Effect on integrated fruit drop management in kinnow mandarin (*Citrus nobilis* × *Citrus deliciosa*L.)

THESIS

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MASTER OF SCIENCE
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BY
RAMESH KUMAR
Registration Number: 11307722

Under the supervision of
Dr. MADHU SHARMA

Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, India
June, 2015

CERTIFICATE- I

This is to certify that thesis titled **"Effect on integrated fruit drop management in kinnow mandarin (*Citrus nobilis* × *Citrus deliciosa*L.)"**submitted in partial fulfillment of the requirement for the award of degree of **Master of Science** in the discipline of **Horticulture** is a bonafide research work carried out by **Mr. Ramesh Kumar (Registration No. 11307722)** under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

(Signature of Supervisor)
Dr. Madhu Sharma
Assistant Professor
School of Agriculture
Lovely Professional University
Jalandhar, Punjab.

CERTIFICATE- II

This is to certify that the thesis entitled **"Effect on integrated fruit drop management in kinnow mandarin (*Citrus nobilis* × *Citrus deliciosa*L.)"**submitted by **Ramesh Kumar**to the Lovely Professional University, Phagwara in partial fulfilment of the requirements for the degree of **Master of Science** in thediscipline of **Horticulture**has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

(Dr. Madhu Sharma)
Chairperson
Advisory Committee

( )
External Examiner

(Dr. Shailesh Kumar)
Member

(Mr. Vivek Srivastave)
Member

Head of the Department

Dean, School of Agriculture

DECLARATION

I hereby declare that the thesis entitled **"Effect on integrated fruit drop management in kinnow mandarin (*Citrus nobilis* × *Citrus deliciosa*L.)"**is an authentic record of my work carried out at Lovely Professional University as requirement for the degree of **Master of Science** in the discipline of **Horticulture**, under the guidance of Dr. Madhu Sharma, Assistant Professor, School of Agriculture and no part of this thesis has been submitted for any other degree and diploma.

Ramesh Kumar
(Registration No.11307722)

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(Ramesh Kumar)

Table of contents

Certificate I…………………………………………………………….	ii
Certificate II…………………………………………………………….	iii
Declaration……………………………….……………………………………………	iv
Acknowledgements………………………………………………………………………..	v
Table of contents ………………………………………………………………………	vi
List of figures …………..……………………………………………………………	vii
Abbreviations………………………………..……………………………………	viii-ix
Abstract ……………………..……………………………………………………………….	x
CHAPTER I	
Introduction ………………………………………………………………………………	1-3
CHAPTER II	
Review of literature ……………………………………………………………………….	4-8
CHAPTER III	
Materials and Research Methodology ……..……………..………………………………….	9-12
CHAPTER IV	
Results and discussion……………………..…………………………………………	13-22
CHAPTER V	
Summary and conclusion………………………………………………………………….	23
REFERENCES……………………………..…...……………………………………	24-31
Annexure I…………………………………………………………………………......	32

LIST OF FIGURES

Sr.No.	Title	Page No.
3.1		12
4.1	Effect of growth regulators, fungicides and their time of application on entomological fruit drop in Kinnow mandarin	20
4.2	Effect of growth regulators, fungicides and their time of application on pathological fruit drop in Kinnow mandarin	22
4.3	Effect of growth regulators, fungicides and their time of application on physiological fruit drop in Kinnow mandarin	24
4.4	Effect of growth regulators, fungicides and their time of application on monthly fruit drop in Kinnow mandarin	26
4.5	Effect of growth regulators, fungicides and their time of application on fruit yield in Kinnow mandarin	28
4.6	Effect of growth regulators, fungicides and their time of application on fruit weight in Kinnow mandarin	30
4.7	Effect of growth regulators, fungicides and their time of application on fruit size in Kinnow mandarin	32
4.8	Effect of growth regulators, fungicides and their time of application on TSS in Kinnow mandarin	34

LIST OF ABBREVIATIONS

/	per
%	Percent
&	And
@	At the rate of
^{0}Brix	Degree Brix
^{0}C	Degree calcius
2, 4-D	2, 4-Dichlorophenoxyacetic acid
2, 4-5TP	2, 4,5- Trichlorophenoxy acetic acid
ABA	Abscissic acid
Ca	Calcium
cm	Centimetre
Dec	December
EC	Emulsifiable Concentrate
EC	Electrical conductivity
GA_3	Gibberellic acid
gm	Gram
i.e.	That is (Id est)
IAA	Indole acetic acid
K	Potassium
kg	Kilogram
KNO_3	Potassium nitrate
LSD	Latin Square Design
Max	Maximum
Min	Minimum
mm	Millimetre
mmhos	Millimhos
MN	Million
NAA	Naphthalene acetic acid
No	Number
Nov	November

Oct	October
PFD	Postbloomfruit drop
PGR	Plant growth regulator
pH	Power of hydrogen
ppm	part per million
R	Replication
RCBD	Randomized Complete Block Design
RH	Relative humidity
SA	Salicylic acid
SC	Soluble Concentrate
Sep	September
T	Tone
Temp	Temperature
TSS	Total Soluble Solids
WP	Wettable powder
Zn	Zinc

Effect on integrated fruit drop management in kinnow mandarin (*Citrus nobilis* × *Citrus deliciosa*L.)

ABSTRACT

Abstract

Punjab, is leader of Kinnow producer in India and has emerged as number one fruit with respect to area (46,000 ha) and production (9, 88,000 MT). Among the various problems, fruit drop is major bottleneck as the fruits continue to drop at various stages of the fruit growth and development. Imbalance of growth regulators and plant pathogens has been found to be responsible for causing this problem. The pathological fruit drop *(Colletotrichum gloeosporioides)* in the month of September and October is the most detrimental, as the fruit are near maturity and have drawn nourishment from the tree. Therefore, an experiment was carried outin Kinnow Orchard of a progressive farmer in Hoshiarpur districtduring Kharif 2014. Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%), Carzim-50 0.1% + 2, 4-D (20 ppm) + KNO_3 (1%), Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%),COPRUS 50WP 0.3% + 2, 4-D (20 ppm) + KNO_3 (1%)and Cyproconazole 25EC 0.1% +2, 4-D (20 ppm) + KNO_3 (1%)were sprayed in first week of September and October during 2014.Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%) excelled all the other treatments and provided maximum control of fruit drop. The second best was Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)and was at par with Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%) but differed significantly from Cyproconazole 25EC 0.1% +2, 4-D (20 ppm) + KNO_3 (1%), Carzim-50 0.1% + 2, 4-D (20 ppm) + KNO_3 (1%)and COPRUS 50WP 0.3% + 2, 4-D (20 ppm) + KNO_3 (1%). Therefore, Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%) and Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%) sprays are recommended for the integrated fruit drop management in Kinnow mandarin.

CHAPTER I

Introduction

Kinnow (*Citrus nobilis* × *Citrus deliciosa*L.), is a hybrid variety of mandarin group of citrus. It has become exceedingly popular among the growers and consumers in North India because of its superb fruit quality coupled with good tree vigour, higher cropping potential and better performance than other citrus fruits. The major citrus species grown in Punjab are mandarins with two varieties viz. Kinnow and Feutrell covering 80 percent of the total citrus growing area (Altaf, 2006). Because of its wider adaptability, high yield and more economic return, Kinnow cultivation has gained momentum in Punjab. Kinnow is commercially grown as a foreign exchange earner in Freozpur, Faridkot, Muktsar, Bathinda, Mansa, Hoshiarpur, Ropar and Gurdaspur. After Mexico, India is the leading producer of citrus fruits with an area of 763 lakh hectares and production of 599 lakh tones annually (Anonymous, 2012). In India, it ranks third in production after banana and mango (Anonymous, 2012 a). In Punjab, among fruits, kinnow ranks first in area (46,000 ha) and production (9, 88,000tonnes) (Anonymous 2014). It occupies 64.20 % of the total area under fruits in Punjab (Anonymous 2014 a). Citrus is a rich source of vitamin-C, vitamins A & B, sugar, amino acids, and other nutrients (Khan *et al.*, 1992).

