

**EFFECT OF AGRO TECHNIQUES ON POLLEN
VIABILITY AND FRUIT SET IN CUSTARD APPLE
(*Annona squamosa* L.) Cv.
BALANAGAR**

By

Miss. Khalate Snehal Madhukar

(Reg. No. 014/323)

**A thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST.AHMEDNAGAR,
MAHARSHTRA, INDIA**

in partial fulfillment of the requirements of the degree

of

MASTER OF SCIENCE IN (HORTICULTURE)

in

FRUIT SCIENCE

**DEPARTMENT OF HORTICULTURE
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST.AHMEDNAGAR,
MAHARASHTRA, INDIA**

2016

**EFFECT OF AGRO TECHNIQUES ON POLLEN
VIABILITY AND FRUIT SET IN CUSTARD APPLE
(*Annona squamosa* L.) Cv.
BALANAGAR**

By

Miss. Khalate Snehal Madhukar

(Reg. No. 014/323)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST. AHMEDNAGAR,
MAHARASHTRA, INDIA

in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (HORTICULTURE)

in

FRUIT SCIENCE

APPROVED BY

Dr. H.K. Shirsath

(Chairman and Research Guide)

Dr. V.S. Supe
(Committee Member)

Dr. V.R. Shelar
(Committee Member)

Dr. C.A. Nimbalkar
(Committee Member)

Department of Horticulture
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA
2016

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: MPKV., Rahuri

(Khalate S.M.)

Date: / /2016

Dr. H.K.Shirsath

Asstt.Horticulturist,
I/C Horticulture Farm & Nursery
Department of Horticulture,
Mahatma Phule Krishi Vidyapeeth,
Rahuri - 413 722, Dist. Ahmednagar,
Maharashtra, INDIA.

CERTIFICATE

This is to certify that the thesis entitled, “**EFFECT OF AGRO TECHNIQUES ON POLLEN VIABILITY AND FRUIT SET IN CUSTARD APPLE (*Annona squamosa* L.) Cv. BALANAGAR**”, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE**, embodies the results of piece of bona *fide* research work carried out by **Miss. Khalate Snehal Madhukar**, under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

Place: MPKV.,Rahuri

Date: / / 2016

(H.K. Shirsath)

Chairman & Research Guide

Dr.B.R. Ulmek

Associate Dean,
Post Graduate Institute,
Mahatma Phule Krishi Vidyapeeth,
Rahuri - 413 722, Dist. Ahmednagar,
Maharashtra, India

C E R T I F I C A T E

This is to certify that the thesis entitled, “**EFFECT OF AGRO TECHNIQUES ON POLLEN VIABILITY AND FRUIT SET IN CUSTARD APPLE (*Annona squamosa* L.) Cv. BALANAGAR**”, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE**, embodies the results of piece of *bona fide* research work carried out by **Miss. Khalate Snehal Madhukar**, under the guidance and supervision of **Dr.H. K. Shirsath**, Asstt. Horticulturist, I/C Horticulture Farm & Nusery , Department of Horticulture, MPKV., Rahuri and that no part of the thesis has been submitted for any other university for degree or diploma.

Place : MPKV., Rahuri

(B.R. Ulmek)

Date : / /2016.

ACKNOWLEDGEMENT

Work is worship. The almighty who lives in every soul truly manifests through work. First of all, I ascribe all glory to the gracious “ALMIGHTY” for his heartfelt benediction and silent blessing which always acts as my savior in the face of all sorts of peril and paved the path of my life.

Mere words are inadequate to express the sense of gratitude and indebtedness to those whose assistance was indispensable for the completion of my thesis work. But often we have to give vent to our sentiment through the medium of words written or spoken.

I feel elysian and unfathomable euphoria to pronounce my heartfelt adoration and gratitude to my honourable Chairman of Advisory Committee, Dr. H. K. Shirsath, Asstt. Horticulturist, I/C Horticulture Farm & Nursery, M.P.K.V. Rahuri for his guidance, precious counsel, unstinted help, constant encouragement during the course of investigation and constructive criticism in the preparation of the manuscript of the thesis which can never be forgotten. His valuable suggestions, innovative ideas and meticulous nature helped me in execution of my investigation and degree. His close monitoring and stimulating influence made the work complete with perfection.

I feel proud to express my deep feelings of gratitude towards Dr. B. R. Ulmek, Dean Faculty of Agriculture, Dr. R. S. Patil, Director of Research and Dr. B. R. Ulmek, Associate Dean, Post Graduate Institute, MPKV., Rahuri for providing all the facilities during my research work.

Words are inadequate to express and acknowledge my deep feeling of respect and gratitude towards Dr. S. A. Ranpise, Head Department of Horticulture, MPKV., Rahuri for his expert guidance and advice during the course of this investigation.

With the profound and unfading sense of obligation I express my heartfelt thanks to the member of my Advisory Committee, Dr. V. S. Supe, Horticulturist, AICRP on Arid Zone Fruits, M.P.K.V., Rahuri, Dr. V. R. Shelar, Associate Professor of Botany, M.P.K.V., Rahuri and Dr. C. A. Nimbalkar, Associate Professor, Department of Statistics, M.P.K.V., Rahuri, for their help through the course of investigation work. I would like to thank Dr. V. R. Joshi sir, Dr. A. R. Walunj sir, Mr. A. P. Karjule Sir, Mr A. V. Attar sir, Mrs. Dhanashree Patil madam, Mr. Shinde sir and peon Mahale mama who had helped me lot during my lab work. I would like to thank all the authors whose literature cited by me while working on my research topic.

I would like to take this opportunity to convey my sincere thanks to all others respected teachers and non-teaching staff of Horticulture, Biochemistry and Seed technology, all fieldworkers especially Mumtaz Bhabi who assisted me a lot in the field work, my all classmates, my roommates Divya, Bhagyashri,, pooja, Hemlata, vrushali, my seniors Shradha di, Bhagyashri di, Varsha di, Monika di, who had continuously encouraged me for doing my research work.

I would like to thank my whole and sole and my father Mr. Madhukar M. Khalate and my lovely mom Hemlata M. Khalate, my lovely brother Abhishek M. Khalate whose guidance is the secret of my success till today and forever.

I am equally thankful to my grandfather shri. Manikrao J. Khalate, grandmother sau. Gangubai M. Khalate. My kaka Mr. Suresh Khalate, kaku Ratnmala Khalate, my lovely and very caring best friend Priyanka Kadam and all family members for their continuous moral support and heartiest blessings, which are the source of constant inspiration throughout my career.

Once again thank you all and my almighty god.

Place : MPKV., Rahuri

(Khalate S. M.)

Date : / /2016

CONTENTS

CANDIDATE'S DECLARATION	iii
CERTIFICATES	
1. Research Guide	iv
2. Associate Dean (PGI)	v
ACKNOWLEDGEMENTS	vi
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF PLATES	xiii
LIST OF ABBREVIATIONS	xiv
ABSTRACT	xv
1. INTRODUCTION	1
2. REVIEW OF LITERATURE	8
2.1 Effect of cover crops on fruit set in custard apple	8
2.2 Effect of irrigation systems on fruit set.	16
3. MATERIAL AND METHODS	18
3.1 Materials	18
3.2 Methodology	18
3.2.1 Treatment Details	19
3.2.2 Statistical analysis	19
3.2.3 Observations	20
4. EXPERIMENTAL RESULTS	26

4.1	Flowering, fruit setting and pollen viability	26
4.1.1	Days require for initiation of flowering	26
4.1.2	Number of flowers per branch	27
4.1.3	Number of flowers per tree	27
4.1.4	Pollen viability (%)	28
4.1.5	Fruit set (%)	29
4.2	Yield and yield contributing characters	29
4.2.1	Average number of fruit per branch	29
4.2.2	Average number of fruit per tree	30
4.2.3	Average weight of fruit (g)	30
4.2.4	Yield (kg/tree)	31
4.3	Quality parameters	32
4.3.1	Total soluble solids (^o Brix)	32
4.3.2	Acidity (%)	32
4.3.3	Pulp (%)	34
4.3.4	Seed (%)	34
4.3.5	Total sugars (%)	36
4.3.5.1	Reducing sugar (%)	37
4.3.5.2	Non reducing sugar (%)	37
4.4	Incidence of mealy bug (%)	37

5. DISCUSSION	39
5.1 Flowering, fruit setting and pollen viability	39
5.2 Yield & yield contributing parameters	46
5.3 Quality parameters	50
5.4 Incidence of mealy bug (%)	52
6. SUMMARY AND CONCLUSION	54
6.1 Flowering, fruit setting and pollen viability.	55
6.2 Yield & yield contributing parameters	56
6.3 Quality parameters	56
6.4 Conclusion	58
7. LITERATURE CITED	59
8. APPENDICES	66
9. VITA	69

LIST OF TABLES

No.	Title	Page No.
1.	Effect of cover crops on flowering, pollen viability and fruit set.	28
2.	Effect of cover crops on yield and yield contributing characters.	31
3.	Effect of cover crops on total soluble solids and percent acidity	33
4.	Effect of cover crops on pulp (%) and seed (%)	35
5.	Effect of cover crops on sugars (%)	36
6.	Effect of cover crops on incidence of mealy bugs(%)	38

LIST OF FIGURES

No.	Title	Between Pages
1.	Effect of cover crop and agronomic techniques on days required for initiation of flowering.	28-29
2.	Effect of cover crop and agronomic techniques on number of flowers per branch	28-29
3.	Effect of cover crop and agronomic techniques on number of flowers per tree.	28-29
4.	Effect of cover crop and agronomic techniques on per cent fruit set and per cent pollen viability.	28-29
5.	Effect of cover crop and agronomic techniques on average number of fruits per branch.	31-32
6.	Effect of cover crop and agronomic techniques on average number of fruits per tree.	31-32
7.	Effect of cover crop and agronomic techniques on average weight of fruits.	31-32
8.	Effect of cover crop and agronomic techniques on fruit yield (kg/tree).	31-32
9.	Effect of cover crop and agronomic techniques on TSS (°Brix)	33-34
10.	Effect of cover crop and agronomic techniques on acidity (%)	33-34
11.	Effect of cover crop and agronomic techniques on pulp and seed per cent	35-36
12.	Effect of cover crop and agronomic techniques on total sugar (%).	36-37
13.	Effect of cover crop and agronomic techniques on reducing sugar (%).	36-37
14.	Effect of cover crop and agronomic techniques on non reducing sugar (%).	36-37
15.	Effect of cover crop and agronomic techniques on incidence of mealy bug (%).	38-39

LIST OF PLATES

No.	Title	Between Pages
1.	Plate 1: Cover crop Maize (T ₁) in Custard apple.	19-20
2.	Plate 2 : Cover crop Bajra (T ₂) in custard apple.	19-20
3.	Plate 3 : Cover crop Dhaincha (T ₃) in custard apple.	19-20
4.	Plate 4 : Cover crop Jowar (T ₄) in custard apple.	19-20
5.	Plate 5 : Cover crop Sunhemp (T ₅) in custard apple.	19-20
6.	Plate 6: Fogger(T ₆) in custard apple	19-20
7.	Plate 7: Sprinkler (T ₇) in custard apple	19-20
8.	Plate 8: Sod culture (T ₈) in custard apple	19-20
9.	Plate 9: Control (T ₉) (conventional method)	19-20
10.	Pollen viability of Custard apple in Maize (T ₁)	28-29
11.	Pollen viability of Custard apple in Bajra (T ₂)	28-29
12.	Pollen viability of Custard apple in Dhaincha (T ₃)	28-29
13.	Pollen viability of Custard apple in Jowar (T ₄)	28-29
14.	Pollen viability of Custard apple in Sunhemp (T ₅)	28-29
15.	Pollen viability of Custard apple in Fogger (T ₆)	28-29
16.	Pollen viability of Custard apple in Sprinkler (T ₇)	28-29
17.	Pollen viability of Custard apple in Sod culture (T ₈)	28-29
18.	Pollen viability of Custard apple in Control (T ₉)	28-29

LIST OF ABBREVIATIONS

%	:	Per cent
/	:	Per
°C	:	Degree Celsius (S)
C.D.	:	Critical difference
cm	:	Centimeter (s)
Cv.	:	Cultivar
<i>et al.</i>	:	And others (et alli)
etc.	:	Etcetera
Fig.	:	Figure
g	:	Gramme (s)
ha	:	Hectare (s)
hr	:	Hours (s)
i.e.	:	That is (<i>id est</i>)
mm	:	Millimeter (s)
MPa	:	Megapascal
N.S.	:	Non significant
No.	:	Number (s)
S.Em.	:	Standard error of means
t	:	Tonne (s)
TSS	:	Total soluble solids
<i>viz.</i>	:	Namely

ABSTRACT

**EFFECT OF AGRO TECHNIQUES ON POLLEN VIABILITY AND
FRUIT SET IN CUSTARD APPLE (*ANNONA SQUAMOSA L.*)
CV. BALANAGAR**

By

Miss. Khalate S. M.

