D_3B_2, D_3B_3, D_3B_4, D_3B_5 and D_3B_6. Which might be due to the favorable micro environment created inside the bags and less numbers of fruits in closer distance provide more photosynthetic materials to the fruits.

Damage fruit (%): The data regarding damaged fruit (%) presented in Table 4 clearly indicated that there was minimum percentage of damaged fruits (26.96 %) in 3 m × 3 m (D_2) and it was at par with 5 m × 5 m (D_1). It might be due to dense canopy in closer spacing leads to more mechanically damage fruits as well as black patched or spotted fruits. Minimum damage fruit (22.26 %) was recorded in fruits bagged with newspaper bag (B_2) and it was at par with B_6 (muslin cloth bag). This might be due to prevent the damage through bruise and wound in bagging (Bayogan *et al*. 2006) [4]. It reduces splitting of fruits (Song and Song, 1993) in grape. Gowad *et al.* (2017) [12] found minimum number of sunburned fruits in mango. Hegazi *et al.* (2014) [14] and Ghorbani *et al.* (2015) [11] found minimum percentage of sunburned fruits in pomegranate bagged fruit. Abou El-Wafa (2014) [3] found less mechanical damage in bagged fruits of pomegranate. In present study, maximum damage fruit was observed in transparent PP bag. Poly- propylene bag caused sun scorched in the surface of fruits due to the effect of direct sunlight and excess heat generated within the bag (Mondal *et al.*, 2015) [22] in guava. Combined effect of planting distance and fruit bagging with different materials on damage fruit (%) was observed significant. Minimum damage fruit (17.10 %) was noted in D_1 (5 m × 5 m) with fruits bagged with B_2 (newspaper bag). It might be due to both the factor create less favorable condition for mechanical damage fruits, bruise fruits as well as black spotted fruits.

Insect-pest and diseases (fruit fly and anthracnose percentage): The planting distance significantly affect the fruit fly (%). The minimum percent of fruit fly damage (6.15 %) was noted in 5 m × 5 m (D_1) and it was at par with 3 m × 3 m (D_2) being 6.83 %. which might be due overcrowded growth of canopy results in buildup of high humidity, reduced cross ventilation in orchard and it is conductive for more incidence of pest (Mishra and Goswami, 2016) [20]. It also might be due to fly gets more opportunity to visit more number of fruits per unit area and per unit time in closer spacing (Poornima *et al*., 2018). There was a significant effect of bagging materials also on fruit fly damage (%). Minimum fruit fly damage (0.74 %) was recorded in B_2 (newspaper bag), B_5 (butter paper bag) and B_6 (muslin cloth bag). It might be due to bagging provide a physical barrier between fruit and pest (Mingire *et al.*, 2017) [19] in mango. The results are in conformity with Mondal *et al*. (2002) and Abbasi *et al*. (2014) [1] in guava for reducing fruit fly damage; Bentley and Viveros (1992) [5] in apple for reducing codling moth infestation; Purbey and Kumar (2015) [27] in litchi for reducing fruit borer infestation. Interaction effect between planting distance and fruit bagging with different materials significantly affected the fruit fly damage (%). There was no fruit fly damage in the interaction of D_1B_2, D_1B_3, D_1B_6, D_2B_2, D_2B_3, D_2B_5, D_2B_6, D_3B_2, D_3B_5, and D_3B_6. It might be due to this interaction of planting distance and fruit bagging with different material provide less favorable condition for fruit fly multiplication (Table 5).

Table 4: Effect of planting distance and bagging materials on damaged fruit (%) of mango cv. Sonpari

Damaged fruit (%)				
Planting distance Bagging materials	**D_1 5 m × 5 m**	**D_2 3 m × 3 m**	**D_3 3m× 2m**	**Mean (B)**
B_1: Control	29.5(24.44)	32.47(28.88)	35.25(33.33)	32.43(28.88)
B_2: Newspaper bag	17.10(8.88)	26.55(20.00)	23.12(15.55)	22.26(14.81)
B_3: Brown paper bag	24.84(17.78)	29.57(24.44)	26.55(20.00)	26.99(20.74)
B_4: Transparent PP bag	29.57(24.44)	32.47(28.88)	36.57(35.55)	32.87(29.63)
B_5: Butter paper bag	29.24(24.44)	23.12(15.55)	24.84(17.78)	25.73(19.26)
B_6: Muslin cloth bag	24.84(17.78)	23.12(15.55)	26.55(20.00)	24.84(17.78)
B_7: Non woven bag	33.85(31.11)	21.41(13.33)	36.57(35.55)	30.61(26.66)
Mean (D)	27.00(21.27)	26.96(20.95)	29.92(25.40)	
	D	B	D × B	
S.Em.±	0.62	0.95	1.65	
C.D. at 5 %	1.78	2.72	4.72	
C.V. %	10.22			

Table 5: Effect of planting distance and bagging materials on infestation of fruit fly (%) of mango fruit cv. Sonpari