Citrus, particularly Kinnow, tends to bear heavily in early years of production. If Kinnow is left unthinned, it can bear over 300 fruits in the third or fourth year of age. In the 5th year, the bearing may increase to 600 fruits per tree (Anonymous, 2014 b). The floral load depends on the cultivar, tree age and environmental conditions (Monselise & Goren, 1978). Sweet Oranges produce around 50,000 flowers per tree in blooming season but 95% to more than 99% flowers drop and only a small amount of these flowers become mature fruits (Chaudhary, 2006).The fruits may be infected in orchards right from the setting to harvesting stage leading to pre-mature fruit dropping. Incipient preharvest infection causes subsequent post-harvest rotting during storage and transit under favorable conditions of temperature and moisture (Naqvi, 1993). Tayde and Ingle (1997) observed that out of total fruit drop of Nagpur mandarin, 70-83 % was physiological, 8-17 % entomological and 8-10 % was pathological in ambia crop (spring flowering and fruiting). It was further stated by him that in mrig crop 73-78 % physiological, 11-12 % entomological and 10-13 % pathological factors are responsible for fruit drop.Premature fruit drop is a disease of economic importance which occurs throughout India and other citrus growing countries (Rattanpal *et. al*., 2012). From different parts of the world, premature fruit drop is reported to be caused by many fungi. Species of fungi causing premature fruit drop, are *Alternaria*, *Colletotrichum*, *Botrytis* and several stem end rotting fungi. This disease is characterized by limited lesions on stem, leaf or fruit, often accompanied by wither tip or die back symptoms and abnormal persistence of buttons after the fruitlets have dropped in months of July and August as reported by Reuther (1969) and Fagan (1971 & 1972). The disease symptoms are also observed on the stalk end of the fruit, which develop rapidly under humid and warm conditions and ultimately infect the fruit leading to fruit drop. Such fruit act as a source of primary infection for further spread of the disease which ultimately results in heavy crop losses (Jawanda and Singh, 1973). Outside India, fruit drop problem has also been reported from many countries like Japan (Yamada *et. al*., 1965), Montenegrin coast (Mijuskovic, 1979), Argentina (Alippri, 1971), Santa Catarina State&South Brazil (The odoro *et. al.,* 2005) and South Florida (McMillan, 1994).

Beside biotic, abiotic factors such as high temperature, water deficits and wind velocity of the area also contribute in excessive premature fruit drop (Ibrahim *et al*., 2007; Ashraf *et. al*., 2012; Razi *et. al*., 2011). Premature fruit drop of kinnow caused by *Colletotrichum gloeosporioide* is one of the major causes of decline in quality & total fruit production and thus is of great concern for the citrus growers in Punjab and other citrus growing states of India (Randhawa and Dhillon, 1965; Bhullar, 1978).

Nearly twenty four per cent post-harvest fruit losses have also been observed due to pre-harvest quiescent infection (Anonymous, 1990). The application of plant growth regulator (PGR) can provide significant economic advantages to citrus growers when used in appropriate situations as these have proven effective in stimulating a number of desired responses such as flowering, fruit set, increase in fruit size, delay in fruit maturity and fruit drop (Coggins Jr & Hield, 1968, El-Otmani *et. al*., 1995 and Berhow, 2000). However, Greenberg *et. al., (*1975) have reported that the pre-harvest drop of Valencia orange in Florida was not reduced by the application of plant growth regulators, stressing the importance of climatic conditions on the effectiveness of growth regulators treatment. Tree drops its fruit when the concentration of auxins decreases and the concentration of abscissic acid (ABA) increases (Browning, 1986; Marinho *et. al*., 2005). The balance of these endogenous hormones plays a modulating role in the mobilization of nutrients to the developing organs. Application of plant growth regulators can control the hormone balance at the abscission layer, reducing or retarding the early fruit fall and harvest losses (Modise *et. al*., 2009). Furthermore, they can maintain hormone balance in the peel there by reducing the pre harvest drop and the losses at harvest. The application of 2, 4-D and GA_3 reduces pre-harvest fall which retards abscission, rind softening, senescence and inhibits chlorophyll degradation (El-Otmani, 1992). The application of auxin prevents the fruit from falling by preventing the synthesis of hydrolytic enzymes, such as cellulase (Monselise & Goren, 1978).

Fruit drop is genetically, physiologically and environmentally regulated but plant stress and premature ethylene production are the basis of true physiological drop (Robinson *et. al*., 2006, 2010; Yuan and Carbaugh, 2007; Yuan and Li, 2008; Li and Yuan, 2008; Zhu *et. al.*, 2008, 2010). Stress factors such as heat, drought, nutrient imbalance or deficiency, and heavy crop load can contribute to fruit drop (Racsk *et. al*., 2007; Robinson *et. al*., 2006, 2010). Fruit drop is also reported to be heavier on alluvial soils (Kaneko *et. al*., 1979). Increased fruit drop on these soil types may be due to water logging (Suzuki *et al*., 1988).

Many fruit trees, including citrus, set large numbers of flowers and young fruit but undergo natural fruit drop to maintain favorable source/sink relationships as young fruit develop and mature (Bonghi *et. al*., 2000). In citrus, more than 85% flowers are dropped naturally after bloom and only 0.5% to 2% flowers will eventually develop into mature fruit (Erickson, 1986). Thus, the application of plant growth regulators can provide significant economic advantages to citrus growers when used in proper doses (Jain *et. al*., 2009). Keeping in view the above facts, the present investigation entitled “Effect on integrated fruit drop management in kinnow mandarin (*Citrus nobilis* × *Citrus deliciosa*L.)” was carried outin Kinnow Orchard of a progressive farmer in Hoshiarpur districtduring Kharif 2014 with following objectives **:-**

1. To test the efficacy of plant growth regulator in reducing the fruit drop,

2. To identify the best combination of plant growth regulator and fungicide in controlling the fruit drop.

CHAPTER II

REVIEW OF LITERATURE

The relevant literature pertaining to the fruit drop of citrus and other subtropical and tropical fruits have been discussed under following subheads:-

2.1 - Effects of growth regulators

2.2 - Effect of fungicides

2.1 Effects of Growth Regulators

Al-Qurashi and Awad(2011) observed that one of the major problems in date palm cultivars production in the Hada Al-Shame valley at the western region of the Kingdom of Saudi Arabia was the low fruit set and/or abnormal flowering accompanied by subsequent high fruit drop percentage. Modise *et. al.,*(2009) reported that flower and fruit dropoccured at anthesis and continued till time of harvest. The initial drop has due to abscission of weak fruit lets, which appear after anthesis. They further reported that the drop of ripe fruit is of great significance in commercial cultivars. Application of plant growth regulators can control the hormone balance at the abscission layer, reducing or retarding the early fruit fall and harvest losses. Modise *et. al.,(*2009) and Ashraf *et. al.,(*2010 & 2012) stated that in citrus profuse flowering was shaded off to reduce heavy fruit load, so that fruit can be enhanced.

Ansari *et. al.,*(2008)revealed plant growth regulators,GA_3,2,4-D,NAA and Urea (all at two levels) were sprayed on 14 years old Nagpur mandarin trees to control physiological fruit drop. The maximum percentage of fruit drop was observed when 2,4-D was sprayed at 20 ppm followed by NAA (10 ppm) and 2,4-D (10 ppm) respectively. Maximum juice percent, TSS-Acidity ratio and number of fruit per plant also observed in 2,4-D (20 ppm) spray treatment. Thus 2,4-D (20 ppm) proves to be the most effective measures for the control of physiological fruit drop of Nagpur mandarin.

Gill and Bal (2008) conducted an experiment to study the efficacy of foliar sprays of NAA (20, 30 and 40ppm), potassium nitrate (0.5, 1.0 and 1.5 %) and zinc sulphate (0.3, 0.4 and 0.5 %) on fruit drop and retention of Indian Jujube. The sprays were applied in last week of October and again super imposed in last week of November. Minimum fruit drop and maximum fruit retention was recorded in plants sprayed with NAA 30ppm.

Rodríguez *et. al.,(*2005) reported that the application of suitable combinations of plant growth regulators and macro & micro nutrients, can control the excessive fruit drop. Thereby improve the yield as well as quality of citrus fruits. Ashraf *et. al.*,(2012) also supported the findings of Rodríguez *et. al.,(*2005) by claiming that foliar application of Zn can improve the citrus fruit yield and quality as well as control the premature fruit drop. Yuan *et. al*., 2007 stated that the fruit drop is mainly due to an imbalance between the level of IAA and ethylene within fruit tissues and abscission zone.

Almeida *et. al.*,(2004) stated that the auxins and gibberellins improve fruit quality and can control fruit drop in citrus. Coggins &Lovatt(2004) and Ashraf *et. al.*,(2012) said that PGRs like salicylic acid **(**SA) and 2, 4-D have been reported to be effective in controlling fruit drop in citrus. Lahey *et. al.*,(2004) Chen &Dekkers(2006) and Balal *et. al*.,(2011) stated that abscission layer at the stem resulting in fruit drop was formed due to imbalance of auxins, cytokinins, and gibberellins.

Singh *et. al.*,(2002)stated that potassium improves fruit quality by enhancing fruit size, juice content, colour, size and juice flavour.The result was in consonance with Tiwari(2005) and Ashraf *et. al.*,(2010). Liu *et. al.*,(2000)revealed that post-harvest losses (spoilage) of kinnow fruits can be estimated around 25-30 per cent.Alva & Tucker(1999) claimed that citrus fruits use large amount of K as compared to other macronutrients because K is involved in several basic physiological functions i.e. formation of sugars and starch, synthesis of proteins, cell division and growth and neutralization of organic acids. The similar findings were also reported by Rademcher (2000) and Luckwill (1970)who observed that plant growth regulators modify growth and development in various ways. Plant growth regulators can be well integrated into orchard production systems.

