

**STUDIES ON PRE-HARVEST FRUIT BAGGING OF
POMEGRANATE FRUIT.**

by

Miss. Gethe Apurva Sanjeev

(Reg. No. 2018/299)

**HORTICULTURE SECTION,
COLLEGE OF AGRICULTURE, DHULE – 424 004.**

**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST - AHMEDNAGAR,
MAHARASHTRA, INDIA.**

2020

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A Thesis submitted to the
**MAHATMA PHULE KRISHI VIDYAPEETH,
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MAHARASHTRA, INDIA**

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (HORTICULTURE)

in

FRUIT SCIENCE



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APPROVED BY

Dr. S. A. Hiray
(Chairman and Research Guide)

Dr. C. V. Pujari
(Committee Member)

Dr. R. V. Patil
(Committee Member)

Dr. V. P. Bhalerao
(Committee Member)

**DEPARTMENT OF HORTICULTURE,
COLLEGE OF AGRICULTURE, DHULE – 424 004.**

**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST - AHMEDNAGAR,
MAHARASHTRA, INDIA.**

2020

CANDIDATE'S DECLARATION

**I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institute
for a Degree or
Diploma.**

Place: College of Agriculture, Dhule. **(Miss. Apurva Sanjeev Gethe)**

Dated: 26/ 11 / 2020

Dr. S. A. Hiray
Officer In charge,
PRTTC Lakhmapur,
Tal. Satana, Dist- Nashik,
Maharashtra State (India).

CERTIFICATE

This is to certify that the thesis entitled, “**STUDIES ON PRE-HARVEST FRUIT BAGGING OF POMEGRANATE FRUIT**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE** embodies the results of a piece of bonafide research work carried out by **MISS. GETHE APURVA SANJEEV** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

Place: College of Agriculture, Dhule.

Date: 26 / 11 / 2020.

(S. A. Hiray)

Research Guide

Dr. C. V. Pujari

Professor of Horticulture

College of Agriculture, Dhule- 424004,

Maharashtra State (India).

CERTIFICATE

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Place: College of Agriculture, Dhule.

(C. V. Pujari)

Date: 26 / 11 / 2020.

Dr. C. D. Deoker

Associate Dean,

College of Agriculture, Dhule- 424004

Maharashtra State (India).

CERTIFICATE

This is to certify that the thesis entitled, “**STUDIES ON PRE-HARVEST FRUIT BAGGING OF POMEGRANATE FRUIT**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE** embodies the results of a piece of bonafide research work carried out by **MISS. GETHE APURVA SANJEEV** under the guidance and supervision of **Dr. S. A. HIRAY**, Officer Incharge, Pomegranate Research and Technology Transfer Center Lakhamapur and that no part of the thesis has been submitted for any other degree or diploma.

Place: College of Agriculture, Dhule.

(C.D. Deokar)

Date: 26/11 / 2020

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Place: College of Agriculture, Dhule

(**Gethe Apurva Sanjeev**)

Date: 26/11/2020

CONTENTS

Chapter No.	Title	Page No.
	CANDIDATES DECLARATION	I
	CERTIFICATE OF RESEARCH GUIDE	II
	CERTIFICATE OF HEAD OF THE DEPARTMENT	III
	CERTIFICATE OF ASSOCIATE DEAN	IV
	ACKNOWLEDGEMENT	V
	CONTENTS	VI
	LIST OF TABLES	IX
	LIST OF FIGURES	X
	LIST OF PLATES	XII
	LIST OF ABBREVIATIONS AND SYMBOLS	XIII
	ABSTRACT	XIV
1	INTRODUCTION	1-2
2	REVIEW OF LITERATURE	3-19
	2.1 Effect of Pre-harvest fruit bagging on physical parameters.	3-7
	2.2 Effect of Pre-harvest fruit bagging on aril percentage	8
	2.3 Effect of Pre-harvest fruit bagging on biochemical parameters	8-13
	2.4 Effect of Pre-harvest fruit bagging on Physiological parameters	13
	2.5 Effect of Pre-harvest fruit bagging on Shelf life	13-14
	2.6 Effect of Pre-harvest fruit bagging on Cracked and sunburn fruit percentage	14-16
	2.7 Effect of Pre-harvest fruit bagging on Disease and Pest infestation	16-19
3	MATERIALS AND METHODS	20-27
	3.1 Experimental Site	20
	3.2 Experimental Details	20
	3.2.1 Number of Replications	20
	3.2.2 No of fruits bagged	20
	3.2.3 Number of plants/treatments	20
	3.2.4 Design of Experiment	20
	3.2.5 Stage of bagging	20
	3.2.6 Size of bag	20

Chapter No.	Title	Page No.
	3.3 Treatment details	20
	3.4 Observation Recorded	24
	3.4.1 Fruit Physical parameters	24
	3.4.1.1 Fruit length (cm)	24
	3.4.1.2 Fruit diameter (cm)	24
	3.4.1.3 Fruit weight (g)	24
	3.4.2 Aril Percentage (%)	24
	3.4.3 Chemical parameters	24
	3.4.3.1 Total Soluble Solids (⁰ Brix)	24
	3.4.3.2 Total sugars (%)	24
	3.4.3.3 Reducing sugars (%)	25
	3.4.3.4 Non-reducing sugars (%)	25
	3.4.3.5 Titratable acidity (%)	25
	3.4.4 Physiological parameters	25
	3.4.4.1 Physiological loss in fruit weight (%)	25
	3.4.4.2 Shelf life (days)	25
	3.4.5 Cracked fruit percentage	26
	3.4.6 Sunburn fruit percentage	26
	3.4.7 Pest incidence (%)	26
	3.4.8 Disease incidence (%)	26
	3.4.9 Economic of fruit bagging	26
	3.4.9.1 Cost of bags (Rs/ha)	27
	3.4.9.2 Cost of cultivation	27
	3.4.9.3 Gross monetary returns (Rs/ha)	27
	3.4.9.4 Net monetary returns (Rs/ha)	27
	3.4.9.5 Benefit cost ratio (B:C Ratio)	27
	3.10 Statistical Analysis	27
4	RESULTS AND DISCUSSION	28-42
	4.1 Physical characteristics of fruit	28
	4.1.1 Fruit length (cm)	28
	4.1.2 Fruit diameter (cm)	28
	4.1.3 Fruit weight (g)	29
	4.1.4 Yield (kg/plant and ton/ha)	30
	4.2 Aril percentage	30

Chapter No.	Title	
	4.3 Quality characters	31
	4.3.1 Total Soluble Solids (T.S.S.) (°B)	31
	4.3.2 Titratable acidity (%)	32
	4.3.3 Total Sugar content (%)	33
	4.3.4 Reducing sugar content (%)	34
	4.3.5 Non-reducing sugar content (%)	35
	4.3.6 Physiological Loss in Weight (PLW) (%)	35
	4.3.7 Shelf life (Days)	36
	4.4 Fruit cracking percentage	37
	4.4.1 Sunburn fruit percentage	38
	4.5 Pest incidence (%)	39
	4.5.1 Fruit borer infestation (%)	39
	4.5.2 Mealy bug infestation (%)	39
	4.6 Disease (Oily spot) incidence %	40
	4.6.1 Oily spot and Leaf spot (%)	40
	4.7 Economics of pre-harvest fruit bagging of pomegranate	41-42
5	SUMMARY AND CONCLUSION	43-46
6	LITERATURE CITED	47-59
7	APPENDIX	60
	7.1 Appendix I	60
	7.1.1 Weekly meteorological data	60
8	VITAE	61

LIST OF TABLES

Table No.	Description	Page No.
4.1	Effect of types of bag on Fruit length (cm), Fruit diameter (cm), and Fruit weight (g) of pomegranate cv. Phule Bhagwa Super at harvest.	29
4.2	Effect of types of bag on Marketable yield of pomegranate cv. Phule Bhagwa Super at harvest.	30
4.3	Effect of types of bag on Aril Percentage (%) of pomegranate cv. Phule Bhagwa Super at harvest.	31
4.4	Effect of types of bag on Total Soluble Solids (T.S.S) (°B) of pomegranate cv. Phule Bhagwa Super at harvest.	32
4.5	Effect of types of bag on Titratable acidity (%) of pomegranate cv. Phule Bhagwa Super at harvest.	33
4.6	Effect of types of bag on Total sugars content (%) of pomegranate cv. Phule Bhagwa Super at harvest.	34
4.7	Effect of types of bag on Reducing sugars content (%) of pomegranate cv. Phule Bhagwa Super at harvest.	34
4.8	Effect of types of bag on Non-reducing sugars content (%) of pomegranate cv. Phule Bhagwa Super at harvest.	35
4.9	Effect of types of bag on Physiological Loss in Weight (PLW) (%) of pomegranate cv. Phule Bhagwa Super at harvest.	36
4.10	Effect of types of bag on Shelf life (days) of pomegranate cv. Phule Bhagwa Super at harvest.	37
4.11	Effect of types of bag on Cracked fruit % and Sunburn fruit % of pomegranate cv. Phule Bhagwa Super at harvest.	38
4.12	Effect of types of bag on incidence of Fruit borer (%) and Mealy bug (%) in pomegranate fruits cv. Phule Bhagwa Super at harvest.	40
4.13	Effect of types of bag on incidence of Bacterial blight (Oily spot) (%) and Leaf spot (%) in pomegranate fruits cv. Phule Bhagwa Super at harvest.	41
4.14	Economics of the fruit bagging in pomegranate cv. Phule Bhagwa Super.	42

LIST OF FIGURES

Fig. No.	Description	Page between No.
4.1	Effect of types of bag on Fruit length (cm) at harvest.	29-30
4.2	Effect of types of bag on Fruit diameter (cm) at harvest.	29-30
4.3	Effect of types of bag on Fruit weight (g) at harvest.	29-30
4.4	Effect of types of bag on Marketable yield (kg/plant)	30-31
4.5	Effect of types of bag on Marketable yield (ton/ha)	30-31
4.6	Effect of types of bag on Aril percentage at harvest	31-32
4.7	Effect of types of bag on Total Soluble Solids (T.S.S) (°B) at harvest	32-33
4.8	Effect of types of bag on Titratable acidity (%) at harvest	33-34
4.9	Effect of types of bag on Total sugars content (%) at harvest	34-35
4.10	Effect of types of bag on Reducing sugars content (%) at harvest	34-35
4.11	Effect of types of bag on Non-reducing sugars content (%) at harvest	35-36
4.12	Effect of types of bag on Physiological Loss in Weight (PLW)% at harvest	36-37
4.13	Effect of types of bag on Shelf life (days) at harvest	37-38
4.14	Effect of types of bag on Cracking fruit % at harvest	38-39
4.15	Effect of types of bag on Sunburn fruit % at harvest	38-39
4.16	Effect of types of bag on Fruit borer infestation % at harvest	40-41
4.17	Effect of types of bag on Mealy bug infestation % at harvest	40-41
4.18	Effect of types of bag on Leaf spot infestation % at harvest	41-42

LIST OF PLATES

Plate No.	Description	Page No.
3.1	Different types of bags used in fruit bagging of Pomegranate.	21
3.2	Treatments given to plants (a)	22
3.3	Treatments given to plants (b)	23

LIST OF ABBREVIATIONS AND SYMBOLS

%	:	Per cent
@	:	At the rate of
°C	:	Degree Celsius
µg	:	Microgram
⁰ Brix	:	Degree Brix
A.O.A.C.	:	Association of Official Analytical Chemist
Anon.	:	Anonymous
C.D.	:	Critical Difference
Cm	:	Centimeter
cv.	:	Cultivar
B:C	:	Benefit Cost ratio
DAB	:	Days After Bagging
DAFB	:	Days After Full Bloom
Dist.	:	District
<i>et al.</i>	:	and others
Fig.	:	Figure
g	:	Gram
gsm	:	Grams per Square Meter
ha	:	Hectare
<i>i.e.</i>	:	That is
kg	:	Kilogram
M	:	Metric
M ha	:	Million ha
M Mt	:	Million metric ton
Max.	:	Maximum
Min.	:	Minimum
MPKV	:	Mahatma Phule Krishi Vidyapeeth
M.S.	:	Maharashtra State
ml	:	Milliliter

NS	:	Non-Significant
PLW	:	Physiological Loss in Weight
RBD	:	Randomized Block Design
RH	:	Relative Humidity
Rs.	:	Rupee (s)
SE (m).	:	Standard error of mean
Sr no	:	Serial number
T	:	Treatment
ton	:	Tonne(s)
TSS	:	Total soluble solids
Var.	:	Variety
Viz.,	:	Videlicet (Namely)

ABSTRACT

“STUDIES ON PRE-HARVEST FRUIT BAGGING ON POMEGRANATE FRUIT”.