A candidate for the degree

of

MASTER OF SCIENCE (HORTICULTURE)

in

FRUIT SCIENCE

Post Graduate Institute,

Mahatma Phule Krishi Vidyapeeth, Rahuri - 413 722

2016

Research Guide : Dr. H.K. Shirsath

Discipline : Horticulture (Fruit Science)

The present study “Effect of agro techniques on pollen viability and fruit set in custard apple” was carried out at Instructional-Cum-Research Orchard of AICRP on Arid Zone Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 2015-16 on 18 years old orchad, spaced at 5 x 5 m² in randomized block design.

It involved five cover crops i.e. Maize (T₁), Bajra (T₂), Dhaincha (T₃), Jowar (T₄) and Sunhemp (T₅), two irrigation systems i.e. Foggar (T₆) and Sprinkler (T₇), Sod culture (T₈) and control i.e. conventional method (T₉). Cover crops were sown on 3th of February 2015.

The statistical analysis revealed that significantly minimum number of days required for initiation of flowering in T₃-Dhaincha cover crop (21.00) which were statistically at par with the treatments T₁-Maize and T₄-Jowar (21.67). Significantly maximum number of flowers per branch was recorded in T₂-Bajra cover crop (116.90) which was statistically at par with the T₁-Maize cover crop (102.40). The treatment T₃-Dhaincha recorded significantly higher pollen viability percentage (91.77 %) and fruit set percentage (27.52 %).

The average number of fruits per branch was maximum in T₂- Bajra (26.63) which is at par with the T₄-Jowar (25.68). The highest number of fruits per tree was recorded in T₃- cover crop Dhaincha (169.03) and it was followed by T₅-cover crop Sunhemp (149.68). The average weight of fruits per tree was significantly influenced by sowing of various cover crops. Significantly maximum weight of fruit was recorded in T₂-Bajra cover crop (195.67 g). The highest yield per tree was recorded in T₃-Dhaincha cover crop (33.05 kg). Quality parameters i.e. total soluble solid (°B), acidity(%), seed (%) and sugars (%) were statistically non significant in relation to the sowing of different cover crops in custard apple.

However, in case of pulp (%), significant results were obtained due to sowing of different cover crops. Lowest incidence of mealy bug was noticed in T₄-cover crop Jowar (1.53 %).

The present investigation reveals that sowing cover crops is a promising tool for improving flowering, pollen viability, fruit set and yield of custard apple. Though most of the quality parameters such as TSS(°B), acidity(%) and sugars(%) are not significantly correlated to the sowing of cover crops and irrigation system, the pulp percentage and seed percentage shows large variation. The incidence of mealy bug also reduced due to the sowing of different cover crops. Thus it can be concluded that the treatment T₃ -cover crop Dhaincha is superior over all treatments. It is proved responsible for improving pollen viability, fruit set and yield in custard apple.

1. INTRODUCTION

Annona species are adapted to tropical or subtropical conditions. Sugar apple (*Annona squamosa L.*) is widely distributed through-out tropical South America and also grown commercially in Africa, Australia, China, India, Mexico, Southern United States, Philippine and Thailand. Custard Apples are a sub-tropical deciduous tree belonging to the Annonaceae family. This family contains over 2000 members spread throughout the world. The other important features of annonaceous fruits are their wide adaptability to soil and climatic conditions and freedom from pests and diseases. Due to their hardy nature and escape from animal damage, they have become naturalized in many tropical and subtropical parts of the world along with a tremendous scope for further expansion.

In different countries, the name custard apple is given to separate species of genus *Annona*. In India, the custard apple is *Annona squamosa*, in the USA, *Annona reticulata* or *Annona glabra* and in Australia *Annona atemoya*. According to Hayes (1957), the term custard apple may be applied to all the *Annona species* producing edible fruits.

Custard apple (*Annona squamosa L.*) is the most widely cultivated species in India and probably in the tropics of the world. It is popularly known as custard apple, sugar apple, sweetsop or *ate* and in the northern India *Sharifa*, while in southern part *sitaphal*. It is a deciduous, tall, woody shrub or small tree of about 5 to 6 metres in height with irregularly spreading branches. The alternate double-ranked

leaves are lanceolate and acuminate. The greenish yellow flowers arise at an extra axillary position, usually in clusters and rarely solitary. Six petals are in two whorls, the outer petals are thick, linear and rounded at the apex while inner ones are minute, ovate or obovate and keeled on the outside. The flower has numerous stamens and carpels. The fruit is composed of loosely cohering carpels forming a squamose or tuberculated surface. The black seeds are surrounded by white, creamy or custard-like pulp which is very sweet and pleasantly flavoured.

Among annonaceous fruits, custard apple botanically known as *Annona squamosa* L., is most important dry land fruit of India. It is popular by virtue of its spontaneous spread in forest, wastelands, rocky slope and other uncultivated places. It is generally classed as a semi-wild fruit. Custard apple has gained commercial significance and exclusive orchards are emerging in Andhra Pradesh and Maharashtra. Custard apple is grown on 29,870 ha in India mainly in the states of Andhra Pradesh, Assam, Tamilnadu and grows wild in Deccan plateau and some parts of central India and the production was 2,28,370 MT. In 2014-15, the area covered under this crop was 8,660 ha and the production was 59,330 MT in Maharashtra (Anon,2014-15)

Custard apple (*Annona squamosa* L.) is an arid fruit crop and hardy in nature requires dry climate with mild winter. It can grow successfully upto 100 m above the mean sea level. Due to high temperature, low atmospheric humidity, lack of irrigation water and natural stress resulted less number of

flower, poor fruit setting and low yield and degraded quality of fruit too. In comparison with many other tree fruits, custard apple has a short juvenile phase. Seedling as well as vegetatively propagated plants begin flowering within four years of planting, the former taking more time to come into bearing than the latter.

It is small semi-deciduous tree that produces solitary flowers in the axils of leaves. Flowers are specialized in to a floral chamber with three fleshy white/green petals enclosing many sex organs. Flowers are hermaphrodite and protogynous that is both male and female reproductive structures are produced within the same flower although female and male reproductive organ do not mature at the same time. The female reproductive structure mature first and can remain receptive for up to twenty four hours (Gazit *et al.* 1982). *Annona species* bears flowers on both old and current season growth and very rarely on older wood. The flowering period of custard apple is very long commencing from March-April, continuing up to July-August. The peak flowering is observed in April and May. No fruit set occurs during the entire spring and summer and it commences only in the rainy season.

Custard apple is considered as one of the delicious and nutritionally valuable fruit meant for table purpose. Fruits have an edible, soft, granular, juicy and sugary pulp with mild flavor and with slight acidity. Fruits are considered for their medicinal value besides their general use in ice cream, confectionery and certain milk product. The pulp of Custard apple is mostly consumed as dessert fruits. They can be

preserved as jam and jelly. The edible portion of fruit is creamy, granular with an excellent blend of sweetness and acidity. The immature fruits, seeds, leaves and roots are known for their medicinal use in Ayurveda (Parekh and Sharma, 1993). The seed cake contains nitrogen, thus can be used as manure. It has a pleasant texture and flavour. It is sweet with moderate acidity.

Custard apples are an excellent source of Vitamin C, a good source of dietary fibre, a useful source of Vitamin B6, magnesium and potassium, and with some B2 and complex carbohydrate. 100g of flesh will provide over 110% of the recommended daily allowance of Vitamin C. They are considered good energy source with the value of 104 Kcal. Custard apple fruit contains carbohydrates 20.82 g, protein 1.89 g, mineral 0.9 g, fiber 1.41 g, calcium 17 mg, phosphorus 54 mg, iron 0.30 mg and vitamins 37mg. These values are based on 100gm fruit pulp. The Philippine company produces sugar apple wine.

Low productivity of annonaceous fruits is the main constraint in expanding their commercial cultivation (Hayes, 1957; George and Nissen, 1986). Enough flowers are born on a custard apple plant to give a good crop but the poor fruit set causes low yield. Only one to eight percent fruit set has been reported under natural conditions (Ahmad, 1936a; Venkataratnam, 1963; Thakur and Singh, 1965; Kumar *et al*, 1977; George and Nissen, 1988).

The low fruit set in custard apples is due to poor pollination which has been attributed to both the external and

internal factors, such as very high and low humidity prevailing at the time of flowering, soil moisture stress, competition between vegetative and floral growth, hypogyny, dichogamy, poor pollen germination and dearth of insect pollinators. Flowering and fruit set are affected not only by the environmental conditions during flowering, but also by vegetative flushing of the tree. Flowering was closely associated with vegetative flushing. Soil moisture stress (mid-day leaf water potential -2.0 MPa) also reduced flowering and fruit set, particularly at high temperature (28°C). Hand-pollination of flowers, even under high VPD conditions, resulted in a significantly higher set ($>20\%$). Productivity of custard apple in the field may be improved by cultural techniques such as overhead misting, windbreaks and efficient irrigation scheduling (George and Nissen, 1988). Thakur and Singh (1965) found pollen grains shriveled and sterile in May and June when temperature was very high and relative humidity very low. Hopping (1983) also reported that low humidity and hot days could impair pollen viability. Therefore, fruit set occurs only in rainy season on reversal of environmental conditions. Early fruit set occurs in southern India where humidity is higher and temperature lower than in northern India. Under dry land condition due to high temperature and low relative humidity, receptivity of stigma and viability of pollen reduced due to high temperature and low humidity.

The cultural practices including close planting, regular irrigation in summer months, overhead spraying of water and mulching help in enhancing setting of fruits (Ahmad, 1936b;

Rao, 1974; George and Nissen, 1988). Sowing of cover crops in orchard also creates micro-climate changes under their canopies by reducing soil and air temperature, irradiance and wind speed. These changes may significantly affect crop growth depending upon climate. Air temperature is important as excessively hot condition during critical developmental stages may greatly reduce the yield. Temperature exceeding 30 °C may induce pollen sterility and reduce the fruit yield. In custard apple, period of flowering is very important commencing from March-April, continuing up to July-August (Kumar *et al.*, 1977; Sahoo *et al.* 2000). The peak flowering period of custard apples coincides with the summer season in northern India when the temperature goes beyond 40°C, humidity is extremely low, desiccating wind is prevalent and the soil is in dry condition. Neither the pollen is produced nor does fruit set occur in this situation (Hayes, 1957; Kumar *et al.*, 1977).

By growing cover crops like Maize, Bajara, Dhaincha, Jowar, Sunhemp and installing sprinkler irrigation and fogger irrigation in the canopy of custard apple, we can develop the microclimate and increase the fruit set and yield. Therefore, present investigation on “Effect of agro techniques on pollen viability and fruit set in custard apple” was planned and executed at Instructional Cum Research Orchard, Arid Zone Fruit Project, Department of Horticulture, MPKV., Rahuri during the year 2015-2016 with following objectives-

- i) To study the effect of cover crops on fruit set in custard apple
- ii) To study the effect of irrigation systems on fruit set in custard apple
- iii) To study the effect of cover crops and irrigation system on yield of custard apple.

2. REVIEW OF LITERATURE

Custard apple (*Annona squamosa L.*) is grown throughout India except temperate regions. It is hardy and tropical fruit crop and can be grown successfully on diverse soils and agro-climatic conditions; hence it is very popular fruit in dry land areas of Maharashtra. However, poor pollen viability which leads to low fruit set and thus low productivity is a major constraint in the expansion of its cultivation. Poor pollen viability and fruit set is mostly related to climatic condition. Therefore, by improving pollen viability and fruit set we can increase the fruit yield which is one of the most important practical approaches towards this problem in custard apple. Cover crops could be used to increase pollen viability, fruit set and yield in custard apple. The work done on this aspect is very scanty.

