

**GROWTH, YIELD AND QUALITY OF KAGZI LIME  
( Citrus aurantifolia Swingle ) AS INFLUENCED BY  
DIFFERENT ROOT STOCKS UNDER AKOLA  
CLIMATIC CONDITION**

**T H E S I S**

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**I N**  
**A G R I C U L T U R E**  
( H O R T I C U L T U R E )



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## DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the thesis entitled "Growth, yield and quality of Kagzi lime (Citrus aurantifolia Swingle) as influenced by different rootstocks under Akola climatic condition" or part thereof has not been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or Scientific Organisation. The sources of materials used and all assistance received during the course of investigation have been duly acknowledge .

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# CERTIFICATE

This is to certify that the thesis entitled "Growth, yield and quality of Kagzi lime (Citrus aurantifolia Swingle) as influenced by different root stocks under Akola climatic condition" submitted in partial fulfillment of the requirements for the degree of Master of Science in Agriculture of the Punjabrao Krishi Vidyapeeth, Akola, is a record of bonofide research work carried out by Shri S.D. Babhale under my guidance and supervision. The subject of the thesis has been approved by the student's advisory committee.

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# LIST OF ABBREVIATIONS USED

AGR	- Absolute growth rate
Cm	- Centimeter
CD	- Critical difference at 5 percent level of significance
°C	- Degree centigrade
et al.	- <u>et alli</u> , and others
Fig.	- Figure
g	- Gram
%	- Per cent
Kg	- Kilogram
K <sub>2</sub> O	- Potash
mm	- Millimeter
m	- Meter
m <sup>3</sup>	- Cubic meter
N	- Nitrogen
P <sub>2</sub> O <sub>5</sub>	- Phosphate
S.E. (m)	- Standard error of mean

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## CHAPTER I

### INTRODUCTION

Acid lime locally known as 'Kagzi-Nimboo' (Citrus aurantifolia Swingle) is one of the commercial citrus fruit crops of the citrus industry. This fruit is well known for its diatic value. The fruit juice is very acidic and is consumed in almost every family in the country. The fruit has many medicinal uses as is mentioned in Ayurvedic treatments . The fruit is used in the preparation of refreshing drinks, in seasoning food, in the making of pickles, in preparing the commercial citric acid and citrate and in making cosmetics. The preserved products particularly the pickles, syrups etc. are in great demand since centuries. The fresh juice is quite apatising and in great demand perticularly in summer season. Considering the above advantages and the growing need of the Indian population, this fruit crop is gaining more importance in the citrus industry.

The Kagzi lime plantation has increased substantially during the past. decade in Vidarbha region, perticularly in Akola, Buldhana and Nagpur districts which is now representing the major Kagzi lime growing area of the Maharashtra State. It occupies about 400 hactares area in Vidarbha region and 2500 hactares in Maharashtra State

(Anon; 80) . The statistics of area under this crop is much more in the nature of estimates rather than exact figures based on the actual surveys .

The Vidarbha region is well known for its best mandarin variety 'Nagpur Santra'. The area under this crop is largest in the State particularly in Vidarbha region, however, this fruit needs more water than the acid lime. Considering the sources of water, the area under Nagpur Santra is concentrated along the foot hills of Satpura and the area lying along the Wardha river comprising the parts of the districts of Nagpur and Amravati. As this crop is facing very serious problems like decline, it is necessary to find out some suitable crop of easy technology to the growers where the rainfall is comparatively low and the source of water supply is also limited. In such situation substitute for Nagpur Santra is Acid lime , which is now representing the second most citrus fruit of Vidarbha.

The plantation of Kagzi lime in this region has been raised by using seedlings. Sexual method of propagation is much more popular all over the country due to the polyembryonic nature of the seeds. The apogamic seedlings are identical to the parent in growth and production. However, it is rather difficult to identify correctly the apogamic seedlings for plantation and if the apogamic



seedlings are not chosen for planting, the trees remain usually stunted and results in poor quality fruits .

If Kagzi lime is propagated by budding which offer some advantages over the seedlings, the trees will be uniformly true to type to parents. Moreover, if a certain rootstock species is found to impart tolerance/ resistance against certain diseases and seasonal exigencies of the weather, the cultivation of Kagzi lime can be extended to the areas where diseases and unsuitable climatic conditions are the limiting factors in its cultivation.

The significance of rootstocks in citriculture needs no emphasis because rootstocks have contributed, perhaps, more than any other factor to the success or failure of citrus industry around the world (Wutscher, 1979). The rootstocks not only influences early production, but it is one of the techniques to mitigate the adverse effects of climate and soil and thus make the scion adopted to wide range of climatic conditions . Apart from the influence on tolerance / resistance to certain diseases and pests, the rootstocks also plays vital role on growth and nutritional uptake of the scion which ultimately affects the production and quality of the fruit. In India, citrus canker, a bacterial disease is reported to the endemic on acid lime, it is worth

to study the influence of root stocks on the intensity of the citrus canker on Kagzi lime .

Based on the findings of the earlier research workers (Singh; 1966; Chadha et al., 1970; Jawanda and Singh, 1973; Singh and Saxena, 1978) nine rootstocks were chosen for the study .

The research work pertaining to the effect of different rootstocks on growth, yield and quality has been found lacking and not much work has been reported on this aspect. Keeping this in view, the present investigation was undertaken on "Growth, yield and quality of Kagzi lime (Citrus aurantifolia Swingle ) as influenced by different rootstocks under Akola climatic condition" at Punjabrao Krishi Vidyapeeth, Akola (M.S.) during the year 1988-89 .

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## CHAPTER II

### REVIEW OF LITERATURE

Rootstock problems in citriculture have assumed a significance . Every citrus growing country is faced with this problem. A considerable amount of work has been carried out all over this world in citrus on the effect of rootstocks on the various aspects of tree performance . The information available on the aspects pertaining to rootstock influence on growth, yield and quality of commercial citrus fruits has been presented in this chapter under the appropriate heading.

#### 2.1 Growth of scion on different rootstocks

##### 2.1.1 Rough lemon (Citrus jambhiri Lush)

Rough lemon is the promising second most rootstock in the world (Chadha et al., 1970).

Burke (1963) noticed that orange trees on Rough lemon produced the earliest and consistently high yield.

In Ciprus, Marsh seedless grape fruit trees on Rough lemon were found largest and consistently produced more yield (Economides., 1976 a).

In U.S.A., it has been possible to accelerate growth in the tops of trees propagated on this rootstock,

the crown being high and upright (Wolfgang, 1970).

In India, Rough lemon is one of the leading rootstocks of most scion varieties. Nagpur mandarin (Phadnis, 1961), Kinnow mandarin (Jawanda, 1978) and Mosambi (Reddy, 1964) were found vigorous on Rough lemon.

In Punjab, Rough lemon is one of the leading rootstocks for growth characteristic and percentage chlorosis. Kinnow trees grafted on 5 different rootstock were evaluated, over 6 years. On the basis of tree overall performance during pre-bearing period, the rootstocks rough lemon, Troyes citrange and Rangpur lime (Citrus limonia) were found to be superior (Jalikap, et al., 1986).

Singh (1962) stated that Hill mandarin shrinagar, mandarin were found vigorous on Italian 76 and florida Rough lemon respectively. None of the Mosambi trees on Jambheri and Karna Khatta died or declined at Shrirampur in Maharashtra (Frazer, 1967), while Mosambi on Gajanimma and Rangpur lime were vigorous but declined much faster than those on Sathgudi rootstock (Swamy et al., 1972).

Rough lemon and Karna were found to impart more vigour to sweet orange scion as compared to other rootstock in the nursery (Deshmukh, 1973).

Results of experiments available so far at Abohar and at other places showed that Jatti Khatti was a suitable rootstock for Kinnow mandarin (Jawanda and Singh , 1973). Similar observations were reported in Coerg, Hassan and Chickmanglore districts of Karnataka, Wynad and Palghat districts of Kerala, Oottackmond and Madurai districts of Tamilnadu on Rough lemon rootstock (Srivastava and Bopaiah, 1978) .

Jawanda and Mehrotra (1974) found that Jatti Khatti excelled all other rootstocks in imparting tree vigour to sweet orange cultivars.

Bhullar and Nauriyal (1974) observed in six years trial with nine rootstocks that blood red orange trees on Jambheri were the most vigorous and had the highest fruits fruits per tree.

Bhullar and Khokhar (1977) reported that Jambheri was found to be the most competible rootstock for Emperior, Kinnow and Nagpur mandarin scion.

Dhuria et al. (1977) observed maximum growth and yield in all stionic combinations with Jambheri and Jatti Khatti came next to Jambheri. Similar results were reported by Deshpande et al. (1977) in respect to Nagpur mandarin

where Jambheri stock produced superior growth and maximum yield closely followed by Kata Janur and Karna.

Mehrotra et al. (1977) found that Jatti Khatti excelled all other rootstock followed by Cleopatra where as trees on Rangpur lime and Karna made poor growth.

Srivastava et al. (1977) found maximum growth of coorg mandarin on Rough lemon and Rangpur lime rootstocks.

Mehrotra et al. (1982) reported that Jatti Khatti excelled all other rootstocks in increasing the tree volume of Mosambi cultivar of sweet orange.

Ganapathy (1983 b) observed largest girth of Mosambi tree on Rough lemon rootstock at Indian Institute of Horticulture Research Hissarghatta, Bangalore.

Philip and Mammen (1984) observed Rough lemon as most promising rootstock in a trial conducted on effect of quantitative and qualitative attributed of Coorgmandarin under the agroclimatic conditions of Wynad in Kerala.

Misra (1986) reported that Rough lemon and Trifoliate orange rootstocks were found to impart more vigour to pant lemon-1 scion while Rangpur lime produced poor growth.



### 2.1.2 Karna Khatta (Citrus Karna Raf.)

Karna Khatta is more popular in Uttarpradesh and Punjab. It is quite vigorous and fit for budding earlier than other rootstocks. Singh and Nagpal (1954) reported that for Matta local, Karna Khatta and Nasnaran were the most vigorous seedlings rootstocks.

Karna Khatta was found to be the most suitable rootstock for Vanille, Navelencia and Mosambi cultivars of Sweet orange (Frazer, 1967), and Shrinagar and Rangtara mandarin (Singh, 1961 a, 1962). Pineapple sweet orange on Karna Khatta produced smooth union and vigorous scion trees under Delhi conditions (Anon; 1972). On the contrary, it was found that Karna imparted less vigour to Coorg mandarin in South India (Aiyappa et al., 1967). However, Sohasarkar gave the maximum spread and height of Kinnow mandarin and the least growth was recorded on Trifoliate orange (Singh et al., 1977).

### 2.1.3 Marmalade orange (Citrus limonia Osbeck )

It is a cultivar of Rangpur lime and misnomer of marmalade (Sour orange). It shows the morphological characters to that of Rangpur lime. It can be considered as a rootstock with high potentially (Choudhari, 1980).



Tayde et al. (1988) reported that per-bearing growth of Kinnow mandarin on Marmalade orange rootstock was more as compared to other rootstocks under Akola conditions in Maharashtra .

#### 2.1.4 Nasnaran (Citrus Japonica Thunb )

There have been favourable reports on the performance of Nasnaran in India (Singh, 1954) and in California (Bitters, 1974). Sangtra local and Malta local on this stock in Montgomery were more vigorous, prolific and produced fruits of outstanding quality (Singh, 1966) . Similar results were obtained by Chadha et al. (1970). At Shrirampur, the volume of Mosambi trees budded on Nasnaran, Marmalade orange and Billikichili were highest (Anon; 1975).

#### 2.1.5 Nemutenga (Citrus lemon Linn )

Nemutenga is a very popular with the Assamese and it usually meets the demand of lime (Kagzi) because of its smallness in size and some resemblance with round sour lime (Bhattacharya and Dutta, 1952). This variety is smooth type of Rough lemon found in Assam and is sometimes erroneously called sour lime (Singh and Singh, 1968). There has been very little research work available on Nemutenga as a rootstock. Prebearing growth of Kinnow mandarin on Nemutenga was found vigorous under Akola conditions in

Maharashtra (Tayde et al., 1980).

#### 2.1.6 Rangpur lime (Citrus limonia Osbeck)

Weir (1976) in Jamaica reported that Rangpur lime was found to be the most vigorous rootstock next to Jambheri for Valencia orange, Marsh seedless grapefruit and ortanique scion.

At Poona, Rangpur lime rootstock appeared to be more satisfactory for Mosambi scion. A medium crop and vigour were obtained in Nagpur mandarin on Rangpur lime stock (Gopal Krishna and Kunte, 1958 ; Phadnis, 1961) .

Frazer (1967) reported that maximum vegetative growth resulted when Rangpur lime rootstock used for Mosambi.