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A Candidate for the degree

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Mahatma Phule Krishi Vidyapeeth Rahuri- 413 722

2020

Research Guide : Dr. S. A. Hiray

Department : Horticulture

Major Field : Fruit science

The investigation entitled “Studies on Pre-harvest fruit bagging on pomegranate fruit” was carried out during the year 2019-20 with the objectives to find the effect of pre-harvest fruit bagging of effect of different bagging material on post-harvest quality of fruit, effect of bagging on pest and disease infestation and the cost benefit ratio (B:C ratio) on quality of pomegranate. The experiment was conducted in Randomized Block design with cv. Phule Bhagwa Super which were replicated four times. The treatments given classified as T₁- Butter paper bag, T₂- Brown paper bag, T₃- Parchment bag, T₄- English newspaper bag (60 gsm) T₅- Marathi newspaper bag (35 gsm) T₆- Control (Without bagging). Fruits were bagged at 30 days after fruit set. While bagging the brown paper bags, Marathi and English newspaper bags, butter paper bags were stapled properly, so that it will not fall down as well as there will not be open space for entry of insects or rain etc.

Pre-harvest fruit bagging had a significant influence on all parameters studied. Significant differences were observed in physical, chemical, physiological parameters due to pre-harvest fruit bagging. Among the different bagging materials bagged in Parchment bag resulted in maximum fruit weight, fruit diameter, fruit length, marketable yield, aril percentage, minimum physiological loss in weight, maximum shelf life, minimum (nil) infestation of cracked and sunburn fruit percentage, and pest and disease incidence and maximum B:C ratio and in respect to chemical parameters control resulted maximum total sugars, reducing sugars, non-reducing sugars and Titratable acidity followed by Parchment bag.

Results indicated significant impact of pre-harvest fruit bagging on all parameters. When Fruits were bagged in Parchment bag *i.e.* T₃ the maximum fruit weight (316.44 g), fruit diameter (6.34 cm), fruit length (6.61 cm), marketable yield (25.68 kg/plant and 19.00 ton/ha) aril percentage (72.89 %) and in control condition maximum TSS (15.76 °Brix), total sugars (14.07 %), reducing sugars (11.89 %), non-reducing sugars (2.07 %) and titratable acidity (0.32 %) followed by parchment bag. Minimum physiological loss in weight (5.76, 12.23 and 18.03 %), at 3rd, 6th, 9th days after harvest, respectively. And maximum shelf life (24.71 days) in treatment T₃ *i.e.* Parchment bag. Minimum (nil) infestation of cracked and sunburn fruit percentage, pest and disease incidence were observed in the treatment T₃ *i.e.* Parchment bag. The maximum gross return and B:C ratio (3.64) was observed in T₃ *i.e.* Parchment bag.

The above investigation showed that significantly influence on physical, chemical and physiological parameters. Fruit bagging reduced cracking and sunburn fruit Percentage, pest and disease incidence in pomegranate cv. Phule Bhagwa Super with improving yield and market quality.

Key words: Pomegranate, Fruit bagging, Bhagwa, Newspaper etc.

1 to 61

1. INTRODUCTION

Pomegranate (*Punica granatum L.*) belongs to the Punicaceae family. It is native to Persia (Iran) and widely cultivated in the Mediterranean region (Holland *et al.*, 2009). Pomegranate is known to have been domesticated in the Middle East about 5000 years ago (Adsule *et al.*, 2005) and is highly suitable for growing under arid and semi-arid regions. In recent past, its significance in health, nutrition and livelihood security has been recognized which resulted in heavy demand for fruits not only in India but throughout the globe. The edible part called aril of the fruit is consumed fresh or processed in to jams, jellies, wine, and beverages (Aarabi *et al.*, 2008; Mousavinejad *et al.*, 2009 and Opara *et al.*, 2009). The processed product anardana is famous in North India.

Its versatile adaptability to soil and climatic conditions, hardy nature, less cost in orchard management, high yield potential, excellent keeping quality, fine table and therapeutical values have made this fruit more lucrative and remunerative. To highlight its importance, it was chosen as a symbol of the 18th International Horticultural Congress held during 1970, showing it in a basket.

In India, the area under pomegranate is 2,62,000 hectares with production of 30,34,000 MT. Maharashtra is leading producer of pomegranate with 148,000 hectares area and 17,89,000 MT production (Saxena, 2019). As India produces the finest edible quality of pomegranates, available almost throughout the year, there is tremendous potential for export.

In the country pomegranate is cultivated in the states of Maharashtra, Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh, Haryana and Uttar Pradesh. Maharashtra accounts for its maximum area (148,000 ha) and is grown particularly in Ahmednagar, Solapur, Satara, Sangali, Nasik, Dhule and Pune. It is commercially grown for its sweet-acidic fruits used for dessert purpose. Pomegranate is a very promising and emerging crop for its refreshing arils, juice and its chemo-preventive properties having medicinal value. There has been a remarkable increase in the commercial farming of the pomegranate globally due to the potential health benefits of the fruit such as its high antioxidant, anti-mutagenic, anti-hypertension activities and the ability to reduce liver injury. Pomegranate anthocyanins have been demonstrated scavenging activities. The pomegranate polyphenolic compounds are able to elevate the antioxidant capacity of the human body. The juice of pomegranates is one of the nature's most powerful antioxidants. Nutritional composition of the pomegranate per 100 g is 68 Kcal consumption energy, 0.95 g protein, 0.3 g total lipid, 17.17 g carbohydrate, 0.6 g

total dietary fibre, 16.57 g total sugar, 259 mg potassium, 8 mg phosphorus, 3 mg sodium and calcium and 6.1 mg ascorbic acid (Dhinesh and Ramaswamy, 2016).

Pomegranate has come as a boon for farmers in Maharashtra because of better remuneration and tremendous export potential even in European countries. Although fruits preferred by consumer for its soft red arils as they offer a burst of sweetish cream coloured juice, followed by the crunchiness of the tiny seed embedded in each aril, but external appearance i.e. rind colour is also equally important as it influences consumer acceptance and fruits for export, fruits must be free from scars, resetting, disease spots, insect injury, scratches, etc. Pomegranate suffers from many biotic stresses such as oily spot and abiotic stresses such as high temperature affecting its quality which results in significant economic losses to growers. Therefore adopting good agricultural practices (GAP) which are eco-friendly, cost effective are necessary to combat biotic and abiotic factors (Sharma, 2009) to maintain its quality.

Among these approaches, pre-harvest fruit bagging has emerged as an effective method. Bagging is a physical protection method which not only improves the visual quality of fruit by promoting skin colouration and reducing blemishes, but can also change the micro-environment for fruit development, which have several beneficial effects on physical properties as well as internal fruit quality (Sharma *et al.* 2014). There research reports that pre-harvest bagging of fruit can also reduce the incidence of disease, insect pest and/or mechanical damage, sunburn of the skin, fruit cracking, agrochemical residues on the fruit, and bird damage (Kitagawa *et al.*, 1992; Bayogan *et al.*, 2006; Asrey *et al.* 2019).

Due to several beneficial effects, fruit bagging has become an integral part of peach, apple, pear, grape, and loquat cultivation in Japan, Australia, China, USA, Mexico and Chile. However, the work on pomegranate in India is limited. There is need to study the effect of different types of bagging materials on fruit size, maturity, skin colour, fruit quality, pest and diseases incidence and standardize suitable bagging material with cost: benefit ratio in pomegranate. Hence, the present study entitled “Studies on Pre-Harvest Fruit Bagging of Pomegranate Fruit” on the cultivar Phule Super Bhagwa, a commercial variety of Maharashtra was undertaken with the following objectives-

1. To study the effect of different bagging material on post-harvest quality of fruit.
2. To study the effect of bagging on pest and disease infestation
3. To study the cost benefit ratio (B:C ratio)

2. REVIEW OF LITERATURE

The research investigation entitled “Studies on pre-harvest fruit bagging of pomegranate fruits” was executed during the year 2019-20. In pomegranate, pre-harvest bagging is effective instrument to improve quality of fruits and to prevent attack of fruit borer and bacterial disease (Bacterial blight) in pomegranate. Here efforts have made to review the research work on this aspect and research findings are discussed under the appropriate titles.

2.1 Effect of pre-harvest fruit bagging on physical parameters

Hussien *et al.* (1994) used paper for fruit bagging and reported improvement in physical fruit quality, in terms length, diameter, weight of fruit and size of pomegranate. Abd El-Rhman.(2010) reported that, the bagging pomegranate fruits gave higher weight compared with the control. Samra and Shalan (2013) increase fruit weight and yield (kg/ tree) of pomegranate was also reported due to different bagging treatment

Hegazi *et al.* (2014) attempted to improve quality of pomegranate cvs. Manfaloty and Wonderfull by imposing treatments constituted of control (sprayed with water only), fruit bagging, and spraying treatments with GA₃ at 50 ppm & 100 ppm, CaCl₂ at 2 and 4%; kaolin at 2.5% and 5.0 %. Bagging and spraying with GA₃, CaCl₂ and kaolin improved yield and fruit quality of both Manfaloty and Wonderfull pomegranate cultivars. However, the highest fruit length and diameter obtained by GA₃ 50 or 100 ppm and CaCl₂ 2 or 4% treatments and bagging. Spraying with GA₃ at 50 ppm and kaolin at 5% recorded maximum yield in both the cultivars.

Wang *et al.* (2003) studied the effect of bagging on weight of *Litchi chinensis* L. by using different colour bags to cover fruits and reported significant increased weight of fruit. Among all bags white bag was found to be the best bagging material. Purbey and Kumar (2015) evaluated four different type of bags namely plastic bag, brown paper / kraft paper bags, butter paper bags and muslin cloth bags to study their effect on fruit borer infestation management and quality improvement of litchi fruit cv. Shahi. Bagging of litchi fruit bunches was done at 40 and 50 days after anthesis. Results revealed that bagging with white butter paper bags 40 days after anthesis recorded highest fruit weight (25.12 g) and highest marketable fruits (90.77 %).

Debnath and Mithra (2008) studied the effect of panicle bagging in litchi and reported that both Brown Paper and Newspaper bags showed an increase fruit weight than control.

The highest fruit weight was observed in Newspaper bag (23.20 g) as compared to control (22.51 g).

Lei and Kun (2006) studied the effect of bag texture on micro environment and fruit development of tomatoes and reported that average fruit weight recorded was the highest in parchment bag. Wang *et al.* (2007) studied the effect of bagging on fruit quality in tomato and reported that bagging increased fruit weight. The highest fruit weight was recorded in parchment bag (213.74 g) as compared to control (185.32 g). Xu *et al.* (2008) studied the effect of bagging on fruit growth of carambola and reported that bagging with plastic bags increased average fruit weight.

Watanawan *et al.* (2008) reported bagging of fruit could increase the fruit weight compared to control in mango cv. 'Nam Dok Mai'. The highest fruit weight was observed in 2-layer paper bag (498.1g) followed by paper bag (490.1g) as compared to control (468.6 g).

Chonhenchob *et al.* (2011) covered mango fruits with different light transmittance bags (cv. Nam Dok Mai 4) at 45 days after full bloom (DAFB) and compared the Kraft paper bag with black paper liner and with non-bagging as a control. Fruits were randomly harvested at 65, 75, 85, 95, and 105 DAFB. Results revealed significant reduction in diseases and blemishes. Also observed increase in mango weight approximately 15% by VM and V plastic bagging, as compared to paper bagging and control at 95 DAFB. Plastic bagging accelerated mango ripening as well as growth. Plastic-bagged mangoes reached maturity stage at 95 DAFB, while non-bagged mangoes reached maturity stage at 105 DAFB. Paper bagging resulted in a pale-yellow peel beginning at 65 DAFB, while plastic bagging improved peel glossiness.

Dutta and Majumder (2012) noted in "Himsagar" mango grown in new alluvial zones of West Bengal that use of pre-harvest bagging at different stages of fruit development improved the appearance of fruit, fruit weight and size through other effects such as increased relative humidity and a consequently reduced fruit water loss.

Haldankar *et al.* (2015) studied the influence of bagging of fruits at marble stage (30 days from fruit set) on quality of mango cv. Alphonso using seven types of bags (newspaper bag, brown paper bag, skirting bag, polythene bag, butter paper bag, muslin cloth bag, brown paper bag with polythene coating) with control (no bagging). The pre-harvest bagging modified fruit retention, period required for harvesting after bagging, physico-chemical composition of mature and ripe fruit, shelf life, occurrence of spongy tissue and pest incidence. Bagging with newspaper bag and brown paper bag improved fruit retention,

weight of fruit, diameter of fruit. The brown paper bag with polythene coating improved fruit retention, weight of fruit, pulp weight and decreased occurrence of spongy tissue and incidence of mealy bag. The butter paper bag, muslin cloth bag and skirting bag improved fruit retention, reduced occurrence of spongy tissue and incidence of mealy bag.