Gibberellin biosynthesis inhibitors have received the most attention because of their key role in cell elongation. Buban *et. al.*,(2003) and Basak &Rademacher (2000) reported that Prohexadione-Ca (Regalis) is an inhibitor of late stages of gibberellins biosynthesis. This compound is under actual development for use as a growth retardant in different crops. Trials with prohexadione-Ca to control vegetative growth of apple, pear and plum trees were demonstrated by other authors. Dawood *et. al*.,(2001) and Anora &Yamdagni(1986) observed positive effects of Zn sprays on nutritional status, fruit retention, fruit drop, yield and fruit quality in sweet orange and sweet lime. Haidry *et. al.*,(1997) evaluated the effects of naphthalene acetic acid (NAA) on fruit drop in mango cv. Langra. Full grown mango plants were sprayed with 10, 20, 30 and 40 ppm NAA at different stages of fruit development. They reported that although the application of NAA in any concentration significantly reduced the fruit drop, but the dose of 20ppm NAA drastically reduced the fruit drop at all the stages of development. Ram(1992) stated that naturally occurring hormones play a major role in fruit growth and drop of mango.

Sharma *et.al*.,(1990)concluded that urea, KNO_3 and NAA sprays significantly increases fruit retention and fruit yield. However, Berhow (2000) observed that foliar application of different levels of GA3 (5, 50, 100 and 500 mg L-1) to young fruitlets just after fruit set increase the fruit weight, peel thickness, juice content and taste in grapefruit. Dennis(1986) and Racsk *et.al*.,(2007) reported that plant hormones such as auxins, cytokinins and gibberellins have critical role in fruit set and subsequent growth, maturation and ripening. However in date palm, Al-Juburi *et. al*., (2001) reported that the application of GA3, ethephon or mixture of both growth regulators and NAA did not affect fruit set, and subsequent fruit drop of 'Khaniezy ' cultivar. Abd-Alaal *et. al*.,(1982) reported that the growth regulators viz., 2,4-D; 2,4-5TP 2,4-5T; NAA and GA_3 were sprayed three times at four weeks interval from the start of flowering, at the concentration of 25 to 100 ppm, successfully produced normal seedless dates of identical quality as compared to the seeded dates .

Chen (1983); Notodimedjo (2000);Oosthuyse(1995) and Ram *et. al.*,(1983) observed that various phytohormones and their synthetic analogs, called plant growth regulators (PGR) were efficient for the control of fruit drop in mango. Maurya and Singh (1981) reported that application of GA and NAA before flowering and three weeks after fruit setting significantly increase fruit length, diameter, fruit weight and ultimately crop yield. Gomez-Cadena *et. al*.,(2000) observed highest fruit drop control by application of 2,4-D resulting in high yield and quality, whereas exogenous application of gibberellins had no effect on abscission in citrus. Kaur*et. al.*,(2000) reported that growth regulators treatments of 2,4-D, GA, NAA at 15 and 20ppm concentrations respectively reduced fruit drop in Kinnow mandarin. Tucker (1977) stated that six week old citrus fruit sprayed in may, showed no external damage and no abnormal drop.

Pal e*t. al.,*(1997) reported that the foliar application of 2, 4-D (10 ppm) and Cycocel (100 ppm) increased the fruit diameter considerably irrespective of their lower concentration. Stewart and Klotz (1947); Agusti *et. al*.,(1982) and Racsko *et. al*.,(2006) reported three periods of fruit abscission; the first period of fruit set, which usually lasts for a month following full bloom is called as cleaning drop whereas, the second period of intense fruit drop may occur at the onset of hot summer and is referred as 'June drop' the third period of intense fruit abscission is called as 'preharvest drop'. However Saleem *et. al*.,(2005) stated that most of the fruit drop (80-91%) occured during the first month after final fruit set.

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2.2 Effect of different Fungicides

Geraldo José Silva-Juniora *et. al.,* (2014) reported that four sprays of trifloxystrobin + tebuconazole, carbendazim, difenoconazole or cyprodinil + fludioxonil were effective in reducing yield losses due to postbloom fruit drop (PFD) however, the trifloxystrobin + tebuconazole mixture was significantly more effective than all other treatments. The trifloxystrobin + tebuconazole mixture was effective at controlling PFD under favourable conditions for infection and can be recommended in PFD control programmes.Thind and Anita (2013) stated that Propiconazole + 2, 4-D excelled over all the treatments and provided maximum control of fruit drop in kinnow mandarin.

N.B. Patil and S.H. Ingle (2011)counted fruit dropped at weekly interval and classified into physiological, pathological and entomological fruit drop. Intensity of physiological and pathological fruit drop was minimum *i.e.* 5.93 % and 1.04 %, respectively with (2,4-D 10 ppm + Carbendazim 0.1 %) whereas, entomological fruit drop was not significantly influenced by plant growth regulators and fungicides. Maximum days (290 days) required for maturity, and higher cost benefit ratio (1:2.72) were observed with (2,4-D 10 ppm + Carbendazim 0.1%). Sharma, R.N., Maharshi, R.P.and Gaur, R.B. (2008) stated that prochloraz proved most effective fungicide in checking the post-harvest fruit rotting followed by Carbendazim which provided complete protection to the fruits from infection up to 30 and 15 days of storage respectively.

Rattanpal H. *et. al.,*(2009) revealed that dropping of fruits in Kinnow mandarin cause severe yield losses. The influence of growth regulator (2,4-D) and fungicides (carbendazim, copper oxychloride, zineb and ziram) on fruit drop was investigated. The growth regulator (2,4-D) was applied alone and in combination with fungicides during the last week of April, July, August and September in four sprays. The combined application of Zineb 75 WP (0.25%) and 2,4-D (10 ppm) resulted in the highest percentage of fruit retention. Maximum fruit drop was recorded early in the season. 2,4-D (20 ppm) alone was at par with combinations of 2,4-D (10 ppm) with fungicides in retaining fruits upto 90 days after treatment initiation (upto July), thereafter treatments comprising fungicides were more effective.

Singh and Bal (2008) investigated the effect of potassium sulphate (0.5, 1.0 and 1.5%), potassium nitrate (0.5, 1.0 and 1.5%), paclobutrazol (100, 200, 300 ppm) and naphthalene acetic acid (20, 40 and 60 ppm) on fruit retention and quality on ber cv. Umran They concluded that the fruit retention was increased with the foliar application of 0.5 per cent potassium sulphate.Ingle S.H., *et. al.*,(2008) observed that *Colletotrichum gloeosporioides* is responsible for twig blight; dieback and fruit drop in Nagpur mandarin. *In vitro* studies of bioagents, botanicals and fungicides efficacy against *Colletotrichum gloeosporioides* revealed that Curzate M 8 @ 0.3% and carbendazim @ 0.1%, completely inhibited (100%) growth of pathogen. Among bioagents, *Pseudomonas fluorescens* inhibited the growth of *C. gloeosporioides* to the extent of 89.05 per cent. Among two botanical extracts, neem seed extract (5.0%) found to inhibit the mycelial growth to the extent of 78.09 per cent. Maximum reduction in per cent fruit drop (26.0%) was recorded in sprays of Curzate M 8 (0.3%) followed by copper oxychloride which showed 34.00 per cent reduction in mandarin fruit drop.

Ladaniya M.S. (1997) studied the effect of pre- harvest application of GA_3 and carbendazim on physico-chemical characteristics of Nagpur mandarin during holding of fruit on the tree as well as on losses during post-harvest storage at ambient and refrigerated conditions. GA_3 treatments (10, 15 and 20 ppm) delayed rind colour development and fruit softening and minimized fruit drop and puffiness during on-tree storage without adverse effect on TSS/acid ratio and fruit productivity in subsequent years. Fruit weight loss was reduced in storage by GA_3 treatment; however, results were inconsistent with respect to decay. The pre-harvest treatment with 10 ppm (twice at colour break with 15 days interval) was found to be optimum for on-tree storage upto 1 month beyond normal harvest Combination of GA_3 with carbendazim further reduced fruit drop and storage decay.

CHAPTER III

MATERIAL AND METHODS

The present investigation was carried outin Kinnow Orchard of a progressive farmer in Hoshiarpur districtduring Kharif 2014. The details of materials used and methods employed for the present study in order to understand the effect of growth regulators and fungicide on fruit drop management in Kinnow (*Citrus nobilis* × *Citrus deliciosa*L.) are presented as under.

