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Studies on pre-harvest fruit bagging on fruit characters, fruit yield and economics of pomegranate cv. Phule Bhagwa Super

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Abstract
A field experiment was conducted during 2019-2020 to investigate the effects of pre-harvest fruit bagging on the characteristics, yield and economic aspects of pomegranate cv. Phule Bhagwa Super. The experiment was set in Randomized Block Design with six treatments, each replicated four times. The bagging treatments included Butter paper bag (T_1), Brown paper bag (T_2), Parchment bag (T_3), English newspaper bag (60 gsm) (T_4), Marathi newspaper bag (35 gsm) (T_5), and Control (no bagging) (T_6). These treatments were applied to pomegranate fruits 30 days after fruit set. Results indicated a significant impact of bagging treatments on fruit characteristics and yield. Fruits enclosed in Parchment bags (T_3) exhibited increased weight (316.44 g) with the highest fruit yield (25.68 kg per plant and 19.0 t ha^{-1}). Additionally, this treatment showed the highest aril percentage (72.89%), elevated Total Soluble Solids (TSS) content (15.48^{0}B), maximum total sugar content (13.91%), and moderate acidity (0.32%). No cracked and sun burnt fruits were observed in all bagging treatments. Incidence of fruit borer were absent in the bagging treatments except for those using bags made from Marathi newspaper. The fruits remained unaffected by oily spots. Among all bagging treatments, the use of parchment bags recorded the highest Benefit-Cost (B:C) ratio of 2.64. Thus, pomegranate fruit bagging with parchment bag was found to be most promising and cost effective.

Keywords: Pomegranate, parchment bag, fruit bagging, cracking, sunburnt, B:C ratio

Introduction
Pomegranate is renowned worldwide as a "Super-food" due to its nutritional attributes and therapeutic properties. Besides, its nutritional value, the fruit's cosmetic appeal holds significance for both export and domestic markets. Pomegranate faces various biotic stresses such as oily spot and abiotic stresses like high temperatures, impacting its quality and external appearance. Fruit bagging emerges as an eco-friendly solution to enhance pomegranate fruit quality and yield. Bagging serves as a physical protection method, not only enhancing the visual appeal of the fruit by encouraging skin coloration and reducing blemishes but also altering the micro-environment for fruit development, which can positively influence internal fruit quality (Sharma *et al*., 2014) [15]. This study was conducted on pomegranate cv. Phule Bhagwa to assess the effectiveness of various bagging materials on fruit characteristics and yield. The economics of fruit bagging was also worked out to find out most suitable and cost-effective bagging material.

Materials and Methods
The field experiment was conducted during the year 2019-20 on a five-year-old orchard of pomegranate cv. Phule Bhagwa Super, spaced at 4.5 m x 3 ms, located at the Pomegranate Research and Technology Transfer Centre (PRTTC) in Lakhmapur Tal, Satana Dist, Nasik. The experiment coincided with the Hasta bahar season. Employing a Randomized Block Design, each treatment was replicated four times. Five types of bags namely Butter paper bag, Brown paper bag, Parchment bag, English newspaper bag (60 gsm) and Marathi newspaper bag (35 gsm) having 25 x 20 cm size were employed in the study. Perforations with a diameter of 4 mm were made at the bottom of each bag to ensure proper ventilation. Bagging of fruits commenced 30 days after fruit set. For the recording of various fruit characteristics and biochemical parameters, five fruits per treatment per replication were

randomly selected. Observations were recorded on fruit weight and yield (kg perplantand t per ha). As regards quality parameters, observations were recorded on aril percentage, TSS (^{0}B), Total sugars (%) and acidity (%). As regards the cosmetic value, cracked fruits (%), sunburnt fruits (%) along with incidence of fruit borer (%), mealy bug (%) and oily spot (%). Economics of fruit bagging was also worked out by computing B:C ratio.