Islam *et al.* (2017a) used four types of bags (brown paper bag, white paper bag, polythene bag and muslin cloth bag) with no bagging (control) and observed maximum fruit weight of 329.2 g in brown paper bag at 35 days after fruit set. Bagging with brown paper bag and white paper bag also improved fruit retention and diameter of fruit.

Islam *et al.* (2017 b) investigated the influence of fruit bagging on quality and shelf life of mango cv. Langra. Mango fruits were bagged at 35, 45 and 55 days after fruit set with different types of bags which constituted transparent polythene bag, white paper single layered bag and brown paper double layered bag with control (no bagging). Mango fruits bagged at 35 days after fruit set with white paper and brown paper bag recorded maximum fruit length (97.93 and 103.5 mm), fruit diameter (79.27 and 84.85 mm), fruit weight (311.66 g and 329.2 g), pulp weight (278.9 g and 289.8 g) respectively, and minimum result was found in polythene bag and control.

Hossain *et al.* (2020) studied the effects of pre-harvest fruit bagging on the postharvest quality and shelf life of mango cv. Amrapali using five types bagging materials viz., non-bag, control, brown paper, white paper, white polythene and black polythene bag and noticed significant influence on fresh weight, length and breadth of fruit. The maximum fruit fresh weight, length and breadth were found in black polythene bag (175.54g, 8.77 cm and 6.63 cm, respectively) followed by white paper bag (162.81g, 8.67 cm and 6.38 cm, respectively), white polythene bag (162.08 g, 8.55 cm, and 6.27 cm, respectively), brown paper bag (160.66 g, 8.40 cm and 6.29 cm, respectively) and the lowest fruit fresh weight, length and breadth were recorded in non- bagged control fruit (149.18g, 8.23 cm and 5.94 cm, respectively).

Akter *et al.* (2020) performed study on mango cv. Amrapali during by using mango fruits at marble stage (45 days after fruit set) with various treatments viz: Brown paper double-layered bag (BPB); White paper single-layered bag (WPB); Perforated polythene bag (PB), White cloth bag (WCB) and No bagging (control) for minimum use of pesticides. In physical parameters, brown and white paper bag recorded the maximum fruit weight (169.10 g and 147.6 g), fruit length (8.57 and 8.33 cm), fruit diameter (5.63 and 5.87 cm) and pulp

weight (124.47 g and 105.60 g) respectively, while minimum result was found in the other treatments and control.

Harshash and Al-Obeed (2010) noticed in date palm that blue coloured plastic bags recorded the highest fruit weight (10.40 g) and the longest fruit length (3.53cm) and it was followed by white cover. Kassem *et al.* (2011) also significant increase in fruit weight fruit length and diameter in date palm in polyethylene bagging treatment which was removed at later growth stage. Awad and Al-Qurashi (2012) reported in 'Barhee' date Palm cultivar, that bunch bagging increased bunch weight and fruit length as compared to control and also improved fruit weight and flesh weight.

Mostafa *et al.* (2014) performed a field study was on Seewy date palms to evaluate the effect of different bagging treatments on yield and fruit quality by subjecting bunches to seven bagging treatments, white, blue, black and green perforated polyethylene bags as well as sackcloth, gauze bags and unbagged (control). Bagging bunches was performed at pre-fruit colouring stage and remained covered until harvest date. The results show that bagging bunches significantly increased the bunch weight, accelerated ripening and improved fruit quality compared with the unbagged ones. Blue and black polyethylene bags increased fruit weight and flesh percentage compared to other treatments. Blue colour surpassed the other bagging treatments in these traits. The bagging with blue or black perforated polyethylene bags recorded the highest scores dealt with fruiting quality suggesting the use of blue or black perforated polyethylene bags for Seewy date plant bunches at pre-fruit colouring stage. Omar *et al.* (2014) in a field trial 11 years old 'Rothana' semi-dry date palm using bagging (paper kraft and grill cloth) reported that all the bagging treatments improved fruit quality with respect to fruit set, bunch weight, fresh fruit weight, yield and fruit flesh weight. However, the bagging treatment with grill cloth was most promising over paper kraft bag.

Zhao *et al.* (2011) in loquat demonstrated that the average fruit weight in the bagged fruits was lower than that in non-bagged fruits.

Tran *et al.* (2015) observed improvement in physical fruit quality, in terms of fruit length, diameter, weight and size of dragon fruit (*Hylocereus undatus*) with paper for fruit bagging

The effects of bagging date and bag type on fruit size, fruit quality and fruit drop of carambola were investigated by Xu *et al.* (2008) using three types of bags, plastic bag, self-made newspaper bag and non-woven cloth bag. Self-made newspaper bag and non-woven cloth bag were used 17 days after full bloom and bagging with plastic bags was carried out

10, 17, 24, and 31 days after full bloom respectively. The results showed that bagging with plastic bags increased average fruit weight, and it was the highest when bagging was carried out 10 days after full bloom. The effect of fruit bagging on fruit width and length varied with bagging dates. Increases in fruit width and length of earlier two times of bagging were larger than that of non-bagging. On the contrary, those of later two times of bagging were not affected or slightly smaller than that of non-bagging. On the other hand, fruits bagged with newspaper bag or non-woven cloth bag were slightly smaller than non-bagging fruits.

Yang *et al.* (2009) studied the effects of bagging on fruit development and quality in cross-winter off-season Longan (*Dimocarpus longan* Lour) cv. Chuliang) using three types of bags viz. perforated translucent plastic bag (TPB), white adhesive-bonded fabric bag (WAFB) with about 70% light transmittance, and black adhesive-bonded fabric bag (BAFB) with <10% light transmittance. Bagging treatments began at 34 days after anthesis and continued until harvest. The results showed that bagging modified the microenvironment for fruit development. Bagging with TPB was most effective in increasing humidity, and air moisture within TPB maintained above 90% from 2 weeks after bagging. Bagging with BAFB or WAFB increased humidity most of the time, and the effect was more prominent when the weather was very dry (RH<60%). All bag types tended to increase temperature and promoted fruit development, resulting in larger sized fruit. Bagging tended to promote early fruit drop but reduced late fruit drop, and the final fruit retention rate was not significantly affected by bagging. Their results suggested that WAFB increased fruit size and fruit retention rate while significantly reduced fruit cracking incidence and could be a promising practice for cross-winter long a production.

Meena *et al.* (2016) carried out an investigation on improvement of quality of guava cv. Lalit fruits through bagging by using various polyethylene covers with different colours i.e. silver, white, yellow, green, black and pink were included for the study and uncovered fruits were kept as control. It was also observed that fruit size, weight and pulp content increased due to fruit covering. Fruit was found maximum in size under yellow polythene followed by white polythene while, black polythene showed maximum pulp percentage followed by green polythene. Among the various fruit covering materials bagging with yellow coloured polythene was found to be the best for overall improvement of physico-chemical quality of winter season guava cv. Lalit under subtropical climate of central Uttar Pradesh.

However, Amarante *et al.* (2002) observed no significant difference in fruit weight of pear in bagged and non-bagged fruits. Hwang *et al.* (2004) also reported that fruit weight covering 'Ruby' grape fruit with black paper bag did not differ significantly. Harach and Wanichkul (2006) evaluated the influence of different bagging methods on the fruit quality of guava cv. Yen Song and stated that there was no significant difference in the fruit weight.

In banana also Muchui *et al.* (2010) observed that, polyethylene bunch covers did not influence bunch weight, finger diameter (grade) and finger length.

2.2. Effect of preharvest fruit bagging on aril percentage

Wassel *et al.* (2015) reported that fruit bagging significantly increased the total arils, red arils weight and percentage as compared to unbagged fruit in both seasons in pomegranate cv. Wonderful.

2.3 Effect of preharvest fruit bagging on biochemical parameters

The biochemical parameters namely Total soluble solids (TSS), titratable acidity, reducing, non-reducing and total sugars, colour contribute to the quality of fruits. Bagging with different materials is also found to influence these parameters.

Abou El-Wafa (2014) investigated the effect of bagging type on reducing pomegranate fruit disorders and improving fruit quality of pomegranate for two years. The bagging treatments were, brown paper bag, white paper bag, prgmen bag, agrail white bag, agrail red bag, agrail blue bag and plastic bag which were started at 21 days after fruit set. In general, decrease in TSS was in all the bagging treatments except prgmen bag as compared to control. Prgmen bag treatment recorded 16.0 and 15.0 °B during 2011 and 2012, respectively, whereas it was 15.0 and 16.0 °B in control during 2011 and 2012, respectively. Inconsistent trend was observed in case of acidity. During both the years lowest acidity was recorded in control (1.23 and 1.26 %), followed by prgmen bag treatment (1.25 and 1.27 %). Plastic bag and brown paper bag treatments recorded maximum acidity during both the years of study. Maximum ascorbic acid content was recorded in prgmen bag treatment (26.0 g /100 ml juice) followed by the control treatment (25.0 and 27.0 g /100 ml juice). Anthocyanin was maximum in control (0.30 and 0.31%) followed by prgmen bag treatment (0.29 and 0.28 %). Total sugars were maximum in the control treatment (10.45 and 11.60 %) followed by prgmen bag treatment (11.41 and 11.70 %).

In an attempt to improve quality of pomegranate cvs. Manfaloty and Wonderful using treatment namely control (sprayed with water only), fruit bagging, spraying of GA₃ at

50 ppm and 100 ppm, spraying of CaCl_2 at 2 and 4%; spraying of kaolin at 2.5% and 5.0 %, Hegazi et al. (2014) observed that GA_3 , kaolin and bagging treatments improved Soluble Solid Content (SSC), total acidity and SSC/acid ratio.

Asrey *et al.* (2019) investigated the effect of pre-harvest bagging and bag colour on physico-chemical, nutraceutical quality and consumer acceptability of pomegranate arils using three coloured bags (red, blue and white) single layer cellulosic bags along with control. Results revealed that total soluble solids and total sugars were maximum in control (unbagged) fruits.

Yang *et al.* (2009) studied the effects of bagging on fruit quality in cross-winter off-season Longan (*Dimocarpus longan* Lour) cv. Chuliang) using three types of bags viz. perforated translucent plastic bag (TPB), white adhesive-bonded fabric bag (WAFB) with about 70% light transmittance, and black adhesive-bonded fabric bag (BAFB) with <10% light transmittance. Bagging treatments began at 34 days after anthesis and continued until harvest. The results showed that bagging modified the microenvironment for fruit development. Bagging with TPB was most effective in increasing humidity, and air moisture within TPB maintained above 90% from 2weeks after bagging. Sugar content was not significantly affected by bagging but organic acids including vitamin C were considerably affected. Concentration of malic acid, the dominant organic acid in longan aril, was 605.6, 830.0, 1161.0 and 1428 mg/g FW in TPB, BAFB, WAFB and the control. vitamin C in the aril was significantly reduced by BAFB (108.4 mg/g FW), slightly increased by WAFB (183.9 mg/g FW) and significantly increased by TPB (264.5 mg/g FW) as compared with the control (174.7 mg/g FW).

Al Obeed and Harhash (2010) Carried out field study during two successive years (2007 &2008) on two date plum cultivars “Succary” and “Khalas” by bagging bunches with four coloured plastic bags namely white, blue. Black, yellow and control (unbagged) and reported that blue coloured plastic bags significantly increased TSS, reducing and non-reducing sugars during both the years.

Omar *et al.* (2014) conducted field trial 11 years old ‘Rothana’ semi-dry date palm to study the effect of bagging (paper kraft and grill cloth) on fruit quality. All the bagging treatments improved fruit quality with respect total and reducing sugars contents.

Awad and Al-Qurashi (2012) reported that bunch bagging and spray of GA_3 at 150 ppm increased vitamin C, TSS and acidity in date palm cv. ‘Barhee’.

Sarker *et al.* (2009) evaluated different bagging materials (black polybag, transparent polybag, brown paper bag) for the fruit quality and control of mango fruit fly in Langra and Khirshapat varieties of mango and reported in Langra and Kirshapat varieties of mango that brown paper bagged fruits showed comparable TSS (24.2-25.2%) when compared with control (24.6-25.9%).

The effect of polybagging of mango (*Mangifera indica* L.) fruits was evaluated at different stages of fruit development (35, 45, 55 and 65 days after fruit set) for two years was evaluated by Dutta and Majumder (2012). Fruits were harvested at different stages of maturity (75, 85 and 90 days after fruit set) and allowed to ripen at room temperature (34-36°C, RH 85-90%). Results revealed that the total soluble solids and sugar content were higher and titratable acid content was always less in unbagged fruit at all stages of fruit harvest and fruit ripening.

Devalla *et al.* (2014) studied the effect of bagging on growth and development of mango cv. Alphonso by objecting mango fruits to six types of bagging treatments (brown paper bag, newspaper bag, butter paper bag, plastic bag, muslin cloth bag, skirting bag) with control. Bags were applied at 60 days after fruit set. Results showed that the chemical parameters such as moisture content, acidity, TSS, reducing, non-reducing sugars and β carotene were not significantly varied due to bagging. Further the total sugars in fruits of muslin cloth and skirting bags were improved at ripe stage over control. The sensory quality in fruits of skirting and muslin cloth bags was improved over control.