Fruit fly (%)				
Planting distance Bagging materials	**D_1 5 m × 5 m**	**D_2 3 m × 3 m**	**D_3 3m× 2m**	**Mean (B)**
B_1: Control	14.95(6.66)	14.95(6.66)	21.41(13.33)	17.10(8.88)
B_2: Newspaper bag	0.74(0.00)	0.74(0.00)	0.74(0.00)	0.74 (0.00)
B_3: Brown paper bag	0.74(0.00)	0.74(0.00)	14.95(6.66)	5.48(2.22)
B_4: Transparent PP bag	4.95(6.66)	4.95(6.66)	1.41(13.33)	17.10(8.88)
B_5: Butter paper bag	0.74(0.00)	0.74(0.00)	0.74(0.00)	0.74 (0.00)
B_6: Muslin cloth bag	0.74(0.00)	0.74(0.00)	0.74(0.00)	0.74(0.00)
B_7: Non woven bag	0.21(4.44)	14.95(6.66)	14.95(6.66)	13.37(5.92)
Mean (D)	6.15(2.54)	6.83(2.85)	10.70(5.71)	
	D	B	D × B	
S.Em.±	0.39	0.60	1.03	
C.D. at 5 %	1.12	1.71	2.95	
C.V. %	22.68			

The data presented in Table 6 pertaining to anthracnose (%) was clearly showed that minimum percentage of fruits affected by anthracnose (4.12 %) was recorded in 3 m × 3 m (D_2) and which was at par with 5 m × 5 m (D_1) being 4.80 %. It might be due to wet, humid and warm weather conditions favor anthracnose infection (Nelson, 2008). Mishra and Goswami (2016) [20] also reported that overcrowded growth of canopy in closer spacing results in buildup of high humidity, reduced cross ventilation in orchard which is conductive for more incidences of diseases. The data related to anthracnose (%) was found significant as affected by fruit bagging with different materials. Anthracnose free fruits were recorded in newspaper bag, brown paper bag, butter paper bag and muslin cloth bag. This might be due to fruit bagging prevents pathogens from reaching the developing fruits, which protect them from several diseases that can cause several losses (Sharma *et al.*, 2014) [32]. These findings are in agreement with those of Mingire *et al*. (2017) [19], Chonhenchob *et al*. (2011) [8] and Dutta and Majumder (2012) in mango. The combination of planting distance and bagging materials significantly influenced the anthracnose damage of fruit (%). Anthracnose free fruits were recorded in the interaction of D_1B_2, D_1B_3, D_1B_5, D_1B_6, D_1B_7, D_2B_2, D_2B_3, D_2B_5, D_2B_6, D_3B_2, D_3B_3, D_3B_5 and D_3B_6. It might be due to this interaction providing less beneficial condition for multiplication of *Colletotrichum gloeosporioides*, the fungus responsible for occurrence of anthracnose.

Table 6: Effect planting distance and of bagging materials on incidence of anthracnose (%) of mango fruit cv. Sonpari

Anthracnose (%)				
Planting distance Bagging materials	**D_1 5 m × 5 m**	**D_2 3 m × 3 m**	**D_3 3m× 2m**	**Mean (B)**
B_1: Control	14.95(6.66)	14.95(6.66)	14.95(6.66)	14.95(6.66)
B_2: Newspaper bag	0.74(0.00)	0.74(0.00)	0.74(0.00)	0.74(0.00)
B_3: Brown paper bag	0.74(0.00)	0.74(0.00)	0.74(0.00)	0.74(0.00)
B_4: Transparent PP bag	14.95(6.66)	10.21(4.44)	14.95(6.66)	13.37(5.92)
B_5: Butter paper bag	0.74(0.00)	0.74(0.00)	0.74(0.00)	0.74(0.00)
B_6: Muslin cloth bag	0.74(0.00)	0.74(0.00)	0.74(0.00)	0.74(0.00)
B_7: Non woven bag	0.74(0.00)	0.74(0.00)	14.95(6.66)	5.48(2.22)
Mean (D)	4.80(1.90)	4.12(1.59)	6.83(2.85)	
	D	B	D × B	
S.Em.±	0.39	0.60	1.03	
C.D. at 5 %	1.12	1.71	2.95	
C.V. %	34.10			

Marketable fruit (%)

The planting distance as well as bagging material significantly affect the marketable fruit (%). It was presented in Table 7. The data indicated that marketable fruit (60.20 %) was maximum in 5 m × 5 m (D_1), which was at par with 3 m × 3 m (D_2) *i.e.* 60.16 %. Which might be due to the less damaged as well as less insect-pest and diseases incidence in wider spacing. It showed significant effect with respect to different bagging materials. Maximum marketable fruit (67.70 %) was reported in fruits bagged with newspaper bag (B_2) and it was at par with B_6 (muslin cloth bag being 65.13 %) and B_5 (butter paper bag being 64.22 %). Less damage fruits and fewer incidences of insect and pest was observed in these bags which are the probable reasons for maximum marketable fruits. The results are in accordance with Hegazi *et al.* (2014) [14] and Abou El-Wafa (2014) [3] in pomegranate; Mondal *et al*. (2015) [22] in guava; Purbey and Kumar (2015) [27] in litchi. The data indicated that marketable fruit (%) was significantly influenced by interaction between planting distance and bagging materials. Maximum marketable fruit (72.86 %) was noted in the interaction of D_1B_2 (5 m × 5 m and newspaper bag). which might be due to less damaged fruit as well as fruit fly and anthracnose damage fruits in this interaction of planting distance and fruit bagging.

