Survey For Selection Of Superior Kagzi Lime (Citrus aurantifolia Swingle) Strains In The Marathwada Region

BY

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DEPARTMENT OF HORTICULTURE

Marathwada Agricultural University,

PARBHANI. 1978

AFFECTIONATELY DEDICATED

TO MY PARENTS

CERTIFICATE I

Shri Suryakant Dhondiram Jature has satisfactorily prosecuted his course of research for a period of not less than one academic year and that the dissertation entitled "Survey for selection of superior kagzi lime (*Citrus aurantifolia* Swingle) strains in the Marathwada region" submitted by him is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the dissertation or part thereof has not been previsouly submitted by him for a degree of any university.

Dated: 12/5/78

(V.R. CHAKRAWAR)
Guide

CERTIFICATE II

This is to certify that the dissertation entitled "Survey for selection of superior Kagzi lime (*Citrus aurantifolia* Swingle) strains in the Marathwada region" submitted by Shri Suryakant Dhondiram Jature to the Marathwada Agricultural University in partial fulfilment of the requirement for the degree of Master of Science (Agriculture) in the subject of Horticulture has been approved by the student's advisory committee after oral examination in collaboration with the External Examiner.

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CANDIDATE'S DECLARATION

I hereby declare that the dissertation or part thereof has not been previously submitted by me for a degree of any university.

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Signature

Date: May 12,1978. (S.D. JATURE)

C O N T E N T S

List of Tables

List of Figures

APPENDIX

1. Meteorological data collected during the period January 1977 - January 1978.

2. Physico-chemical characters of fruit, yield and general information of 69 Kagzi lime strains

3. List of cultivators

4. Proforma of the general observations recorded during survey work.

I. INTRODUCTION

I INTRODUCTION

Kagzi lime (Citrus aurantifolia Swingle) is one of the important citrus species, widely grown in India for various purposes. The fruits are extensively used for squashes, pickles, syrups, cordials, manufacture of citric acid and for table purpose in the daily life of Indians (Cheema et al., 1954). The fruit is valued not only for its nutritional qualities but also for medicinal purposes (Kirtikar and Basu,1935).

Among the fruit crops, citrus is the third most important crop in India having an area of 1,36,997 ha (Anon; 1970). Citrus occupies an area of 29,300 ha in Maharashtra and 5,300 ha in Marathwada region of the state. Among the various citrus species grown in the state, acid lime (Kagzi lime) is cultivated on 2,200 ha in state and 200 ha in the Marathwada region (Anon;1975). Small plantations of Kagzi lime are very common with the cultivators of this region especially where well irrigation is available. It is a more popular fruit of south and central India. The acid lime production of south India is more than half of the total production in India (Naik, 1949).

Kagzi lime (Sour lime) is commercially propagated by seeds in India (Naik, 1949), as it comes true to type

because of high degree (39 to 60%) of nucellar embryony (Hume,1957 and Reuther et al., 1967). It is also a cheapest and easiest method of propagation. Therefore, seed propagation is still employed in most of the countries like India, Egypt and Mexico (Reuther et al., 1967).

It has been reported that the over all performance of Kagzi lime seedlings is better than budded plants. The mortality of seedlings is also less as compared to budded ones (Naik, 1949) as the seedlings of citrus are generally free from virus (Swingle,1948). The acid lime buddings on gajanimma, jamberi or acid lime are a little early to commence cropping and yield somewhat more than seedlings in the first 10-15 years, thereafter seedlings also catch up the budlings in yield potential (Reddy,1972). In Andhra Pradesh, Kagzi lime seedlings are found to live fof 20-25 years even under conditions leading to decline (Swamy et al., 1972). Thus, these findings establish the superiority of seedling plantations over budlings.

Under North and North Eastern regions of India kagzi lime is generally propagated by layers or cuttings. But the recent trend is towards the use of budded plants rather than seedlings or layers. However, for budding

purpose kagzi lime cultivars have not been standardized for the various agro-climatic regions of the country.

Even though the phenomenon of nucellar embryony is common in kagzi lime, seedling variations do occur (Hume,1957). The selection of superior strains from existing variation is one of the easy and best methods of crop improvement. In case of acid lime few isolated efforts were made in the past to survey the various types. Such survey works were undertaken on a very limited scale with rather broad objectives and were discontinued further. Therefore, at present we do not have any standard or specific cultivar which can be recommended.