Haldankar *et al.* (2015) seven types of bags (newspaper bag, brown paper bag, skirting bag, polythene bag, butter paper bag, muslin cloth bag, brown paper bag with polythene coating) along with control (no bagging) to study effect of bagging at marble stage (30 days from fruit set) on quality of mango cv. Alphonso using. They observed significant influence of fruit bagging on physico-chemical composition of mature and ripe fruit, shelf life, occurrence of spongy tissue and pest incidence. Increase in total soluble solids and reducing sugars at ripe stage with newspaper bag and brown paper bagging and the fruits produced were spongy tissue free. The brown paper bag with polythene coating improved fruit retention, weight of fruit, pulp weight and decreased occurrence of spongy tissue and incidence of mealy bag. The butter paper bag, muslin cloth bag and skirting bag improved fruit retention, reduced occurrence of spongy tissue and incidence of mealy bag. However, preharvest bagging with different types of bag did not change the sensory qualities of ripe fruits mango cv. Alphonso.

Islam, *et al.* (2017a) imposed various treatments *viz.*, brown paper bag; white paper bag; polythene bag muslin cloth bag and no bagging (control) to study the effect of pre-harvest bagging on fruit quality of mango cv. Mollika and observed that bagging with brown paper bag and white paper bag improved pulp weight, total soluble solids, ascorbic acid, per cent of citric acid, reducing sugars and β -carotene at harvest and ripe stage over control. Brown paper bag changed fruit colour.

Islam *et al.* (2017b) studied the effect of pre-harvest bagging on quality of mango cv. “Langra” by using various bagging treatments *viz.*, transparent polythene bag, white paper single layered bag, brown paper double layered bag and control (no bagging) which were initiated at 35 days after fruit set. Results revealed that fruit chemical parameter total sugars, reducing and non-reducing sugars, total soluble solids, ascorbic acid, pH and β -carotene were improved over control. Brown paper bag changed fruit colour.

Islam *et al.* (2019) reported that pre-harvest bagging enhanced quality of mango cv. Langra. Mango fruits were bagged at 35, 45 and 55 days after fruit set with different types of bagging treatments which constituted transparent polythene bag, white paper single layered bag, brown paper double layered bag and control (no bagging) and observed improvement in fruit chemical parameter of total sugar, reducing and non-reducing sugars, total soluble solids, ascorbic acid, pH and β -carotene over control. Maximum TSS was observed in brown paper bag treatment (18.7 °B) at 45 days, total sugars (14.82 %) in white paper bags at 45 days, non-reducing sugars (3.63%) in white paper bag at 45 days, ascorbic acid content (44.74) white paper bag at 55 days of bagging.

Hossain *et al.* (2020) evaluated five bagging materials *viz.*, non-bag (control), brown paper, white paper, white polythene and black polythene bag to study to their effect on postharvest quality and shelf life of mango cv. Amrapali and noticed significant variations were among the preharvest bagging materials in relation to physio-chemical quality attributes and shelf life of mango cv. Amrapali. The highest vitamin C content (29.72mg/100g) and TSS content (22.87 °Brix) was found in non-bagged control fruit, while the lowest vitamin C content (19.67 mg/100g) was in brown paper bag and TSS content (17.97 °Brix) was found in white polythene bagged fruits. The maximum reducing sugar content (10.68%) was recorded in white polythene bagged fruit while the minimum was found in white paper bagged fruit (8.99%). Highest non-reducing sugar (11.21%) was observed in non-bagged control fruits lowest in brown paper bagged fruit (10.15%). Total sugar content was maximum in non-bagged control fruits (21.13%) followed by white polythene bagged fruit (20.89%), black

polythene bagged fruits (20.24%), brown paper bagged fruit (19.32%), while the lower amount of total sugar (19.31%) was recorded in white paper bagged fruits. White paper bagged fruit contained the highest amount of titratable acidity (2.58%) and black polythene bagged fruit contained the lowest (1.78%).

Abbasi *et al.* (2014) using different materials (newspaper bags, perforated polyethylene bags, muslin cloth bags and netted cloth bags) studied their influence on quality of guava and recorded highest values for reducing sugars (3.45%), non-reducing sugars (3.03%) and total sugars (7.34%) were observed in fruit covered with perforated polyethylene bags.

Meena *et al.* (2016) carried out an investigation on improvement of quality of guava cv. Lalit fruits through bagging by using various polyethylene covers with different colours i.e. silver, white, yellow, green, black and pink were included for the study and uncovered fruits were kept for the control. In general, improvement in quality of guava fruits as compared to unbagging control. In terms of TSS, total sugars and TSS: acid ratio which were found maximum (14.25 °Brix, 11.14% and 30.07, respectively) under yellow polythene but, maximum vitamin C (171.14 mg 100 g⁻¹) content was recorded under white polythene.

Rahaman *et al.* (2018) carried out investigation effect of pre-harvest fruit bagging on post-harvest quality of guava cv. Swarupkathi using brown paper bag, white paper bag, white polythene bag, and black polythene bag as bagging material along with control treatment (uncovered fruits).

Hwang *et al.* (2004) covered 'Ruby' grapefruit (*Citrus paradisi* Macf.) with black paper bags in late May or early June (early bagging) or early July (late bagging), and observed that TSS in early bagging fruit in 1999 and 2000 seasons (8.3°Brix and 7.6°Brix) respectively, but differences were non-significant.

Wang *et al.* (2007) observed the effects of bagging on fruit characteristics and quality of tomato fruits through winter and witnessed bagging showed decreased TSS, sugars to acid ratio significantly in tomato.

Debnath and Mitra (2008) evaluated different types of bagging material for fruit borer management, commercial-maturity regulation and quality improvement of litchi fruit and observed significant improvement in colour development and TSS/acid ratio under cellophane paper bags, compared with the unbagged (control) fruits (24.10 vs. 8.20 mg anthocyanin /100 g of peel and TSS/acid ratio of 51.00 vs. 46.41).

Purbey and Kumar (2015) assessed effects of four different type of bags namely plastic bag, brown paper / kraft paper bags, butter paper bags and muslin cloth bags quality improvement in litchi fruit cv. Shahi. Bagging of litchi fruit bunches was done at 40 and 50 days after anthesis. Results revealed that maximum TSS of 19.25⁰B was observed in control at 50 days after anthesis followed by muslin cloth bags (18.90⁰B). Maximum acidity (4.35%) was recorded in butter paper bag at 40 days after anthesis, whereas maximum ascorbic acid content was registered in white butter paper bags (64.93 mg/100 g FW) 40 days after anthesis. However, Senanan *et al.* (2011) reported that fruit bagging material had no effect on TSS content of litchi cv. Hong Huay.

Shwet Prabha *et al.* (2018) carried out experiment on effect of fruit bagging on physico-chemical properties of pineapple cv. Mauritius with 5 treatments i.e. Jute bag, Paper bag, Transparent polythene bag, Black polythene and Control (No bagging). Their results showed that paper bag recorded maximum TSS (14.22⁰B), non-reducing sugars (5.81%), reducing sugars (2.89 %), total sugars (8.69 %) and lowest acidity (0.63 %) suggesting the good option for fruit bagging of pineapple cv. Mauritius for better fruit quality.

2.4 Effect of Pre-harvest fruit bagging on Physiological Parameters

Visalakshi *et al.* (2012) reported the maximum (9.54%) PLW in banana fruits packed with polyethylene bags of 400 gauges with 1.5 per cent ventilation and minimum (4.54 %) was recorded in polyethylene bags of 500 gauges without ventilation after 15 days of storage.

Aryama Deepti, Shashi Kala and Prem Prakas (2019) investigated the effect of different type of bunch protection material on postharvest quality of banana by covering banana bunches at finger curling stage with Blue HDPE, Silver HDPE, White LDPE, Non-woven bag along with the Control (uncovered). Among bagging the best results were obtained in non-woven bags followed by Blue HDPE bag. In non-woven the maximum fruit weight 124.89 g, pulp to peel ratio 4.41 and moisture content 71.52% were recorded and same time minimum weight loss 1.76 % was observed.

2.5 Effect of preharvest fruit bagging on Shelf life of fruits (days)

Islam *et al.* (2017a) studied the influence of pre-harvest bagging (Brown paper bag, White paper bag and muslin cloth bag) on fruit quality and shelf life of mango cv. Mollika and observed increased shelf-life in all the bagging treatments over control. Maximum shelf was recorded in White paper bag (18 days) followed by brown paper bag (17 days) and Muslin cloth bag (16 days) as compared to control (15 days).

Islam *et al.* (2019) studied the effect of different types of bagging material Transparent polythene bag, White paper single layered bag, Brown paper double layered bag along with T₄ control (no bagging) on quality and shelf life of mango cv. Langra. Mango fruits were bagged at 35, 45 and 55 days after fruit set. Results obtained showed that fruits treated with brown paper bag showed shelf life upto 11 days with lowest weight loss and good physical quality as against 6 days of unbagged fruits (control).

Asrey *et al.* (2019) investigate the effect of preharvest bagging and bag colour on fruit cracking in pomegranate cv. Kandhari by covering fruits with three coloured single layer cellulosic bags 60 days after flowering. They reported that red coloured cellulosic minimized fruit cracking (66%) over control.

Hossain *et al.* (2020) studied the effect of preharvest fruit bagging on postharvest on shelf life of mango cv. Amrapali imposing the treatments namely control (non-bag), brown paper, white paper,) white polythene and black polythene bag and observed significant difference in the shelf life of bagged and non-bagged fruits. The longest shelf life (15 days) was found in brown paper bagged whereas the shortest shelf life (8 days) was in non-bagged control fruits.

Akter *et al.* (2020) studied the effect of various bagging treatments *viz*: Brown paper double-layered bag (BPB); White paper single-layered bag (WPB); Perforated polythene bag (PB), White cloth bag (WCB) and No bagging (control) and observed that fruits with brown paper bags had shelf life up to 18 days with good physical quality and the lowest loss in fruit weight against 15 days in control (non-bagged) fruits.

2.6 Effect of preharvest fruit bagging on cracked and sunburn fruit percentage

Abou El-Wafa (2014) studied the effect of bagging type on reducing pomegranate fruit disorders with brown paper bag, white paper bag, prgmen bag, agrail white bag, agrail red bag, agrail blue bag and plastic bag which were started at 21 days after fruit set. They reported that percentage of fruit cracking and sunburnt fruits very less in the prgmen bag treatment and it were 1.0 % and 2.0 %, respectively during both the years.

Hegazi *et al.* (2014) attempted to improve quality of pomegranate cvs. Manfaloty and Wonderfull by imposing treatments constituting, control (sprayed with water only), fruit bagging, spraying of GA₃ at 50 ppm & 100 ppm, spraying of CaCl₂ at 2 and 4%; spraying of kaolin at 2.5% and 5.0 %. Spraying with Kaolin 5% and spraying by CaCl₂ and GA₃ treatments with bagging treatment recorded lowest percentage of fruit creaking and sunburn compared with the control treatment.

Asrey *et al.* (2019) investigated the effect of preharvest bagging and bag colour on fruit cracking and bacterial blight incidence in pomegranate cv. Kandhari by covering fruits with three colored single layer cellulosic bags 60 days after flowering. They reported that red coloured cellulosic bags were found to be much effective in producing quality fruits which also minimized fruit cracking (66%) and bacterial blight incidence (78%) over control.

Sarkomi *et al.* (2019) evaluated the effects of preharvest fruit bagging time (July and August), and bag color (white and brown) on sunburn, cracking, anthocyanin content, and quality of pomegranate fruit and observed that maximum (90%) and minimum (25%) sunburn percentage was observed in control (non-bagged fruits) and white-bagged fruits at August (WBA), respectively. Similarly, the highest percentage of cracking (65%) and the lowest (5%) was obtained in control and white bags in August, respectively. Interestingly, bagging in both white and brown bag effectively reduced fruit sunburn and cracking and decreased the total damaged fruits, particularly when fruits were bagged in August, as compared with non-bagged control.

Karar *et al.* (2019) evaluated effects of bagging on insect-pests complex, sun burn and fruit cracking, yield and quality of mango fruits cv. Anwar Rataul. Fruits were bagged during 1st week of May (at stone size stage) to 1st week of July 2017 (at maturity stage). They observed that bagged fruits suggesting the effectiveness of fruits had no cracks, sunburn, mechanical injury, bird damage, skin blemishes and agrochemical residue suggesting the effectiveness of fruit bagging practice for quality production of blemish less and quality mango fruits for export purposes.