Swamy et al. (1972) stated that Sathgudi scions on this stock were vigorous but of late.

Sinha et al. (1977) reported that height, girth and volume of Nagpur mandarin were more on Rangpur lime stock than other rootstock used. However, Indrasenam and Mammen (1981) reported medium growth in respect of height and girth of Coorg mandarin on this stock.

Haleem (1984) reported that Sathgudi and Mosambi cultivars of Sweet orange budded on Rangpur lime rootstock gave best results as compared to other rootstocks in respect of tree height, spread, crown volume and stock / scion diameter .

### 2.1.7 Sweet lime (Citrus limettioides Tanaka )

Chandha *et al.* (1970) reported that Sweet lime has been commonly used as rootstock for shamouti orange in Israel and adjacent countries.

Frazer (1967) observed that Sweet lime was the most satisfactory stock next to Jambheri for Coorg mandarin scion at Chethali in South India.

Phadnis (1961) reported that Nagpur mandarin trees on Sweet lime and Rangpur lime showed medium vigour at Tharsa. Similar observations were also recorded by Tayde *et al.* (1988) in case of kinnow scion at nursery stage under Akola conditions.

### 2.1.8 Trifoliate orange (Poncirus trifoliata Raf.)

Trifoliate orange is commonly used rootstock in California, Australia, Newzealand, Japan and Formosa. It gives dwarfing effect on scions (Phillips, 1969). On the contrary, Tanaka (1969) and Ikeda *et al.*, (1978) reported that Trifoliate was the most compatible, vigorous and precocious rootstock for satsuma oranges and for Navel orange respectively. Tayde *et al.* (1988) obtained similar observations in case of kinnow mandarin scion under Akola conditions. However, Singh (1963) reported that for vanille Sweet orange, this rootstock proved to be less vigorous.

Most of the scion growth on Trifoliate rootstock showed dwarfing character in Mosambi and Nagpur Santra.

Trifoliolate and Citranges showed over growth of stock portion with most of the scion. (Chosh, 1963; Anon; 1972). Deshmukh (1973) reported that Trifoliolate imported poor growth to Sweet orange scion and stock portion showed over growth than the scion. Roose (1986) found more growth and yield of Valencia tree on Poncirus trifoliolate rootstock.

Singh and Singh (1974) reported that Trifoliata orange for Nagpur mandarin was found to be incompatible. The trees of Georgian lemon, Washington Navel orange and Satsuma were grown on trifoliolate orange produce early fruiting and trees were found comparatively dwarf (Tutberidze et al., 1987).

#### 2.1.9 Troyer citrange

Poncirus trifoliolate Raf. X Citrus Sinensis Osbeck)

Bitters (1961) reported that Troyer and Carrizo citranges used as rootstocks resulted in comparatively vigorous trees.

Castle and Krezdon (1975) observed shortest trees of Orlando tangelo on Rusk Citrange and Trifoliolate orange.

Hassaballa (1978) stated that Sweet orange trees on Troyer citranges and Cleopatra mandarin were smallest. On the contrary, Coorg mandarin trees on Troyer citrange at lower Palni hills in Tamilnadu registered more height, volume and stock and scion girth followed by Rough lemon and Rangpur lime in prebearing stage.

## 2.2 Effect of different rootstocks on yield

In general, the vigorous rootstocks are reputed to produce greater crops over a longer period. On the other hand, trees on dwarfing stocks may be fruitful and closely planted, produce higher yields per unit area.

Sweet oranges on Rough lemon stock gave higher yields than others as reported by Cohen and Reitz (1963) and Gradner and Horanic (1961) .

Economides (1976 b) reported higher yields of Washington Navel oranges on Rough lemon, Cleopatra mandarin and Palestine Sweet lime . Similar observations were made by Bhullar and Nauriyal (1975) for Blood red oranges on Rough lemon rootstock. Hutchison (1975) also reported greatest fruit production of Valencia oranges on Rough lemon followed by Troyer citrange .

Ganapathy (1983 a) observed the highest yield of Coorg mandarin on carrizo citrange and Rough lemon under Bangalore conditions.

Hutchison and Hearn (1977) reported that Nova on Rough lemon and Orlando on Troyer citrange rootstocks gave higher yield.

Holtzhausen et al. (1978) observed highest yield in case of Frost nucellar Eureka and Ryan Eureka on Rough lemon rootstock.

Tribulato (1979) observed, while finding out the performance of MOROnucellai lime on seven rootstock, that maximum growth and yield were noticed on Rough lemon and Volkamercana lemon rootstocks.

It was observed by Chohan et al. (1980) that Blood red Sweet orange on Rough lemon and Cleopatra mandarin gave best yield but quality of fruits was poor.

Rodney and Harris (1977) reported that Frost Nucellar Lisbon lemon trees on Rough lemon had the next highest crops than Citrus macrophylla .

Maxwell and Wutscher (1976) noticed that grapefruit trees budded on karna khatta and sour orange were most productive in a trial with 10 rootstocks.

Castle and Phillips (1980) reported that Marsh grapefruit and Valencia Sweet orange trees on Rough lemon were largest and most productive.

Economides (1977) reported higher yield of campbell Valencia orange on Rough lemon and Palestine Sweet lime rootstocks than on Cleopatra and Troyer citrange, but quality was poor.

Chohan and Kumar (1983) reported that Musambi cultivar of Sweet orange on Rangpur lime gave good yield of quality fruits.



Bouderbala and Blondel (1974) found that Sweet oranges on *Poncirus trifoliata* rootstock gave highest yield of juicy fruits as compared to sour orange and Cleopatra mandarin stocks. Similar results were obtained by Roose (1986) for Valencia trees on *poncirus trifoliata* rootstock and Flamenac (1976) for Sweet orange cultivar, Domestic and Washington Navel oranges. Ganapathy (1983 b) reported highest yield of Mosambi on Trifoliolate orange stock at Indian Institute of Horticulture Research Hissar-ghatta, Bangalore.

Bevington and Duncan (1980) reported higher yield of Ellendate Tangor on *Poncirus trifoliata* and Rangpur lime stock in heavy and calcareous sandy soil respectively.

However, Brown (1986) recorded lower yield of Washington Navel orange on Trifoliolate orange stock but quality of fruits was best.

Youtsey and Bridges (1979) recorded higher yield of Washington naval nucellar selection on Carrizo, Troyer citrange and *Poncirus trifoliata* rootstocks.

Deidda and Milella (1978) reported that the growth and productivity of Frost Navel were better on Troyer citrange than on sour orange and Hamlin on Troyer citrange were found productive.

Blondel (1978) reported Troyer citrange as best rootstock for oranges and Satsumas while Trifoliolate and Carrizo citrange were promising.



Zaragoza Adriaensens et al. (1984) reported highest yield of Washington Navel and Valencia late Sweet oranges on Troyer Citrange.

### 2.3 Effect of different rootstocks on quality of fruits.

In citrus, striking effects of rootstocks are more often observed in many fruit characters of the scion. Many workers reported the distinctive effect of rootstock on fruit size and quality of fruit of the scion variety.

Ranjit Singh et al. (1978) found that Troyer citrange induced precocity in Kinnow mandarin.

Albert et al. (1979) reported that fruits from Late Valencia orange on Troyer citrange were heavier, had greater length/diameter ratio, higher juice yields, thinner peel than fruits of Late Valencia on Sour orange.

Ali and Rahim (1960) reported that the fruits of Valencia orange on Rough lemon rootstock had lowest ascorbic acid content and it was due to abnormal size and weight of fruit on this rootstock.

Similarly, Boyee (1960) also observed lemon fruits from trees on Rough lemon stock were of lower juice content, soluble solids and citric acid than fruits from trees on other rootstocks.

Campbell and Goldweber (1980) reported that Tahiti lime and lemon grew well on Rough lemon and C. macrophylla rootstocks and produced fruits of good quality.

Levy and Mendel (1982) observed that fruit size of Washington navel and Shamouti was largest on Rough lemon, however, T.S.S. and acid content were found to be low.

Aranjo et al. (1972) found that para orange fruits on Rangpur lime and Cleopatra mandarin rootstock contained higher juice and T.S.S. and relatively low acidity.

Valle N-Del et al. (1979) observed that greatest mean fruit weight and diameter of Dancy mandarin were obtained on Rangpur lime and lowest acidity on Rough lemon, Rangpur lime and Troyer citrange (0.73, 0.76, 0.79 respectively ).

Kefford and Chandler (1961) stated that fruits of Valencia Late and Washington Navel on Trifoliate orange rootstock contained higher juice, more acidity and soluble solids but low ascorbic acid, while Rough lemon rootstock associated with low juice content, less acidity and soluble solids but rich ascorbic acid.

Chohan et al. (1980) reported that the fruits of Campbell Valencia / Sweet orange on Troyer citrange and carrizo citrange had maximum T.S.S. and T.S.S. / acid ratio while it was minimum on Jatti Khatti rootstock.

Hutchison and Bistline (1982) reported that Valencia Sweet orange on Poncirus trifoliata and Sour orange produced fruits with highest T.S.S.

Mehrotra et al. (1983) reported that Sweet orange fruits on Carrizo and Troyer citrange stock produced better quality fruit (more T.S.S. and acidity) than the Sweet orange fruits on Jatti Khatti and Karna Khatta rootstock.

Haleem (1983) observed that Sathgudi and Mosambi on Trifoliate and its hybrid produced fruits with high T.S.S. while on Rough lemon, fruits were of poor quality.

Philip and Mammen (1984) reported that fruits of Coorg mandarin on Rough lemon had more fruit weight, Rind thickness and lower pulp / rind ratio, less number of seeds and lower juice content, while fruits on carrizo citrange and Trifoliate rootstock had more juice under the agroclimatic conditions of Wynad in Kerala.

Thornton and Dimsey (1987) reported that fruits of Valencia orange on Rough lemon contained low juice and Sugar. The fruits on Rangpur lime and Poncirus trifoliata were of smaller size.

Bhullar and Nauriyal (1975) reported that fruits of Blood red orange on Poncirus trifoliata rootstock had highest juice content, T.S.S. and acidity while T.S.S. / acid was highest on C. Karna .

Brown (1985) reported that Navel orange trees on Troyer citrange gave poor quality fruits while high brix and acidity ratio, thinner skin and better flavour were observed on Trifoliate orange rootstock.

Economides (1976 b) reported that in Washington navel orange the total solids and acidity and rind thickness were not affected by rootstocks employed.

#### 2.4 Effect of different rootstock on occurrence of canker diseases .

Citrus canker is the most prevalent bacterial disease reported to be endemic on acid lime (Kagzi lime) in India.

Falico De Alcaraz and Rodriguez (1970) reported that the infection of canker on lemon variety Villafranca on Rangpur lime rootstock remained low between September to March and then increased rapidly .

Danos et al. (1981) reported that spread of canker disease was affected by scion types and rootstocks. On the contrary, Mohan et al. (1985) observed that consistent differences were not found between the rootstocks as to their influence on the reaction of scion to canker. Similarly, Cheema et al. (1975) reported that rootstock did not impart resistance to the scions budded on it .

Cheema et al. (1982) reported that Sweet oranges (Musambi, Pineapple, Jaffa and Valencia ) budded on Rangpur lime, Pearl tangelo and mandarin on Carrizo citrange were tolerant of canker .

Agostini et al. (1985) reported that canker diseases spread was higher on vigorous and intermediate rootstocks than on non-vigorous rootstocks.

The rate of increase in disease severity was also greater on vigorous and intermediate rootstocks such as Rough lemon, Carrizo citrange than on non-vigorous like Trifoliate orange rootstock .

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## CHAPTER III

### MATERIALS AND METHODS

The present study was carried out during the year 1988-89 in the orchard and laboratory of the Department of Horticulture, Punjabrao Krishi Vidyapeeth, Akola (M.S.). The details of material used and methods adopted during the course of present investigation are given in this chapter.

#### 3.1 Climatic and Weather conditions

Akola is situated in the sub-tropical zone at the latitude of  $22.42^{\circ}$  North and longitude of  $77.02^{\circ}$  East . The attitude of the place is 307.4 m from mean sea level. Average annual precipitation is 720 mm. Most of the rains are received during June to September (about 84%). The mean annual maximum and minimum temperature are  $34.0^{\circ}\text{C}$  and  $20.4^{\circ}\text{C}$  respectively.

Summer months are hot with temperature and humidity ranging from  $34.5^{\circ}\text{C}$  to  $43.9^{\circ}\text{C}$  and 37 to 47 per cent respectively. The winter months experiences mild cold with average temperature ranging from  $20.0^{\circ}\text{C}$  to  $24.0^{\circ}\text{C}$  . December is the coldest months in which the lowest temperature touches upto  $9.3^{\circ}\text{C}$ . The highest temperature is recorded in the month of May ( $43.9^{\circ}\text{C}$ ). Daily maximum and minimum values of temperature evaporation rate rise from February onwards upto June and then drop progressively upto December . Meteorological data for the period of present investigation as recorded at University Meteorological centre are presented in Appendix - I .