However, in addition to available literature on custard apple, studies in other fruit crops relevant to present investigation have been reviewed and presented here under the following subheads.

2.1 Effect of cover crops on fruit set in custard apple

Thakur and Singh (1965) reported that, the low fruit set in custard apple is due to poor pollination which has been attributed to both the external and internal factors, such as very high and low humidity prevailing at the time of flowering, soil moisture stress, competition between vegetative and floral growth, hypogyny, dichogamy, poor pollen germination and dearth of insect pollinators. Pollen grains found shrivelled and

sterile in May and June when temperature was very high and relative humidity very low.

Kumar *et al.*, (1977) revealed that the peak flowering period of custard apple coincides with summer season in Northern India when the temperature goes beyond 40°C, humidity is extremely low, desiccating wind is prevailing and the soil is in dry condition. Neither the pollen is produced, nor does fruit set occur in this situation. They obtained maximum pollen germination in 20 per cent sucrose-agar solution. They further reported that the receptivity of stigma started disappearing at the time of dehiscence and was completely lost after six hours resulting in poor fruit set. It is suggested that more fruit set may be obtained if the receptivity of stigma is enhanced by auxin sprays.

Hopping, (1983) also reported that, low humidity and hot days could impair pollen viability. Therefore, fruit set occurs in rainy season on reversal of environmental conditions. Early fruit set occurs in Southern India where humidity is higher and temperature lower than in Northern India.

George and Nissen, (1987) reported that the temperatures above 32°C are more conducive to vegetative flushing and increased competition between fruit-lets and vegetative growth, resulting in reduced fruit set in custard apple.

George and Nissen, (1988) revealed that the flowering and fruit set were affected not only by the environmental conditions during flowering, but also by vegetative flushing of

the tree. Flowering was closely associated with vegetative flushing. Soil moisture stress (mid-day leaf water potential -2.0 MPa) also reduced flowering and fruit set, particularly at high temperature (28°C). Hand-pollination of flowers, even under high VPD conditions, resulted in a significantly higher set ($>20\%$). Productivity of custard apple in the field may be improved by cultural techniques such as overhead misting, windbreaks and efficient irrigation scheduling. He also showed that, the protogynous dichogamy is the main limiting factor for fruit set in *atemoya*.

Sanewski, (1988) reported that the temperatures above 28°C resulted in more growth, fewer flowers and more drying of flower parts in custard apple. Temperatures of 25°C to 28°C during flowering (October to February) are favourable for good fruit set.

Shivanna and Cresti (1989) studies the effects of high humidity and temperature stress on pollen membrane integrity and pollen vigor in *Nicotiana tabacum*. In other species, different methods have been reported to evaluate pollen germination in vitro by Shivanna and Heslop-Harrison (1981) and also in vivo.

George *et al.*, (1995) stated that the conditions conducive to high fruit set are moderate temperatures, high relative humidity, lack of tree water stress and no wind or continuously heavy rain. If relative humidity falls below 70 per cent, fruit set and fruit shape are adversely affected. High relative humidity in the orchard can be maintained by establishing windbreaks. Light applications of irrigation in the

late afternoon using wide-row mini sprinklers will also help in opening flowers maintaining their stigma receptivity until the following morning in custard apple.

Carol, (1997) reported several cultural practices to increase pollination, fertilization and yield at proper time. Inter planting, pollinizer to enhance cross-pollination, importing bees into an orchard with pheromones. The result concluded that the roles of endogenous plant hormones increase fruit set, fruit retention of avocado.

Higuchia *et al.*, (1998) reported that, high temperatures decreased fruit set percentage in custard apple. However he further obtained highest percentage fruit set in the 'cool' pollen ± 'cool' flower pollination treatment (10 out of 10) and the lowest (3 out of 11) was observed in the 'warm ± warm' pollination treatment. The pollen germination percentage was adversely affected by warm temperatures and pollen development period was more heat-sensitive than pollen germination.

Roselle *et al.*, (1999) reported that temperature has a clear effect on pollen germination of cherimoya (*Annona cherimola* Mill.) with the best results between 20°C and 30°C. They also alluded that these temperatures agree with Sanewski (1985), who considered it to be the most adequate for successful fruit set in the orchard. Temperatures under 15°C and over 30°C reduced pollen germination and produced abnormal pollen tube development similar to that which has been recorded in other species.

Sahoo, *et al.*, (2000) recorded, the viability of pollen varied from 52.30% to 93.33% in the green types and 45.10% to 93.33% in the red types in custard apple. Further, the highest pollen viability is recorded from June to August in both varieties. Fruit set by controlled self-pollination was only 0.75%. Cover crops have the advantages not only to increase water-holding capacity of soil but also to modify the microclimate under the tree canopy. These advantages reduce tree stress which has positive effect on the fruit set percentage and negative effect on fruit drop percentage.

Kubilay and Sinan (2001) showed that, the highest pollen viability and germination rate were obtained from male flowers of Hicaz (71.24% viability in TTC, 82.45% viability in FDA, 61.50% germination in 1% Agar + 10 % Sucrose medium in agar plate method) in pomegranate.

George and Nissen, (2002) showed that the moderate drought ($L=21.5$ MPa) reduced shoot growth by 20-30% and increased the number of flowers per lateral by about 40% compared with well-watered controls due to reduced apical dominance and increased lateral branching.

Jalikop and Kumar, (2007) reported that, pollen source had significant effect. *Annona squamosa* pollen gave the highest fruit set (greater than 91%) and good to moderate fruit set was recorded with *Annona reticulata* and self-pollen (31% to 86%); and with *Annona atemoya* and *Annona cherimola* pollen, the set was poor (4% to 13%), whereas natural set was as low as 2%. 'Arka Sahan' fruits resulting from *Annona squamosa* pollen showed quicker fruit maturity (128 days).

Walser, *et al.*, (2007) revealed that the use of cover crops with compost amendments will provide adequate mineral nutrition and increase soil organic matter as well as provide for ecological gains.

Abdel Aziz *et al.*, (2008) showed that the cover crops, the cultivation methods and their interaction were insignificant in the first season whereas only the cover crops gave a significant result in the second season. In this respect, it is clear that the *T. alexandrinum* L. and *T. foenum* gave the highest value compared to the fallow treatment in Valencia orange trees. The results showed that fruit set, tree vegetative growth, fruit yield, soil organic carbon and soil moisture content, were enhanced and fruit drop was decreased with the cover crop treatments. However, the (BR and BWR) cultivation methods with the Egyptian clover gave the best results without significant differences between them regarding vegetative growth, yield and soil fertility. This increase could be due to the fixed nitrogen by the cover crop which influences the tree vegetative growth.

Lopes, *et al.*, (2008) indicated that cover cropping can be a valuable tool for controlling vigour and enhancing vine quality in the vine growing region.

Rebecca and Paul, (2010) reported that the cover crops did not alter shoot growth, pruning mass, leaf water potential, fine root density or colonization of roots by AMF. Stigmas may remain receptive for longer under high humidity conditions, providing opportunities for higher level of pollination and fruit set. High temperature and low humidity has the opposite

effect. Relative humidity below 75% has a negative impact on fruit set by affecting stigma receptivity.

Nainwad and Dheware (2010) reported that the different intercrops like cowpea, sorghum, horse gram, stylo hamata and cenchrus ciliars along with the application of recommended dose of fertilizer and farm yard manure, which maintained the nutritional requirement of custard apple orchard. The intercrops raised suppressed the weed growth, added more bio-mass, maintained soil fertility and gave surplus income to growers.

Yaxin Ge *et al.*, (2011) reported that the pollen viability dropped rapidly with increasing temperature in *Panicum virgatum* L. After treatment at various temperatures (18-40°C), pollen viability of the cultivar Alamo declined faster than that of Cave-in-Rock.

Hellenn, *et al.*, (2012) showed that the percentage of pollen grain germination *in vitro* was highest for 'Brazilian seedless' (52.5%) and lowest for cultivar Gefner (5.9%). Preliminary results indicated that pollen grains of 'Brazilian seedless' are viable and that natural or artificial pollination is essential for fruit set.

Calic and Devrnja (2012) Studied the pollen morphology and exine ornamentation of an important autochthon plum cultivar (*Prunus domestica* cv. Požegača L.), which has horticultural, medicinal and alimentary uses, was examined in detail using both light and scanning electron microscope (SEM). Acetocarmine and fluorescein diacetate were used to assess the pollen viability of four Požegača plum genotypes.

The effect of polyethylene glycol-PEG (10, 15 and 20%, w/v) on pollen germination and tube growth was evaluated. Overall, the inclusion of PEG in the medium improved both pollen germination and tube growth.

Patel and Patel (2013) reported that the influence of wheat straw mulch and different plant growth regulators on fruit set, yield and quality of custard apple. Maximum flowering duration and fruit retention was observed with wheat straw mulch + GA3 (5 t/ha + 50 ppm) treatments. Highest number of fruits, fruit yield, fruit diameter and fruit pulp were also recorded under same treatments.

Pereira and Montas (2014) studied to determine the effect of pollen storage duration on pollen viability; the percent fruit set by hand pollination of 'Red' sugar apple, 'Lessard Thai' green sugar apple and 'Gefner' atemoya; resulted fruit characteristics as a result of pollen source in South Florida. Hand pollination and in vitro pollen germination tests were arranged in a 3 × 5 factorial design, with three cultivars, five treatments, and five replicates per treatment. It showed that hand pollination promoted high percentage of fruit set.

2.2 Effect of irrigation systems on fruit set.

George *et al.*, (1992) revealed that the fruit set and productivity of custard apple in the field could be improved by techniques which raise relative humidity, such as the use of windbreaks and overhead intermittent misting.

George and Nissen, (2002) who reported that the overall fruit set was not adversely affected by drought. Drought also increased the number of fruit harvested per tree by 47% compared with well-watered controls. This response was mainly due to the increase in flower number per tree. Drought reduced average fruit size by 11% possibly due to effects on cell division in the first 4-6 weeks after fruit set or on net carbon assimilation. In summary, mild to moderate drought during the flowering period and fruit set increased flowering without adversely affecting fruit set, but decreased fruit size.

Wang, *et al.*, (2003) reported that the pineapple produced heavier fruits following sun-hemp than in the other treatments ($P < 0.05$), commercial yields were not different among rapeseed, weed, and sun-hemp treatments.

Caspari, *et al.*, (2007) stated that the flower management has not affected the total yield in the first five years of the trial in grape vineyards. Over five years, total yield was 6% higher with standard irrigation. However, significant differences in yield were found only after three years.

Wolfram, *et al.*, (2009) concluded that deficit irrigation strategies can save considerable amount of water without

affecting the yield to a large extent, possibly increasing the average fruit weight, apparently without negative, effects in mango in long term.

Harel *et al.* (2014) reported that in the hot Mediterranean summer months, the mean daily (day/night) temperature of up to 26 °C and 70 RH% during day time should be achieved when using evaporative cooling such as low pressure fogging systems in shelters. A moderate reduction of 1–1.5 °C in mean daily temperatures together with the increased RH (relative humidity) from 50% to 70% during day time improved the pollen grain's viability in Tomato.

3. MATERIAL AND METHODS

The present study “Effect of agro techniques on pollen viability and fruit set in custard apple” was carried out at Instructional-Cum-Research Orchard of AICRP on Arid Zone Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 2015-16. The research site is located at 20°-10' North latitude and 74°-39' East longitude and about 657m above mean sea level. The average rainfall for the year 2015 was 400 mm and mean maximum temperature in summer was 38.4°C while the minimum was 15°C in winter.

The details of the materials used, method adopted and statistical analysis followed during the course of this investigation are described bellow.

3.1 Material

The experiment was conducted on 18 year old trees of Balanagar variety of custard apple spaced at 5 x 5 m. Healthy trees of uniform growth and vigour were selected for the experiment. The soil of experimental plot was light to medium with 1.5 m depth and good drainage. It has well leveled topography.