Yang *et al.* (2009) studied the effects of bagging on fruit quality in cross-winter off-season Longan (*Dimocarpus longan* Lour) cv. Chuliang) using three types of bags viz. perforated translucent plastic bag (TPB), white adhesive-bonded fabric bag (WAFB) with about 70% light transmittance, and black adhesive-bonded fabric bag (BAFB) with <10% light transmittance. Bagging treatments began at 34 days after anthesis and continued until harvest. The results showed that bagging modified the microenvironment for fruit development. Bagging with TPB was most effective in increasing humidity, and air moisture within TPB maintained above 90% from 2 weeks after bagging. Bagging with different materials showed differential effects on incidence of fruit cracking. WAFB and BAFB reduced cracking incidence significantly as compared to the control (5.1% and 11.6%, 32.8%).

Purbey and Kumar (2015) assessed effects of four different type of bags namely plastic bag, brown paper / kraft paper bags, butter paper bags and muslin cloth bags quality improvement in litchi fruit cv. Shahi. Bagging of litchi fruit bunches was done at 40 and 50 days after anthesis. Results showed that at 40 days after bagging, fruits bagged with white butter paper bag recorded very less percentage of cracked fruits (1.85 %) followed by brown paper / kraft paper bags (2,2 %) as compared to control (20.27 %), whereas, at 50 days after bagging, less percentage of cracked fruits was observed in butter paper bags (2.59 %) followed by white butter paper bag (3.33 %) as against 21.48 % in control.

2.7.Effect of preharvest fruit bagging on disease and pest incidence

Asrey *et al.* (2019) studied the effect of preharvest bagging and bag colour on bacterial blight incidence in pomegranate cv. Kandhari. The pomegranate fruits were covered three coloured single layer cellulosic bags 60 days after flowering. Their results showed the effectiveness of red coloured cellulosic bags which minimized bacterial blight incidence (78%) over control.

Sarker *et al.* (2009) evaluated different bagging materials (black polybag, transparent polybag, brown paper bag) for the fruit quality and control of mango fruit fly in Langra and Khirshapat varieties of mango and reported that all bagging materials gave 100% protection of mango fruits against the fruit fly infestation in both the varieties of mango. However, bagging of fruits with brown paper bag was found to be the best in protecting both varieties of mango.

Effect of pre-harvest bagging of mango fruits was evaluated by Dutta and Majumder (2012) at different stages of fruit development (35, 45, 55 and 65 days after fruit set). The pre-harvest bagging delayed the ripening and thus increased the shelf life. Also, anthracnose and stem end rot (SER) caused by *Colletotrichum* and *Diplodia* spp., respectively were reduced by bagging in both years through are duction in contact between disease propagules and fruits indicating that bagging can improve fruit quality by reducing disease.

Mingire, *et al.* (2017) studied the effect of pre-bagging using nine different types of bags namely, news paper bag, brown paper bag, transparent PP bag, butter paper bag, muslin cloth bag, brown paper bag with polythene coating, black polythene bag,, opaque polythene bag, scurting bag and control (no bagging). The per cent spotted fruits; incidence of diseases and peats was significantly reduced by pre-harvest bagging. The news paper bag, scurting bag and muslin cloth bag were found to be meritorious. The news paper bag, scurting bag

and muslin cloth bag recorded 10.0 13.33 16.67 % spotted fruits, respectively, whereas percentage of stem end rot, anthracnose mealy bug, fruit fly was zero per cent.

Bahadure (2018) investigated the effect of impregnated bags on quality of mango cv. Mallika. The treatments were Methoxam treated bag, Decis bag, Potassium metabisulphite treated bag, Methoxam + Decis treated, Potassium metabisulphite + Decis treated bag, Untreated bag and Control (no bagging). The result showed that no incidence of pest (fruit fly, stone weevil, mealy bug and spotted fruit) all the impregnated bag. However, highest percentage of incidence of pest at harvest and also spotted fruits was noticed in Untreated bag and Control.

Islam *et al.* (2019) studied the influence of pre-harvest bagging (Brown paper bag, White paper bag and muslin cloth bag) on fruit quality and mealy bug incidence on mango cv. Mollika at ripening stage and observed the superiority of all the bagging treatments over control. Incidence of mealy bug was zero in all the bagging treatments and it was 25.00 per cent in the control.

Karar *et al.* (2019) performed experiment to evaluate bagging effects on insect-pests complex, yield and quality of mango fruits cv. Anwar Rataul. Fruits were bagged during 1st week of May (at stone size stage) to 1st week of July 2017 (at maturity stage). The results indicated that the attack of fruit flies and other insect-pests complex were zero in bagged fruits suggesting that fruit bagging on mango cv. Anwar Rataul trees at stone size stage proved to be an effective practice against insect-pests complex and for production quality mango fruits.

Shinde *et al.* (2015) studied effect of pre-harvest bagging with different type of bags on physico-chemical properties of mango cv. Kesar using six types of bags namely Newspaper bag, Brown paper bag, Polythene bag, Butter paper bag, Muslin cloth bag, Scurting bag and Control (no bagging) and noted that there significant reduction in disease incidence and pests in preharvest bagged fruits.

Buganic *et al.* (1997) studied the effect of wrapping mango fruits with brown paper or newsprint two months after flower induction and observed that 70 per cent mango fruits were exportable as compared to 50 percent in control *i.e.* without bagging and rejection in unbagged fruits was due to insect damage (30%), scab (23%) and deformities (14%).

Akter *et al.* (2020) while studying the effect of various bagging treatments namely Brown paper double-layered bag (BPB); White paper single-layered bag (WPB); Perforated

polythene bag (PB), White cloth bag (WCB) and no bagging (control) reported that there was no incidence of mealy bug as against the control (25.0 %) in mango.

Purbey and Kumar (2015) assessed effects of four different type of bags namely plastic bag, brown paper/kraft paper bags, butter paper bags and muslin cloth bags quality improvement in litchi fruit cv. Shahi. Bagging of litchi fruit bunches was done at 40 and 50 days after anthesis. Results showed that at 40 and 50 days after bagging, fruit borer infested fruits were least in fruits bagged with white butter paper bag (6.12%) and paper bag (8.8 %) followed by white butter paper bag (9.36 %), respectively as compared to control (21.30 and 20.73% 40 and 50 days after bagging, respectively). Brown/black paper spotted fruit percentage was less in white butter paper bagged fruits (3.43 %) as against control (18.50 %) at 40 days after bagging, whereas at 50 days after bagging the least percentage (3.71 %) was observed in butter paper bagged fruits followed by white butter paper bagged fruits (4.21 %) as compared to control (19.08 %).

Amarante *et al.* (2002) examined in pear cv. Doyenne du Comice that pre-harvest bagging increased the percentage of fruit accepted for export from 27.2 to 63.2% mainly due to reduction in bird damage (28.4%), skin blemish (49.5%), cheek russet (2.3%) and tracery russet (0.5%) in control, whereas unbagged fruits were rejected for export (36.8%) as a result of skin blemish (33.4%) and cheek russet (3.4%).

Debnath and Mithra (2008) noticed the effect of panicle bagging on fruit borer management in litchi and reported that bagging served as physical barrier and successfully protected the fruits against borer infestation.

Abbasi *et al.* (2014) used different materials (newspaper bags, perforated polyethylene bags, muslin cloth bags and netted cloth bags) for on-tree bagging of guava fruit to improve fruit quality and observed that least infestation was perforated polyethylene bags (3.93) as against 96 % in control.

Mondal *et al.* (2015) studied the performance of performance of nine different types of wrapping materials (butter paper bag, polypropylene bag of 20 μ gauge with and without paper piece inside, non-woven poly fabric bags of white, green and blue colour with 20 gsm and 40 gsm thickness) along with two chemical approaches against untreated control. Their results showed that fruit fly infestation varied between 1.32 % and 17.31% in all treatments using wrapping materials and 13.14% in case of combined use of pheromone trap (Bacu lure) and Dichlorvos spray as compared to 21.71% in sole use of Dichlorvos and 66.67% in control plots.

Karajeh (2018) reported that grape clusters bagged with or without pesticide treatment, using brown paper bag significantly reduced grape berry moth infestation to 1.8 and 2.3%, black mould to 0.6 to and 2%, grey mould to 2.2 and 1.1 % and powdery mildew to 0.0 and 5.4% respectively compared to non-bagged control where 95.2% clusters were damage by insect larvae, 93 % rotten by secondary infection of black mould, 26.1 % by gray mould, 63.1 % damaged by powdery mildew, and 15.2 % attacked by birds.

3. MATERIALS AND METHODS

3.1 Experimental Site

The field experiment was conducted on five years old orchard of the pomegranate cultivar Phule Bhagwa Super spaced at 4.5 m x 3 m at Pomegranate Research and Technology Transfer Centre (PR&TTC), Lakhmapur Tal. Satana, Dist. Nashik in year 2018-19. The experiment was conducted on *Hast bahar*. The materials used and methods adopted are discussed in this chapter.

3.2 Experimental details

1	Experimental design	:	Randomised Block Design (RBD)
2	Number of treatments	:	06 (Six)
3	Number of replications	:	04 (Four)
4	Plant unit per treatment	:	01 (One)
5	Number of fruits bagged	:	25 (Twenty five)
6	Size of bag	:	25 x 20 cm
7	Stage of bagging	:	30 Days after fruit set

3.3 Treatment details

T ₁	:	Butter paper bag
T ₂	:	Brown paper bag
T ₃	:	Parchment bag
T ₄	:	English newspaper bag(60 gsm)
T ₅	:	Marathi newspaper bag(35 gsm)
T ₆	:	Control (Without bagging)

Perforations were made on all bags at the bottom of bag (4mm) for proper ventilation required for fruit development. Fruits at 30 days after fruit set were selected for bagging. After covering the fruit with bag (brown paper bags, Marathi and English newspaper bags) were stapled properly so that it will remain in the position and will not fall down. Further there will be no open space for entry of insects or rain etc. Five fruits were randomly selected per treatment per replication to record various physical parameters and chemical compositions were estimated by the procedures as given below.

3.4 Observations recorded

3.4.1. Fruit physical parameters

3.4.1.1 Fruit diameter (cm)

The diameter of fruit was measured with the help of digital vernier calliper and was expressed in cm.

3.4.1.3 Fruit length (cm)

The length of fruit from stalk end to stylar end was measured in cm with the help of a digital vernier calliper and was expressed in cm.

3.4.1.3 Fruit weight (g)

Fivefruits from each observational plant were selected randomly and their weight was recorded on electronic weighing balance and was summed and averaged out.

3.4.2. Aril Percentage (%)

Fruits were carefully opened to avoid damaging arils. The arils were separated from pericarp/membrane fractions, total aril weight per fruit was obtained. The aril percentage is calculated by using following formula (Wetzstein, *et al.*,2011)

$$\text{Aril percentage (\%)} = \frac{\text{Weight of aril}}{\text{Weight of fruit}} \times 100$$

3.4.3. Chemical parameters

3.4.3.1 Total soluble solids (⁰B)

The total soluble solids were recorded with the help of Erma Hand Refractometer (0-32°Brix) at room temperature and expressed in terms of ⁰Brix.

3.4.3.2 Total sugars (%)

The total sugars were estimated by titration against standard Fehling's mixture (Fehling A and B) using methylene blue as an indicator to brick red end point. (Ranganna, 1986) and was worked out with the following formula. It was expressed in per cent total sugars.

$$\text{Total sugars (\%)} = \frac{\text{Fehling Factor} \times \text{volume made}}{\text{Burette reading} \times \text{weight of sample}} \times 100$$

3.4.3.3 Reducing sugars (%)

The reducing sugars were estimated by the procedure suggested by Ranganna (1986) and was worked out with following formula. It was expressed in per cent reducing sugars.

$$\text{Reducing sugars (\%)} = \frac{100 \times 0.05 (\text{glucose value}) \times 250}{\text{Burette reading} \times \text{Weight of sample}}$$

3.4.3.4. Non-reducing sugars (%)

Non-reducing sugar content was determined by subtracting the reducing sugar content from total sugar content. Non-reducing sugar content was determined by using the following formula and was expressed in per cent total sugars.

$$\% \text{ Non-reducing sugar} = (\% \text{ Total sugar} - \% \text{ Reducing sugar}) \times 0.95$$

3.4.3.5 Titratable acidity (%)

It was estimated as per the method suggested by Ranganna (1986) and was expressed by using following formula. The acidity was expressed in percent of citric acid.

$$\text{Titrate (B.R.)} \times \text{Normality of NaOH} \times \text{meq. wt. of acid} \times 100$$

$$\text{Titrateable acidity (\%)} = \frac{\text{Volume of the sample used}}$$

3.4.4 Physiological parameters

3.4.4.1 Physiological loss in weight (%)

The weight of fruit was recorded at three days interval up to end of shelf life. PLW was calculated by using following formula (Shankar *et al.* 2009) and it was expressed in per cent.

$$\text{PLW (\%)} = \frac{\text{Initial weight fruit (g)} - \text{Final weight of fruit (g)}}{\text{Initial weight of fruit (g)}} \times 100$$

3.4.4.2 Shelf life (days)

The shelf life of fruits was determined by recording the number of days the fruits remained in good condition during storage. When the spoilage of fruits exceeds 50 per cent it was considered as the end of shelf life or storage life and Shelf life of pomegranate was expressed in terms of days.