3.1 Experimental site and Location

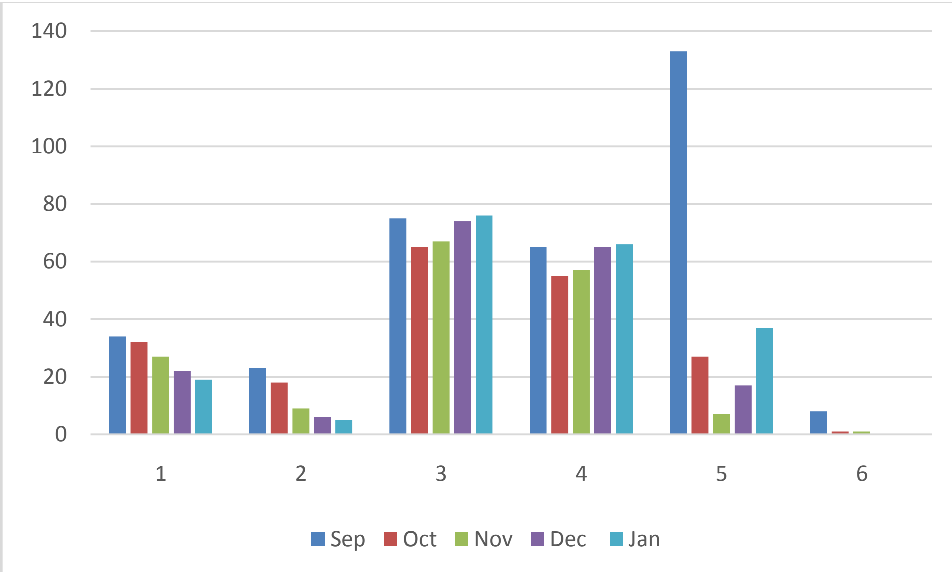
The experimental site is located at an elevation of 296 meter above mean sea level at31^0 32' North latitude and 75^0 57' East longitude, representing piedmont and alluvial plain agro-eco-subregion of Punjab.

3.2 Climate

The sub-region is characterized by hot dry sub-humid to semi-arid transition with dry summers and cool winters. The mean annual air temperature ranges from 24 to 26^{0}C. The mean maximum summer (May to July)temperature ranges from 34 to 38^{0}C rising to a maximum of 40^{0}Cin May to June. The minimum temperature ranges from 5^{0}C to 7^{0}C during December and January. The sub-region receives annual mean rainfall ranging between 700-1000 mm covering 52-60 percent of mean annual PET ranging between 1300-1500 mm. The monsoon ranges set in last week of June and end month of September covering 75-80 per cent of total annual rainfall. The monthly meterological data is presented in annexure.

3.3 Soil

The soil of the sub-region is deep to very deep, loamy sand to loam and developed on alluvium. Soil is moderately well drained and alkaline in reaction with pH ranging from 7.5 to 8.3, electrical conductivity up to 0.5 mmhos/cm. Both calcareous as well as non-calcareous soils occur in this sub-region. In general, soil has low to medium organic carbon and low salt content.



3.4 Experimental detail

Uniform healthy ten year old Kinnow fruit trees were selected at Orchard in Khaila Bulanda, dist. Hoshiarpur, to record the periodical fruit drop. Five tree were selected randomly per replication and data on fruit drop was recorded at weekly interval starting from September till harvest (end January) seasons of 2014-15.

3.4.1 Experimental layout

The fruits trees were sprayed with the growth regulators & fungicides as follow:

Notations	**Treatments**
T0	Water spray
T1	Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)
T2	Carzim-50 (Carbendazim) 0.1% + 2, 4-D (20 ppm) + KNO_3 (1%)
T3	Curzate M8 (Cymoxanil 8% + Mancozeb 64%) 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)
T4	COPRUS (Copperoxychloride) 50WP 0.3% + 2, 4-D (20 ppm) + KNO_3 (1%)
T5	Cyproconazole 25EC 0.1% +2, 4-D (20 ppm) + KNO_3 (1%)

Spraying schedule

The two sprays for all treatment were made on five randomly selected plant in replicaton as follow. Five fungicides namely; Zeneb75WP (0.25%), Carzim-50 (0.1%), Curzate M8 (0.25%), COPRUS 50WP (0.3%), and Cyproconazole 25EC (0.1%) in combination with growth regulators 2,4-Dichlorophenoxyacetic Acid (2,4-D 20 ppm) and potassium nitrate (KNO_3 1%) were sprayed in September and October. In each treatment threereplications were taken and five trees per unit replication were sprayed.

3.5 Observations recorded:

3.5.1. Physical parameters

(I) Fruit weight (gm)

The average fruit weight of ten randomly selected fruits in each replication was determined by weighing the fruits on the pan balance and the average fruit weight was calculated.

(II) Fruit size (length * breadth) (cm)

The fruit size was measured with the help of vernier calliper on random selected fruits per replication per treatment.

(III) Fruit drop

The data on the fruit drop (physiological, pathological and entomological) was recorded starting from September, 2014 to January, 2015. The pathological drop was separated from physiological drop by visually diagnosing the dropped fruits showing pale yellow colour and rotting. Citrus bud mite and orange bug are some of the important pests which cause heavy drop of flowers and fruits in entomological fruit drop. Number of fruits per plant at spray time and after spray was counted on the tagged tree.

Fruit dropping was calculated by counting fruits again in december and percent fruit drop calculated as given below:

$$\text{Fruit drop (\%)} = \frac{\text{Total no. of fruitlets} - \text{No. of fruits till january}}{\text{Total no. of fruit-lets}} \times 100$$

3.5.2 Chemical parameters

(I) Total soluble solids (^{0}Brix)

Total soluble solids (TSS) were determined from the juice at ambient temperature with the help of hand refractometer and expressed in percent. These reading were corrected with the help of temperature correction chart at 20^0C temperature AOAC (1989).

STATISTICAL METHOD OF ANALYSIS

The data recorded for all the parameter were analyzed according to the method of Randomized Block Design (RBD) as advocated by Duncan's Multiple Range tests to compare significant differences among treatment at $p \leq 0.05$.

Month	**Weeks**	**Temperature (°C)**		**Relative humidity (%)**		**Rainfall (mm)**	
		Max	Min	Max	min	Max	Min
Sep	36^{th} -40^{th}	34	23	75	65	133	8
Oct	40^{th} -44^{th}	32	18	65	55	27	1
Nov	44^{th} -48^{th}	27	9	67	57	7	1
Dec	49^{th} -1^{st}	22	6	74	65	17	0
Jan	1^{st} -5^{th}	19	5	76	66	37	0

CHAPTER- IV

RESULT AND DISCUSSION

The present investigation entitled, “Effect on integrated fruit drop management in kinnow mandarin” was carried out in Kinnow orchard of a progressive farmer in Hoshiarpur district during Kharif 2014. The results and discussion obtained are presented as under.

4.1 ENTOMOLOGICAL FRUIT DROP

The perusal of data in Figure-1 indicates that all the growth regulator and fungicide treatments helped in reducing the fruit drop significantly as compared to T_0 [Water spray]. The minimum (1.90%) entomological fruit drop was obtained with application of T_3[Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)] which was at par with T_1 [Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)] having 2.17% fruit drop;T_5 [Cyproconazole 25EC 0.1% +2, 4-D (20 ppm) + KNO_3 (1%)]fruit drop 2.40%; T_2 [Carzim-50 0.1% + 2, 4-D (20 ppm) + KNO_3 (1%)] with 2.40% fruit drop; and T_4 [COPRUS 50WP 0.3% + 2, 4-D (20 ppm) + KNO_3 (1%)] with 2.76% fruit drop while The maximum fruit drop (4.2%) was obtained in water spray.The possible reason for reduction in fruit drops by using these treatments may be by reducing the infestation caused by insects due to inhibition of mould development caused by fungal growth. Furtherwere, the present of growth regulator along with fungicide is responsible for maximum fruit retaintion by reducing the formation of abscission layer as reported by Rattenpal *et. al.,* (2009) for integrated control of fruit drop in Kinnow. Storer (2000) and antheny & Coggens (2001) had also proposedsignificant influence of auxins in controlling the pre-harvest fruit drop in citrus crop. Superiorty of K as KNO_3zinc from zineb for effective control of citrus fruit drop has also been proved by Asharaf *et. al.,*(2010,2012). Effectiveness of curzate M8 in controlling fruit drop of Nagpur mandarin has also been reported by Ingle *et. al.,*(2015). Similar results were confirmed by Thind and Arora (2013) who had stated thatapplication of fungicide in combination with 2, 4-D excelled over all the treatments and provided maximum control of fruit drop in Kinnow mandarin.