3.2 Methodology

The experiment was started one month after harvesting of previous year fruits. The experiment was conducted in randomized block design with three replications during the month of January to June for off season cropping. The

intension of the studies was to harvest the fruits during August-September. The following treatments were given to unit of two plants per replication. The light pruning and removal of dried and diseased branches were performed before sowing of cover crops. Cover crops were sown on 3rd of February. Different cover crops as per the treatments are shown in Plate 1 to Plate 5. All recommended inter-culture operations, manures and fertilizer applications and removal of water shoots were adopted from time to time.

3.2.1 Treatment Details-

A) Cover crops

1. Maize (T₁)
2. Bajra (T₂)
3. Dhaincha (T₃)
4. Jowar (T₄)
5. Sunhemp (T₅)
6. Sod Culture (T₈)

B) Use of irrigation system

7. Foggers (T₆)
8. Sprinkler (T₇)

C) Control

9. Conventional Method)(T₉)

3.2.2. Statistical analysis-

The statistical analysis was completed by standard statistical method suggested by Panse and Sukhatme, (1995).

3.2.3. Observations

The observations in respect of vegetative growth, flowering, yield and quality contributing characters were recorded as follows.

A) Growth Parameters

The effect of cover crops on pollen viability, days required for initiation of flowering, number of flower per branch (shoot), number of flowers per tree and fruit set were recorded as follows.

1. Days required for initiation of flowering

The date of visible appearance of flower on each of the tree was recorded and the average number of days from the date of sowing of cover crops till the date of appearance of flower was counted and recorded as the period required for appearance of flower.

2. Number of flowers per branch (shoot)

From onset of flowering, the total number of flowers per branch was counted from tagged branch on each tree.

3. Number of flowers per tree

From onset of flowering, the total number of flowers per tree was counted from tagged tree.

4. Percent fruit set (%)

The percentage of fruit set was calculated by dividing total number of fruit set by total number of flowers per tree multiplied by 100.

$$\text{Fruit set (\%)} = \frac{\text{Total number of fruits per tree}}{\text{Total number of flowers per tree}} \times 100$$

B) Pollen studies

Testing of pollen viability using aceto-carmin

This was studied by using stain test for the fresh pollen grains from flowers collected separately in glass petri-dishes and transferred separately to the microscopic slide. A drop of 1 % aceto-carmin stain solution was placed in the center of the slide and viewed under the light microscope after a few minutes. Full sized and dark-deep stained pollen grains were counted as viable ones while those broken and unstained were counted as non-viable ones. Average for both the categories were calculated (Jalilop and Kumar, 2007).

C) Environmental parameters

1. Relative humidity within the canopy at an interval of flowering for 15 days

Relative humidity within the canopy was recorded by automatic digital hygrometer.

2. Temperature within the canopy at an interval of flowering for 15 days

Temperature within the canopy was recorded by automatic digital thermohygrometer.

D) Yield and yield contributing characters

1. Average number of fruits per branch (shoot)

As and when the fruits were matured the total number of fruit per branch was counted from tagged tree.

2. Average number of fruits per tree

As and when the fruits were matured the total number of fruit per tree were counted from tagged tree. They were harvested and counted at each harvesting from each observational tree. The total of all the harvestings were averaged.

3. Average weight of fruits (g)

The average fruit weight was calculated by dividing the total weight of fruits per tree (yield) by the total number of fruit per tree.

4. Fruit yield (kg/tree)

The total weight of fruits harvested was taken at each harvesting for each observational tree. The total weight of all harvesting from each tree was done to get weight of fruits harvested per tree during the season.

E) Quality parameters

1. Total soluble solids (°B)

Homogeneous pulp sample was used for recording TSS percentage. The total soluble solids (TSS) were recorded by the Hand Refractometer (Erma Tokyo A⁰32) by taking a drop of

pulp on prism of the refractometer and the readings were recorded for respective treatments.

2. Acidity (%)

The titrable acidity of the pulp was determined from well homogenized pulp with 20 ml water and titrated against 0.1 % NAOH phenolphthalein as an indicator as per the method advocated by A.O.A.C. (1985) and Ranganna, (1986) and expressed as percentage of gluconic acid.

3. Pulp content (%)

For calculating weight of pulp, sum of weight of rind and weight of seed was subtracted from weight of fruit. The weight of pulp was taken separately from each fruit. The percentage pulp was calculated by dividing actual weight of pulp by total weight of fruit multiplied by 100

4. Seed content (%)

The seed were separated from fruits, by separating pulp and outer cover (rind) of fruit. The seed percentage was calculated by dividing total weight of seed by total weight of fruit multiplied by 100.

5. Sugars (%)

The total sugar were worked out as per the method advocated by Ranganna, (1986) and expressed as percentage.

5.1.1 Total sugar (%)

A total sugar was determined by method of Lane and Eynon (1960) as modified by Ranganna(1986)

In a 250 ml volumetric flask, 50 ml custard apple juice was taken. To this, 5 ml concentrated HCl was added and the flask was kept in hot water bath at 70°C to 80°C temperature for 30 minutes. After cooling, the hydrolysate was neutralized by adding a pinch of sodium carbonate till formation of effervescences stopped. The volume of the neutralize hydrolysate was made to 250 ml with distilled water. The total sugars in the neutralize hydrolyate were determined in the same way as described under reducing sugars.

5.1.2 Reducing sugars (%)

Reducing sugars were determined by method suggested by Lane and Eynon (1960) as modified by Ranganna(1986)

Five ml each of Fehlings 'A' and ' B ' solution were pipetted in 250 ml conical flask and diluted to about 50 ml with distilled water. The mixture was heated to boiling, during boiling the clarified sample was added carefully through the burette until the brick red colour appeared. Methylene blue indicator was added and titration was continued until brick red precipitate was formed. The reducing content was calculated and expressed as percent.

5.1.3 Non-Reducing sugars (%)

The non reducing sugars were estimated by subtracting reducing sugars from the total sugars and multiplied by 0.95.

Non reducing sugars= (Per cent Total sugars- Per cent Reducing sugars) x 0.95

F) Incidence of mealy bug (%)

The incidence of mealy bug was recorded by dividing total no. of mealy bug colonies actually present on fruit and total unit area of fruit multiplied by 100.

4. RESULTS

The field experiment entitled “Effect of agro techniques on pollen viability and fruit set in custard apple” was carried out at Instructional-Cum-Research Orchard of AICRP on Arid Zone Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 2015-16. The data has been statistically analysed by using randomized block design. The results obtained are presented under suitable headings and subheadings.

4.1 Flowering, fruit setting and pollen viability

The data in respect of days required for initiation of flowering, number of flowers per branch, number of flowers per tree, pollen viability and fruit set is presented in Table 1.

4.1.1 Days require for initiation of flowering

The data pertaining to days required for initiation of flowering from sowing of different cover crops is presented in Table 1 and graphically depicted in Fig. 1. The total number of days required for initiation flowering was significantly influenced by sowing of different cover crops.

Significantly minimum number of days required for initiation of flowering was recorded in treatment T₃-i.e. Dhaincha (21.00) which were statistically at par with the treatments T₁-Maize(21.67) and T₄-Jowar (21.67).

In case of days required for initiation of flowering from sowing of different cover crops, the treatments T₁-Maize (21.67), T₄-Jawar (21.67) were at par with each others.

Maximum days required for initiation of flowering was observed in treatment T₉-control (Conventional Method) (40.33).

4.1.2 Number of flowers per branch

The data regarding number of flowers per branch presented in Table 1 and graphically depicted in Fig. 2. depicted that the average number of flowers per branch was significantly affected by sowing of different cover crops.

Significantly maximum number of flowers per branch was recorded in the treatment T₂- Bajara (116.90) which was statistically at par with the treatment T₁-sowing Maize (102.40). Lowest numbers of flowers per branch were recorded in T₉- control i.e. Conventional Method (74.81).

4.1.3 Number of flowers per tree

The data regarding number of flowers per tree presented in Table 1 and graphically depicted in Fig. 3. depicted that the average number of flowers per tree was significantly affected by sowing of different cover crops.

Significantly maximum number of flowers per tree was recorded in the treatment T₃-Dhaincha (615.63) which was statistically at par with the treatment T₅- Sunhemp (590.19). Lowest numbers of flowers per tree were recorded in T₉-control i.e. Conventional Method (415.54).

Table 1: Effect of cover crops on flowering, pollen viability and fruit set.

Tr. No	Treatment details	Days required for initiation of flowering	Number of flower per branch	Number of flower per tree	Pollen viability (%)	Fruit set (%)
T ₁	Maize as cover crop	21.67	102.40	551.83	88.95	24.47
T ₂	Bajra as cover crop	22.33	116.90	548.05	90.81	22.79
T ₃	Dhaincha as cover crop	21.00	88.26	615.63	91.77	27.52
T ₄	Jowar as cover crop	21.67	100.99	558.05	84.11	26.51
T ₅	Sunhemp as cover crop	25.67	85.79	590.19	88.10	25.33
T ₆	Foggers	34.33	101.87	473.02	82.83	15.64
T ₇	Sprinklers	29.33	85.23	508.80	79.62	17.54
T ₈	Sod culture	37.07	97.97	458.41	70.11	14.88
T ₉	Control (conventional method)	40.33	74.81	415.54	70.94	13.86
	S. E. +	1.02	6.45	35.91	2.58	0.70
	C. D. at 5%	3.09	19.43	108.19	7.79	2.12

4.1.4 Pollen viability (%)

The data regarding pollen viability percentage presented in Table 1 and graphically depicted in Fig. 4. Treatment wise microscopic images of pollen viability are shown in plate number 10 to 18. The data revealed that pollen viability percentage was significantly influenced by the sowing of different cover crops under study.

The treatment T₃-Dhaincha recorded significantly highest pollen viability percentage (91.77%) which was statistically at par with T₂-Bajara (90.81%). It was on par the treatments T₁-Maize (88.95 %), T₅-Sunhemp (88.10 %) and T₆-Fogger irrigation (82.83%) were at par with each others. The lowest pollen viability percentage was recorded in T₉-control i.e. conventional method (70.94 %).

4.1.5 Fruit set (%)

The data in regarding percent fruit set are presented in Table 1 and graphically depicted in Fig. 4. Sowing of different cover crops significantly influenced fruit set percentage in custard apple.

Significantly maximum fruit set percentage (27.52 %) was observed in the treatment T₃-Dhaincha on par T₄-Jawar(26.51%) were at par with each others. The lowest fruit set was recorded in T₉-control (conventional method)(13.86 %).

4.2 Yield and yield contributing characters

The data regarding average number of fruits per branch, average number of fruits per tree, average weight of fruits and yield per tree are presented in Table 2.

4.2.1 Average number of fruit per branch:

The significant effect of the treatments applied on average number of fruits per branch is graphically depicted in Fig. 5. Average number of fruits per branch was significantly influenced by sowing of different cover crops. The average number of fruits per branch was recorded maximum in T₂-

Bajara (26.63) which is at par with the T₄-Jawar (25.68). The lowest number of fruits per branch was recorded in T₉-control conventional method (10.28).

4.2.2 Average number of fruit per tree

In case of average number of fruits per tree, significant results were obtained due to sowing of different cover crops. The data regarding average number of fruits per tree is presented in Table 2 and graphically depicted in Fig.6.

The highest number of fruits per tree was recorded in treatment T₃-Dhaincha (169.03) and it was on par T₅-Sunhemp (149.68).

The next three best treatments were T₄- i.e. Jowar (142.90), T₁-Maize (134.92) and T₂-Bajara (125.04) which were statistically at par with each other. The lowest number of fruits per tree was registered in T₉-control i.e. conventional method (57.84).

4.2.3 Average weight of fruit (g)

The data regarding average weight of fruits per tree is presented in Table 2 and graphically depicted in Fig.7. The average weight of fruits per tree was significantly influenced by sowing of various cover crops. Significantly maximum weight of fruit was recorded in the treatment T₂- i.e. Bajra (195.67 g). It was on par the treatments T₅- Sunhemp (185.33g), T₃-Dhaincha(170.33g), T₆-Fogger(169.67g), T₁-Maize(162.33),T₄-Jawar(159.67),T₈-Sod culture(136.00) and T₇-Sprinkler (127.00 g) were statistically at par with each

other. The lowest weight of fruit was recorded in T₇-Sprinkler (127.00 g).