3.4.5. Cracked fruit percentage

The total numbers of cracked and uncracked fruits per plant were counted and fruit cracking was calculated on percent basis (Singh *et al.*, 2014).

$$\text{Fruit cracking \%} = \frac{\text{No of cracked fruits per plant}}{\text{Total no of fruits per plant}} \times 100$$

3.4.6. Sunburn fruit percentage

The total numbers of sun burnt and normal fruits per plant were counted and sun burnt fruit percentage was calculated on percent basis (Abdel *et al.* 2017).

$$\text{Sunburn fruit \%} = \frac{\text{No of sunburn fruits per plant}}{\text{Total no of fruits per plant}} \times 100$$

3.4.7. Pest incidence (%)

The incidence of fruit borer or anar butterfly on pomegranate fruits was made by counting the number of infected fruits at maturity stage. Thus the percentage of pest incidence was calculated as below.

$$\text{Incidence of pest (\%)} = \frac{\text{Number of infected fruits in each replication}}{\text{Total number of fruits in each replication}} \times 100$$

3.4.8 Diseases incidence(%)

The diseased fruits were identified symptomatically and incidence disease was measured by counting the number of infected fruits at maturity stage. The percentage disease incidence was calculated as follows-

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected fruits in each replication}}{\text{Total number of fruits in each replication}} \times 100$$

3.4.9. Economics of fruit bagging

Economics of different fruit bagging materials is determined by BCR *i.e.* benefit cost ratios detailed below-

3.4.9.1 Cost of bags (Rs/ha)

Requirement of number of bags was considered for one hectare area and accordingly the cost of bags one hectare was worked out.

3.4.9.2. Cost of cultivation

The cost of cultivation of each treatment was worked out by considering the quantity of inputs required and the prevailing prices of variable inputs required. The cost of cultivation was worked out by following recommended procedure for one hectare area.

3.4.9.3. Gross monetary returns (Rs/ha)

The gross monetary returns received from the produce of each treatment were recorded by considering the average selling price of fruits.

3.4.9.4. Net monetary returns (Rs/ha)

The net monetary returns of each treatment were worked out by subtracting the cost of cultivation of each treatment from the gross monetary returns gained from the respective treatment.

Net monetary returns (Rs/ha) = Gross monetary returns – Cost of cultivation

3.4.9.5. Benefit: Cost ratio

The benefit: cost ratio of each treatment was calculated by dividing the gross monetary returns by cost of cultivation of the respective treatment.

3.4.10. Statistical analysis

The data generated for each parameter was subjected to statistical analysis as per the standard procedures suggested by Panse and Sukhatme (1995). The significance of the treatments was determined by developing analysis of variance (ANOVA) and the means were compared by calculating critical difference (CD) at < 0.05 per cent.

4. RESULT AND DISCUSSION

The results of present research entitled “Studies on pre-harvest fruit bagging on pomegranate fruit” was conducted at Research cum Demonstration Farm of Pomegranate Research and Technology Transfer Center, Lakhmapur, Tal. Satana, Dist. Nashik during the year 2019-2020. The study was conducted in Randomized Block Design with six treatments replicated four times. The results obtained are presented and discussed in this chapter appropriate headings.

4.1 Physical characters of fruit.

4.1.1. Fruit length (cm)

The data in respect of average fruit length has been presented in Table 1 and graphically in Fig.1. Pre-harvest bagging with different types of bag did not influence fruit length. However, numerically, the maximum fruit length of 6.51 cm was recorded in Parchment bag (T₃). The lowest fruit length was registered in control (T₆) which was 5.96 cm. The results are in conformity with the findings of Samra and shalan (2013), Hegazi *et al.* (2014) and Saad *et al.* (2017) on “Wonderful” pomegranate trees; Abd El-Rhman (2010); Senanan *et al.* (2011) in litchi; Mostafa *et al.* (2014) on “Seewy” date palm; Harhash and Al – Obeed (2010) and Awad and Al-Qurashi (2012) in date Palm; Meena *et al.* (2016) in guava, Islam *et al.* (2017a) in mango.

4.1.2. Fruit diameter (cm)

The data pertaining to effect of different bagging material on the average fruit diameter is presented in Table 1 and graphically in Fig. 2. Data revealed that bagging did not influenced fruit diameter. However, numerically maximum fruit diameter of 6.34 cm was recorded in Parchment bag (T₃), whereas minimum fruit diameter of 5.72 cm was recorded in control (T₆). These results are in agreement with those reported by Abd El-Rhman (2010) in pomegranate; Samra and Shalan (2013); Saad *et al.* (2017) and Hegazi *et al.* (2014) on “Wonderful” pomegranate; Harhash and Al-Obeed (2010) on date palm and Mostafa *et al.* (2014) on “Seewy” date palm; Harach and Wanichkul. (2006); and Mishra *et al.* (2017) in guava; Mathooko *et al.* (2011) in mango; Senanan *et al.* (2011) and Tyas, *et al.*(1998) in litchi.

Development of favourable microclimate around fruit would have increased fruit size (fruit length and diameter).

4.1.3. Fruit weight (g)

The data regarding fruit weight (g) has been shown in Table 1 and graphically in Fig. 3. Irrespective of the bagging material, there was increase fruit weight. Significantly, the highest fruit weight was observed in treatment Parchment bag (T₃) which recorded 316.44 g fruit weight followed by Butter paper bag (T₁). The lowest fruit weight was observed in control (T₆) and it was 260.68 g. Results are in agreement with Hussien *et al.* (1994); Abd El-Rhman (2010); Samra and Shalan (2013) in pomegranate

Similar results were also reported by Wang *et al.* (2007) in Tomato; Debnath and Mithra. (2008); Harshash and Al-Obeed (2010) in date palm; Haldankar *et al.* (2015) in mango; Islam *et al.* (2019) in mango; Purbey and Kumar (2015) in litchi and Hossain *et al.* (2020) in mango and Jat (2019) in guava.

The increase weight might be due to increase in fruit length and fruit diameter; and also enhanced fruit development as reported by Yang *et al.* (2009) in Longon. Bagging Improved microclimate around the fruit due to bagging would have helped in the improvement of fruit weight (Kireeti *et al.*, 2016). Bagging can affect fruit size through effects such as increased relative humidity and therefore reduced fruit water loss (Tombesi *et al.*,1993).

Table 1: Effect of types of bag on fruit length (cm), fruit diameter (cm) and fruit weight (g), in pomegranate cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Fruit length (cm)	Fruit diameter cm)	Fruit weight (g)
T ₁	Butter paper bag	6.46	6.28	307.47
T ₂	Brown paper bag	6.35	6.15	292.25
T ₃	Parchment bag	6.51	6.34	316.44
T ₄	English newspaper bag	6.43	6.25	305.42
T ₅	Marathi newspaper bag	6.26	5.93	266.45
T ₆	Control (without bag)	5.96	5.72	260.68
	S. E. ±	0.2114	0.1628	2.02
	C. D. 0.5%	N.S	N. S	6.10

4.1.4. Yield (kg plant⁻¹ and ton ha⁻¹)

As evident from the data on yield (kg plant⁻¹ and t ha⁻¹) presented in Table 2 and graphically in Fig. 4 & 5, yield increased in all bagging treatments over the control. The treatment Parchment bag (T₃) recorded the highest yield of 25.68 kg plant⁻¹ and 19.00-ton ha⁻¹ respectively. But in case of yield ton/ha⁻¹, the treatment it was at par with treatment T₁ (Butter paper bag), T₄ (English newspaper bag), T₂ (Brown paper bag) and T₅ (Marathi newspaper bag) were on par with each other and T₃ which recorded 17.98, 17.73, 17.31 and 17.11 yield (t ha⁻¹). The results are in close agreement with Abou El-Wafa (2014) in pomegranate and Abdel Gawad Nehad *et al.* (2017) in mango.

Increase in yield (kg plant⁻¹ and t ha⁻¹) of pomegranate is due to increase in the fruit size and fruit weight.

Table 2 : Effect of types of bag on Marketable yield of pomegranate cv. Phule Bhagwa Super at harvest.

Treatment	Treatment details	Marketable yield	
		Kg plant ⁻¹	t. ha ⁻¹
T ₁	Butter paper bag	24.30	17.98
T ₂	Brown paper bag	23.39	17.31
T ₃	Parchment bag	25.68	19.00
T ₄	English newspaper bag	23.96	17.73
T ₅	Marathi newspaper bag	23.13	17.11
T ₆	Control (without bag)	18.65	13.80
	S. E. ±	0.9218	0.6835
	C. D. 0.5%	2.7788	2.0601

4.2. Aril percentage

The data regarding aril percentage has been presented in Table 3 and graphically in Fig. 6. Pre-harvest fruit bagging with different types of bag significantly influenced Aril percentage. Maximum aril percentage was observed in the treatment Parchment bag (T₃) recording 72.89 aril percentage. The treatments T₁ (Butter paper bag) and T₄ (English newspaper bag) was on par with the treatment T₃ (Parchment bag). These treatments recorded 71.71 and 68.30 per cent aril, respectively. Lowest aril percentage was observed in T₆ (control) which 58.87 per cent. Wassel *et al.* (2015) also reported significant increase in total arils and red arils weight and percentage in pomegranate due to fruit bagging.

Salama *et al.* (2016) also reported significant increase in total arils and red arils weight and percentage as compared to unbagged pomegranate fruits.

The increase in aril weight and aril per cent might be due to increased cell size and intercellular spaces coupled with accumulation of water, sugars and other soluble solids in greater amount as a result of translocation of metabolites towards the fruits.

Table 3 : Effect of types of bag on Aril percentage (%) of pomegranate cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Aril percentage (%)
T ₁	Butter paper bag	71.71
T ₂	Brown paper bag	67.76
T ₃	Parchment bag	72.89
T ₄	English newspaper bag	68.30
T ₅	Marathi newspaper bag	66.80
T ₆	Control (without bag)	58.87
	S. E ±	2.1026
	C. D. 0.5%	6.3379

4.3 Quality characters

The parameters which determine the quality of pomegranate fruit are TSS, titratable acidity, total sugars, reducing sugars, non-reducing sugars. The data obtained on these parameters are presented in Tables from 4 to 8.

4.3.1. Total Soluble Solids (°Brix)

It appeared from data that (Table 4 and Fig. 7) all the bagging treatments exhibited low TSS as compared to control (T₆) which recorded maximum TSS and it was 15.76 °B. The bagging treatments T₃ (Parchment bag), T₁ (Butter paper bag) and T₄ (English newspaper bag) which recorded 15.48, 15.35 and 15.12 °B TSS were on par with control (T₆). The bagging treatment T₅ (Marathi newspaper bag) recorded the lowest TSS (14.05° B). Similar increase in TSS content of pomegranate fruits by bagging was reported by Abd El-Rhman (2010), Hegazi *et al.*(2014), Abou El-Wafa (2014); Asrey *et al.* (2019) in pomegranate; Zhou *et al.* (2012) in *Canarium album*; Pubey and Kumar (2015) in Litchi and Hossain *et al.*(2020) in mango.

Direct exposure fruits to sunlight in control (unbagged fruits) would have resulted highest TSS. Zha *et al.* (2019) in grapes revealed that soluble sugar contents were lower in bagged grape bunches than those in un-bagged fruits, but rapidly restored to normal levels after removing bags suggesting that light affects the accumulation of sugar in grape berries

Table 4: Effect of types of bag on total soluble solids (°Brix) of pomegranate cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Total Soluble Solids (°B)
T ₁	Butter paper bag	15.35
T ₂	Brown paper bag	15.05
T ₃	Parchment bag	15.48
T ₄	English newspaper bag	15.12
T ₅	Marathi newspaper bag	14.05
T ₆	Control (without bag)	15.76
	S. E. ±	0.2268
	C. D. 0.5%	0.6838

4.3.2 Titratable Acidity (%)

As revealed from the Table 5 and Fig. 8, in general there was increase in titratable acidity, except the treatment T₃ when compared with the control (T₆). The lowest acidity was observed in T₆ (control). The treatments T₃ (0.32 %), T₁ (0.33%) and T₄ (0.34%) were on par with T₆. The highest percentage of acidity was recorded in T₅ (Marathi newspaper) which recorded 0.38 % acidity. Devalla *et al.* (2016) recorded highest percentage of acidity at harvest in mango fruits bagged with marathi newspaper and lowest in the control, the highest acidity (%) was observed in the treatment T₁ *i.e.* butter paper bag whereas the lowest was recorded in the treatment T₆ *i.e.* control.