### 3.2 Soil

The plot on which Kagzi lime trees on different rootstocks are existing has medium black clayey soil which was analysed for various physico-chemical properties. The relevant data are presented in Table - 1 .

Table 1 : Mechanical and chemical composition of surface soil (0-22 cm layer )

Particulars	Contents
(A) Mechanical composition	
1. Clay %	55.2
2. Silt %	19.5
3. Sand %	15.6
4. Textural class	Clay
(B) Chemical composition	
1. Total N (%)	0.046
2. Available $P_2O_5$ (%)	0.0016
3. Available $K_2O$ (%)	0.026
4. PH of the soil	7.8

### 3.3 Details of Experiment

The present investigation was carried out on 54 trees of Kagzi lime on different nine rootstocks planted in July, 1981 at 5m x 5m spacing in the orchard of the University; Department of Horticulture, Punjabrao Krishi Vidyapeeth, Akola.



R III

	TROY	MRLO	NASN	JMB
	TROY	MRLO	NASN	JMB
KRN	NMTG	RLM	SLM	TRIF
KRN	NMTG	RLM	SLM	TRIF

R II

KRN		MRLO	NASN	RLM
KRN		MRLO	NASN	RLM
SLM	NMTG	JMB	TRIF	TROY
SLM	NMTG	JMB	TRIF	TROY

R I

SLM	MRLO	TRIF	TROY	KRN
SLM	MRLO	TRIF	TROY	KRN
NMTG		NASN	RLM	JMB
NMTG		NASN	RLM	JMB

Fig. I PLAN OF LAYOUT



These rootstocks considering them as treatments, were replicated three times in a Randomized Block Design. There were two trees on each rootstock as a unit in each replication. The details of layout adopted and rootstocks used are given in Figure - I and Table -2 respectively.

### 3.4 Plant material used

The nine rootstocks taken for the study are given in Table-2 .

Table 2 : Details of rootstocks used

Sr.	Common name	Botanical name	Symbol used
1.	Jambheri	<u>Citrus jambhiri</u> Lush	JMB
2.	Karna khatta	<u>Citrus karna</u> Raf.	KRN
3.	Marmalade orange	<u>Citrus limonia</u> Osbeck	MRLO
4.	Nasnaran	<u>Citrus japonica</u> Thunb	NASN
5.	Nemutenga	<u>Citrus limon</u> Linn.	NMTG
6.	Rangpur lime	<u>Citrus limonia</u> Osbeck	RLM
7.	Sweet lime	<u>Citrus limettioides</u> Tanaka	SLM
8.	Trifoliate orange	<u>Poncirus trifoliata</u> Raf.	TRIF
9.	Troyer citrange	<u>Poncirus sinensis</u> Osbeck	TROY
-----			

### 3.5 Cultural operations -

The plot was kept free from the weeds by attending timely weeding operations. Other cultural practices such as manuring, fertilization, plant protection measures and irrigations were attended as and when required. The experimental

trees were given stress (Bahar treatment) during the month of May, 1988 for inducing flowering during June-July, 1988. Each tree was given 25 kg well decomposed farm yard manure alongwith 1/2 kg N and 1/2 kg  $P_2O_5$  at the time of releasing the water stress. Remaining 1/2 kg N was supplied when the fruits were of pea size.

### 3.6 Details of the observations noted

#### 3.6.1 Growth

The growth observations in respect of height, spread, scion and stock girth were recorded at monthly interval (in first week of each month) during the course of investigation from April, 1988 to March, 1989.

##### 3.6.1.1 Height

The height was measured from the bud joint upto the highest point of the growth in meters with the help of measuring scale.

##### 3.6.1.2 Spread

The spread of the trees was measured by measuring scale in North - South and East - West direction in meters.

##### 3.6.1.3 Volume of tree

The volume of tree was calculated as per the formula given below suggested by Westwood et al. (1963).

$$\text{Volume of tree} = \frac{4}{3} \pi \frac{1}{2} a^2 \cdot \frac{1}{2} b .$$

Where ,

'a' represents spread of the crown of tree and

'b' denotes the tree height.

#### 3.6.1.4 Stock and scion girth

In order to assess the stionic compatibility the girth of stock and scion was measured 5 cm below and above the bud union respectively with the help of string and measuring scale in centimeters.

#### 3.6.1.5 Scion / stock ratio

The scion / stock ratio was worked out by dividing the girth of scion by girth of stock.

#### 3.6.1.6 Absolute growth rate (A.G.R.)

The absolute growth rate gives the idea of the pattern and of critical growth stages. It was calculated as under :

$$A.G.R. = \frac{H_2 - H_1}{t_2 - t_1}$$

Where ,

A.G.R. = Absolute growth rate in terms of growth character in a month per plant during  $t_2$  and  $t_1$  .

$H_2$  = Growth of tree at  $t_2$

$H_1$  = Growth of tree at  $t_1$

$t_2$  and  $t_1$  = months

### 3.6.2 Yield

The fruits were harvested in several pickings from October to November, 1988.

#### 3.6.2.1 Number of fruits

The total number of fruits harvested per tree were recorded by taking into account the number of fruits from each picking.

#### 3.6.2.2 Weight of fruits

The total weight of fruits from a tree was recorded by adding the weight of fruits picked from each picking. They were weighed gravimetrically on a pan balance.

#### 3.6.2.3 Fruit drop (%)

The fruit drop percentage was calculated on the basis of fruit dropped and the total number of fruits harvested.

### 3.6.3 Quality

In order to study the quality of kagzi lime fruits as influenced by different rootstocks, following quality parameters were studied.

#### 3.6.3.1 Weight of fruit

The fruits were weighed gravimetrically on a pan balance and mean weight was calculated.

### 3.6.3.2 Volume of fruit

The volume of fruits was measured by water displacement method in millilitres with the help of measuring cylinder.

### 3.6.3.3 Specific gravity of fruit

The specific gravity of fruit was calculated by dividing the weight of fruit by its volume.

### 3.6.3.4 Rind thickness

With the help of vernier calliper, the rind thickness was measured in mm after cutting the fruit in two halves.

### 3.6.3.5 Juice content (%)

The juice was extracted from the fruit and was weighed gravimetrically on the pan balance . The percentage of juice extracted was calculated.

### 3.6.3.6 Rind - Pomace (%)

The rind weight was taken after extraction of juice with the help of pan balance. The rind percentage including pomace in a fruit was calculated.

### 3.6.3.7 Number of seeds

The seeds were counted from each fruit and the number of sound and unsound seeds were recorded.

### 3.6.3.8 Total Soluble Solids (T.S.S.)

After extraction of juice, the same was strained through a muslin cloth. The percentage of total soluble solids (T.S.S.) was determined by using hand refractometer.

### 3.6.3.9 Acidity

In order to determine the acidity of kagzi lime juice, 25 ml of pure juice was pipetted and transferred to 250 ml. volumetric flask into which distilled water was added and the volume was made up to the mark. 25 ml of the above diluted juice was titrated against N/10 NaOH solution using phenolphthalein as an indicator. The percentage of citric acid in juice was calculated from the relation : 1 ml of 0.1 N NaOH which is equivalent to 0.0064 g of citric acid.

### 3.6.3.10 Ascorbic acid content

The ascorbic acid was determined by the method as described by Jacobs (1958). To the 25 ml of diluted juice as described above in the case of estimation of acidity, 2 ml of 1% freshly prepared soluble starch solution was added as an indicator and then it was titrated against 0.01 N Iodine solution which was run through a burette. 1 ml of 0.01 N Iodine solution is equivalent to 0.88 mg of ascorbic acid. From this relation, quantity of ascorbic acid in mg per 100 ml of pure juice was determined.



#### 3.6.3.11 T.S.S. / acid ratio

The T.S.S. / acid ratio was calculated by dividing the values of total soluble solids by acidity values.

#### 3.6.4 Citrus canker

The observations were recorded to study the influence of rootstocks on the severity of canker disease on Kagzi lime in the peak period i.e. in the month of August and October.

##### 3.6.4.1 Per cent disease index

Three twigs of the current season growth per tree were selected randomly and from each twig five leaves were selected for observations .

##### 3.6.4.2 Per cent leaves infected

For per cent leaves infection, total number of leaves on a twig infected by canker was recorded.

#### 3.6.5 Statistical analysis

The data on all the above parameters were subjected to statistical analysis. Analysis and interpretation of the data were done by the statistical methods of Snedecor and Cochran (1967) .

## CHAPTER IV

### RESULTS

The experimental findings on growth, yield and quality of kagzi lime (Citrus aurantifolia, swingle) as influenced by different rootstocks are presented under appropriate heading in this chapter.

#### 4.1 Growth

The data in respect of the effect of different rootstocks on growth of Kagzi lime in terms of absolute growth rate, height, spread, canopy volume, stock and scion girth are presented in Tables - 3,4,5,6,7 and are interpreted and graphically depicted in figure II.

##### 4.1.1 Absolute growth rate

##### 4.1.1.1 Height of the trees

The rate of growth as influenced by different rootstocks (Table 3) in respect of height of Kagzi lime tree exhibited the differential pattern of growth. The kagzi lime trees on Trifoliate orange, Jambheri, Rangpur lime and Troyer citrange exhibited more rate of growth followed by Sweet lime and Nemutenga which showed moderate rate of growth in respect of the height of Kagzi lime tree. The trees on Nasnaran, karna khatta and marmalade orange showed slow rate of growth as compared to other rootstocks.

Table 3 : Monthly increase in height (m)  
(A.G.R.)

Rootstock	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total during the year
Jambheri	0.02	0.01	0.02	0.04	0.07	0.04	0.05	0.08	0.10	0.10	0.09	0.07	0.69
Karna khatta	0.03	0.02	0.02	0.02	0.03	0.04	0.02	0.04	0.07	0.09	0.04	0.08	0.50
Marmalade orange	0.02	0.01	0.02	0.03	0.02	0.02	0.04	0.03	0.08	0.09	0.07	0.06	0.49
Nasnaran	0.04	0.01	0.02	0.02	0.07	0.04	0.01	0.03	0.08	0.09	0.07	0.04	0.52
Nemutenga	0.03	0.01	0.05	0.04	0.01	0.01	0.05	0.03	0.09	0.10	0.08	0.07	0.57
Rangpur lime	0.01	0.02	0.05	0.02	0.05	0.02	0.04	0.07	0.10	0.11	0.07	0.05	0.61
Sweet lime	0.01	0.01	0.02	0.01	0.04	0.03	0.03	0.06	0.09	0.11	0.12	0.05	0.59
Trifoliate orange	0.03	0.02	0.03	0.02	0.05	0.06	0.07	0.09	0.10	0.09	0.09	0.08	0.73
Troyer citrange	0.04	0.01	0.03	0.02	0.02	0.07	0.03	0.04	0.09	0.10	0.08	0.07	0.60
	0.23	0.12	0.27	0.22	0.36	0.33	0.34	0.47	0.80	0.88	0.71	0.57	

Table 4 : Monthly increase in spread (m)

Rootstock	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total during the year
Jambhari	0.10	0.03	0.07	0.07	0.05	0.03	0.04	0.11	0.02	0.09	0.08	0.04	0.73
Karna Khatta	0.09	0.01	0.02	0.04	0.03	0.03	0.02	0.04	0.09	0.10	0.15	0.08	0.70
Marmalade orange	0.08	0.02	0.05	0.07	0.09	0.01	0.02	0.03	0.07	0.10	0.11	0.16	0.81
Nasnaran	0.04	0.01	0.02	0.02	0.08	0.09	0.01	0.01	0.07	0.01	0.01	0.04	0.61
Nemutenga	0.11	0.01	0.01	0.05	0.03	0.04	0.03	0.11	0.07	0.17	0.05	0.09	0.77
Rangpur lime	0.09	0.03	0.02	0.01	0.02	0.02	0.09	0.09	0.09	0.05	0.10	0.10	0.71
Sweet lime	0.12	0.01	0.02	0.02	0.03	0.06	0.10	0.09	0.05	0.16	0.20	0.12	0.98
Trifoliate orange	0.05	0.00	0.05	0.09	0.05	0.04	0.02	0.03	0.03	0.19	0.04	0.03	0.53
Troyer citrange	0.07	0.02	0.03	0.05	0.05	0.06	0.09	0.02	0.10	0.07	0.11	0.10	0.77
	0.75	0.14	0.29	0.42	0.43	0.38	0.42	0.53	0.59	0.85	0.85	0.76	

Maximum rate of growth in terms of all rootstocks was observed to be more in the month of January and showed decreasing trend upto May where onwards it again showed increasing trend upto June, but in July it decreased slightly. From the month of August it showed increasing trend upto January. The maximum and minimum rate of growth (Table 3) was observed in the month of January and May respectively irrespective of rootstock effect.