Table 2 : Effect of cover crops on yield and yield contributing characters.

Tr. No	Treatment details	Average number of fruit per branch	Average number of fruit per tree	Average weight of fruits (g)	Yield (Kg/tree)
T ₁	Maize as cover crop	24.98	134.92	162.33	21.90
T ₂	Bajra as cover crop	26.63	125.04	195.67	21.58
T ₃	Dhaincha as cover crop	24.26	169.03	170.33	33.05
T ₄	Jowar as cover crop	25.68	142.90	159.67	22.81
T ₅	Sunhemp as cover crop	21.64	149.68	185.33	27.59
T ₆	Foggers	15.87	74.69	169.67	12.63
T ₇	Sprinklers	14.93	89.56	127.00	11.44
T ₈	Sod culture	14.48	67.67	136.00	9.20
T ₉	Control (conventional method)	10.28	57.84	141.00	8.05
	S. E. +	1.09	9.08	8.9	1.81
	C. D. at 5%	3.30	27.37	26.89	5.46

4.2.4 Yield (kg/tree)

The data regarding yield per tree is presented in Table 2 and graphically depicted in Fig.8. The data in respect of yield (kg/tree) was significantly influenced due to sowing of different cover crops. The highest yield per tree was recorded in the treatment T₃-Dhaincha (33.05 kg) over rest of the

treatments , however it was followed by T₅-Sunhemp (27.59) which is at par with T₄-Jowar (22.81).

The treatments T₁-Maize (21.90 kg) and T₂-Bajara (21.58 kg) were statistically at par with each others. The lowest yield per tree was noticed in T₉ – control conventional method (8.05 kg).

4.3 Quality parameters

The data regarding the effect of cover crops on quality parameters such as TSS (°B) and acidity (%) presented in the Table 3. pulp (%), seed (%) and total sugars (%), reducing sugar (%) and non reducing sugars (%) are presented in the Table 4 and 5.

4.3.1 Total soluble solid (°B)

The data regarding the effect of cover crops on TSS is presented in the Table 3 and graphically depicted in Fig.9. It is observed from the Table 3 that effect of sowing of different cover crops on TSS was statistically non significant. However, numerically maximum TSS was recorded in treatment T₁-i.e. Maize (24.25 °B). The lowest total soluble solids content was recorded in T₅-sunhemp (21.95 °B).

4.3.2 Acidity (%)

It is observed from the Table 3 that sowing of different cover crops recorded statistically non significant influence on acidity.

However, numerically lowest acidity was found in the treatment T₄-Jawar (0.23%) and T₇-sprinkler and highest percentage of acidity was noticed T₃-Dhaincha (0.28 %), T₈ and T₉.

Table 3: Effect of cover crops on total soluble solids and percent acidity

Tr. No.	Treatments details	Total soluble solid (°B)	Acidity (%)
T ₁	Maize as cover crop	24.25	0.26
T ₂	Bajra as cover crop	22.83	0.27
T ₃	Dhaincha as cover crop	22.19	0.28
T ₄	Jowar as cover crop	23.36	0.23
T ₅	Sunhemp as cover crop	21.95	0.22
T ₆	Fogger	23.13	0.24
T ₇	Sprinkler	22.27	0.23
T ₈	Sod Culture	23.49	0.28
T ₉	control (conventional method)	22.03	0.28
	S. E. ±	0.56	0.01
	C. D. at 5%	NS	NS

4.3.3 Pulp (%)

The data regarding pulp percentage are presented in Table 4 and graphically depicted in Fig. 10. As evident from the data, significant differences were observed with respect to pulp percentage due to the sowing of different cover crops.

Significantly highest pulp percentage was recorded in the treatment T₂-Bajra (55.30 %) and it is followed by T₃-Dhaincha (52.10 %). The treatments T₆-Fogger (44.89%) and T₇-Sprinkler (43.40 %), T₁-Maize (43.02%) and were also at par with each others. The lowest pulp percentage was recorded in the treatment T₉-control conventional method (40.43 %).

4.3.4 Seed (%)

The data regarding seed percentage are presented in Table 4 and graphically depicted in Fig. 11. There was non significant influence of sowing of cover crops on seed percentage. However, numerically minimum seed percentage was recorded in T₄-Jawar (9.44 %). The maximum seed percentage was recorded in T₉-control (13.45 %)

Table 4 Effect of cover crops on pulp (%), seed (%)

Tr. No	Treatments details	Pulp (%)	Seed (%)
T ₁	Maize as cover crop	43.02	11.82
T ₂	Bajra as cover crop	55.30	10.32
T ₃	Dhaincha as cover crop	52.10	11.89
T ₄	Jowar as cover crop	46.14	9.44
T ₅	Sunhemp as cover crop	42.01	10.83
T ₆	Fogger	44.89	10.34
T ₇	Sprinkler	43.40	10.35
T ₈	Sod culture	45.07	11.28
T ₉	control (conventional method)	40.43	13.45
	S. E. ±	1.60	0.95
	C. D. at 5%	4.84	NS

4.3.5 Total Sugars (%)

The data regarding total sugars were presented in Table 5 and graphically depicted in Fig.12. Sowing of different cover crops showed non significant effect on total sugar percentage. However, numerically the maximum total sugar percentage was recorded in T₁-Maize (15.21 %). The minimum total sugars were recorded in T₅-sunhemp (14.17 %).

Table 5. Effect of cover crop on sugars

Tr. No	Treatment details	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)
T ₁	Maize as cover crop	15.21	13.08	2.02
T ₂	Bajra as cover crop	14.70	12.27	2.32
T ₃	Dhaincha as cover crop	14.36	12.77	1.50
T ₄	Jowar as cover crop	14.67	12.47	2.10
T ₅	Sunhemp as cover crop	14.17	11.80	2.20
T ₆	Fogger	14.46	12.53	1.83
T ₇	Sprinkler	14.93	12.72	2.03
T ₈	Sod Culture	14.38	12.41	1.73
T ₉	Control	14.50	13.04	1.38
	S. E. ±	0.63	0.57	0.35
	C. D. at 5%	NS	NS	NS

4.3.5.1 Reducing sugar (%)

The data regarding reducing sugars were presented in Table 5 and graphically depicted in Fig.13. Sowing of different cover crops showed non significant effect on reducing sugar percentage. However, numerically the maximum reducing sugar percentage was recorded in T1-Maize (13.08 %). The minimum reducing sugars were recorded in T₅-sunhemp (11.80 %)

4.3.5.2 Non reducing sugar (%)

The data regarding non reducing sugars were presented in Table 5 and graphically depicted in Fig.14. Sowing of different cover crops showed non significant effect on non reducing sugar percentage. However, numerically the maximum non reducing sugar percentage was recorded in T2-Bajra (2.32%). The minimum non reducing sugars were recorded in control conventional method (1.38 %).

4.4 Incidence of mealy bug (%)

The data regarding incidence of mealy bug is presented in Table 6 and graphically depicted in Fig.15. The significant differences were observed with respect to the incidence of mealy bug on the fruits due to sowing of various cover crops and agronomic techniques.

Lowest incidence of mealy bug was noticed in the treatment T₄-Jowar (1.53 %) which were at par with the treatments T₇-Sprinkler (2.59 %), T₈-Sod culture (3.53%), T₅-Sunhemp (3.99 %),and T₃-Dhaincha (5.72). However, the highest incidence of mealy bug was observed in the treatment

T₉-control conventional method (20.10 %) which was at par with T₁-Maize (18.22 %)

Table 6 : Effect of cover crops on incidence of mealy bug

Tr. No.	Treatment details	Incidence of mealy bug (%)
T ₁	Maize as cover crop	18.22
T ₂	Bajra as cover crop	8.49
T ₃	Dhaincha as cover crop	5.72
T ₄	Jowar as cover crop	1.53
T ₅	Sunhemp as cover crop	3.99
T ₆	Fogger	8.68
T ₇	Sprinkler	2.59
T ₈	Sod culture	3.53
T ₉	Control (conventional method)	20.10
	S. E. ±	0.86
	C. D. at 5%	2.61

5. DISCUSSION

The present investigation entitled, “Effect of agro techniques on pollen viability and fruit set in custard apple” was carried out at Instructional-Cum-Research Orchard of AICRP on Arid Zone Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 2015-16. The results obtained with respect to various experimental characters are discussed in this chapter.

5.1 Flowering, fruit setting and pollen viability

The results of growth parameters *viz.*, days required for initiation of flowering, percent fruit set affected by various cover crops sown in the present investigation differed significantly.

5.1.1 Days required for initiation of flowering

The data on days required for initiation of flowering presented in Table 1 indicated that, days required for initiation of flower decreased significantly due to cover crops sown in custard apple. The data showed that, significantly minimum number of days required for initiation of flowering was recorded in treatment T₃-Dhaincha (21.00) which were statistically at par with the treatments T₁-Maize (21.67) and T₄-Jowar (21.67). The treatments T₂-Bajara (22.33), T₅-Sunhemp (25.67) were at par with each others. Maximum days required for initiation of flowering was observed in treatment T₉-control i.e conventional method (40.33).

The above results are obtained due to high humidity and low temperature within canopy of crop. Weather data showed that there was decrease in canopy temperature from 0.6 to 2.3 °C and increase in relative humidity from 0.9 to 3.9 % in treatment T₃-Dhaincha as compared to open conditions during the period under study. Therefore, least days recorded for flowering could be due to sowing of cover crop of Dhaincha, which decreases canopy temperature and increases relative humidity. The canopy temperature found decreasing and relative humidity increasing more or less in all the treatments than open conditions under study (Appendix-II).

George and Nissen, (1987) reported that the temperatures above 32°C are more conducive to vegetative flushing and increased competition between fruit-lets and vegetative growth, resulting in reduced fruit set in custard apple.

The results obtained are also in accordance with Sanewski (1988) who studied that the temperatures above 28°C, custard apples produce more vegetative growth and fewer flowers and drying of flower parts increases. Temperatures at 25°C to 28°C during flowering (October to February) are favourable for good fruit set. A relative humidity 70 % to 80 % is best for fruit set and the development of good fruit shape.

As compared with the control conventional method the treatment T₆-Fogger irrigation and T₇-Sprinkler irrigation also reduced the days required for initiation of flowering. These results are in accordance with the George *et. al.* (1995) who

studied that light applications of irrigation in the late afternoon using wide-row mini sprinklers also will help opening flowers maintain their stigma receptivity until the following morning.

5.1.2 Number of flowers per branch

Significantly maximum number of flowers per branch was recorded in the treatment T₂-Bajara (116.90) which was statistically at par with the treatment T₁-Maize (102.40). Lowest numbers of flowers per branch were recorded in T₉-control (74.81).

These results are more or less in conformity with George and Nissen, (2002) and showed that the moderate drought ($\Psi_L = 21.5$ MPa) reduced shoot growth by 20-30% and increased the number of flowers per lateral by about 40% compared with well-watered controls due to reduced apical dominance and increased lateral branching.

Results are also in accordance with the Abdel Aziz *et al.*, (2008) who showed that the cover crops, the cultivation methods and their interaction were insignificant in the first season whereas only the cover crops gave a significant result in the second season. In this respect, it is clear that the *T. alexandrinum* L. and *T. foenum* gave the highest value compared to the fallow treatment in Valencia orange trees. This increase could be due to the fixed nitrogen by the cover crop which influences the trees vegetative growth (Esteban, 2001).

5.1.3 Number of flowers per tree

Significantly maximum number of flowers per tree was recorded in the treatment T₃-i.e. Dhaincha (615.63) which was statistically at par with the treatment T₅-i.e. Sunhemp (590.19). Lowest numbers of flowers per tree were recorded in T₉- control i.e. conventional method (415.54).

5.1.4 Pollen viability percentage

The data regarding pollen viability percentage presented in Table 1 and its microscopic images shown in Plate 6 to Plate 14. The data revealed that pollen viability percentage was significantly influenced by the sowing of different cover crops under study.

The treatment T₃-Dhaincha recorded significantly highest pollen viability percentage (91.77 %) which was statistically at par with T₂-Bajara (90.81%). The treatments T₁-Maize (88.95 %), T₅-Sunhemp (86.12 %) and T₆-Fogger (82.83 %) were at par with each others. The lowest pollen viability percentage was recorded in T₉-control conventional method (70.94%).