Similar results were reported by Islam *et al.* (2017 b) who observed increase in acidity in mango at ripen stage in white paper and brown paper bag as compared to control (no bagging). The guava fruit which developed in newspaper bags and harvested during mature green and green yellow stage had significantly higher values of acidity in comparison to un-bagged (control) fruits (Abbasi *et al.*, 2014).

Table 5 : Effect of types of bag on Titratable acidity (%) of pomegranate cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Titratable acidity (%)
T ₁	Butter paper bag	0.33
T ₂	Brown paper bag	0.35
T ₃	Parchment bag	0.32
T ₄	English newspaper bag	0.34
T ₅	Marathi newspaper bag	0.38
T ₆	Control (without bag)	0.32
	S. E. \pm	0.014
	C. D. 0.5%	0.042

4.3.3 Total sugar content (%)

As observed from the Table 6 and Fig 9, there was decrease in total sugar content as compared to control (T₆). The control treatment (T₆) recorded the highest total sugars 14.07 %. However, the treatments T₃ (Parchment bag) (13.91%) and T₁ (Butter paper bag) (13.69 %) were at par with T₆ (control). Lowest total sugar content was recorded in the treatment T₅ (Marathi newspaper bag) and it was 13.19 %. Results are in accordance with Asrey *et al.* (2019) who reported decrease in total sugar content as compared to control in pomegranate and found maximum total sugar content in white paper bag. Devalla *et al.* (2016) reported decrease in total sugar content as compared to control in mango cv. Alphonso and found maximum total sugar content at harvest in scurting bag (14.27 %) followed by muslin bag (14.25%). Haldankar *et al.* (2015) also reported decrease in total sugar content as compared to control in mango cv. Alphonso and found maximum total sugar content (7.48 %) at harvest in brown paper bag.

Maximum total sugar content in control might be due to exposure of fruit to direct sunlight and high temperature.

Table 6: Effect of types of bag on of total sugar content (%) of pomegranate cv. Phule Bhagwa Super at harvest

Treatment	Treatment detail	Total Sugars (%)
T ₁	Butter paper bag	13.69
T ₂	Brown paper bag	13.33
T ₃	Parchment bag	13.91
T ₄	English newspaper bag	13.56
T ₅	Marathi newspaper bag	13.19
T ₆	Control (without bag)	14.07
	S. E. ±	0.160
	C. D. 0.5%	0.482

4.3.4. Reducing sugars content (%)

As regards reducing sugar content, similar trend was observed in Table 7 and Fig 10. Significantly the highest reducing sugar content was registered in the treatment T₆ (control) which was 11.89 %. Among the bagging treatments, T₃ (Parchment bag) recorded maximum reducing sugar (11.72%) which was at par with the treatment T₃ (Parchment bag). Lowest total sugar (%) was recorded in the treatment T₅ (Marathi newspaper bag) which was 11.25%. Lin *et al.* (2008) in pear and Yang *et al.* (2009) in logon showed that total as well as reducing sugar content was reduced on bagged fruit because of microenvironment and also due to exposure of fruit to direct sunlight and high temperature.

Liu *et al.* (2013) is of that opinion that bagging was inhibit synthesis of sugars and organic acids which quickly increased during 0–4 days after bag removal in apple cv. Grany Smith.

Table 7 : Effect of types of bag on Reducing sugar content (%) of pomegranate cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Reducing Sugars (%)
T ₁	Butter paper bag	11.57
T ₂	Brown paper bag	11.36
T ₃	Parchment bag	11.72
T ₄	English newspaper bag	11.47
T ₅	Marathi newspaper bag	11.25
T ₆	Control (without bag)	11.89
	S. E. ±	0.101
	C. D. 0.5%	0.305

4.3.4 Non-reducing sugar content (%)

As evident from the data (Table 8 and Fig 11), non-reducing sugars were reduced in bagging treatments as compared to control (T₆). In control non-reducing sugar content was 2.07 per cent. Among the bagging treatments, Maximum non-reducing sugar content was observed in Parchment bag (T₃) which was 2.06 per cent. The treatments Parchment bag (T₃), Butter paper bag (T₁) and English newspaper bag (T₄) were at par with treatment T₃ (Parchment bag). Lowest non-reducing sugar content was recorded in the treatment T₅ (Marathi newspaper bag) which was 1.84 per cent. Hossain *et al.* (2018) also reported reduction in non-reducing sugar content in guava cv. Swarupkathi. Devalla *et al.* (2016) in mango cv. Alphonso also reported reduction in non-reducing sugar content at harvest in the fruit bagged with brown paper bag, new paper bag, butter paper bag and plastic bag.

Table 8 : Effect of types of bag on Non-reducing sugars (%) of pomegranate cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Non-reducing Sugars (%)
T ₁	Butter paper bag	2.01
T ₂	Brown paper bag	1.87
T ₃	Parchment bag	2.06
T ₄	English newspaper bag	1.98
T ₅	Marathi newspaper bag	1.84
T ₆	Control (without bag)	2.07
	S. E. ±	0.055
	C. D. 0.5%	0.166

4.3.6 Physiological loss in weight (%)

The data on the physiological loss in weight is presented in Table.9 and graphically in Fig. 12 that the Physiological Loss in weight indicated significant difference in weight loss among the different bagging treatments and unbagged (control) fruits which increased with the period of storage. However, lowest loss in fruit weight was observed in the Parchment bag (T₃) which was 5.76, 12.23 and 18.03 per cent against 7.88, 14.48 and 20.47 per cent at 3, 6 and 9 days after harvest of fruit. These results are accordance with those of Mane (2018) in pomegranate. Similar results were also reported by Abbasi *et al.* (2014) in guava fruits when covered with newspaper. In banana, Aryama *et al.* (2019) noticed higher rate of loss of fruits in control (3.94 %) which was quite higher than the other bagging treatments and the lowest (1.76 %) rate of weight loss was recorded in bunch covered with non-woven sleeve that was followed by Blue HDPE (2.17 %) on harvesting day and on 9th day. In banana, Rubel *et al.* (2019) noticed significant reduction in loss of weight of fruit and the lowest moisture loss (11.18%) was registered in blue

polythene bagged banana as against the highest moisture loss (21.56%) in control. Malshe and Parulekar (2017) reported lowest physiological loss in weight (14.67%) in mango fruits bagged at marble stage and removed bags at 75 days after bagging.

Maximum postharvest loss in weight in unbagged (control) fruits might be due to high rate of respiration and transpiration from fruit surface as compared to fruits bagged different bagging material. .

Table 9 : Effect of types of bag on physiological loss in weight (%) (PLW) of pomegranate cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Physiological loss in weight (PLW) (%)		
		3 DAS	6 DAS	9DAS
T ₁	Butter paper bag	6.18 *(14.39)	12.45 (20.66)	18.14 (25.20)
T ₂	Brown paper bag	6.41 (14.66)	12.71 (20.88)	18.58 (25.53)
T ₃	Parchment bag	5.76 (13.88)	12.23 (20.46)	18.03 (25.12)
T ₄	English newspaper bag	6.33 (14.57)	12.68 (20.86)	18.27 (25.30)
T ₅	Marathi newspaper bag	6.71 (15.01)	13.43 (21.49)	19.31 (26.06)
T ₆	Control (without bag)	7.88 (16.30)	14.48 (22.36)	20.47 (26.90)
	S. E. ±	0.1103	0.1422	0.2118
	C. D. 0.5%	0.3326	0.4286	0.6386

* Figures in parenthesis indicate Arc sin transformed value

4.3.7 Shelf life (days)

The data regarding shelf life content of the pomegranate fruits presented in Table 10 and graphically in Fig. 13 showed maximum shelf life of 24.71 days in Parchment bag (T₃) treatment. Butter paper bag (T₁) treatment was at par with the treatment Parchment bag (T₃) which recorded shelf life of 24.33 days. The minimum shelf life was observed in the control (T₆) which was 20.51 days. Akter *et al.* (2020) in mango cv. Amrapalli; Mingire *et al.* (2017) in mango cv. Ratna and Devalla *et al.* (2014) in mango cv. Alphonso noticed improvement in shelf-life of mango. Minigire *et al.* (2017) reported significant effect of bagging on shelf life of mango cv. Ratna and found maximum shelf life of 17.83 days in news paper bag, scurting bag and muslin cloth bag. Devalla *et al.* (2016) also

observed maximum shelf life of 14 days in mango cv. Alphonso in muslin cloth bag and scurting bag, whereas Haldankar *et al.* (2015) observed maximum shelf life of 17.50 days in mango cv. Alphonso in newspaper bag followed by 16.50 days in brown paper bag. Jakhar and Pathak (2016) also observed that fruits treated with 2% CaCl_2 +1% K_2SO_4 +bagging showed shelf life up to 12 days with lowest weight loss and highest organoleptic quality as against 6 days of untreated fruits (control).

Modified microenvironment around the fruit would have delayed the ripening resulting in the improvement in shelf life of pomegranate fruits.

Table 10: Effect of types of bag on Shelf life (days) of pomegranate cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Shelf life (days)
T ₁	Butter paper bag	24.33
T ₂	Brown paper bag	23.12
T ₃	Parchment bag	24.71
T ₄	English newspaper bag	23.29
T ₅	Marathi newspaper bag	22.67
T ₆	Control (without bag)	20.51
	S. E. ±	0.4575
	C. D. 0.5%	1.3790

4.4 Fruit cracking percentage

It is apparent from the data (Table 11 and Fig. 14) that bagging had significant effect on fruit cracking. No fruit cracking was observed in all the bagging treatments as against 6.0 per cent fruit cracking in control (unbagged fruits) (T₆). Abou-El –Wafa (2014) noticed significant reduction in cracked fruits and sun-burn fruits in pomegranate. Lowest significant cracking (1%) were recorded in Prgmen bag as against 24 per cent in control, respectively. Sarkomi *et al.* (2019) observed significant reduction in cracking in bagging with different materials as compared to non-bagged fruit and reported highest percentage of cracking (65%) in control and the lowest (5%) in white-bagged fruits in pomegranate. Reduction in the incidence of fruit cracking was also reported in in litchi (Oosthuizen, 1989) and nectarine (Ding *et al.*, 2004) fruit. Yang *et al.* (2009) in Longan fruit, observed that black adhesive-bonded fabric bag, and white adhesive bonded fabric bag treatments significantly reduced fruit cracking in compared with the control. Rathore and Pal (2016) reported significant reduction in fruit cracking in mango in bagging treatments as

compared to unbagged fruit and found blue paper bag most effective in controlling fruit cracking.

Maintenance of moisture around bagged fruit and avoidance of contact with direct strong and hot winds to the skin of fruit would have been effective in reducing the cracking in pomegranate (Yilmaz & Ozguven, 2006).

Table 11: Effect of types of bag on Cracked fruit (%) and sunburn fruit (%) of pomegranate cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Cracked fruit %	Sunburn 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%	-	-

4.4.1. Sunburn fruit percentage

Results showed (Table 11 and Fig. 15) that bagging had a significant effect on controlling the sun burn injury. No sunburnt fruit were recorded in the all the bagging treatments as against the 21.50 per cent in control (non-bagged fruit). Abou El –Wafa (2014) noticed significant reduction in sun-burn fruits in pomegranate and lowest significant sun burnt fruits (2%) were recorded in Prgmen bag , whereas it was 25 per cent in control. Hegazi (2014) obtained No sunburnt fruits in both the cultivars of pomegranate (Manfaloty and Wonderful pomegranate). Results of Sarkomi *et al.* (2019) showed that bagging had a significant effect on the percentage and severity of sunburnt fruits in pomegranate who obtained lowest percentage of sunburnt fruits (25%) in bagged fruit with white bags as against 90 per cent in control (non-bagged fruit). Significant reduction in peel burn in pomegranate was also reported by Grinan *et al.* (2018). As reported by Karar *et al.* (2019), bagged fruits of mango cv. Anwar Rataul had no sunburn injury. Abdel Gawad- Nehad *et al.* (2017) also observed significant reduction in sun burn fruits in mango cv. Keitt and in Agrail red bag no fruit was affected by sun burn injury. Goodwin *et al.* (2018) showed a clear decrease in sunburn (amount and severity) in red-blushed pear fruit from the netted trees.

4.5 Pest incidence (%) (Fruit borer and mealy bug)

4.5.1. Fruit borer infestation (%)

The data pertaining to fruit borer infestation presented in Table 12 and Fig. 16 indicated that pre-harvest bagging of pomegranate fruits had significant effect on controlling fruit borer infestation. No infestation of fruit borer was observed in the bagging treatments except marathi news paper bag. In Marathi news paper bag the infestation was 2.50 per cent, whereas in Control (T_6) it was 5.12 per cent.