#### 4.1.1.2 Spread of tree

The rate of growth of Kagzi lime trees in respect of spread of trees as influenced by different rootstocks (Table 4) showed some what fluctuating trend. Maximum rate of growth in respect of spread was observed in trees growing on Sweet lime which supersucceed all the remaining rootstocks. The intermediate growth rate was observed on Marmalade orange, Nemutenga, Troyer citrange and Jambheri. The trees on Trifoliate orange showed least rate of growth in respect of spread.

Maximum rate of growth in all rootstocks was observed in the month of February and January followed by April and March. In the month of January and February, it showed increasing trend. From the month of May, it increased upto August whereas in September it was observed to be decreased. The minimum rate of growth in respect of spread of tree was observed in the month of May.

Table 5 : Monthly increase in girth of stock (cm)

Rootstock	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total during the year
Jambheri	0.05	0.09	0.08	0.10	0.12	0.06	0.23	0.25	0.12	0.11	0.05	0.12	1.38
Karna khatta	0.04	0.10	0.22	0.10	0.05	0.05	0.20	0.22	0.15	0.10	0.09	0.07	1.39
Marmalade orange	0.09	0.07	0.09	0.10	0.20	0.12	0.15	0.25	0.12	0.13	0.10	0.06	1.48
Nasnaran	0.06	0.15	0.16	0.07	0.37	0.21	0.30	0.32	0.12	0.14	0.13	0.17	2.20
Nemutenga	0.12	0.17	0.12	0.07	0.10	0.07	0.05	0.20	0.13	0.15	0.12	0.24	1.54
Rangpur lime	0.09	0.06	0.07	0.08	0.05	0.17	0.12	0.21	0.12	0.12	0.16	0.14	1.39
Sweet lime	0.15	0.12	0.09	0.23	0.07	0.05	0.15	0.10	0.17	0.12	0.18	0.21	1.64
Trifoliate orange	0.10	0.15	0.10	0.07	0.12	0.06	0.27	0.15	0.23	0.13	0.16	0.09	1.63
Troyer citrange	0.11	0.15	0.23	0.11	0.12	0.07	0.23	0.31	0.15	0.11	0.17	0.21	1.97
	0.81	1.06	1.16	0.93	1.20	0.86	1.70	2.01	1.31	1.11	1.16	1.31	



Table 6 : Monthly increase in girth of Kagzi lime scion (cm)

Rootstock	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total during the year
Jambheri	0.04	0.09	0.12	0.04	0.17	0.12	0.05	0.32	0.25	0.23	0.07	0.12	1.62
Karna khatta	0.05	0.14	0.15	0.09	0.04	0.05	0.10	0.35	0.15	0.10	0.09	0.06	1.37
Marmelade orange	0.02	0.10	0.21	0.12	0.09	0.03	0.21	0.37	0.09	0.05	0.12	0.12	1.53
Nasnaran	0.09	0.02	0.25	0.12	0.20	0.09	0.24	0.09	0.12	0.31	0.10	0.07	1.70
Nemutenga	0.05	0.03	0.27	0.09	0.05	0.01	0.12	0.23	0.12	0.11	0.17	0.05	1.30
Rangpur lime	0.11	0.30	0.03	0.29	0.24	0.03	0.17	0.18	0.12	0.07	0.06	0.09	1.69
Sweet lime	0.07	0.02	0.02	0.01	0.05	0.07	0.12	0.07	0.12	0.30	0.13	0.17	1.15
Trifoliate orange	0.04	0.03	0.00	0.07	0.05	0.13	0.25	0.12	0.13	0.16	0.12	0.03	1.13
Troyer citrange	0.05	0.10	0.30	0.04	0.02	0.05	0.20	0.32	0.10	0.12	0.16	0.15	1.61
	0.52	0.83	1.35	0.87	0.91	0.58	1.46	1.68	1.20	1.45	1.02	0.91	



#### 4.1.1.3 Height spread ratio

The data presented in Table 7, show that the low Height / spread ratio was noticed in the case of Nemutenga and Sweet lime. The medium values were observed to be Marmalade orange, Karna Khatta and Troyer citrange. The more Height / spread ratio was noticed in the case of Rangpur lime, Jambheri and Trifoliate orange.

#### 4.1.1.4 Girth of stock

The girth of stock as influenced by different rootstock (Table 5) showed maximum rate of growth with Nasnaran, Troyer citrange and Sweet lime. The medium was observed with Trifoliate orange, Nemutenga and marmalade orange, whereas it was found to be minimum with Karna khatta, and Rangpur lime and least being with Jambheri .

Irrespective of rootstock effect, the growth rate was observed more in the month of October and November, intermediate was observed in June, December, January and March and least was in February, May and April. In the month of April, it was found to be poor.

Data presented in Table 5 show fluctuating trend right from April to March .

#### 4.1.1.5 Girth of scion

It is revealed from the data presented in Table 6 that maximum rate in respect of girth of scion was observed

with Nasnaran, Rangpur lime and Jambheri . Intermediate was observed with Troyer citrange, Marmalade orange, whereas least rate of growth was observed with Nemutenga, Karna khatta, Sweet lime and Trifoliolate orange.

The maximum growth rate irrespective of rootstock effect was found in the month of November. The increasing trend in growth rate was observed from April to June. In July, it was decreased and again increased in August. In the month of December, there was a decline in growth rate .

#### 4.1.2 Tree height

Among the nine rootstocks, Jambheri, Sweet lime and Troyer citrange imparted maximum height to Kagzi lime scion. These three rootstocks showed significantly maximum height over remaining rootstocks, except on Karna khatta and Marmalade orange which were found to be at par. The Kagzi lime trees on Nemutenga were found to have least height. The trees on Trifoliolate orange, Rangpur lime were found to be statistically at par and were observed to have intermediate height.

It would in general be observed from the results from Table 7 that Kagzi lime trees growing on nine rootstocks fell into three categories in respect of the height. The trees on Jambheri, Sweet lime, Troyer citrange, Karna khatta showed more height, while intermediate values were associated

CANOPY VOLUME OF KAGZI LIME TREE (m<sup>3</sup>)

1. Jambheri
2. Karnd Khalta
3. Marmalade Orang
4. Nasnaran
5. Nemutenga
6. Rangpur Lime.
7. Sweet Lime.
8. Trifoliate Orange
9. Troyer Citrange

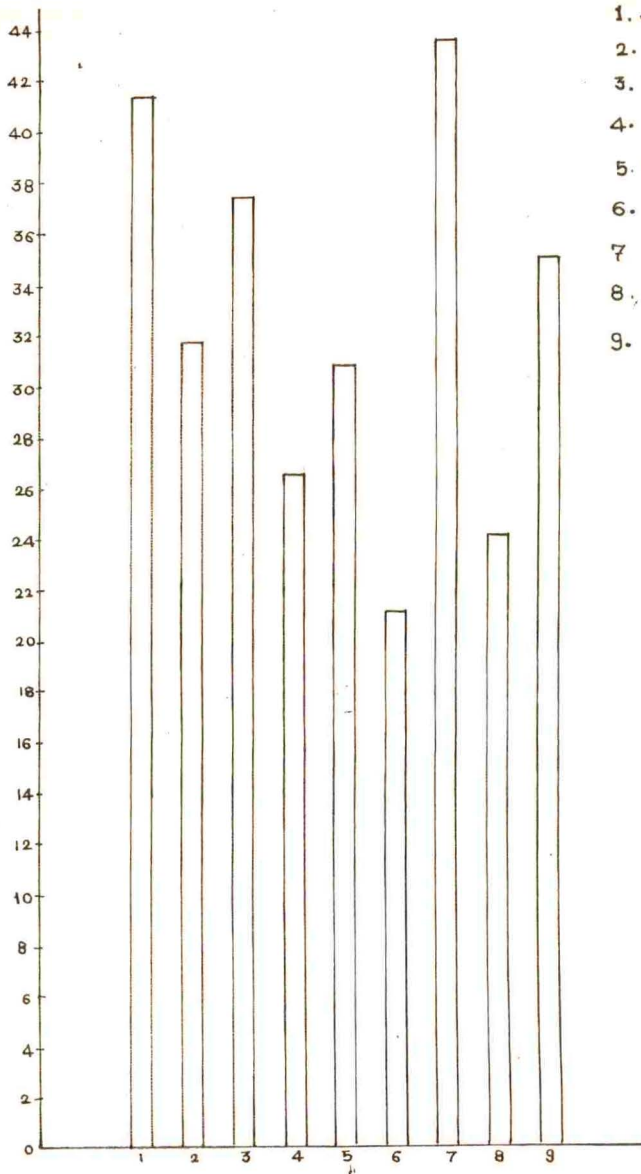


Fig. II - EFFECT OF DIFFERENT ROOT STOCKS ON  
CANOPY VOLUME OF KAGZI LIME TREE (m<sup>3</sup>).

with trees growing on Marmalade orange and Trifoliate orange. The trees on Nasnaran, Nemutenga and Rangpur lime had the lower height.

#### 4.1.3 Average spread

It would be seen from the data presented in the Table 7 that average spread of Kagzi lime trees on Sweet lime rootstocks was significantly more except on Marmalade orange and Jambheri which were found to be at par. The spread of Kagzi lime trees on Nemutenga, Troyer citrange, Karna khatta were found to be at par and the trees on Nasnaran and Trifoliate orange were at par in respect of spread. The trees on Rangpur lime were found to have least spread.

#### 4.1.4 Volume of trees

The data presented in Table 7 reveal that the Kagzi lime trees on Sweet lime and Jambheri were found more vigorous than the trees on other rootstocks and significant differences were observed among them. The trees growing on Marmalade orange, Troyer citrange and Karnakhatta were found to be vigorous next to Sweet lime and Jambheri. The trees growing on Trifoliate orange, Nasnaran and Nemutenga were found to impart semi - vigorous canopy volume. The Kagzi lime trees growing on Rangpur lime were found to have produced significantly minimum tree volume than on other rootstocks.

Table 7 : Growth of Kagzi lime as influenced by different rootstocks

Rootstock	Height (m)	Spread (m)	Height / spread ratio	Stock / girth (cm)	Scion / girth (cm)	Scion / stock ratio	Volume of tree (m <sup>3</sup> )
Jambheri	3.72	4.59	0.810	39.67	38.85	0.979	41.12
Karna khatta	3.37	4.24	0.796	41.06	38.50	0.936	31.753
Marmalade orange	3.33	4.62	0.719	35.72	36.50	1.0213	37.32
Nasnaran	3.07	4.05	0.757	37.36	35.33	0.958	26.49
Nemutenga	3.03	4.41	0.686	35.16	33.37	0.948	30.92
Rangpur lime	3.09	3.61	0.861	32.84	32.58	0.993	21.11
Sweet lime	3.49	4.89	0.715	43.19	41.50	0.960	43.72
Trifoliate orange	3.11	3.85	0.808	32.38	31.30	0.967	24.18
Troyer citrange	3.48	4.37	0.798	36.06	38.10	1.057	35.12
S.E. (d)	0.173	0.133	0.0537	2.570	2.098	0.0512	2.235
C.D. at 5%	0.36	0.28	0.113	5.44	4.44	N.S.	4.73

On the basis of above results, the trees growing on nine rootstocks can be categorised into three classes. The trees growing on Sweet lime and Jambheri and Marmalade orange can be classed as vigorous, while the trees growing on Troyer citrange, Karna khatta and Trifoliolate orange can be classed as semi vigorous. The trees on Nemutenga, Nasnaran and Rangpur lime exhibited the least volume and can be classed under dwarfing class.

#### 4.1.5 Girth of stock

The data in respect of girth of stock presented in Table 7 reveal that the maximum stock girth was observed on Sweet lime rootstock followed by Karna khatta and Jambheri. The intermediate values were observed to be associated with Nasnaran, marmalade orange, Troyer citrange, Nemutenga and Rangpur lime which were found to be at par. The trees on Trifoliolate orange rootstock were found to have least stock girth.

#### 4.1.6 Girth of scion

It can be seen from the data presented in Table 7 that maximum scion girth was observed on Sweet lime rootstock which was closely followed by Jambheri and Karna khatta rootstocks. The intermediate values were observed with the trees on Marmalade orange, Troyer citrange and Nasnaran. The minimum scion girth was found with the trees on Rangpur lime followed by Trifoliolate orange.