As per the weather data recorded, there was decrease in canopy temperature from 0.6 to 2.3 °C and increase in relative humidity from 0.9 to 3.9 % in treatment T₃- Dhaincha as compared to open conditions during the months under study. Therefore, highest pollen viability percentage could be due to sowing cover crop of Dhaincha which decreases canopy temperature and increases relative humidity. The canopy temperature found decreasing and relative humidity

increasing more or less in all the treatments than open conditions under study (Appendix-II).

Kumar *et al.*, (1977) reported that maximum pollen germination was obtained in 20 per cent sucrose-agar solution. At the time of dehiscence, receptivity of stigma started disappearing and completely lost after six hours resulting in poor fruit set. It is suggested that more fruit set may be obtained if the receptivity of stigma is enhanced by auxin sprays.

Results obtained pertaining to pollen viability are in accordance with the results obtained by Higuchia *et al.*, (1998) who reported that the pollen germination percentage was adversely affected by warm temperatures and pollen development period was more heat-sensitive than pollen germination.

Sahoo, *et al.*, (2000) recorded, the viability of pollen varied from 52.30% to 93.33% in the green type and 45.10% to 93.33% in the red type in custard apple. Hence the highest pollen viability is recorded from June to August in both varieties. Fruit set by controlled self-pollination was only 0.75%.

Yaxin Ge *et al.*, (2011) reported that the pollen viability dropped rapidly with increasing temperature in *Panicum virgatum* L. After treatment at various temperatures (18-40°C), pollen viability of the cultivar Alamo declined faster than that of Cave-in-Rock.

These results are more or less in conformity with Hellenn, *et al.*, (2012) who showed that the percentage of pollen grain germination in vitro was highest for 'Brazilian seedless' (52.5%) and lowest for cultivar Gefner (5.9%). Preliminary results indicated that pollen grains of 'Brazilian seedless' are viable and that natural or artificial pollination is essential for fruit set.

5.1.5 Fruit set (%)

The data regarding percent fruit set and fruit retention are presented in Table 1. The result revealed that percent fruit set and fruit retention percentage was significantly influenced by the sowing of different cover crops in custard apple.

Significantly maximum fruit set percentage (27.52) was observed in the treatment T₃-Dhaincha. In case of fruit set percentage, the treatments T₁-Maize, T₄- Jowar, T₅- Sunhemp were at par with each others. The lowest fruit set was recorded in T₉- control conventional method (13.86 %).

As per the weather data recorded, there was decrease in canopy temperature from 0.6 to 2.3 °C and increase in relative humidity from 0.9 to 3.9 % in treatment T₃- Dhaincha as compared to open conditions during the months under study. Therefore, percent fruit set recorded maximum due to sowing cover crop of Dhaincha which decreases canopy temperature and increases relative humidity. The canopy temperature found decreasing and relative humidity increasing more or less in all the treatments than open conditions under study (Appendix-I).

The present investigation is in confirmation with the results obtained by George and Nissen, (1988) who observed that the flowering and fruit set were affected not only by the environmental conditions during flowering, but also by vegetative flushing of the tree. Flowering was closely associated with vegetative flushing. Soil moisture stress (mid-day leaf water potential -2.0 MPa) also reduced flowering and fruit set, particularly at high temperature (28°C). Productivity of custard apple in the field may be improved by cultural techniques such as overhead misting, windbreaks and efficient irrigation scheduling.

Cover crops have the advantages not only to increase water-holding capacity but also to modify the microclimate under the tree canopy. These advantages reduce tree stress which can positively affect on the fruit set percentage and negatively affect on fruit drop percentage.

Higuchia *et al.*, (1998) reported that, high temperatures decreased fruit set percentage; the highest percentage fruit set was obtained in the 'cool' pollen \pm cool' flower pollination treatment (10 out of 10 flowers/fruit), and the lowest (3 out of 11) was in the 'warm \pm warm' pollination treatment in custard apple.

These results are more or less in conformity with Abdel-Aziz *et al.*, (2008) observed that the effect of the interaction on the fruit set percentage was not significant whereas both the cultivation methods and the cover crops had significant differences on fruit set in Valencia orange trees. Both the *T. alexandrinum* L. and *T. foenum* cover crops

decreased the percentage of total fruit drop without significant differences between them compared with the fallow treatment.

Stigmas may remain receptive for longer under high humidity conditions, providing opportunities for higher level of pollination and fruit set. High temperature and low humidity has the opposite effect. Relative humidity below 75% has a negative impact on fruit set by affecting stigma receptivity.

Patel and Patel (2013) reported that the influence of wheat straw mulch and different plant growth regulators on fruit set, yield and quality of custard apple. Maximum flowering duration and fruit retention was observed with wheat straw mulch + GA3 (5 t/ha + 50 ppm) treatments. Highest number of fruits, fruit yield, fruit diameter and fruit pulp were also recorded under same treatments.

5.2 Yield & yield contributing parameters

The data regarding average number of fruits per tree, average weight of fruit (g) and fruit yield (kg/tree) are presented in table 2. The result revealed that the average number of fruits, average weight of fruit (g) and fruit yield (kg/tree) was significantly influenced by the sowing of different cover crops in custard apple.

Average number of fruits per branch was significantly influenced by sowing of different cover crops. The average number of fruits per branch was recorded maximum in T₂ - Bajara (26.63) which is at par with the T₅- Sunhemp (25.68). The lowest number of fruits per branch was recorded in T₉- control conventional method (10.28).

In case of average number of fruits per tree, significant results were obtained due to sowing of different cover crops. The highest number of fruits per tree was recorded in treatment T₃-Dhaincha (169.03) and it was followed by T₅-Sunhemp (149.68). . The lowest number of fruits per tree was registered in T₉-control i.e. conventional method (57.84).

Significantly maximum weight of fruit was recorded in the treatment T₂-Bajra (195.67 g).

The treatments T₄-Jowar (159.67 g), T₆-Fogger (169.67 g), T₁- Maize (162.33 g), T₈-Sod culture (136.00g), T₅-Sunhemp(171.00), T₇-Sprinkler (170.33), T₃-Dhaincha (185.33g) and T₉ – control i.e. conventional method (141.00 g) were statistically at par with each others. The lowest weight of fruit was recorded in T₈ - Sprinkler (127.00 g).

The data in respect of yield (kg/tree) was significantly influenced due to sowing of different cover crops. The highest yield per tree was recorded in the treatment T₃-Dhaincha (33.05 kg) followed by T₅- Sunhemp (27.59).

The treatments T₄-Jawar (22.81 kg), T₁-Maize (21.90 kg) and T₂-Bajara (21.58 Kg) were statistically at par with each others. The lowest yield per tree was noticed in T₉ – control i.e. conventional method (8.05kg).

As per the weather data recorded, there was decrease in canopy temperature from 0.4 to 2.4 °C and increase in relative humidity from 1.0 to 4.0 % in treatment T₃-Dhaincha as compared to open conditions during the months under study.

Therefore, highest productivity of custard apple could be improved by sowing cover crop of Dhaincha which decreases canopy temperature and increases relative humidity. The canopy temperature found decreasing and relative humidity increasing more or less in all the treatments than open conditions under study (Appendix-II).

The productivity of custard apple in the field could be improved by techniques which raise relative humidity, such as the use of windbreaks and overhead intermittent misting (George *et al.* 1992).

George and Nissen, (2002) revealed that the overall fruit set was not adversely affected by drought. Drought also increased the number of fruit harvested per tree by 47% compared with well-watered controls. This response was mainly due to the increase in flower number per tree. Drought reduced average fruit size by 11% possibly due to effects on cell division in the first 4-6 weeks after fruit set or on net carbon assimilation. In summary, mild to moderate drought during the flowering period and fruit set increased flowering without adversely affecting fruit set, but decreased fruit size.

Caspari, *et al.*, (2007) stated that the floor management has not affected the total yield in the first five years of the trial in grape vineyards. Over five years, total yield was 6% higher with standard irrigation. However, significant differences in yield were found in third year. Under Toshka conditions and similar to those prevailed in the present investigation, Egyptian clover (*Trifolium alexandrinum* L.) could be the best

option to be cultivated in citrus orchards especially in new reclaimed lands.

Walser, *et al.*, (2007) revealed that the use of cover crops with compost amendments will provide adequate mineral nutrition and increase soil organic matter as well as provide for ecological gains.

Results obtained pertaining to fruit set and fruit yield are in agreement with the results obtained by Abdel Aziz, *et al.* (2008) who showed that fruit set, tree vegetative growth, fruit yield, soil organic carbon and soil moisture content, were enhanced and fruit drop was decreased with the cover crop treatments. However, the (BR and BWR) cultivation methods with the Egyptian clover gave the best results without significant differences between them regarding vegetative growth, yield and soil fertility.

Wolfram, *et al.*, (2009) concluded that deficit irrigation strategies can save considerable amounts of water without affecting the yield to a large extent, possibly increasing the average fruit weight, apparently without negative long term effects in mango.

5.3 Quality parameters

The data regarding total soluble solid ($^{\circ}\text{B}$), acidity (%), pulp (%), seed (%), total sugar (%), reducing sugar(%) and non reducing sugar(%) are presented in Table 3, 4 and 5. It revealed that the total soluble solid ($^{\circ}\text{B}$), acidity(%), seed (%), total sugar (%),reducing sugar(%) and non reducing sugar(%) were statistically non significant in relation to the sowing of

different cover crops in custard apple. However, in case of pulp (%), significant results were obtained due to sowing of different cover crops.

It is observed from the Table 3 that effect of sowing of different cover crops on TSS was statistically non significant. However, numerically maximum TSS recorded in treatment T₁-Maize(24.25⁰B). The lowest total soluble solids content was recorded in T₅ -Sunhemp (21.95 ⁰B).

Sowing of different cover crops recorded statistically non significant influence on acidity. However, numerically lowest acidity was found in the treatment T₄-Jawar (0.23 %) and highest percentage of acidity was noticed T₃-Dhaincha (0.28%).

The data regarding pulp percentage are presented in Table 4. As evident from the data, significant differences were observed with respect to pulp percentage due to the sowing of different cover crops.

Significantly highest pulp weight was recorded in the treatment T₂-Bajra (55.30 %) and it is followed by T₃-Dhaincha (52.10 %) which is at par with the T₄-jawar (46.14) T₈-Sod culture (45.07 %) the lowest pulp weight was recorded in the treatment T₉- control i.e. conventional method (40.43 %). The treatments T₆-Fogger (44.89 %) and T₇-sprinkler (43.40 %), T₁-Maize (43.02). There was non significant influence of sowing of cover crops on seed percentage. However, numerically minimum seed percentage was recorded in T₄- Jawar (9.44 %). The maximum seed percentage was recorded in T₉-control

conventional method (13.45 %) and Sod culture (11.28%) were also at par with each others.

The data regarding total sugars were presented in Table 5. Sowing of different cover crops shows non significant effect on total sugar percentage. However numerically the maximum total sugar percentage was recorded in T₁-Maize (15.21 %). The minimum total sugars were recorded in Sunhemp (14.17 %). The Maximum reducing sugar percentage was recorded in Maize (13.08%) and minimum percentage was recorded in sunnhemp (11.80%). High percentage of non reducing sugar was recorded in Bajra (2.32%) and low percentage in control conventional method(1.38%).

The present investigation is in confirmation with the results obtained by Higuchia *et al.*, (1998) suggested that the warm temperatures produced asymmetrical and small fruit containing a small number of seeds, caused by low viability pollen. Temperature had no significant effect on the total soluble solid content in fruit.

Weight of seed was ranged from 18.9 to 26.4 per cent indicating the effect of different locations on weight of seeds per fruit. It was also interesting to note that irrespective of higher number of seeds, the unit weight of the seed was lower in organized orchard compared to unorganized ones. The higher yield of fruit pulp (50.00%) recorded by the fruits collected from the organized orchards. The total sugar content of the pulp notifying the quality of the fruit was recorded in the range of 18.1 to 22.0 per cent with average value of 19.5. The marginal difference in total sugars may be associated with

location and cultivars. A slight variation in acidity in custard apple pulp at different locations was observed. The per cent acidity was recorded in range from 0.23 to 0.28.