Economics

The data pertaining to the effect of different planting distance and bagging materials on net realization and benefit cost ratio are presented in Table 8. It clearly indicate that the interaction of D_1B_2 (5 m × 5 m and fruits bagged with newspaper bag) gave maximum B:C ratio of 3.25, which was followed by D_2B_2 (3 m × 3 m and fruit bagged with newspaper bag) with ratio of 3.23.

Table 7: Effect of planting distance and bagging materials on marketable fruit (%) of mango cv. Sonpari

Marketable fruit (%)				
	D_1 5 m × 5 m	**D_2 3 m × 3 m**	**D_3 3m× 2m**	**Mean (B)**
B_1: Control	52.08(62.24)	49.47(57.80)	43.08(46.68)	48.21(55.57)
B_2: Newspaper bag	72.86(91.12)	63.41(80.00)	66.84(84.45)	67.70(85.19)
B_3: Brown paper bag	65.13(82.22)	60.40(75.56)	58.89(73.34)	61.47(77.04)
B_4: Transparent PP bag	52.08(62.24)	50.76(60.02)	41.80(44.46)	48.21(55.57)
B_5: Butter paper bag	60.72(75.56)	66.84(84.45)	65.13(82.22)	64.22(80.74)
B_6: Muslin cloth bag	65.13(82.22)	66.84(84.45)	63.41(80.00)	65.13(82.22)
B_7: Non woven bag	53.38(64.45)	63.42(80.01)	45.63(51.13)	54.15(65.20)
Mean (D)	60.20(74.29)	60.16(74.61)	54.97(66.04)	
	D	B	D × B	
S.Em.±	0.60	0.92	1.60	
C.D. at 5 %	1.72	2.62	4.54	
C.V. %	4.71			

Table 8: Economics of different treatments (Rs./ha)

Treatment	Marketable fruit yield (t/ha)	Fixed cost (A)	Variable cost (B)	Total income /16* (C)	Total income (D)	Total cost (E=A+B+)	Net return (D-E)	B:C ratio
D_1B_1	11.52	82988	-	25192	403077	108180	294897	2.73
D_1B_2	16.78	82988	32860	41950	671200	157798	513402	3.25
D_1B_3	14.58	82988	50400	36456	583303	169844	413459	2.43
D_1B_4	12.93	82988	20400	28276	452410	131664	320746	2.44
D_1B_5	14.78	82988	99000	36941	591049	218929	372120	1.70
D_1B_6	16.86	82988	220000	42144	674310	345132	329178	0.95
D_1B_7	12.75	82988	39000	31867	509877	153855	356022	2.31
D_2B_1	14.57	103161	-	31872	509950	135033	374917	2.78
D_2B_2	20.09	103161	36690	50234	803752	190085	613666	3.23
D_2B_3	19.89	103161	56280	49735	795764	209176	586587	2.80
D_2B_4	15.76	103161	22780	34471	551530	160412	391118	2.44
D_2B_5	20.09	103161	110550	50216	803452	263927	539526	2.04
D_2B_6	21.95	103161	245653	54865	877844	403679	474165	1.17
D_2B_7	16.64	103161	43550	41589	665417	188300	477118	2.53
D_3B_1	17.53	137511	-	38344	613506	175855	437651	2.49
D_3B_2	22.95	137511	41070	57380	918077	235961	682116	2.89
D_3B_3	22.81	137511	63000	57017	912279	257528	654751	2.54
D_3B_4	18.23	137511	25500	39872	637960	202883	435076	2.14
D_3B_5	22.77	137511	123750	56923	910761	318184	592578	1.86
D_3B_6	23.64	137511	275000	59108	945731	471619	474112	1.01
D_3B_7	20.14	137511	48750	50352	805629	236613	569017	2.40

Conclusion

From the result of the present experiment, it is concluded that, there was maximum fruit retention as well as marketable fruit and fruit fly free fruits obtained in the planting distance of 5 m × 5 m and fruits bagged with newspaper bag. The earlier harvesting of fruits was also observed in planting distance of 5 m × 5 m. Physical parameters *viz*., fruit weight, fruit length, fruit diameter, fruit volume, pulp weight, stone weight were maximum in the planting distance of 3 m × 3 m and fruits bagged with muslin cloth bag and newspaper bag. For

economic point of view, planting distance of 5 m × 5 m and fruits bagged with newspaper bag gave higher benefit cost ratio. Therefore, fruits covered with newspaper bag in the planting distance of 5 m × 5 m can be utilized for enhancing the physical quality of mango fruit cv. Sonpari

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