Results and Discussion

Fruit Weight (g): All bagging treatments led to improvement in fruit weight. Notably, the treatment utilizing Parchment bags (T_3) exhibited a significantly higher fruit weight, measuring 316.44 g. This finding aligns with previous studies by Abd El-Rhman (2010) [2] and Samra and Shalan (2013) [14] in pomegranates. Salama *et al*. (2018) [13] also documented elevated fruit weight values in pomegranate trees treated with 780 g of potassium sulfate per tree and fruit bagged with butter paper compared to unbagged pomegranate fruits of the wonderful variety. Similarly, Islam *et al*. (2017a) [8] observed a maximum fruit weight of 329.2 g in mangoes bagged 35 days after fruit set using brown paper bags. Debnath and Mitra (2008) [5] reported in litchi that both Brown Paper and Newspaper bags resulted in increased fruit weight compared to the control. The augmentation in relative humidity and reduction in fruit water loss likely contributed to the increased fruit weight observed in the bagging treatments.

Yield (kg/ plant and t/ ha)

Yield (kg per plant and tons per hectare) was significantly affected by pre-harvest fruit bagging. The highest yield, 25.68 kg per plant and 19.0 tons per hectare, was recorded in treatment T_3, involving the use of Parchment bags. However, in terms of yield per hectare (tons), it was comparable to treatments T_1 (17.98 t/ha) and T_4 (17.73 t/ha), followed by T_2 (17.31 t/ha) and T_5 (17.11 t/ha). The lowest yield was observed in treatment T_6 (Control), with a yield of 18.65 kg per plant and 13.80 tons per hectare. These findings align with those of Samra and Shalan (2013) [14], who reported increased fruit yield (kg per tree) in pomegranates due to various bagging treatments. Hegazi *et al.* (2014) [7] noted improved yields in Manfaloty and Wonderful cultivars of pomegranate following bagging and spraying with 50 ppm GA_3, 2% or 4% $CaCl_2$, and 5% kaolin. Similarly, Salama *et al.* (2018) [13] reported the highest yield values in pomegranate trees treated with 780 grams of potassium sulfate per tree and fruit bagged with butter paper compared to unbagged pomegranate fruits of the wonderful variety. The increase in pomegranate yield may be attributed to the enhancement in fruit weight.

Table 1: Effect of type of bags on fruit weight (g) and Yield (kg / plant) in pomegranate cv. Phule Bhagwa Super at stage of harvest

Treatment	Treatment detail	Fruit weight (g)	Yield (Kg / plant)	Yield (t/ ha)
T_1	Butter paper bag	307.47	24.30	17.98
T_2	Brown paper bag	292.25	23.39	17.31
T_3	Parchment bag	316.44	25.68	19.00
T_4	English newspaper bag	305.42	23.96	17.73
T_5	Marathi newspaper bag	266.45	23.13	17.11
T_6	Control (without bag)	260.68	18.65	13.80
	S. E. ±	2.02	0.92	0.68
	C. D. 0.5%	6.10	2.77	2.06

Aril percentage (%)

The data regarding Aril percentage has been presented in Table 2. The use of various types of bags for pre-harvest fruit bagging had a significant impact on aril percentage. Notably, treatment T_3, employing Parchment bags, exhibited the highest aril percentage at 72.89% but it was at par with treatment T_1 (71.71%) and T_4 (68.30%) followed by T_2 (67.76%) and T_5 (66.80%). whereas lowest aril percentage% observed in T_6 *i.e.* control (58.87). Results are in close agreement with Abd Al-Hayany and Hathal (2022) [1] who reported highest aril percentage with fruit bagging in pomegranate cv. Salimi. Wassel *et al*. (2015) [16] also reported significantly increased the total arils and red arils weight and percentage due to fruit bagging.

The rise in aril percentage could be attributed to the enlargement of cell size and intercellular spaces, alongside the accumulation of water, sugars, and other soluble solids in larger quantities. This phenomenon may result from the translocation of metabolites towards the fruits.