5.4 Incidence of mealy bug (%)

The data regarding incidence of mealy bugs is presented in Table 6. The significant differences were observed with respect to the incidence of mealy bug on the fruits due to sowing of various cover crops and agronomic practices.

Lowest incidence of mealy bug was noticed in the treatment T₄-Jowar (1.53 %) which were at par with the treatments T₇-Sprinkler (2.59 %), T₈-Sod culture (3.53%), T₅-Sunhemp (3.99 %), T₃-Dhaincha (5.72 %) and T₂-Bajara (8.49). However, the highest incidence of mealy bug was observed in the treatment T₉-control conventional method (20.10 %) which is at par with T₁-Maize(18.22%).

Anonymous, (1991) studied on population dynamics of mealy bugs on pomegranate (*Punica granatum* L.) and custard apple conducted at Rahuri during 1991-1992 indicated that, the peak mealy bug population in pomegranate orchard was recorded in April (31.50 %) and May (21.16 %) and low incidence from October (0.0 %) to December (1.0 %) while, in Custard apple orchard, the infestation of mealy bugs was much evident in October (2.50 %) and November (5.80 %).

During the survey of the pests of grape vine gardens at Arvi Pimpalgaon of Pune district (Maharashtra) in 1991-1992, it was observed that, the mealy bug population was more from

middle of February to May and middle of September to middle of November. The pest was found to be inactive from middle of November to middle of February (Anonymous, 1992).

Another study on pests of custard apple carried out at Solapur (Maharashtra) in 1994 revealed that the infestation of mealy bugs was severe and recorded its peak (85.10% infestation of fruits /plant) in the first fortnight of December and there existed a negative correlation of mealy bug infestation with minimum and maximum temperature, relative humidity and rainfall (Anon, 1995).

6. SUMMARY AND CONCLUSIONS

Among annonaceous fruits, custard apple botanically known as *Annona squamosa* L., is most important dry land fruit of India. It is popular by virtue of its spontaneous spread in forest, waste lands, rocky slope and other uncultivated places. It is generally as a semi-wild fruit. In Maharashtra, approximately 83 percent area is under dry land conditions. Hence, there is very vast scope for cultivation of annonaceous fruit crops. However, high temperature and low relative humidity in dry land conditions, receptivity of stigma and viability of pollen is reduced which affects fruit set and thus yield. By growing of cover crops like Maize, Bajra, Dhaincha, Jowar and Sunhemp in custard apple, we can modify the microclimate which helps to increase the fruit set and yield as reported in literature cited.

Therefore, the present investigation entitled “Effect of agro techniques on pollen viability and fruit set in custard apple” was planned and executed at Instructional Cum Research Orchard, Arid Zone Fruit Project, Department of Horticulture, MPKV., Rahuri during the year 2015. The trial was laid out in the randomized block design with nine treatments and three replications.

The data obtained in respect to days required for initiation flowering, number of flower per branch, number of flower per tree, pollen viability(%), fruit set(%), average number of fruit per branch, average number of fruits per tree, average weight of fruits, yield (Kg/tree), TSS(°B), acidity (%), pulp (%), Seed (%), per cent of total sugar, reducing sugar, non reducing

sugar and incidence of mealy bug (%) has been summarized below.

6.1 Flowering, fruit setting and pollen viability:

Significantly minimum number of days required for initiation of flowering was recorded in treatment T₃-iDhaincha (21.00) which were statistically at par with the treatments T₄-Jawar (21.67) and T₁-Maize (21.67). Maximum days required for initiation of flowering was observed in treatment T₉-control conventional method (40.33).

Significantly maximum number of flowers per branch was recorded in the treatment T₂-Bajra (116.90) which was statistically at par with the treatment T₁-Maize (102.40). Lowest numbers of flowers per branch were recorded in T₉-control conventional method (74.81).

Significantly maximum number of flowers per tree was recorded in the treatment T₃-Dhaincha (615.63) which was statistically at par with the treatment T₅-Sunhemp (590.19). Lowest numbers of flowers per tree were recorded in T₉-control conventional method (415.54).

Significantly maximum fruit set percentage (27.52) was observed in the treatment T₃-Dhaincha. The lowest fruit set was recorded in T₉-control (13.86 %).

The treatment T₃-Dhaincha recorded significantly highest pollen viability percentage (91.77 %) which was statistically at par with T₂-Bajara (90.81 %). The lowest

pollen viability percentage was recorded in T₉-control conventional method (70.11 %).

6.2 Yield and yield contributing characters:

The average number of fruits per branch was recorded maximum in T₂-Bajra (26.63) which is at par with the T₁-Maize (24.98). The lowest number of fruits per branch was recorded in T₉- control conventional method(10.28). The highest number of fruits per tree was recorded in treatment T₃-Dhaincha (169.03). The lowest number of fruits per tree was recorded in T₉-control conventional method (57.84).

Significantly maximum weight of fruit was recorded in the treatment T₂-Bajra (195.67g). The lowest weight of fruit was recorded in T₇ -Sprinkler (127.00g).

The highest yield per tree was recorded in the treatment T₃-Dhaincha (33.05 kg). The lowest yield per tree was noticed in T₉ –control conventional method (8.05kg).

6.3 Quality contributing traits:

The maximum TSS recorded in treatment T₂-Bajara (22.83 °B). The lowest total soluble solids content was recorded in T₅ -Sunhemp (21.95 °B).

The lowest acidity was found in the treatment T₅-Sunhemp (0.22 %) and highest percentage of acidity was noticed T₃-Dhaincha (0.28 %) and same value is recorded in Sprinkler and control conventional method.

Significantly highest pulp weight was recorded in the treatment T₂-Bajra (55.30 %). The lowest pulp weight was

recorded in the treatment T₉- control conventional method (40.43 %).

The minimum seed percentage was recorded in T₄-Jawar (9.44 %). The maximum seed percentage was recorded in T₉-control conventional method (13.45 %)

The maximum total sugar percentage was recorded in T₁-Maize (15.21 %). The minimum total sugars were recorded in Sunhemp(14.17 %). The maximum reducing sugar percentage was recorded in T₁- Maize (13.08 %). The minimum reducing sugars were recorded in sunhemp (11.80 %). The maximum non reducing sugar percentage was recorded in T₂-Bajra (2.32%). The minimum non reducing sugars were recorded in control conventional method (1.38 %).

Lowest incidence of mealy bug was noticed in the treatment T₄-Jowar (1.53 %) which were at par with the treatments T₇-Sprinkler (2.59 %), T₈-Sod culture (3.53), T₅-Sunhemp (3.99 %), T₃-Dhaincha (5.72 %) and T₂-Bajara(8.49).However, the highest incidence of mealy bug was observed in the treatment T₉-control conventional method (20.11 %) which is at par with T₁- Maize (18.22 %).

CONCLUSION

The present investigation reveals that sowing cover crops is a promising tool for improving flowering, pollen viability, fruit set and yield of custard apple. Though most of the quality parameters such as TSS(°B), acidity(%) and sugars(%) are not significantly correlated to the sowing of cover crops and irrigation system, the pulp percentage and seed percentage shows large variation. The incidence of mealy bug also reduced due to the sowing of different cover crops except maize which is more than the control conventional method.

Thus it can be concluded that the treatment T₃-Dhaincha (Sowing during first week of february) is superior over all treatments. It is proved responsible for improving pollen viability, fruit set and yield in custard apple.

7. LITERATURE CITED

- Abdel Aziz, R.A. Salem, S.E. and Al-Bitar, L. (2008) Effect of inter-cropping cover crops on Citrus orchards growth and fruiting under Toshka conditions. J. Agril. Vet. Sci. Vol. 1. (2), pp. 101-110.
- Ahmed, M.S. (1936a) Ministry Agric. Egypt. Hort. Section Bull.,No. 14.
- Ahmed, M.S. (1936b) Ministry Agric. Egypt. Hort. Section Bull.,No.157.
- Anonymous, (1991) A report submitted to the Research Review Sub-Committee Meeting in Agricultural Entomology and Nematology for 1989-90 Mahatma Phule Krushi Vidhyapeeth Rahuri, Maharashtra (India), pp: 20.
- Anonymous, (1992) A report submitted to the Research Review Sub-Committee Meeting in Agricultural Entomology and Nematology for 1991-92 Mahatma Phule Krushi Vidhyapeeth Rahuri, Maharashtra (India), pp: 19.
- Anonymous, (1995) A report submitted to the Research Review Sub-Committee Meeting in Agricultural Entomology and Nematology for the year 1994-95 Mahatma Phule Krushi Vidhyapeeth, Rahuri, Maharashtra (India), pp: 20.
- Anonymous, (2014-15) A report published by ministry of Agriculture, Govt. of India, (ON941).

- A.O.A.C. (1985) Official methods of Analysis, 9th Edn. Associatio of Agricultural Chemists, Washington D.C. 1985.
- Carol, J. L. (1997) Pollination biology and fruit set in Avocado. Proceedings from Conference 97: Searching for quality. Joint Meeting of the Australian Avocado Growers Federation, Inc. and NZ Avocado Growers association, inc., 23-26 September, 1997. pp: 98-105.
- Caspari, H.W., Neal, S. and Naylor A. (2007) Influence of vineyard floor management practices on Grapevine vegetative growth, yield, and fruit composition. Am. J. Enol. Vitic. 58:1-11.
- Callic D. and Devrnja N. (2012) pollen morphology, viability and germination of *Prunus domestican* cv Pozegaca. Sci. Hort.155:118-122.
- Esteban, A.H. (2001). Fertilization programs for apple orchards. New Mexico State University is an equal opportunity/affirmative action employer and educator. NMSU and the U.S. Department of Agriculture cooperating.
- Gazit, S., Galon, I. and Podoler, H.(1982) The role of nitidulid beetles in natural pollination of *Annona* in Israel. J. Amer. Soc. Hort. Sci. 107:849-852.
- George, A.P. and Nissen R.J. (1986) Bienn. Rep. Moroochy Hort. Res.Stn.,4 : 46-68

- George, A.P. and Nissen, R.J. (1987) The effect of day/night temperature on growth and dry matter production of custard apple (*Annona cherimola* x *Annona squamosa*) cv. African Pride. *Sci. Hort.*, 31:269-274.
- George, A.P. and Nissen, R.J. (1988) The effects of temperature, vapor pressure deficit and soil moisture stress on growth, flowering and fruit set of custard apple (*Annona cherimola*, *Annona squamosa*) cultivar African Pride. *Sci. Hort.*, 34, 183-192.
- George, A.P., Nissen, R.J. and Howitt, C. (1992) Effects of environmental variables and cropping on leaf conductance of custard apple (*Annona cherimola* x *Annona squamosa*) 'African Pride'. *Sci. Hort.* 45 (1 & 2):137-147.
- George, A.P., Thomas, M.J., Campbell J.A. and Nissen, R.J. (1995) Hand pollination of custard apples. A DPI Technical Feature. *Queensland Fruit & Vegetable News*, Nov. 16, 1995.
- George, A.P. and Nissen, R.J. (2002) Effects of drought on fruit set, yield and quality of Custard apple (*Annona Spp.* Hybrid) 'African Pride' plants. *J. Hort. Sci. Biotech.* 77 (4): 418-427.
- Harel Danny, Hadar Fadida, Slepoy Alik, Shelly Gantz 2 and Kobi Shilo. (2014). The Effect of Mean Daily Temperature and Relative Humidity on Pollen, Fruit Set and Yield of Tomato Grown in Commercial Protected Cultivation. *Agronomy*, 4: 167-177.