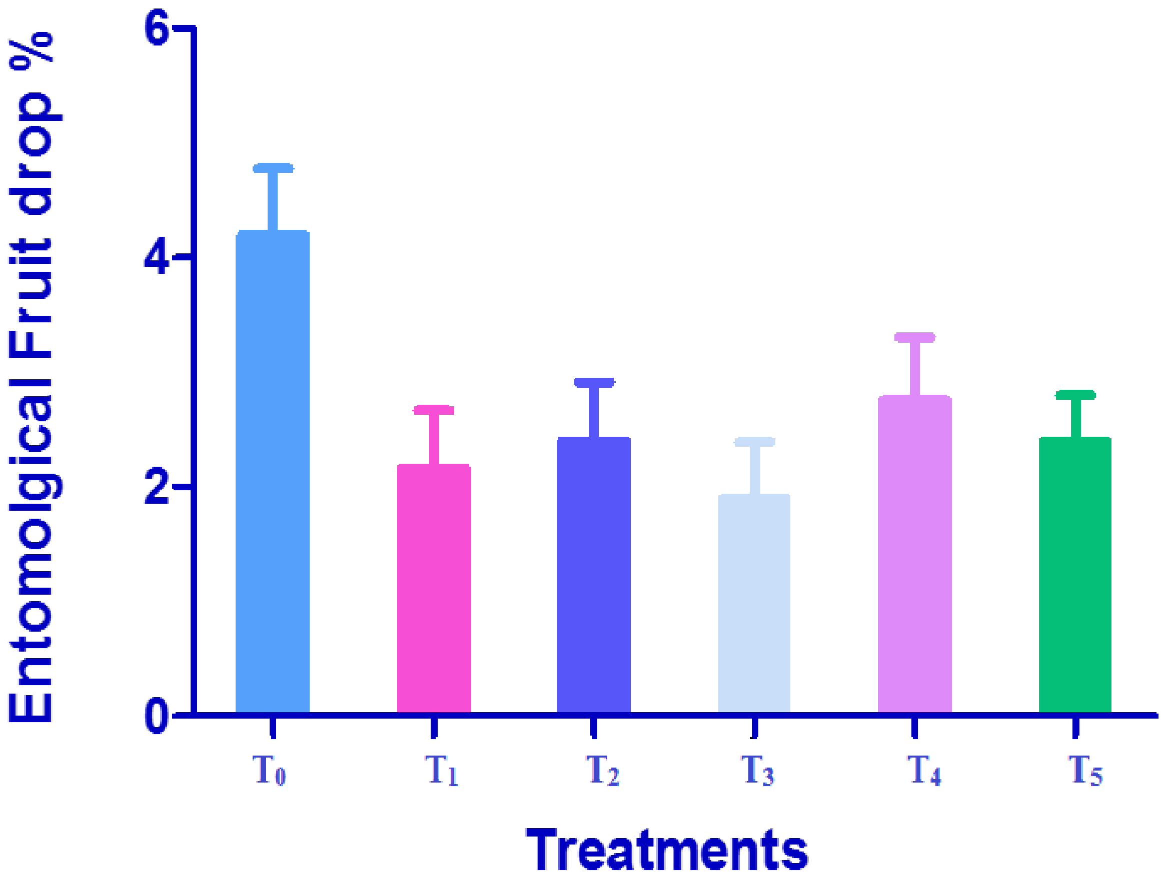


Fig.4.1. Effect of growth regulators, fungicides and their time of application on entomological fruit drop in Kinnow mandarin

4.2PATHOLOGICAL FRUIT DROP

The maximum pathological fruit drop (7.8%)was observed in T_0 [water spray] as given in Figure-2 followed by 5.14% in T_4 [COPRUS 50WP 0.3% + 2, 4-D (20 ppm) + KNO_3 (1%)] and minimum was (3.53%) observed in T_3 [Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)]. There was slow decrease in fruit drop as compared to T_0 [Water spray]. The treatment T1, T2, T3 and T5 were statistically at par in controlling fruit drop. The maximum fruit retaintion was observed in treatment T_3 [Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%) as compared to other treatments. These fungicide reducesthe incidence of fungal pathogen (*Collectotrichum gloeosorioides*) when caused stem-end thereby minimizing the fruit drop in treated plants.The application of fungicides for the control of pathological fruit drop in kinnow mandarin have also been reported by Rajjadhav *et. al.*, (2000) and is in conformity with Thind *et. al.*, (2011) in

Kinnow mandarin and Ingle *et. al.,* (2015) who had proposed curzate M8 (0.3%) and Copper oxychloride as effective fungicide to reduce fruit drop by reducing incidence of (*Collectotrichum gloeosorioides*) in Nagpur mandarin.

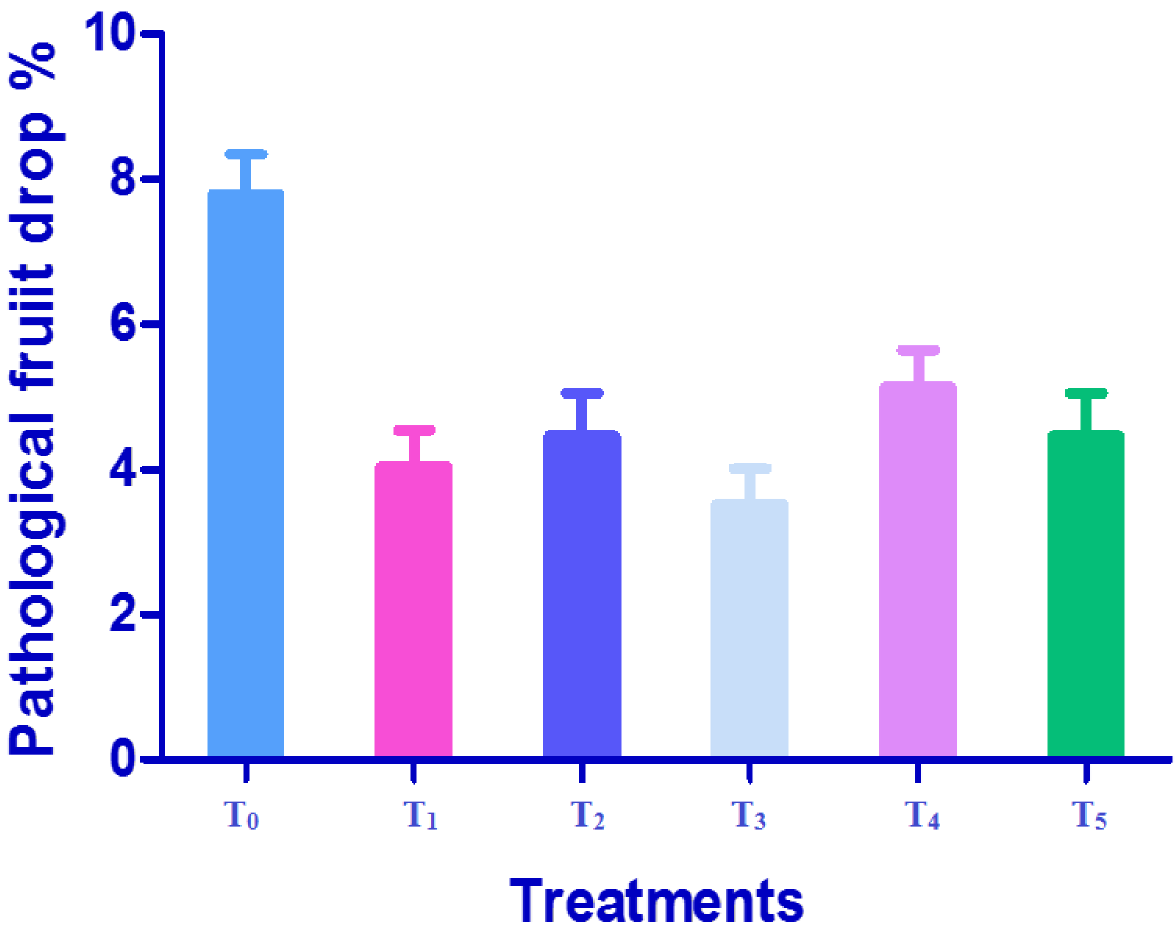


Fig. 4.2. Effect of growth regulators, fungicides and their time of application on Pathological fruit drop in Kinnow mandarin

4.3 PHYSIOLOGICAL FRUIT DROP

The minimum physiological fruit drop (4.75%) was observed with T_3[Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)] followed by 5.75% in T_1 [Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)]; 7.12% in T_5 [Cyproconazole 25EC 0.1% +2, 4-D (20 ppm) + KNO_3 (1%)]; 7.18% in T_2 [Carzim-50 0.1% + 2, 4-D (20 ppm) + KNO_3 (1%)] and 8.16% in T_4 [COPRUS 50WP 0.3% + 2, 4-D (20 ppm) + KNO_3 (1%)]. All the five treatments were statistically at par in controlling physiological fruit drop in compression to T_0 [water spray] as presented in figure-3. The maximum physiological drop (14%) was obtained in T_0 [water spray]. The effective of spray time and the interaction results were reported to be non-significant. The similar results were reported by Mohan *et. al.* (1986) and Sandhu *et. al.* (1986) in sweet orange. Effectiveness of all treatments significant in reducing of fruit drop may be due to herbicidal nature of 2,4-D as it acts as auxins transfer inhibitors (brown *et. al.*,2001). Kaur *et. al.* (2007) application of 2,4-D for control the physiological fruit drop in Kinnow mandarin has also been demonstrated. Ali- Dinar *et. al.*, (1976) had also advocated about effective pre-harvest fruit drop in sweet orange and grapefruit when applied in low concentration.