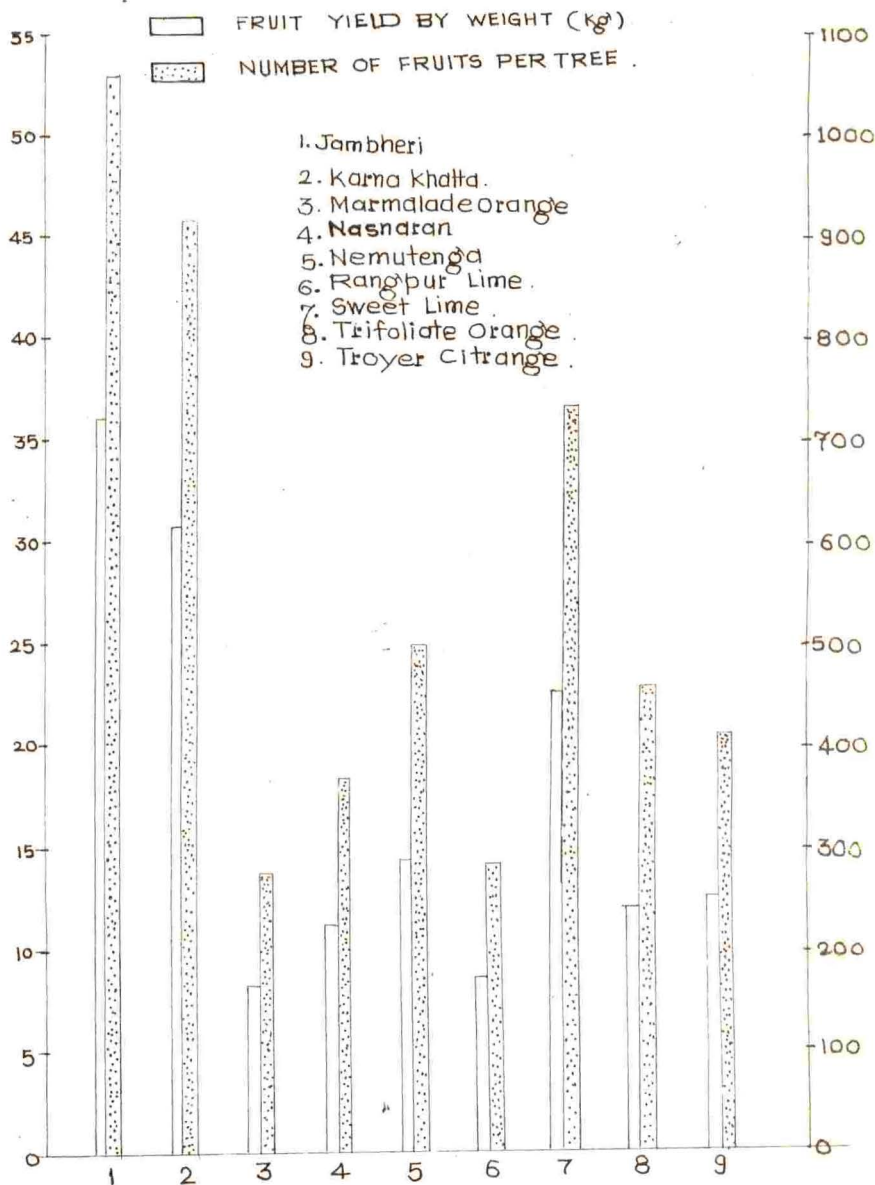


FIG. III. - EFFECT OF DIFFERENT ROOT STOCKS ON FRUIT YIELD BY WEIGHT (kg) & NUMBER OF FRUITS/TREE.



#### 4.1.7 Scion/stock ratio

The data presented in Table 7, reveal that the low scion / stock ratio was noticed in the case of Karna khatta. The best stionic compatability in terms of narrow ratio was observed with that of Troyer citrange and Marmalade orange which were closely followed by Rangpur lime and Jambheri. The medium values for stionic compatabity were observed to be associated with Sweet lime and Trifoliate orange. However, all the rootstocks were found to be statistically non-significant in respect of scion / stock ratio .

#### 4.2 Yield

The data in respect of the effect of different rootstocks on cumulative mean yield i.e. number of fruits and weight of fruits per tree were presented in Table 8 and graphically depicted in figure III .

##### 4.2.1 Number of fruits

The data on number of fruits per tree presented in Table 8 show that significantly more number of fruits were harvested from the trees growing on Jambheri which were closely followed by Karna khatta and Sweet lime rootstocks. Intermediate values in descending order were observed in respect of Nemutenga, Trifoliate orange and Troyer citrange. The least number of fruits were recorded with Rangpur lime and Marmalade orange and found statistically at par . Higher

values were observed to be associated with the trees on Trifoliolate orange and Troyer citrange rootstocks than the trees growing on Nasnaran and Marmalade orange.

#### 4.2.2 Fruit yield by weight

The data presented in Table 8 show that significantly maximum yield of fruits by weight was found in case of Jambheri followed by in descending order in case of Karna khatta and Sweet lime. The low yield of Kagzi lime fruits were obtained from the trees on Marmalade orange and Rangpur lime which were found to be at par. The trees growing on Nemutenga, Trifoliolate orange, Troyer citrange were found to be medium yielder.

#### 4.2.3 Fruit drop

The data on fruit drop presented in Table 8 show that minimum fruit drop was noticed with the trees growing on Marmalade orange closely followed in ascending order by Sweet lime and Jambheri which were observed to be at par. The maximum fruit drop of Kagzi lime fruits was recorded with trees growing on Trifoliolate orange which was closely followed by Nasnaran and Troyer citrange. The per cent fruit drop in Kagzi lime varied significantly due to rootstocks employed.

#### 4.3 Quality of fruit

The data in respect of the effect of different rootstocks on physical and chemical characteristics of the

Table 8 : Yield per tree as influenced by different rootstocks

Rootstock	Weight of fruits (kg)	Number of fruits	Percentage fruit drop
Jambheri	35.970	1058	13.26
Karna khatta	30.741	916	16.10
Marmalade orange	8.353	275	12.81
Nasnaran	11.317	365	21.46
Nemutenga	14.589	502	17.23
Rangpur lime	8.853	280	18.33
Sweet lime	23.013	732	13.10
Trifoliate orange	12.541	459	22.13
Troyer citrange	12.716	410	19.43
S.E. (d)	0.9295	29.995	0.372
C.D. at 5%	1.970	63.591	0.783

Kagzi lime fruits are presented in Table 9 and 10 and depicted graphically in Figure IV and V respectively.

#### 4.3.1 Physical characteristics of fruit

##### 4.3.1.1 Weight of fruit

The data presented in Table 9 reveal that maximum fruit weight was found with the trees growing on Karna khatta closely followed by marmalade orange, Jambheri, and Rangpur lime . The intermediate values for the average weight of fruit were observed to be associated with the trees growing on Nemutenga and Troyer citrange which were found to be at par. Fruits harvested from the trees on Nasnaran, Trifoliolate orange rootstocks were found to be of lesser weight and values obtained were found to be at par.

##### 4.3.1.2 Average volume of fruit

The data presented in Table 9 in respect of volume of fruit showed similar trend as it was observed in the case of weight of fruit. The volume of fruit was significantly more with Marmalade orange followed by Jambheri and Karna khatta. The volume of fruits were observed to be minimum with Nasnaran and Trifoliolate orange rootstocks. The volume of the fruits from the trees growing on Sweet lime, Troyer citrange, Rangpur lime and Nemutenga were found to be intermediate .



Table 9 : Physical characteristics of Kagzi lime fruits

Rootstock	No. of seeds/ fruit	No. of sound seeds per fruit (%)	No. of unsound seeds per fruit (%)
Jambheri	12.30	80.75 (63.98)	19.24 (25.99)
Karna Khatta	11.73	74.99 (60.00)	24.99 (29.97)
Marmalade orange	11.93	79.04 (62.76)	20.27 (27.20)
Nasnaran	8.86	82.25 (64.59)	18.78 (25.67)
Nemutenga	10.73	82.28 (65.11)	17.71 (24.85)
Rangpur lime	10.13	85.84 (67.90)	14.14 (22.05)
Sweet lime	12.36	75.21 (60.15)	24.78 (29.84)
Trifoliolate orange	9.63	73.01 (58.71)	26.97 (31.28)
Troyer citrange	7.90	68.14 (55.66)	31.28 (33.96)
S.E. (d)	0.1586	1.1222	1.1240
C.D. at 5%	0.3362	2.3790	2.38308

Figures in parenthesis are mean values

(Contn.)

Table 9 :

Rootstock	Weight/ fruit (g)	Volume/ fruit (ml)	Specific gravity or density	Rind Thick- ness (mm)	Rind Pomace weight (g)	Rind Pomace % (on weigh basis )
Jambheri	33.10	33.06	1.001	1.20	16.46	49.74 (44.85)
Karna khatta	33.53	32.50	1.031	1.13	16.40	48.72 (44.39)
Marmalade orange	33.30	33.20	0.975	1.20	16.73	50.33 (45.18)
Nasnaran	27.43	27.16	1.009	1.08	14.00	51.02 (45.57)
Nemutenga	29.90	29.66	1.008	0.91	14.36	48.05 (43.89)
Rangpur lime	32.90	30.10	1.012	1.04	15.00	45.61 (42.47)
Sweet lime	31.83	31.80	1.000	1.25	15.16	47.65 (43.65)
Trifoliate orange	27.03	26.76	1.009	1.19	13.33	49.31 (46.27)
Troyer citrange	30.66	30.83	0.994	1.24	14.33	46.77 (43.15)
S.E. (d)	0.999	1.057	0.0282	0.0265	0.3405	1.2247
C.D. at 5%	2.118	2.242	0.059	0.0563	0.7219	N.S.

Figures in parenthesis are arcsine values

1. Jambheri
2. karna khatta
3. Marmalade Orange
4. Nasnadan
5. Nemutenga
6. Rangpur Lime
7. Sweet lime
8. Trifoliate Orange
9. Troyer Citrange

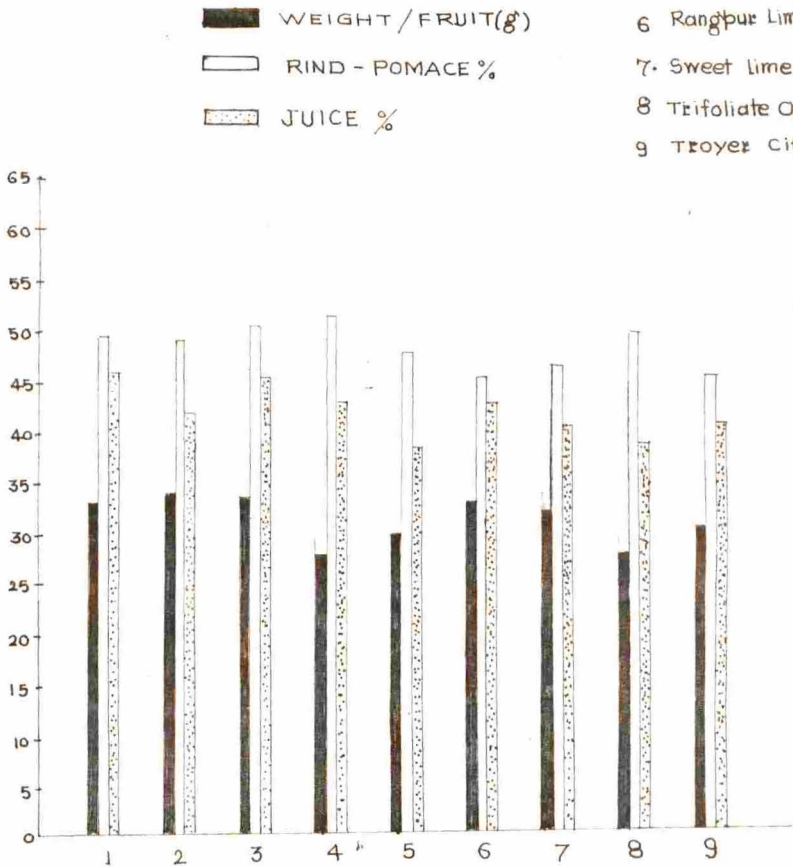


FIG. IV.- EFFECT OF DIFFERENT ROOT STOCKS ON WEIGHT PER FRUIT(g), RIND-POMACE %, JUICE CONTENT OF KAGZI LIME FRUIT.



#### 4.3.1.3 Specific gravity of fruit

It would be seen from the data presented in Table 9 that specific gravity of the fruits were ranged in between 0.975 to 1.031. The more specific gravity of the fruits of Kagzi lime was observed with Karna khatta, Rangpur lime, Nasnaran, Nemutenga, and Trifoliate orange than the remaining rootstocks. The minimum specific gravity of fruits was observed in ascending order with Marmalade orange, Troyer citrange, Sweet lime and Jambheri.