- Hayes, W.B.(1957) Fruit growing in India, Kitabistan, Allahabad, pp.358-387
- Hellenn, T. A. M., Márcia, R. C., Silvia, N., João, A. A. O. and Marlon, C. T. P. (2012) Pollen grain germination and fruit set in 'Brazilian seedless' sugar apple (*Annona squamosa* L.). Crop Breeding and Applied Biotechnology, 12: 277-280.
- Higuchia, H., Utsunomiya, N. and Sakuratania, T. (1998) High temperature effects on cherimoya fruit set, growth and development under greenhouse conditions. Sci. Hort., (77), 23-31.
- Hopping, M.E. (1983) Pollination and fruit set of cherimoya. Orchard. N. Z., 55(2): 56-60.
- Jalikop, S.H. and Kumar, R. (2007) Pseudo-xenic effect of allied *Annona* spp. pollen in hand pollination of cv 'Arka Sahan' [(*A. cherimola* x *A. squamosa*) x *A.squamosa*]. Hort. Sci. 42(7):1534-1538.
- Kumar, R., Hoda M. N. and Singh D. K. (1977) Studies on the Floral Biology of Custard Apple (*Annona Squamosa* Linn.). *Indian Hort.*, Vol.: 34, (3):252-256.
- Kubilay, D. and Sinan E. T. I. (2001) Determination of pollen quality, quantity and effect of cross pollination on the fruit set and quality in the pomegranate. Turk. J. agric. For., 25 (3):169-173.

- Lane, J. H. and Eynon (1960). Determination of reducing sugars by Fehling's solution with methylene blue as internal indicator. *J. Soc. Chem., India.*, 42: 32-37
- Lopes, C. M., Monteiro, A., Machado, J. P., Fernandes, N. and Araújo, A. (2008) Cover cropping in a sloping non-irrigated vineyard: II- effects on vegetative growth, yield, berry and wine quality of 'cabernet sauvignon' grapevines. *Ciência Téc. Vitiv.* 23 (1): 37-43.
- Nainwad R.V. and Dheware R.M.(2010) effect of intercrops on growth and yield of custard apple. *Asian J. Hort.*; 6 (1): 29-31
- Panse, V. G. and Sukhatme, P. V. (1995) *Statistical Methods for Agricultural Workers.* 4th Edi. I.C.A.R., New Delhi pp-347.
- Parekh, O.P. and Sharma, S. (1993) Custard apple, *Indian Hort.* April-June pp: 47-56.
- Patel N.M. and Patel M.M.(2013) effect of cultural and chemical treatments on fruit set and fruit yield of custard apple cv Sindhan. *Asian J.Hort.*,5(2):498-502
- Pereira C. T. and Wanda Montas (2014) effect of storage length and flowering stage of pollen influence its viability, fruit set and fruit quality in Red and Lessard Thai sugar apple and Gefner atemoya. *Sci. Hort.*, 178: 55-60.

- Ranganna, S. (1986) Manuals of analysis of fruit and vegetable production. Tata Mc Grow Hill Pub. Co. Ltd., New Delhi, pp: 7-12.
- Rao S.N. (1974) Indian Hort; 19: 19-21.
- Rebecca M. S. and Paul S. R. (2010) Alleyway cover crops have little influence on Pinot noir Grapevines (*Vitis vinifera* L.) in two Western Oregon vineyards. *Am. J. Enol. Vitic.* Vol. 61:240-252.
- Roselle, P., Herrero, M., Galan Sauco, V. (1999). Pollen germination of cherimoya (*Annona cherimola* Mill.) – In vivo characterization and optimization of in vitro germination. *Sci Hort.* 81: 251-265.
- Sahoo, S.C., Panda, J.M. and Mohanty, D. (2000) A note on pollen morphology, viability, pollination and fruit set in custard apple (*Annona squamosa* L.). *Orissa J. Hort.* 28:109–110.
- Sanewski, G. M. (1988) Growing custard apples. Queensland Department of Primary Industries Information Series Q187014, Maroochy Horticultural Research Station, P.O. Box 5083, Sunshine Coast Mail Centre, Australia.
- Shivanna, K.R., and Cresti, M., (1989). Effects of high humidity and temperature stress on pollen membrane integrity and pollen vigor in *Nicotiana tabacum*. *Sex Plant Reprod.* 2, 137–141.
- Thakur, D.R. and Singh, R.N. (1965) *Indian J. Hort.*, 22 : 10-18

- Venkatratnam,L.(1963) Fruit culture in India (Eds. Sham Singh, S. Krishnamurti and S.L. Katyal , ICAR New Delhi , pp. 217-224.
- Walser, R., Weiss, M., Guldán, S., Ulery, A. and Flynn, R. (2007) Cover crops and compost amendments for organic grape production. Western Nutrient Management Conference. Salt Lake City, UT. Vol. 7: 176-181
- Wang, K. H., Sipes, B. S. and Schmitt D. P. (2003) Intercropping cover crops with Pineapple for the management of *Rotylenchulus reniformis*. *Nematology*, 35(1):39-47.
- Wolfram, S., Somchai, O., Martin, H., Jens N. W. and Joachim, M. (2009) Yield and fruit development in mango (*Mangifera indica* L. cv. Chok Anan) under different irrigation regimes. Science Direct, Agricultural Water Management, 96:574-584.
- Yaxin Ge, Chunxiang Fu, Hem Bhandari, Joseph Bouton, E. Charles Brummer, and Zeng-Yu Wang (2011) Pollen viability and longevity of Switchgrass (*Panicum virgatum* L.).Crop Sci, Vol. 51:5.

APPENDICES

APPENDIX-I : Details of Meteorological data during experimental Period

MW No.	Date	Temp ° C		RH		Sunshine Hrs	Wind speed km/hr	Rainfall (mm)	No. of Rainy Days
		Max	Mini	7.30 hrs	14.30 hrs				
January 2015									
1	01 to 07	24.9	12.7	74	55	04.3	00.4	01.2	-
2	08 to 14	27.2	06.8	48	26	09.7	00.8	00.0	-
3	15 to 21	28.6	10.5	54	33	09.1	00.5	00.0	-
4	22 to 28	29.4	14.0	62	37	06.9	00.9	00.0	-
5	29 to 04	30.1	12.9	52	35	09.2	01.2	00.0	-
February 2015									
6	05 to 11	31.3	12.3	51	24	09.0	01.8	00.0	-
7	12 to 18	33.0	13.0	53	23	10.3	00.0	00.0	-
8	19 to 25	33.2	13.7	54	23	10.2	01.2	00.0	-
9	26 to 04	23.9	13.0	65	37	07.5	02.4	42.4	2
March 2015									
10	05 to 11	31.9	14.8	52	37	08.9	01.2	065.2	3
11	12 to 18	31.0	16.8	67	39	09.1	01.5	011.0	2
12	19 to 25	35.3	19.2	45	23	09.0	01.0	00.0	-
13	26 to 01	36.4	19.4	54	20	07.6	01.2	00.0	-
April 2015									
14	02 to 08	35.8	16.1	51	20	9.5	01.7	00.0	-
15	09 to 15	33.9	19.5	35	37	6.8	01.2	07.2	1
16	16 to 22	37.2	21.5	48	22	9.5	01.0	00.0	-
17	23 to 29	39.1	20.5	40	14	10.2	02.9	00.0	-
18	30 to 06	40.4	21.0	36	16	10.0	03.4	00.0	-
May 2015									
19	07 to 13	39.6	24.4	41	19	10.0	01.7	00.0	-
20	14 to 20	38.6	23.5	48	28	08.5	02.8	08.0	1
21	21 to 27	40.1	23.6	49	22	11.1	07.2	00.0	-
22	28 to 03	39.3	23.3	56	25	07.7	04.7	03.0	1
June 2015									
23	04 to 10	36.0	22.8	68	52	7.8	02.6	36.4	4
24	11 to 17	32.3	23.2	72	64	4.0	02.9	25.8	2
25	18 to 24	31.6	23.6	71	60	2.8	09.4	11.6	2
26	25 to 01	33.8	23.3	66	45	7.8	09.8	00.0	-

Appendix- II

Treatment wise monthly meteorological data (February to June, 2015)

Treatments	Month	Temp°C	RH%	Canopy temp. °C	Canopy RH%	Decrease in canopy temp.°C	Increase in canopy temp.°C
1	2	3	4	5	6	7	8
T₁ (Maize as cover crop)	Feb	28.9	52.0	28.6	52.7	0.3	0.7
	March	33.6	60.0	32.8	62.2	0.8	2.2
	April	38.1	52.8	37.1	55.2	1.0	2.4
	May	39.3	60.0	37.9	62.0	1.4	2.0
	June	34.8	68.0	33.2	70.5	1.6	2.5
T₂ (Bajara as cover crop)	Feb	28.9	52.0	28.7	52.6	0.2	0.6
	March	33.6	60.0	33.2	61.2	0.4	1.6
	April	38.1	52.8	36.9	54.8	1.2	2.0
	May	39.3	60.0	37.7	62.2	1.6	2.2
	June	34.8	68.0	33.0	70.4	1.8	2.4
T₃ (Dhainca as cover crop)	Feb	28.9	52.0	28.5	52.6	0.4	0.6
	March	33.6	60	31.8	62.4	1.8	2.4
	April	38.1	52.8	35.9	56.3	2.2	3.5
	May	39.3	60.0	37.1	64.6	2.2	4.6
	June	34.8	68.0	31.7	73.1	3.1	5.1
T₄ (Jowar as cover crop)	Feb	28.9	52.0	28.7	52.6	0.2	0.6
	March	33.6	60.0	32.5	61.8	1.1	1.8
	April	38.1	52.8	36.7	55.2	1.4	2.4
	May	39.3	60.0	37.1	62.1	1.4	2.3
	June	34.8	68.0	33.3	71.2	1.5	3.2
T₅ (Sunhem p as cover crop)	Feb	28.9	52.0	28.4	51.2	0.3	0.6
	March	38.1	60.0	36.2	55.0	1.6	3.2
	April	33.6	52.2	32.0	53.0	1.4	3.2
	May	39.3	60.0	37.5	62.3	1.4	3.1
	June	36.2	68.0	32.9	71.1	1.9	3.1

Treatments	Month	Temp °C	RH%	Canopy temp. °C	Canopy RH%	Decrease in canopy temp.°C	Increase in canopy temp.°C
1	2	3	4	5	6	7	8
T ₆ (Fogger)	Feb	28.9	52.0	28.3	52.7	0.6	0.7
	March	33.6	60.0	32.8	60.2	0.8	0.9
	April	38.1	52.8	37.3	53.9	0.8	0.9
	May	39.3	60.0	38.7	61.4	0.6	1.4
	June	34.4	67.2	34.1	69.2	0.7	1.3
T ₇ (Sprinkler)	Feb	28.9	52.0	29.3	52.6	0.4	0.6
	March	33.6	60.0	33.0	61.0	0.6	1.0
	April	38.1	52.1	35.2	54.0	0.8	1.2
	May	35.2	60.0	38.8	61.2	0.5	1.3
	June	31.5	68.0	34.2	69.5	0.6	1.2
T ₈ (Sod culture)	Feb	28.9	52.0	27.9	52.6	0.0	0.5
	March	33.5	60.0	33.2	60.2	0.4	0.7
	April	38.1	52.8	37.9	53.3	0.2	0.7
	May	39.3	60.0	39.2	60.9	0.1	0.9
	June	34.8	68.2	34.6	68.8	0.2	0.8
T ₉ (Control) Conventional method	Feb	28.5	52.0	28.9	52.4	0.2	0.8
	March	33.6	60.0	33.6	60.4	0.0	0.4
	April	37.5	50.2	36.0	21.3	0.2	0.6
	May	40.4	54.4	39.1	58.6	0.2	0.7
	June	33.8	64.0	34.2	62.5	0.2	0.5

8. VITA

Miss. Khalate Snehal Madhukar

A candidate for the degree
of
Master of science (Horticulture)
in
FRUIT SCIENCE

Title of the thesis : “Effect of agro techniques on pollen viability and fruit set in custard apple (*Annona squamosa* L.) Cv. Balanagar”

Major Field : Horticulture

Biographical information:

Personal : Born at Phaltan, Tal. Phaltan, Dist. Satara, On 14th January. 1993, Daughter of Sou. Hemlata and Shri. Madhukar Manikrao Khalate.

Educational : Passed S.S.C Examination from Mudhoji High School and Jr. College, Phaltan.

: Passed H.S.C Examination from Mudhoji High School and Jr. College, Phaltan.

: Received B.Sc (Horti.) degree from Shreemant Shivajiraje College of Horticulture, Phaltan.

Address : A/P Khunte
Tal- Phaltan, Pin.- 415 523
Dist. Satara.

Email id : snehal.khalate1429@gmail.com