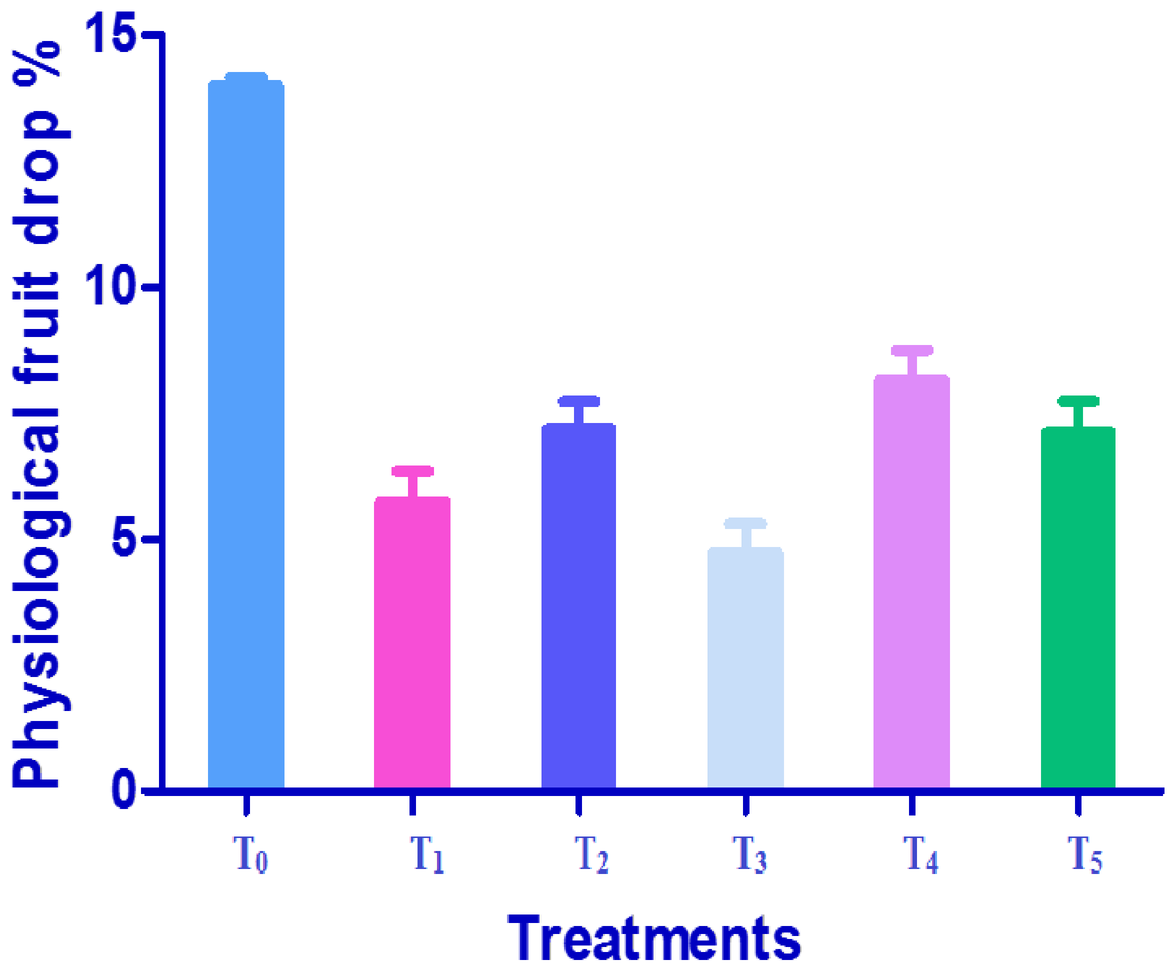


Fig. 4.3. Effect of growth regulators, fungicides and their time of application on Physiological fruit drop in Kinnow mandarin

4.4 FRUIT DROP IN MONTH

The perusal of data Figure-4 indicates that all fungicides in combination with 2,4-D helped in reducing the fruit drop significantly as compared to water spray only pre-harvest. Observation on fruit drop indicated significantly maximum fruit drop in September followed by October and minimum in January. The maximum fruit drop (40 fruits) was reported in T_0 (water spray) in month of September. The minimum fruit drop was recorded in T_3[Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)] followed by T_2 [Carzim-50 (Carbendazim) 0.1% + 2, 4-D (20 ppm) + KNO_3 (1%)] which found better than T_1 [Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)] ; T_5 [Cyproconazole 25EC 0.1% +2, 4-D (20 ppm) + KNO_3 (1%)]; T_4 [CORRUS 50WP 0.3% + 2, 4-D (20 ppm) + KNO_3 (1%)]. Maximum fruit drop reported in month of September and October may be due to severely of pathological fruit drop near the maturity as reported by Thind *et. al.*, (2011), which was due to occurance of *C.gloeosporioides*as confirmed by Reuther (1969) and Singh (1981). Physiological fruit drops may also be one of the factor to reduce formation of abscission layer accompanied with exhaustive use nutrients, which requires further investigation. Effectiveness of 2,4-D to reduce preharvest fruit drop in month of September and October have been reported by Al media *et. al.*, (2004) and Davies & Zalman (2006) in citrus spp., when applied a 20ppm concentration. Similar results were reported by Pal *et. al.*, (1977) in Kinnow mandarin. Patil *et. al.*(1989) in kinnow. During the present investigation, fungicides in combination with growth regulator 2,4-D was found effective in checking the fruit drop in Kinnow mandarin. Similar results were reported by Huchche, A.D. (2001) who proposed the best result of Propiconazole + 2,4-D to present fruit drops in Kinnow mandarin.

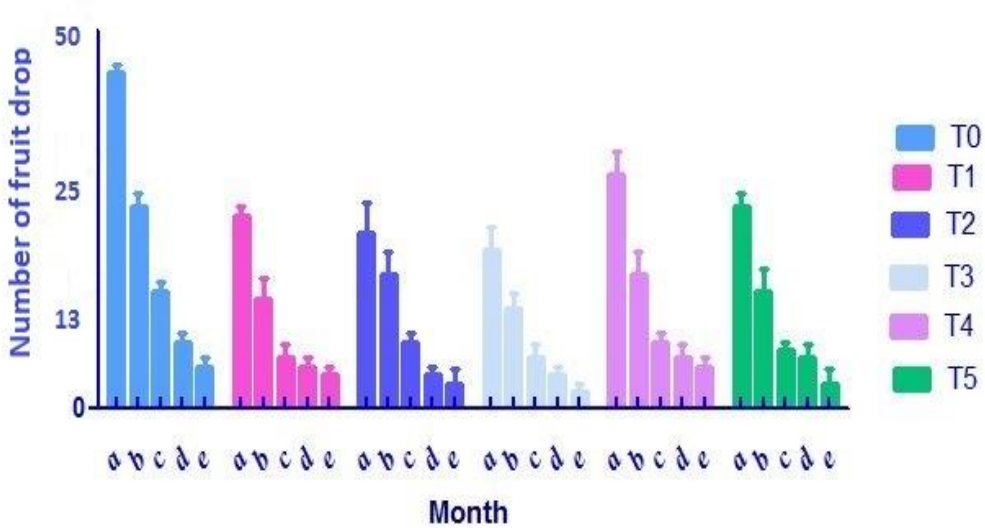


Fig. 4.4. Effect of growth regulators, fungicides and there time of application on monthly fruit drop in kinnow mandarin

Note: a*= September, b*= October, c*=November, d*= December, e*= January

4.5FRUIT YIELD

The maximum fruit yield was observed in (432 fruits) in T3 [Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)] as given in Figure-5 followed by 426 fruits/plant in T_1[Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)] and minimum was observed in (350 fruits/plant) in T_0 [Water spray]. The treatment T1,T4 and T5 where statistically at par in fruit yield. Significantly best result was obtained in treatment T3 [Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)] as compared to T_0[Water spray]. Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%) reported to increase the fruit yield in treated plant. The higher yield in the treatments containing fungicides and 2.4-D is due to reduced pre-harvest fruit drop which is in conformity with the fungicides of Gomez-Cadenas *et. al.*, (2000) and Singh and Mann (1984).