#### 4.3.1.4 Rind thickness

The data presented in Table 9 show that maximum rind thickness of Kagzi lime fruit was found with Sweet lime followed by Troyer citrange and Marmalade orange rootstocks.

#### 4.3.1.5 Rind-Pomace content

Data presented in Table 9 show that the maximum percentage of rind including pomace of fruits was found in the case of Kagzi lime fruits harvested from the trees growing on Trifoliate orange followed by Nasnaran and Marmalade orange. The minimum rind pomace percentage was observed in fruits on rangpur lime rootstock. The fruits on Karna khatta Nemutenga, Sweet lime, Troyer citrange showed intermediate values for rind - pomace percentage and were found to be at par. However, the overall effect of different rootstocks on rind pomace percentage (on weight basis ) of Kagzi lime fruits was found to be non-significant.

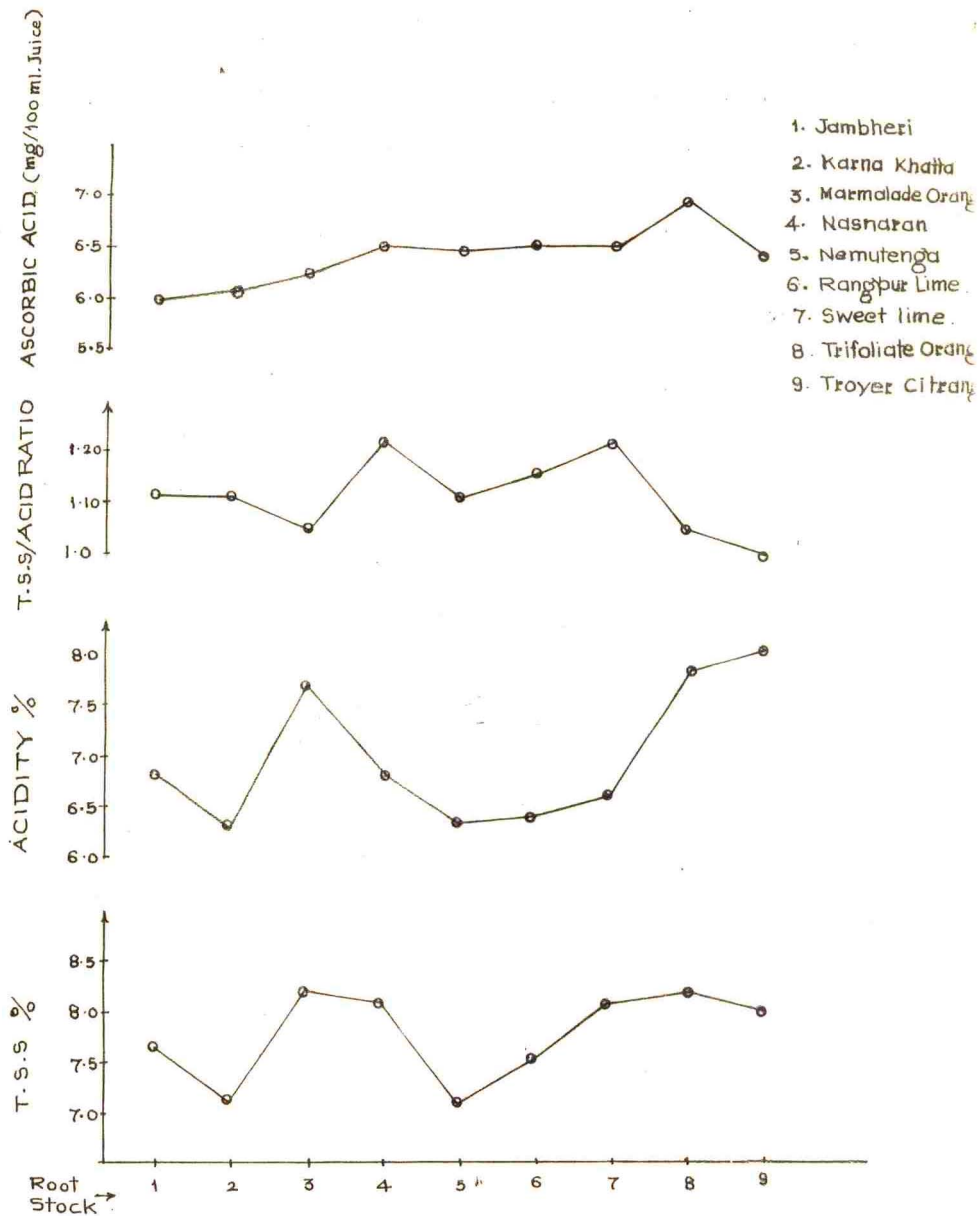


FIG. V- EFFECT OF DIFFERENT ROOT STOCKS ON T.S.S., ACIDITY %, T.S.S./ACIDITY RATIO & ASCORBIC ACID (mg/100 ml. Juice)

#### 4.3.1.6 Seed content

From the data presented in Table 9, it can be seen that maximum number of seeds in fruits were obtained with Sweet lime followed by Jambheri, Marmalade orange, Karna khatta, medium number of seeds were found in fruits on Nemutenga, Rangpur lime, Trifoliolate orange and Nasnaran and significant differences were noticed among themselves. The least number of seeds were observed in the fruits on Troyer citrange.

Maximum number of sound seeds in Kagzi lime fruits were observed with Rangpur lime followed by Nemutenga, Nasnaran and Jambheri and these rootstocks were found to be at par, where as, the minimum sound seed were observed in fruits with Troyer citrange followed by Trifoliolate orange rootstock. Intermediate values were found to be associated with Marmalade orange, Sweet lime and Jambheri rootstocks. The maximum number of unsound seeds were observed in fruits on Troyer citrange followed by Trifoliolate orange.

#### 4.3.2 Chemical characteristics of fruits

##### 4.3.2.1 Juice content

Among the nine rootstocks (Table 10), fruits of Kagzi lime on Jambheri contained more juice followed by Marmalade orange and Rangpur lime rootstock. Intermediate values for juice content were associated with the Kagzi lime fruits on Nasnaran, Karna khatta and Troyer citrange rootstocks which



FIG. VI - Quality of Kagzi lime fruits  
on different rootstocks.

Table 10 : Chemical characteristics of Kagzi lime fruit

Rootstock	Juice content (%)		T.S.S.	Acidity (%)	T.S.S. / acid ratio	Ascorbic acid content (mg/100 ml juice)
Jambheri	46.34	(42.89)	7.65 (16.05)	6.82 (15.15)	1.12	59.50
Karna khatta	41.88	(40.32)	7.11 (15.46)	6.31 (14.56)	1.12	60.56
Marmalade orange	45.20	(42.23)	8.23 (16.66)	7.74 (16.17)	1.05	62.50
Nasnaran	43.13	(41.05)	8.10 (16.52)	6.87 (15.20)	1.22	64.86
Nemutenga	38.78	(38.51)	7.08 (15.42)	6.32 (14.56)	1.11	64.03
Rangpur lime	43.26	(41.12)	7.51 (15.90)	6.43 (14.68)	1.16	64.96
Sweet lime	40.32	(39.41)	8.10 (16.53)	6.63 (14.91)	1.22	65.03
Trifoliate orange	39.08	(38.69)	8.22 (16.66)	7.79 (16.21)	1.05	69.90
Troyer citrange	40.96	(39.79)	8.03 (16.47)	8.07 (16.49)	0.99	64.83
S.E. (d)	0.58616		0.074799	0.1033	0.01936	0.5074
C.D. at 5%	1.24267		0.158574	0.2191	0.04105	1.0757

were found to be at par. Juice content in fruits on Sweet lime and Troyer citrange were found to be at par. The minimum juice content was observed in the fruits of Kagzi lime on Nemutenga rootstock.

#### 4.3.2.2 Total soluble solids (T.S.S.)

It can be seen from the data presented in Table 10 that the juice of Kagzi lime fruits contained significantly higher T.S.S. with Marmalade orange, Trifoliate orange and Sweet lime than remaining rootstocks except Nemutenga and Karna knatta which were found to be at par. Medium T.S.S. was observed in descending order with Marmalade orange, Jambheri and Karna khatta which were found to be at par. The low T.S.S. was observed in fruit juice with Nemutenga.

#### 4.3.2.3 Acidity content

From the data presented in Table 10, it can be seen that the highest acidity in fruit juice was found in the case of Troyer citrange followed by Trifoliate orange and Marmalade orange. Intermediate values of acidity were observed in the fruit juice in the case of Nasnaran, Jambheri, Sweet lime and Rangpur lime rootstocks. The lowest acidity content was found in case of Karna khatta rootstock.

#### 4.3.2.4 T.S.S. / acid ratio

The data presented in Table 10 indicate that maximum T.S.S. / acid ratio in juice was observed with Sweet lime



Table 11 : Effect of different rootstocks on canker incidence

Rootstock	Disease infection and disease index <u>or</u> intensity on leaves							
	Disease intensity (%) August-88		Disease intensity (%) October-88		Leaves infected (%) August- 88		Leaves infected (%) October-88	
Jambheri	14.53	(21.81)	13.74	(21.24)	54.65	(47.70)	54.57	(47.48)
Karna khatta	16.10	(23.20)	14.89	(22.45)	65.70	(54.39)	55.53	(48.23)
Marmalade orange	12.50	(20.58)	10.97	(19.24)	48.36	(44.08)	41.95	(40.22)
Nasmaran	13.55	(21.60)	10.09	(18.46)	62.46	(52.30)	62.39	(52.17)
Nemutenga	14.71	(22.55)	10.20	(18.61)	52.30	(46.32)	54.24	(47.44)
Rangpur lime	17.82	(24.87)	15.41	(23.06)	62.85	(52.07)	66.85	(55.12)
Sweet lime	12.49	(19.69)	10.25	(17.75)	50.83	(45.18)	41.54	(39.78)
Trifoliolate orange	9.16	(17.53)	7.78	(16.04)	24.84	(29.00)	29.46	(32.84)
Troyer citrange	19.75	(26.25)	19.20	(25.67)	64.39	(54.10)	56.60	(49.32)
S.E. (d)	N.S.		N.S.		N.S.		N.S.	
C.D. at 5%	2.59		2.43		6.12		4.78	

Figures in parenthesis indicate Arcsine means



and Nasnaran followed by Rangpur lime. The intermediate values were observed with Jambheri, Karna khatta and Nemutanga, while the minimum values were associated with Marmalade orange and Trifoliolate orange followed by Troyer citrange .

#### 4.3.2.5 Ascorbic acid content

It is clear from the data presented in Table 10 that the Kagzi lime fruits on Trifoliolate orange rootstock had more ascorbic acid content followed by Sweet lime and Rangpur lime which were found to be at par. The lowest ascorbic acid in descending order were observed with Jambheri and Karna khatta . Intermediate values were observed in case of Marmalade orange, Troyer citrange, Nasnaran and Nemutanga rootstocks.

#### 4.4 Effect of different rootstocks on occurrence of citrus canker

The data presented on the occurrence of citrus canker in Table 11 reveal that the maximum occurrence of canker in terms of disease index or intensity and leaves infected were observed of Kagzi lime trees growing on Troyer citrange followed by Rangpur lime, Karna khatta rootstocks, while trees on Trifoliolate orange, Marmalade orange, Nasnaran had minimum incidence in both the months (August and October 1988). Medium values of canker incidence were associated with Jambheri Sweet lime and Nemutanga rootstocks . However, the overall effect of different rootstocks employed was found to be statistically non - significant .

## CHAPTER V

### DISCUSSION

The main objectives of the present investigations were to study the influence of different rootstocks on growth, yield and quality of Kagzi lime.

In the present studies, the different rootstocks showed a marked influence on growth, yield and quality of Kagzi lime. The results obtained during the course of studies are discussed under the appropriate heading in this chapter.

#### 5.1 Growth of Kagzi lime as influenced by different rootstocks

The data presented in Table 7 show that the growth of Kagzi lime influenced significantly by different rootstocks employed. On the basis of growth as influenced by different rootstocks, the rootstocks could be categorised into three groups. Growth in terms of height, spread of tree, canopy volume of tree, stock and scion girth was observed to be influenced by different rootstocks profoundly.

The Kagzi lime trees growing on Sweet lime, Jambheri and Marmalade orange were found to be most vigorous, while the trees growing on Troyer citrange, Karna khatta and Nemutenga were found to be medium size. Comparatively less size of Kagzi lime trees was found on Nasnaran, Trifoliate orange and Rangpur lime rootstocks. Similar observations

were also made by Singh (1961) for Sweet orange cultivar, Mosambi on Sweet lime rootstock. The observations on growth behaviour of Kagzi lime on Jambheri rootstock as observed in the present studies, are in agreement with those of early studies on Mandarin and Sweet orange made by various workers (Phadnis, 1961; Mehrotra et al., 1982; Ganapathy, 1983 b). The trees growing on Sweet lime were found to be more vigorous than the trees on Jambheri as volume and spread were concerned. Similar observations were also reported in case of Rough lemon by Wolfigang (1970) in U.S.A.