In tomato, Leite *et al.* (2014) noticed that bagging of fruit with either organza fabric or tissue non-tissue (TNT) covering reduced insect borer damage by 99.9 %. Results of Karar *et al.* (2019) indicated that the attack of fruit flies and other insect-pests complex were zero in bagged mango fruits of cv. Anwar Rataul indicating high degree of protection by bagging fruits. Studies of Mondal *et al.* (2014) clearly showed that fruit bagging is best bio-friendly practice to control guava fruit fly and wrapping fruits with transparent poly-propylene bag (20 μ gauge) and transparent poly-propylene (20 μ gauge) bag+ paper within the poly-propylene bag as partial cover against sunlight was found to be the best wrapping material in significant reduction of fruit fly infestation.

4.5.2 Mealy bug infestation (%)

As revealed from the data presented in Table 12 and Fig. 17, different bagging treatment significantly reduced the incidence of mealy bug. The lowest infestation of mealy bug was noticed in Parchment bag (T_3) which was 1.46 per cent, whereas highest infestation of 12.02 per cent was observed in unbagged fruits (T_6).

Haldankar *et al.* (2015) reported that bagging treatments showed less incidence of mealy bug in mango cv. Alphonso and fruits covered with news paper bag, plastic paper bag with perforations and butter paper bag were free from mealy bug incidence. Studies of Abbasi *et al.* (2014) on guava showed that bagging treatments significantly reduced the incidence of disease and damage by fruit fly. Shinde (2015) observed significant reduction in disease incidence and pests due to preharvest bagging of mango fruits and newspaper bag and scurting bags were found to be meritorious. Kireeti *et al.* (2016) observed significant effect of bagging mealy bug infestation and fruits enclosed in news paper bag, brown paper bag, polythene bag, butter paper bag and brown paper bag with polythene coating were free from mealy bug infestation. Sharma (2014) reported that, the incidence of sooty blotch and fly speech was significantly reduced (0.0%) over non-bagged apples

(22.6%) in apple bagged with single-layered spun-bounded fabric bags in apple cv. Royal Delicious.

Bagging acts as a barrier between fruit and insect avoiding contact with fruit and reducing the damage by insect pests. Shlomo (2015) had concluded that bagging provides good mechanical protection against serious pest infestation after bagging.

Table 12 : Effect of types of bag on incidence of Fruit borer (%) and Mealy bug (%) in pomegranate fruits cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Fruit borer (%)	Mealy bug (%)
T ₁	Butter paper bag	00	8.18 *(16.61)
T ₂	Brown paper bag	00	9.24 (17.69)
T ₃	Parchment bag	00	1.46 (6.94)
T ₄	English newspaper bag	00	7.54 (15.93)
T ₅	Marathi newspaper bag	2.50 (9.09)	9.97 (18.40)
T ₆	Control (without bag)	5.52 (13.58)	12.02 (20.28)
	S. E. ±	-	0.6966
	C. D. 0.5%	-	2.0998

* Figures in parenthesis indicate arc sin transformed value.

4.6 Disease (Oily spot) incidence

4.6.1 Oily spot and leaf spot

It is revealed from the data given in Table 13; and Fig 18, no incidence of oily spot was observed in all the bagging treatments as well as non-bagged control and pomegranate fruits were 100 per cent free from oily spot incidence.

As regards the leaf spot, bagging had significant effect on controlling infestation. The lowest infestation was noticed in Parchment bag (T₃) (2.40 %), whereas it was 10.76 per cent in control (T₆). Significant reduction in pests and diseases were observed by Karajeh (2018) in grape clusters bagged with or without pesticide treatment, using brown paper bag. Hofman *et al.* (1997) also observed significant reduction in anthracnose and

stem end rot (SER), caused by *Colletotrichum* and *Dothoriella* spp., respectively due to bagging in mango cv. Keitt.

Reduction in disease incidence due to bagging could be due to a reduction in contact between disease propagules and fruit.

Table 13 : Effect of types of bag on incidence of Bacterial blight (Oily spot) (%) and Leaf spot (%) in pomegranate fruits cv. Phule Bhagwa Super at harvest.

Treatment	Treatment detail	Oily spot (%)	Leaf spot (%)
T ₁	Butter paper bag	00	6.05 *(14.23)
T ₂	Brown paper bag	00	6.94 (15.27)
T ₃	Parchment bag	00	2.40 (8.52)
T ₄	English newspaper bag	00	6.86 (15.18)
T ₅	Marathi newspaper bag	00	7.91 (16.33)
T ₆	Control (without bag)	00	10.76 (19.14)
	S. E. ±	-	0.658
	C. D. 0.5%	-	1.986

* Figures in parenthesis indicate arc sin transformed value.

4.7. Economics of pre-harvest bagging in pomegranate

It is evident from the data presented Table14 that all the bagging material were cost effective recording higher BCR as compared to control. However, highest BCR was realized in parchment bag (T₃) which recorded 3.64 as against the 2.58 BCR in control.

Results are in conformity with Abbasi *et al.* (2014) and reported highest BCR for perforated polythene bags followed newspaper bag in guava. Mondal *et al.* (2015) also reported highest CBR in guava fruits wrapped in different materials and transparent poly-propylene (20µ gauge) bag + paper within the poly-propylene bag as partial cover against sunlight, non-woven poly fabric bag of blue colour (40gsm) and non-woven poly fabric bag of green colour (40gsm) recorded 2.20, 2.10 and 2.09 BCR.

Table 14 : Economics of the fruit bagging in pomegranate cv. Phule Bhagwa Super

Treatment	Treatment detail	Total gross returns (Rs/ha)	Net returns (Rs)	B:C ratio
T ₁	Butter paper bag	854050	578273	3.09
T ₂	Brown paper bag	796220	541511	3.12
T ₃	Parchment bag	921500	668374	3.64
T ₄	English newspaper bag	824395	578278	3.34
T ₅	Marathi newspaper bag	769950	527163	3.17
T ₆	Control (without bag)	548550	336455	2.58

5. Summary and Conclusions

The present investigation entitled “Studies on pre-harvest fruit bagging on pomegranate fruit” was undertaken at Research farm of Pomegranate Research and Technology Transfer Center (PRTTC) Lakhmapur Tal. Satana, dist. Nashik. The trial was laid out in the Randomized Block Design with six treatments and four replications. The objectives were to find the effect of pre-harvest fruit bagging of effect of different bagging material on physical parameters, quality of fruit, pest and disease infestation on pomegranate cv. Phule Super Bhagwa. The cost benefit ratio (B:C ratio) was also worked out. The data obtained in respect of fruit, average fruit weight, length, diameter, yield (kg plant⁻¹ and ton ha⁻¹), TSS, reducing sugar, total sugar, non-reducing sugar, titratable acidity, physiological loss in weight and shelf life, cracked and sunburn fruit percentage, pest and disease incidence has been summarized below.

5.1. Physical parameters

5.1.1. Fruit length (cm)

Non-Significantly, the highest length of fruit was recorded in the treatment T₃ (Parchment bag) which was recorded 6.51 cm. The minimum fruit length recorded in the T₆ (control) and it was 5.96 cm.

5.1.2 Fruit diameter (cm)

Non-significantly the highest diameter of fruit was recorded in the treatment T₃ (Parchment bag) which was recorded 6.34 cm. The minimum fruit length recorded in the T₆ (control) and it was 5.72 cm.

5.1.3 Fruit weight (g)

The highest weight of fruit (g) was recorded in the treatment T₃ (Parchment bag) which recorded 316.44 g fruit weight, while minimum (260.68) g in treatment T₆ (control).

5.1.4 Yield (kg plant⁻¹ and ton ha⁻¹)

Significantly, the highest yield kg plant⁻¹ and ton ha⁻¹ was recorded in the treatment T₃ (Parchment bag) which recorded 25.86 kg plant⁻¹ and 19.00 ton ha⁻¹ respectively. The lowest yield kg plant⁻¹ was recorded in the treatment T₆ *i.e.* control which recorded 18.65 kg plant⁻¹ and 13.80-ton ha⁻¹.

2.2. Aril percentage

The Parchment bag (T₃) recorded maximum aril percentage (72.89 %). The lowest aril percentage (58.87 %) in was observed in control (T₆).

5.3 Chemical Parameters

5.3.1. T.S.S (⁰Brix)

Bagging treatments recorded lowest TSS as compared to control. The maximum TSS (⁰brix) was recorded in the treatment T₆ (control) and had 15.76 ⁰B TSS, Whereas the minimum TSS was registered in the treatment T₅ (Marathi newspaper bag) which was 12.49 ⁰B.

5.3.2. Titratable acidity (%)

The bagging treatment T₆ (control) recorded the lowest titratable acidity (0.32 %), whereas maximum titratable acidity was recorded in T₅ (Marathi newspaper bag) which was (0.38

5.3.3. Total sugars (%)

Maximum total sugar (14.07 %) was observed in the treatment T₆ (control) and the minimum was recorded in Marathi newspaper bag (T₅) (13.19 %).

5.3.4 Reducing sugars (%)

Maximum reducing sugar content (11.89 %) was registered in the treatment T₆ (control) and lowest in the Marathi newspaper bag (T₅) (11.25 %).

5.3.5. Non-reducing sugars (%)

Maximum non-reducing sugar content was registered in the Control (T₆) (2.07 %) and lowest was recorded in the Marathi newspaper bag (T₅) (1.84 %)

5.4 Physiological parameters

5.4.1 Physiological loss in weight (PLW) (%)

The Physiological Loss in Weight was significantly lowest in Parchment bag (T₃) which was 5.76, 12.23 and 18.03 % at 3, 6 and 9 days after harvest of fruit. Whereas maximum Physiological Loss in Weight recorded in Control (T₆) and it was 7.88, 14.48 and 20.4 % at 3, 6 and 9 days after harvest.

5.4.2 Shelf life (Days)

The maximum shelf life of 24.71 days was registered Parchment bag (T₃), while minimum Control (T₆) which was 20.51 days.

5.5. Cracked fruit (%)

No infestation was noticed in all the bagging treatments, whereas it was 6.00 % in Control (T₆).

5.5.1 Sunburn fruit (%)

All the bagging treatments exhibited nil infestation, but Control (T₆) recorded 21.50 % sun burn affected fruits.

5.6. Pest incidence (%) (Fruit borer and mealy bug)

5.6.1. Pest infestation % (Fruit borer)

Fruits covered with Butter paper bag, Brown paper bag, Parchment bag, English newspaper bag were free from fruit borer infestation whereas it was 2.50 and 5.52 per cent in Marathi news paper bag (T₅) and control (T₆) respectively.

5.6.2 Pest infestation % (Mealy bug)

Parchment bag (T₃) recorded significantly the lowest infestation (1.46%), whereas the highest mealy bug infestation observed control (T₆) (12.02%).

5.7 Disease incidence (%) (Oily spot and Leaf spot)

5.7.1 Oily spot and leaf spot

All the treatment including control was totally free from oily spot incidence. In case of leaf spot incidence on fruit, Parchment bag (T₃) exhibited lowest incidence (2.40%) and highest infestation observed in control (T₆) (10.76%).

5.8. Economics of the bagging treatments

The maximum to B:C ratio of 3.64 was observed in the treatment parchment bag (T₃) followed by English newspaper bag (T₄) and Marathi newspaper bag having 3.34 and 3.17 BCR, respectively.

Conclusion

Results revealed significant effect of bagging treatments on physical parameters, fruit quality and pest-disease incidence. Among the different bagging materials,

Parchment bag, Butter paper bag and English newspaper bag were found to positive effects on physical properties, aril percentage on pomegranate cv. Phule Bhagwa Super. Whereas chemical properties namely TSS, reducing sugar, non-reducing sugars and total sugars of fruit were better in control treatment followed by parchment bag (T₃). The fruits bagged in parchment bag and butter paper bag exhibited improved shelf life, minimum loss in weight (PLW), maximum marketable yield, B:C ratio etc. than non-bagged fruits. Moreover, incidence of pest and diseases incidence were minimum in all the bagging treatments. In general parchment bag found to be superior bagging treatment. However, English newspaper bag can be best alternative to parchment bag.

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8. VITAE

MISS. GETHE APURVA SANJEEV
MASTER OF SCIENCE (HORTICULTURE)
IN
FRUIT SCIENCE
2020

Title of Thesis		:	“Studies on pre-harvest fruit bagging of pomegranate fruit”.
Major Field		:	Fruit Science
Biographical information:		:	
Personal	Date of Birth	:	28 th April, 1996
	Place of Birth	:	Sangamner
	Father's Name	:	Gethe Sanjeev Mohan
	Mother's Name	:	Gethe Smita Sanjeev
Educational	Bachelor Degree Obtained	:	B.Sc. Agriculture
	Class	:	First class with distinction
	Name of University	:	M.P.K.V Rahuri.
Address		:	Govindnagar lane no 1,Sangamner Tal - Sangamner Dist – Sangamner
	Email-Id	:	getheapurva@gmail.com
	Contact Number	:	8830937507 / 7756981610