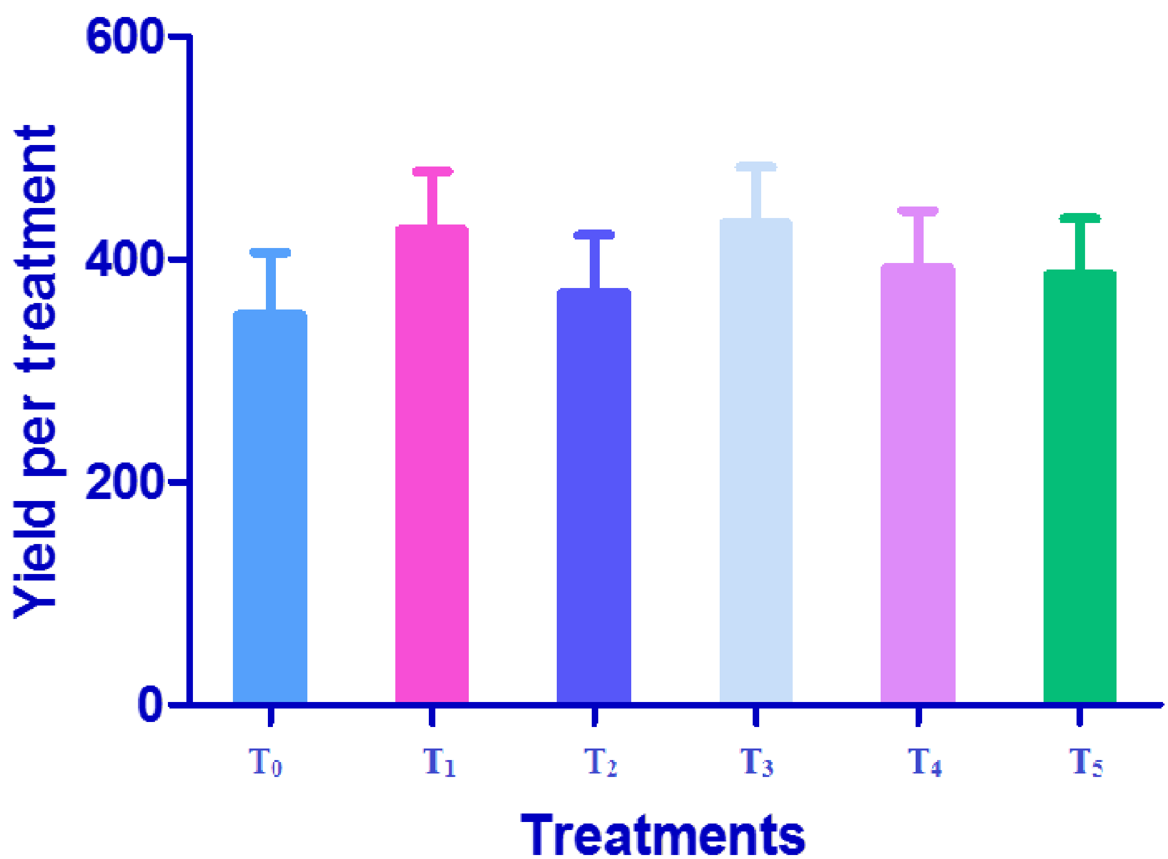


Fig. 4.5. Effect of growth regulator and fungicides their time of application on fruit yield in Kinnow mandarin

4.6 Fruit weight

The data presented in figure 6 indicates that significantly highest fruit weight (149.85 gm) when the growth regulator and fungicide treatments were applied during first week of September with T_3 [Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)]; followed by 143.6 gm with T_1 [Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)]; 142.25 gmT_5 [Cyproconazole 25EC 0.1% +2, 4-D (20 ppm) + KNO_3 (1%)]. The lowest fruit weight (128.38 gm) was obtained in T_0 [water spray] and it was at par with T2 (133.45 gm) and T4 (127.21). The results obtained in this experiment were in conformity with the reports of Singh and Randhawa (1961).

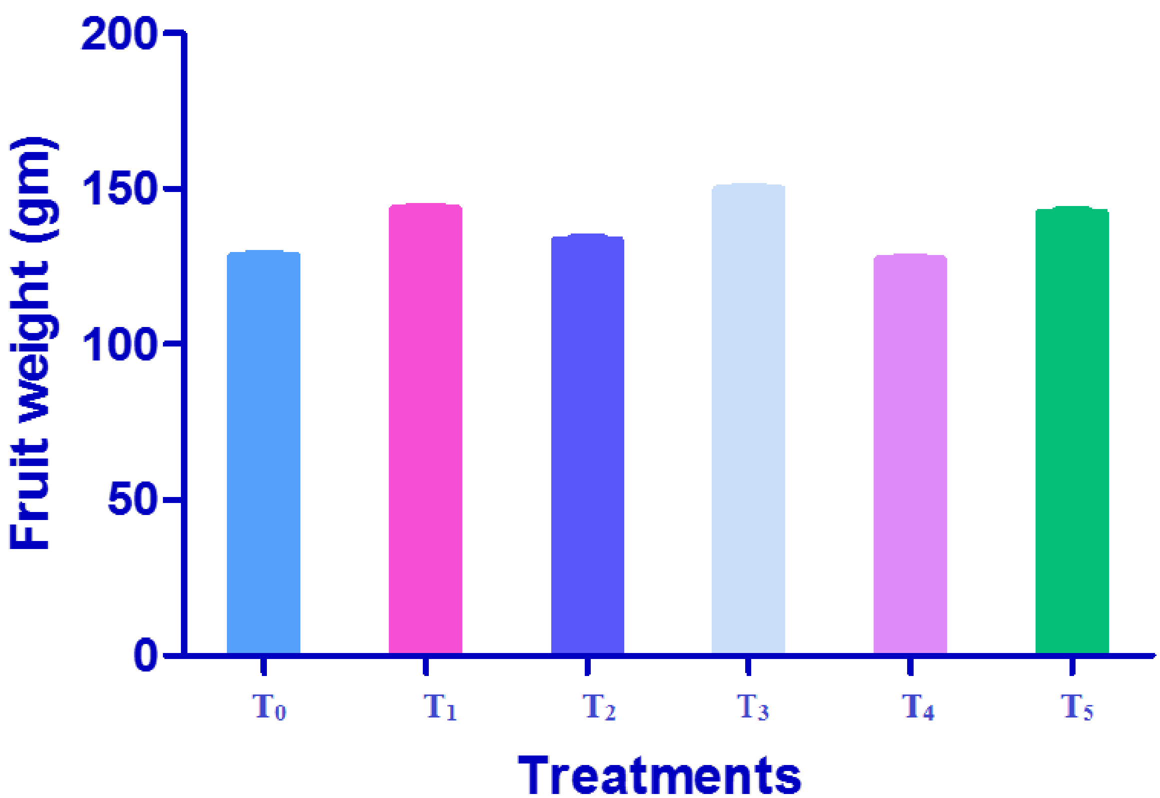


Fig. 4.6. Effect of growth regulators, fungicides and their time of application on fruit weight in Kinnow mandarin

4.7 Fruit size

The data mention in Figure-7 indicates that the maximum fruit size (53.5 cm) was achieved with T_3 [Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)] followed by in T_1 47.8 cm) [Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)]. The minimum fruit size (35.66 cm) was obtained with untreated T_0 [water spray] fruits and it was at par with T_5[Cyproconazole 25EC 0.1% +2, 4-D (20 ppm) + KNO_3 (1%)]. The results obtained in this experiment were in conformity with the reported by Randhawa and Sharma (1962) and Pal *et. al.,* (1977) who observed the larger fruits in trees receiving 2,4-D 20 ppm treatment. Effective of plant growth regulator in increasing fruit size has also been reported by Azher Nawaz *et. al.,*(2008) in Kinnow mandarin.