Next to Sweet lime and Jambheri, trees on Marmalade orange rootstock was found to be vigorous as compared to Troyer citrange and Nemutenga. Tayde et al. (1988) observed that the kinnow mandarin trees on Marmalade orange rootstock were found to be more vigorous as compared to other rootstocks under Akola conditions. The trees growing on Troyer citrange, Nemutenga and Karna khatta were found to be of intermediate nature.

In the present investigations, Nasnaran, Trifoliate orange and Rangpur lime rootstocks imparted less vigour to the Kagzi lime trees. Similar observations were also made by Aiyappa et al. (1967) in case of Coorg mandarin in South India. The results obtained in the present studies were found to be in close conformity with the observations reported by Gosh (1963) and Hassaballa (1978).

In the present studies, Kagzi lime trees growing on Jambheri imparted maximum height. These results are found

Table : 12 Effect of different rootstocks on growth and yield of Kagzi lime (Citrus aurantifolia Swingle).

Rootstock	Height	Spread	Volume of tree <sub>3</sub> (m)	Stock girth (cm)	Scion girth (cm)	Scion / stock ratio	Weight of fruits (kg)	Number of fruits/ tree	Percentage fruit drop
Jambheri	3.72	4.59	41.12	39.67	38.85	0.979	35.970	1058	13.26
Karna khatta	3.37	4.24	31.75	41.06	38.50	0.936	30.741	916	16.10
Marmalade orange	3.33	4.62	37.32	35.72	36.50	1.021	8.353	275	12.81
Nasnaran	3.07	4.05	26.49	37.36	35.33	0.958	11.317	365	21.46
Nemutenga	3.03	4.41	30.92	35.16	33.37	0.948	14.589	502	17.23
Rangpur lime	3.09	3.61	21.11	32.84	32.58	0.993	8.853	280	18.33
Sweet lime	3.49	4.89	43.72	43.19	41.58	0.960	23.013	732	13.10
Trifoliate orange	3.11	3.85	24.18	32.38	31.30	0.967	12.541	459	22.13
Troyer citrange	3.48	4.37	35.12	36.06	38.10	1.057	12.716	410	19.43
S.E. (d)	0.173	0.133	2.235	2.570	2.098	0.051	0.929	29.995	0.372
C.D. at 5%	0.36	0.28	4.73	5.44	4.44	N.S.	1.970	63.591	0.788

to be in agreement with those of earlier workers in case of mandarin and Sweet orange (Phadnis, 1961; Mehrotra et al., 1982; Ganapathy, 1983 a).

In the present studies, the best stionic compatability was observed with Marmalade orange followed by Troyer citrange, Rangpur lime, Jambheri and Sweet lime rootstocks. All the Kagzi lime trees on these rootstocks were found healthy and this may be due to the perfect stionic combinations. The high congineality of these rootstocks for mandarin and Sweet orange were reported by earlier workers (Singh, 1963; Deshmukh, 1973).

In the present studies, it was observed that Karna khatta, Nemutenga and Nasnaran showed some over growth of stock with Kagzi lime scion and exhibited minimum scion / stock ratio. The investigation conducted by Singh and Singh (1974) revealed that Trifoliolate orange rootstock was incompatible due to over growth of stock for Nagpur Santra.

In recent years, the term incompatibility has undergone changes in meaning. Previously, the rootstock scion combination that did not produce healthy, vigorous trees and led to early decline were classified as incompatible. With the advances in citrus virologym the term is better understood than before. The more recently accepted definitions of incompatibility is as genetic or physiological incongeniality between stock and scion (Chadha et al., 1970).

Concluding forgoing discussion, it can be brought out that out of the nine rootstocks employed, the three



rootstocks namely Sweet lime, Jambheri and Marmalade orange produced more growth of Kagzi lime scion while the Kagzi lime trees on Troyer citrange, Karna khatta and Nemutenga attained medium growth. Comparatively smaller trees were observed on Nasnaran, Trifoliate orange and Rangpur lime rootstocks. Erect habit of trees were noticed in case of Jambheri and Sweet lime while spreading habit of trees were observed on Sweet lime Marmalade orange and Jambheri as indicated by height / spread ratio (Table 7 ). This has got a greater significance of influencing a particular growth character of Kagzi lime scion by rootstock.

#### 5.2 Yield of Kagzi lime fruits as influenced by different rootstocks

The data in respect of Mrigbahar fruit yield as influenced by rootstocks employed showed that the Kagzi lime fruit yield i.e. number and weight of fruits per tree harvested during October - November, 1988, were found to be significantly influenced.

The data on yield (Table 8) reveal that maximum yield was recorded from the Kagzi lime trees growing on Jambheri, Karna khatta and Sweet lime. Nemutenga, Trifoliate orange and Troyer citrange were found to be associate with medium yield values. This could be attributed to the more vegetative growth produced by Kagzi lime trees growing on these rootstocks as compared to remaining rootstocks.

Economides (1976 b) reported higher yields of Washington Navel oranges on Rough lemon, Cleopatra mandarin and Palestine Sweet lime. Similar observations were made by Bhullar and Nauriyal (1975) for Blood Red oranges on Rough lemon rootstock.

Next to Jambheri, the Kagzi lime trees on Karna khatta gave more yield. The observations on yield of Kagzi lime fruits on Karna khatta are in agreement with those of earlier workers (Maxwell and Wutscher, 1976). Sweet lime was found next to Karna khatta in respect of yield. Some gardens are still found existing on Sweet lime rootstock (Singh, 1966).

In the present studies, the Kagzi lime trees growing on Trifoliate orange, Nemutenga and Troyer citrange produced intermediate yield. Similar observations were made by Deidda and Milella (1978) for Navel oranges.

Research work reported by Chohan and Kumar (1983), Bevington and Duncan (1980) on citrus in respect of yield of various citrus scion cultivars under the influence of Rangpur lime and Marmalade orange revealed that these were found to be producing high yield. In the present studies, however, this was not the case with these rootstocks. The reason may be due to the fact that different rootstocks vary in their adaptability to different scion under different climatic conditions (Webber, 1948) .



Table 1.15 Effect of different rootstocks on quality of Kagzi lime (*Citrus aurantifolia* Swingle)

Rootstock	Weight/ fruit (g)	Volume/ fruit (ml)	Specific gravity of fruit	Rind Thick- ness (mm)	Rind Pomace weight	No. of seeds/ fruit	Juice %	T.S.S.	T.S.S./ Acid ratio	Acidity	Ascorbic acid content mg/ 100 ml juice
Swingle	33.10	33.56	1.001	1.20	16.46	12.20	46.34 (42.89)	7.65(16.05)	1.12	6.82(15.15)	59.50
Karna Khatwa	33.93	32.59	1.001	1.13	16.40	11.73	41.83 (40.32)	7.11(15.46)	1.12	6.31(14.56)	60.56
Marmelade Orange	34.30	33.20	0.975	1.20	16.73	11.33	45.20 (42.23)	8.23(16.66)	1.05	7.74(16.17)	62.50
Kushnaran	27.43	27.16	1.009	1.08	14.00	8.86	43.13 (41.05)	8.10(16.52)	1.22	6.87(15.20)	64.86
Nemutenga	29.90	29.66	1.008	0.91	14.36	10.73	38.78 (38.51)	7.08(15.42)	1.11	6.32(14.56)	64.03
Rangpur	30.90	30.10	1.012	1.04	15.00	10.13	43.25 (41.12)	7.31(15.90)	1.16	6.43(14.68)	64.96
Sweet lime	31.83	31.80	1.000	1.25	15.16	12.36	40.32 (39.41)	8.10(16.53)	1.22	6.63(14.91)	65.03
Trifoliate Orange	27.33	26.73	1.009	1.19	13.33	9.63	39.08 (38.69)	8.22(16.66)	1.05	7.79(16.21)	69.90
Tanger Citronze	30.66	29.13	0.994	1.24	14.33	7.90	40.96 (39.79)	8.03(16.47)	0.99	8.07(16.49)	64.83
S.E. (d)	0.999	1.057	0.028	0.026	0.740	0.158	0.586	0.074	0.019	0.103	0.507
C.M. at 5%	1.118	2.2-2	0.039	0.056	0.721	0.336	1.242	0.158	0.049	0.219	1.075

Figures in parentheses indicate Aresin means

### 5.3 Quality of Kagzi lime fruits as influenced by different rootstocks

The quality of Kagzi lime fruits is judged on the basis of certain Physico-chemical characteristics namely big size, oval round fruits with bright yellow colour, thin skin containing more juice, less seeds, moderate acidity and T.S.S. content .

In the present investigation, bigger size fruits (Weight and volume basis) of Kagzi lime were harvested from the trees on Karna khatta closely followed by Marmalade orange, Jambheri , Rangpur lime, Nemutenga and Troyer citrange rootstocks as shown in fig VI . It can be seen from the Table 9 that the weight of the fruit was directly related to its volume.

In the present studies, the Kagzi lime fruits on Karna khatta rootstock had maximum volume followed by Marmalade orange and Jambheri while least volume was observed in case of fruits on Trifoliolate orange rootstock. The fruits on Karna khatta had maximum specific gravity (density) closely followed by Rangpur lime and Trifoliolate orange rootstocks, while low specific gravity was observed in case of fruits on Nemutenga.

In the present studies, the rind thickness of Kagzi lime fruits was observed to be maximum with Sweet lime, Troyer citrange and Trifoliolate orange while minimum being associated with Nemutenga, Rangpur lime and Nasnaran root stocks. The pomace content was minimum in fruits with Troyer citrange,

Sweet lime and Nemutenga while maximum being with Marmalade orange, followed Jambheri rootstocks .

The data in respect of seed content of Kagzi lime fruits reveal that the fruits with Sweet lime and Jambheri root stocks contained more seeds followed by Marmalade orange, Karna khatta and Nemutenga . Less number of seeds were found in the fruits with Troyer citrange whereas, medium values being associated with Nemutenga, Rangpur lime, Trifoliate orange and Nasnaran rootstocks. From these observations, it can be said the vigorous rootstocks i.e., Jambheri, Sweet lime and Marmalade orange were found to induce more number of seeds in fruits as compared to less vigorous rootstocks.

The more number of seeds in fruits help the plant to retain the fruits for longer time on the tree due to high auxin activity as the seed is the principal seat of auxin synthesis. The retention of fruits on a plant is dependent on auxin supply in the organ. So lesser the number of seeds, more is the fruit drop (Rajput and Sri Haribabu, 1985). In the present studies, higher fruit drop was observed in the trees on Trifoliate orange followed by Nasnaran and Troyer citrange while minimum being with Sweet lime, Jambheri and Marmalade orange stocks (Table 12). Less fruit drop was observed to be associated with vigorous trees on Sweet lime, Jambheri and Marmalade orange rootstocks. This could be explained on the basis of more energy in terms of finished products supplied for the development

of the fruits by the trees, might have resulted in maximum retention of fruits on such trees.

More juice was found in the fruits harvested from the trees on Jambheri followed by Marmalade orange, Rangpur lime rootstocks. While intermediate values were associated with Karna khatta, Nasnaran, Troyer citrange and Sweet lime rootstock

In the present studies, maximum juice content was observed in fruits with Jambheri and Marmalade orange rootstocks. Similar observations were made by Diamante De Zubrzycki and Rodriguez (1973) in case of Valencia late oranges on Rangpur lime rootstock. Contrary to this, Thornton and Dimsey (1987) reported that Jambheri and Rangpur lime rootstocks imparted lower fruit juice to Valencia orange in Australia. In the present studies, fruits on Trifoliolate orange contained less juice. Contrary to these findings, highest juice content in Blood red oranges on Trifoliolate was reported by Bhullar and Nauriyal (1975) and Philip and Mammen (1984) for Blood red orange and Coorg mandarin, respectively.

T.S.S. of juice of the fruits was significantly affected by different rootstocks employed. The juice of Kagzi lime fruits contained higher T.S.S. with Marmalade orange, Trifoliolate orange and sweet lime followed by Nasnaran. The lesser T.S.S. values were found to be associated with Karna khatta, Nemutenga and Jambheri rootstocks. Levy and Mendel (1982); Boyee (1960) and Thornton and Dimsey (1987) reported that fruits on Rough

lemon rootstock contained low T.S.S. for Sweet orange and lemon contradictory results were also reported by Philip and Mannen (1984) that Jambheri imparted more T.S.S. and T.S.S./acid ratio for Coorg mandarin. Next to Troyer citrange, Trifolia orange imparted more T.S.S. content in the Kagzi lime fruits. Similar observations were recorded by Bhullar and Nauriyal (1975) in case of Blood red orange; Brown (1985) for Washington Navel oranges.