Total Soluble Solids (TSS) (˚Brix)

As demonstrated by Table 2, the utilization of various bag types for pre-harvest fruit bagging had a notable impact on TSS levels. Significantly the highest T.S.S. was found in T_6*i.e.* control which recorded 15.76 ˚B TSS and it was superior to rest of treatments. But it was at par with treatments T_3 (15.48˚B), T_1 (15.35˚B) and T_4 (15.12 ˚B). The lowest TSS was observed in the treatment T_5*i.*e. Marathi newspaper bag and it was14.05˚B.Similar results were reported by AbouEl-Wafa (2014) [3]; Asrey *et al*. (2019) [4] in pomegranate; Hossain *et al*. (2020) in mango.

Total sugars (%)

The treatment T_6, serving as the control (Table 2), notably exhibited the highest total sugar content, reaching 14.07%. This value significantly surpassed that of other treatments. However, it was comparable to the total sugar content observed in treatments T_3 (13.91%) and T_1 (13.69%). Conversely, the lowest total sugar percentage of 13.19% was documented in treatment T_5, utilizing Marathi newspaper bags. Results are in accordance with Asrey *et al*. (2019) [4]. Total sugars were increased in open condition due to exposed fruit in direct sunlight and high temperature continuously.

Titratable Acidity (%)

It was evident from the Table 2 that different bagging treatments substantially influenced the acidity (%). The lowest acidity was found in the treatment T_6 *i.e.* control. and it was 0.32%. but it was at par with treatments T_3 (0.32%), T_1 (0.33%), T_4 (0.34%). The highest percentage of acidity 0.38% was recorded in T_5 *i.e.* Marathi newspaper bag. Similar findings by, Rahman *et al.* (2018) [12] noted that

guava fruit exhibited the highest titratable acidity content (2.02%) under open conditions, whereas the lowest acidity (1.33%) was observed when fruit was enclosed in white polythene bags.

Table 2: Ilustrates the impact of bag types on aril percentage (%), TSS (^{0}B), total sugars (%), and acidity (%) of pomegranate cv. Phule Bhagwa Super at the time of harvest

Treatment no	Treatment details	Aril percentage (%)	TSS (^{0}B)	Total sugars (%)	Acidity (%)
T_1	Butter paper bag	71.71	15.35	13.69	0.33
T_2	Brown paper bag	67.76	15.05	13.33	0.35
T_3	Parchment bag	72.89	15.48	13.91	0.32
T_4	English newspaper bag (Biodegradable)	68.30	15.12	13.56	0.34
T_5	Marathi newspaper bag (Biodegradable)	66.80	14.05	13.19	0.38
T_6	Control (without bag)	58.87	15.76	14.07	0.32
	S. E ±	2.10	0.23	0.16	0.014
	C. D. 0.5%	6.34	0.68	0.48	0.042

Cracked fruit percentage

It was interesting to note that no cracking in all the all the bagging treatments (Table-3). However, 6 per cent cracking was observed in the control treatment (T_6). Similar findings by Yang *et al*. (2009) [17] in Longan. According to Abou El-Wafa (2014) [3], pomegranate fruits enclosed in parchment bags exhibited the lowest significant fruit cracking rate (1%) across both seasons. In contrast, Hamedi *et al.* (2019) [6] discovered that the control group had the highest cracking percentage (65%), while the lowest (5%) was observed in pomegranate fruits bagged with white bags in August (White bag early in August).

Sunburnt fruit percentage

This is very important disorder that affects external appearance of fruit affecting its market value. However, no sunburnt fruit were recorded in all the bagging treatments. The highest infestation rate, reaching 21.50%, was observed in the Control (T_6). These findings align with those reported by Hegazi *et al.* (2014) [7] and Abou El-Wafa (2014) [3] regarding pomegranate.

Table 3: Effect of types of bags on cracked fruit (%) and sunburn fruit (%) of pomegranate cv. Phule Bhagwa Super at stageof harvest

Treatment no	Treatment details	Cracked fruit%	Sunburnt fruit%
T_1	Butter paper bag	0.00	0.00
T_2	Brown paper bag	0.00	0.00
T_3	Parchment bag	0.00	0.00
T_4	English newspaper bag	0.00	0.00
T_5	Marathi newspaper bag	0.00	0.00
T_6	Control (without bag)	6.00	21.50
	S. E. ±	-	-
	C. D. 0.5%	-	-

Fruit borer incidence (%)

Different bagging treatments had significant effect in controlling fruit borer infestation (%) (Table 4). Fruits from the treatments T_1 (Butter paper bag), T_2 (Brown paper bag),T_3 (Parchment bag) and T_4 (English newspaper bag) were absolutely free from fruit borer incidence. However, fruit borer infestation of 2.50 and 5.52 per cent was noted in the treatment T_5 *i.e.* Marathi newspaper bag and T_6 *i.e.* Control. Debnath and Mitra (2008) [5] and Purbey and Kumar (2015) [11] reported similar findings in litchi.