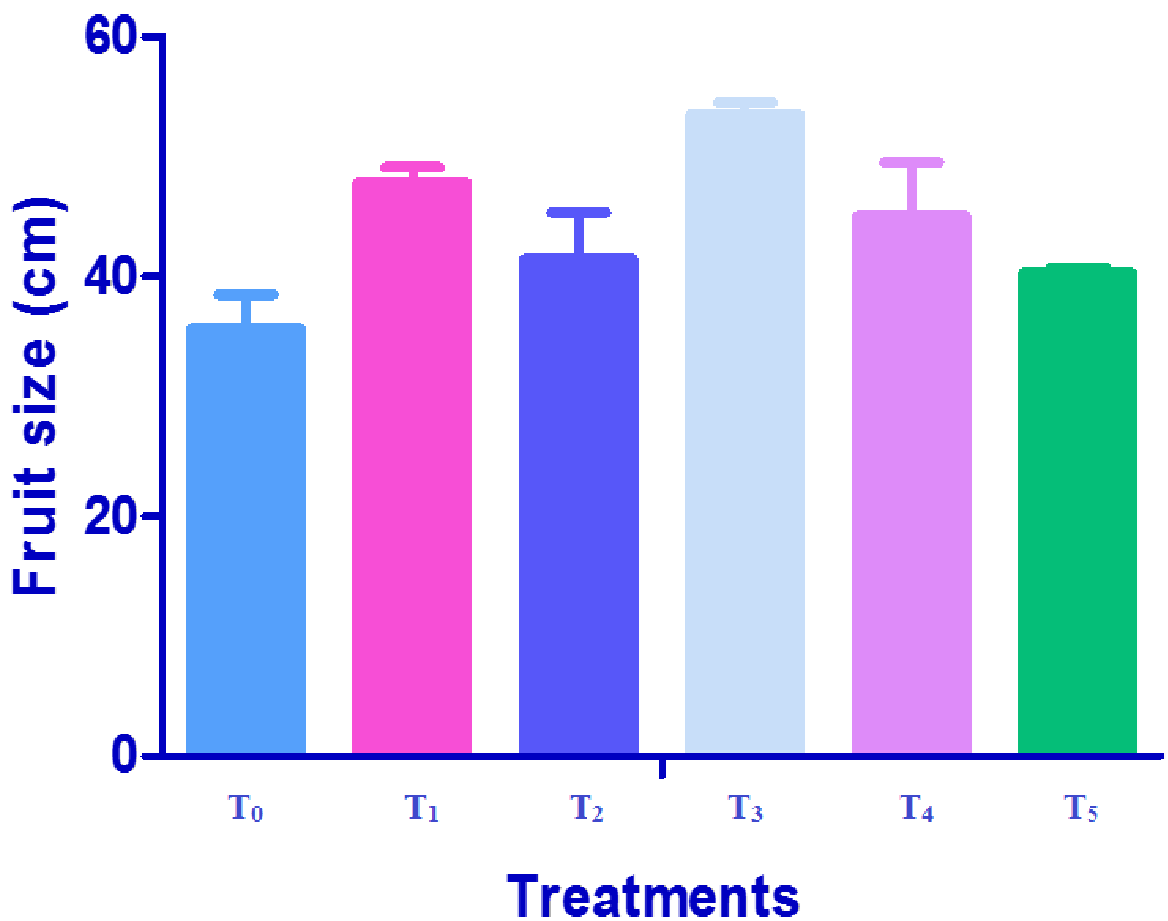


Fig. 4.7 Effect of growth regulator and fungicides their time of application on fruit size in Kinnow mandarin

4.8 TOTAL SOLUBLE SOLIDS

The perusal of data in Figure-8 indicates that all the growth regulator and fungicide treatments but resulted in higher total soluble solids than the water spray. The maximum total soluble solids (11.8 ^{0}Brix) were obtained with T_3 [Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)] which was significantly higher than other treatments. Minimum total soluble solids (9.1 ^{0}Brix) was obtained with untreated fruits T_0 [Water spray] which was statistically at par with T_1 [Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)] having TSS (10.9 ^{0}Brix). Fruit treated with T_3 [Curzate M8 0.25% +2, 4-D (20 ppm) + KNO_3 (1%)] showed considerably higher percentage of TSS in juice. Similar results have been reported by Chundawat *et. al.*, (1975) by using hormonal and fungicidal sprays in Kinnow mandarin. Sleem *et.al.*, (2007) had also reported similar finding while studying effective of exogenous growth regulator on fruit drop and quality & Blood Red orange.

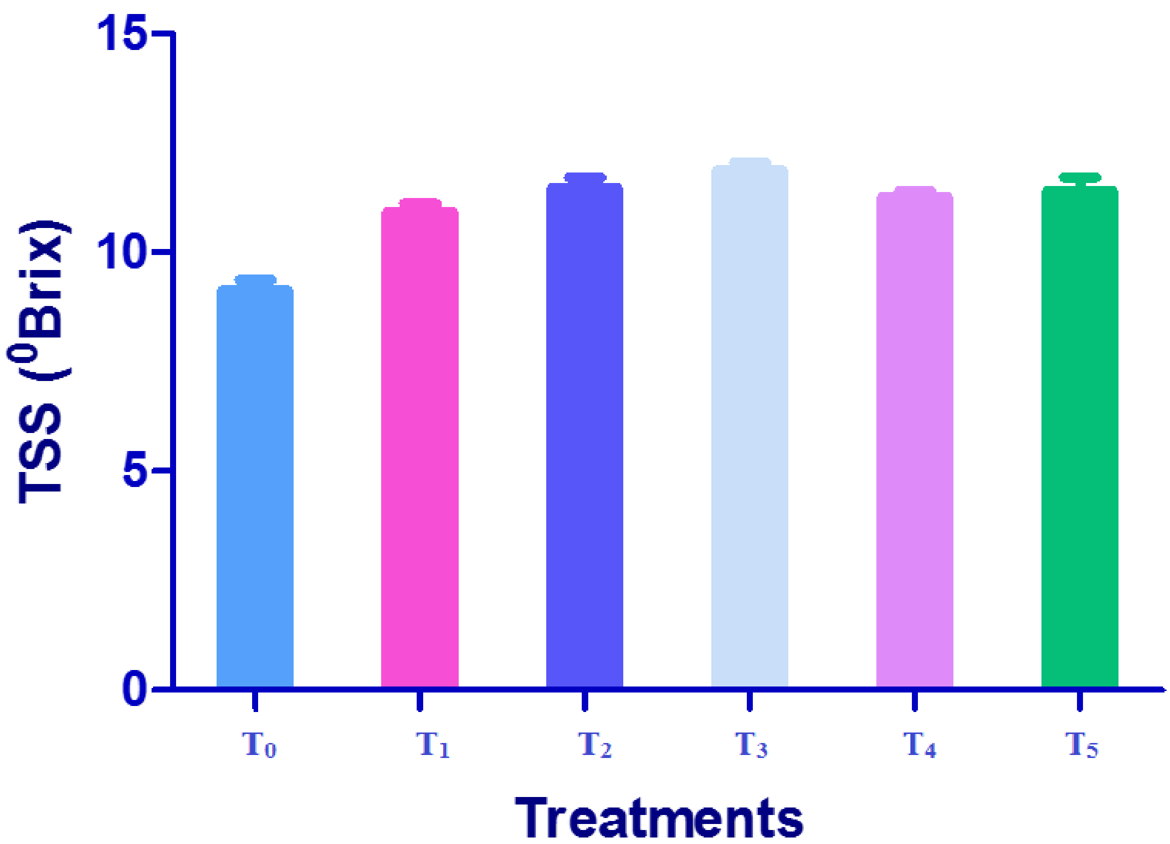


Fig. 4.8. Effect of growth regulators, fungicides and their time of application on TSS in Kinnow mandarins

CHAPTER V

Summary and conclusion

The present investigation was carried outin Kinnow Orchard of a progressive farmer in Hoshiarpur districtduring Kharif 2014.The present study in order to understand the effect of growth regulators and fungicide in Kinnow (*Citrus nobilis* × *Citrus deliciosa*L.). The salient findings of the study are summarise as under.

1. All the treatments reduce the entomological, pathological and physiological fruit drop. The minimum entomological fruit drop (1.90%) was observed with Curzate M8 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%) and Zeneb 75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%) (2.17%). The minimum pathological fruit drop (3.53% and 4.06%) was recorded with Curzate M8 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%) and Zeneb75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%).
2. The minimum fruit drop percentage (10.18%) was obtained with Curzate M8 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%).
3. The maximum fruit drop percentage (26.6%) was observed with untreated fruits.
4. Curzate M8 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)and Zeneb 75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%) applied during first week of September and October produced fruits with maximum weight (149.85 gm) and (142.25).
5. The maximum fruit size (53.5 cm) and (47.8 cm) achieved with treatments Curzate M8 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%) and Zeneb 75WP 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%).

6. The minimum total soluble solids (9.1 ^{0}Brix) were obtained with untreated fruits. The maximum total soluble solids was observed with Curzate M8 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)(11.8 ^{0}Brix) .
7. The maximum fruit drop was observed with untreated fruits in September. The minimum fruit drop was recorded in Curzate M8 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%)

It can be concluded that Curzate M8 0.25% + 2, 4-D (20 ppm) + KNO_3 (1%) is the excellent treatment for controlling integrated fruit drop management in Kinnow mandari

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Annexure - I

Monthly Metrological data of experimental research station Hoshiarpur year 2014-15.

Month	**Weeks**	**Temperature (ºC)**		**Relative humidity (%)**		**Rainfall (mm)**	
		Max	Min	Max	min	Max	Min
Sep	36^{th} -40^{th}	34	23	75	65	133	8
Oct	40^{th} -44^{th}	32	18	65	55	27	1
Nov	44^{th} -48^{th}	27	9	67	57	7	1
Dec	49^{th} -1^{st}	22	6	74	65	17	0
Jan	1^{st} -5^{th}	19	5	76	66	37	0