In the present investigations; fruits on Karna khatta rootstock had low acidity while Trifoliate orange and Troyer citrange imparted more acidity to Kagzi lime fruits. Nasnaran, Jambheri, Sweet lime and Rangpur lime were associated with intermediate values . The results obtained with Rangpur lime rootstock are in conformity with those reported by Araujo et al. (1970) and Valle N-Del et al. (1979) who observed that Rangpur lime produced low acidity in fruits of citrus scion cultivars Para orange and Dancy mandarin. Similar findings were reported by Economides (1976 b) in case of Washington Navel oranges in Cyprus.

The data given in the Table 10 reveal that the highest T.S.S. / acid ratio was observed to be associated with Sweet lime, and Nasnaran followed by Rangpur lime and Jambheri, while it was low in case of Troyer citrange rootstock.

In the present studies, the Kagzi lime fruits harvested from the trees on Trifoliate orange rootstock which contained



significantly more ascorbic acid followed by Sweet lime and Rangpur lime, while it was found low in fruits on Jambheri and Karna khatta. The data in respect of ascorbic acid content show that the rootstock played its role in increasing or decreasing the content of ascorbic acid in Kagzi lime fruits. Ali and Rahim (1960) observed the lowest content of ascorbic in the fruits of valencia late Sweet orange on Rough lemon rootstock. In the present studies also the lowest values of ascorbic acid were associated with Jambheri rootstock. On the contrary, Philip and Mammen (1984) reported maximum ascorbic acid content in coorg mandarin on Jambheri stock. Similarly, Bhullar and Nauriyal (1975) obtained maximum ascorbic acid content in Blood red orange on Jullunduri Khatti in Punjab.

The data on the Occurance of Canker as presented in Table 11 reveal that the minimum Occurance of Canker (per cent disease index or intensity of leaves effected ) was observed on Kagzi lime trees growing on Troyer citrange followed by Rangpur lime, Karna khatta rootstocks. However, significant differences were not found amongst the rootstocks employed. Similar observations were made by Mohan et al. (1985) in case of tangerine cultivars. On the contrary, Cheema et al. (1982) reported that Sweet oranges (Musambi, pineapple, Jaffa and Valencia) budded on Rangpur lime were tolerant to Canker. Danos et al. (1981 ) reported that spread of Canker incidence was affected by rootstocks in several citrus species, varieties

and their combinations. Similarly, Agostini et al. (1985) found that canker disease spread was higher in trees on vigorous and intermediate rootstocks. They also reported that attack was severe on Rough lemon (Vigorous) than Trifoliate orange (non-vigorous) rootstock .

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## CHAPTER VI

### SUMMARY AND CONCLUSION

#### SUMMARY

The present studies on "Growth, yield and quality of Kagzi lime (Citrus aurantifolia Swingle ) as influenced by different rootstocks under Akola climatic condition were undertaken in the orchard and laboratory of Horticulture Department, Punjabrao Krishi Vidyapeeth, Akola, Maharashtra State during the year 1988-89. The observations were recorded on the experimental trees which were already planted. The experiment was laid out in the Randomised Block design consisting of Nine rootstocks (treatments). Two trees were taken as a unit under each treatment in each replication. During the course of investigations, the results obtained are summarised below .

#### 6.1 Growth

##### 6.1.1 Tree height, spread and volume

On the basis of the results obtained in the present studies, the growth of Kagzi lime trees in terms of height, spread and volume were found to be maximum in case of Sweet lime, Jambheri and Marmalade orange rootstocks. Medium values of volume were associated with the trees growing on Troyer citrange, Karna khatta and Nemutenga, while Nasnaran, Trifoliate orange and Rangpur lime rootstocks imparted comparatively less vigour to Kagzi lime trees.

#### 6.1.2 Stock - scion girth and scion / stock ratio

The growth trend of stock and scion girth was observed to be similar as it was noticed in the case of volume of the trees. In case of Nasnaran rootstock, there was overgrowth of stock over scion. The results of stionic compatibility on the basis of narrow ratio of scion and stock was found in the Kagzi lime trees growing on Troyer citrange, Marmalade orange, Rangpur lime and Jambheri, whereas the scion / stock ratio was medium with the trees growing on Trifoliate orange, Sweet lime and Nasnaran rootstocks wide ratio was found in case of trees on Nemutenga and Karna khatta rootstocks.

#### 6.2 Yield

Maximum yield in respect of weight and number of fruits was obtained from the trees growing on Jambheri, Karna khatta and Sweet lime. Medium yield was obtained from the trees growing on Nemutenga, Trifoliate orange and Troyer citrange; while lower yield was obtained from Rangpur lime and Marmalade orange rootstocks. Maximum fruit drop was recorded in trees growing on Trifoliate orange and Nasnaran and minimum being in Marmalade orange and Sweet lime rootstocks.

#### 6.3 Quality

##### 6.3.1 Physical characteristics of fruit

Bigger size fruits were harvested from the trees growing on Karna khatta, Marmalade orange, Jambheri and

Sweet lime rootstocks. Fruits of Kagzi lime on Trifoliate orange and Nasnaran were found to be of comparatively smaller size while fruits on Rangpur lime, Troyer citrange and Nemutenga were of medium in weight and volume .

Maximum rind thickness of Kagzi lime fruits was observed on Sweet lime, Troyer citrange, Trifoliate orange, Marmalade orange and Jambheri while it was found to be comparatively thinner on Nasnaran and Nemutenga rootstocks.

More number of seeds were found in Kagzi lime fruits on Sweet lime, Jambheri, Marmalade orange and Karna khatta rootstocks whereas minimum seeds were recorded in case of Troyer citrange rootstock. Medium values of seeds were found to be associated with Nemutenga, Rangpur lime, Trifoliate orange and Nasnaran rootstocks.

#### 6.3.2 Chemical characteristics of fruit

Maximum juice content was found in the Kagzi lime fruits on Jambheri followed by Marmalade orange and Rangpur lime while it was minimum with Nemutenga rootstock. Medium values were associated with Nasnaran, Karna khatta, Sweet lime and Troyer citrange rootstock.

Kagzi lime fruits on Marmalade orange, Trifoliate orange and Sweet lime had higher T.S.S. where it was found less with Karna khatta rootstock.

Kagzi lime fruits on Troyer citrange, Trifoliate

orange and Marmalade orange had maximum acidity while it was low in fruits on Nemutenga and Karna khatta. Medium values were associated with Jambheri, Nasnaran, Sweet lime and Rangpur lime rootstocks. Maximum T.S.S. / acid ratio in Kagzi lime fruits was found with Sweet lime, Nasnaran and Rangpur lime while it was minimum with Troyer citrange, Trifoliolate orange and Marmalade orange.

Trifoliolate orange imparted maximum ascorbic acid content in the Kagzi lime fruits followed by Sweet lime, Rangpur lime, Nasnaran and Troyer citrange rootstocks, while it was found minimum in fruits on Jambheri and Karna khatta rootstocks.

#### 6.4 Occurance of Canker disease

Kagzi lime trees growing on Troyer citrange rootstock were found to have comparatively more Canker incidence on the basis of percent disease index and per cent leaves infected while it was found less on the trees on Trifoliolate orange rootstock .

#### CONCLUSION

The growth and yield of Kagzi lime trees were significantly influenced by different rootstocks employed and maximum growth was observed on Sweet lime followed by Jambheri and Marmalade orange. Troyer citrange and Karna khatta were found to be medium in comparatively the vigour to Kagzi lime trees on Rangpur lime, Trifoliolate orange in Nasnaran produced

comparatively less growth. In the present investigation the yield on different rootstocks of Kagzi lime were harvested from the trees on Jambheri (1058), Karna khatta (916), Sweet lime (732), Nemutenga (502), Trifoliate orange (459), Troyer citrange (410), Nasnaran (365), Rangpur lime (280) and Marmalade orange (275). There had a direct relationship between number of fruits and size of fruits irrespective of rootstock employed. Vigorous trees produced more number of fruits.

The physico-chemical characteristics of the fruits were also found to be influenced by rootstock. The bigger size fruits (weight and volume) were harvested from the trees growing on Karna khatta and Marmalade orange which had thicker rind and medium T.S.S. / acid ratio. Maximum juice content in fruits was observed with Jambheri rootstock.

Kagzi lime trees on Troyer citrange rootstock had more incidence of citrus Canker while it was minimum on Trifoliate orange rootstock. However, significant differences were not noticed in occurrence of Canker due to rootstock. The results obtained in the present studies need further confirmation.



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APPENDIX - I

Weekly meteorological data for the period April, 1988 to March, 1989

Met. Week	Date	Rainfall (mm)	Rainy days per week	Temperature °C		Relative Humidity		Sunshine Hours	
				Max.	Min.	Morn.	Even.		
1	2	3	4	5	6	7	8	9	
1	April, 88	26-1	0.00	Nil	38.7	17.9	33	11	10.4
2		2-8	0.00	"	42.2	22.2	31	9	9.8
3		9-15	0.00	"	41.9	26.5	36	14	7.0
4		16-22	0.00	"	41.7	24.2	39	15	9.9
5		23-29	0.00	"	40.6	24.7	41	19	9.1
6	May, 88	30-6	2.2	"	41.8	24.5	43	13	9.4
7		7-13	0.0	"	45.6	28.9	40	12	10.8
8		14-20	0.0	"	44.3	28.9	48	18	9.4
9		21-27	12.6	1	43.1	27.7	52	16	9.6
10	June, 88	28-3	0.0	Nil	43.1	28.7	57	23	10.08
11		4-10	0.0	"	42.5	27.4	51	19	9.9
12		11-17	88.8	2	39.0	25.4	72	40	7.0
13		18-24	119.1	4	33.8	22.6	89	60	4.6
14	July, 88	25-1	0.0	Nil	34.4	24.9	74	47	6.2
15		2-8	25.4	3	34.7	23.5	85	51	6.0
16		9-15	65.8	3	32.2	23.1	88	67	3.3
17		16-22	231.2	3	31.5	23.1	89	71	4.7
18		23-29	57.9	4	28.4	22.3	91	77	1.5
19	Aug. 88	30-5	9.6	Nil	29.6	23.2	88	71	0.7
20		6-12	2.8	Nil	32.3	23.2	85	57	5.9
21		13-19	31.8	2	29.2	23.8	85	62	5.4
22		20-26	178.6	5	31.6	22.6	93	79	2.0
23	Sept. 88	27-2	45.8	4	31.9	22.4	91	73	3.5
24		3-9	71.2	3	32.7	22.5	91	70	7.0
25		10-16	37.1	2	31.5	22.5	89	60	7.4
26		17-23	100.1	6	31.5	22.5	92	75	5.6
27		24-30	79.6	3	31.9	22.1	88	69	5.8

Continued --

1	2	3	4	5	6	7	8	9
28	Oct. 88	1-7	153.0	3	30.1	21.4	88	5.3
29		8-14	0.0	Nil	31.8	16.5	84	8.4
30		15-21	0.0	"	34.2	15.9	77	8.8
31		22-28	0.0	"	34.4	13.2	79	9.1
32	Nov. 88	29-4	9.0	1	31.9	17.1	82	5.7
33		5-11	0.0	Nil	30.5	11.6	85	8.3
34		12-18	0.0	"	31.2	9.3	80	10.0
35		19-25	0.0	"	31.0	12.6	71	9.6
36	Dec. 88	26-2	0.0	"	29.7	9.4	68	9.6
37		3-9	0.0	"	30.2	9.1	66	9.4
38		10-16	4.2	1	28.9	9.4	76	8.1
39		17-23	0.0	Nil	30.6	8.5	71	9.6
40		24-31	0.0	"	29.6	10.2	80	9.5
41	Jan. 89	1-7	0.0	"	30.6	9.0	59	9.7
42		8-14	0.0	"	28.4	10.1	68	9.5
43		15-21	0.0	"	30.7	9.7	65	9.9
44		22-28	0.0	"	21.2	11.8	64	9.4
45	Feb. 89	29-4	0.0	"	34.0	9.2	60	9.9
46		5-11	0.0	"	33.6	11.5	55	10.0
47		12-18	0.0	"	33.0	12.1	54	10.0
48		19-25	0.0	"	31.5	7.5	46	10.0
49	March, 89	26-4	0.0	"	37.1	15.2	43	9.7
50		5-11	12.0	2	34.5	17.2	61	7.4
51		12-18	0.0	Nil	35.3	16.7	62	9.8
52		19-25	2.2	"	37.5	20.3	60	8.1
53	April, 89	26-1	21.0	2	31.6	16.2	80	8.0



VITA

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