Mealy bug incidence (%)

Pre- harvest bagging had significant effect on controlling mealy bug infestation (Table 4). The lowest infestation was noticed in T_3 *i.e.* Parchment bag (1.46%). Whereas highest mealy bug infestation observed in T_6 *i.e.* control (12.02%).According to Karar *et al.* (2019) [9], bagging mangoes of the "Anwar Rataul" cultivar provided significant protection against various insect pests such as fruit flies, fruit borers, scales, and others compared to the control group (un-bagged fruits). All harvested fruits were completely free from insect pest attacks.

Oily spot

All the treatments were absolutely free from oil spot incidence. Kitagawa *et al.* (1992) [10] strongly recommend bagging fruit as it is effective not only in controlling diseases and insects but it also enhances the appearance of the fruits and reduces chemical residue.

Table 4: Effect of types of bags on incidence of fruit borer (%), mealy bug (%) and oily spot (%) in pomegranate fruits cv. Phule Bhagwa Super at harvest

Treatment no	Treatment details	Fruit borer (%)	Mealy bug (%)	Oily spot (%)
T_1	Butter paper bag	00	8.18 *(16.61)	00
T_2	Brown paper bag	00	9.24 (17.69)	00
T_3	Parchment bag	00	1.46 (6.94)	00
T_4	English newspaper bag (Biodegradable)	00	7.54 (15.93)	00
T_5	Marathi newspaper bag (Biodegradable)	2.50 (9.09)	9.97 (18.40)	00
T_6	Control (without bag)	5.52 (13.58)	12.02 (20.28)	00
	S. E ±	-	0.70	-
	C. D. 0.5%	-	2.10	-

Economics of fruit bagging in pomegranate

The data regarding on B:C ratio of cv. Phule Bhagwa Super with pre-harvest fruit bagging with different types of bags are presented in Table 5. The maximum to B:C ratio, was observed in the treatment T_3 *i.e.*, parchment bag (2.64) whereas, the lowest B:C ratio. The treatment T_3 recorded higher benefit cost ratio due to its higher net returns was observed in T_6 *i.e.*, control (1.58). The data on benefit cost ratio showed advantage of fruit bagging. Maximum B:C ratio was mainly due to fruit weight and higher yield.

Table 5: Economics of fruit bagging in pomegranate cv. Phule Bhagwa Super

Treat. no.	Treatment detail	Yield (t /ha)	Cost of cultivation (Rs.)	Total gross returns (Rs/ha)	Net returns (Rs)	B:C ratio
T_1	Butter paper bag	17.98	275577	854050	578473	2.10
T_2	Brown paper bag	17.31	254709	796220	541511	2.12
T3	Parchment bag	19.00	253126	921500	668374	2.64
T_4	English newspaper bag	17.73	246117	824395	578278	2.34
T_5	Marathi newspaper bag	17.11	242787	769950	527163	2.17
T_6	Control (without bag)	13.80	212095	548550	336455	1.58
	S. E ±	0.68	--	--	--	--
	C. D. 0.5%	2.06	--	--	--	--

Conclusion

The bagging treatment Parchment bag (T_3) recorded the highest fruit weight and fruit yield. In case of economical parameter, the highest B:C ratio (2.64) was found in Parchment bag (T_3) followed by treatment T_4 (English newspaper bag) which recorded 2.34 B:C ratio.

Among the bagging treatments, the parchment bag (T_3) emerged as the most promising option. However, both the butter paper bag and the English newspaper bag could serve as excellent alternatives to the parchment bag.

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