The first and the most important fruit survey work was carried out in the region in 1932, which indicated the presence of three to four distinct types of kagzi lime under cultivation (Anon., 1932). From the survey of South India, it has been observed that several forms of limes are under cultivation which are yet to prove their superiority over ordinary kagzi limes (Naik,1949). A large variations in fruit size, acidity and juice per cent were recorded in various strains of kagzi limes grown in Madras State (Siddappa,1952). According to Cheema et al., (1954) varieties like kagdi limbu, Pat limbu and Godhadi limbu were cultivated in the Maharashtra State.

The exact specific status of these varieties is yet to be determined. Acid lime survey carried out in Assam, indicated the presence of two distinct types of sour lime (Bhattacharya and Dutta, 1956). Thus, it is clear that very little efforts were made by the research workers for the improvement of kagzi lime through selection of superior types.

Under South Indian conditions kagzi lime produces two distinct behars (crops) viz., Mrig bahar (June to December) and Ambe bahar (January to June) but there are some types which flower almost through out the year (Baramasi). The information on these aspects, about pomological characters and physico-chemical composition of various kagzi lime types grown in Marathwada region is very scanty.

A kagzi lime strain if found tolerant to canker disease will be an asset for boosting the cultivation in the state. At present cultivators are switching over to the cultivation of kagzi lime on large scale, as the mandarins and sweet organges are being wiped out due to die-back complex. So there is a heavy demand for the supply of better types of kagzi lime seedlings. However, there is no specific/standard variety of kagzi lime in the region or state to meet the needs

of cultivators. Therefore, it is highly essential to undertake large scale survey in the various regions with specific objectives.

In view of the above necessity survey was undertaken in the Marathwada region with following objectives :

(1) To isolate productive and quality strains of kagzi lime.

(2) To study relationships between various physical and chemical characters of fruit.

(3) To describe and classify various strains suitable for various purposes.

(4) To collect germplasm for breeding purpose and to isolate baramasi types/novelties if any.

II. REVIEW OF LITERATURE

II REVIEW OF LITERATURE

Citrus is grown in every state of India. Mandarin and sweet orange varieties are most popular as compared to other citrus species. In acid lime, there is no standard variety under cultivation in India. It is commercially propagated by seeds from local strains. So, most of the kagzi lime plantations in North and South India are of seedling nature.

In other fruit crops like mango, ber, guava etc. seedling strains of superior types are well established commercial cultivars. The varietal improvement in these fruit crops is as a result of survey work undertaken by number of research workers. The available relevant literature on the fruit survey work carried out in citrus and other fruit crops is reviewed below :

2.1 Survey work in citrus :

The regions like North-East India and South India enjoys a unique distinction not only in India but in the world as, being very rich in numerous forms of citrus and being the original home of several citrus species both edible and non-edible. Sour lime is

considered almost definitely to be indegenous to India (Royle, 1839 and Tolkowsky, 1938). Although Swingle (1946) holds the view that it is apparantly a native of East India Archipelago. Real sour lime is known as kagzi lime almost everywhere in India.

Kagzi lime is propagated by seeds in India. It is grown in every state and home for catering the domestic needs. As it is propagated through seeds and is grown under different agro-climatic zones of India, there is a lot of variation existing in this species. Very few isolated efforts were made to survey the various superior types in yield potential and other economic characters. This citrus species remained neglected and so, we do not find any specific or standard cultivar under cultivation.

Under South Indian conditions lime is extensively grown in all the states. In Maharashtra state, as early as in 1932 fruit survey was carried out mostly in Marathwada and adjoining regions. In this region three to four distinct types of acid lime strains were observed under cultivation (Anon., 1932). These were i) round, small, thin, skinned, ii) round, large, thin skinned, iii) round, large, thick skinned and iv) long, thick, skinned (Godhadi limbu). But their

physico-chemical characters were not studied at all (Anon., 1932). From the survey of some lime orchards in South India Naik (1949) observed several forms of lime like shiny rind with very thin skinned types with mamilla and without mamilla and one hybrid with red fleshed pulp. Further, he remarked that these novelties are yet to prove their superiority to the kagzi lime.

From Andhra Pradesh two forms of lemon (Citrus limon Osbeck) one oval in shape and other elongated were found in private orchards which were raised from seeds (Naik, (1949). In Tamil Nadu, seven different localities were surveyed for quality of lime fruits. There was a variation in average weight of fruit and percentage of juice and acidity (Siddappa, 1952).

According to Cheema et al, (1954) three types of limes are under cultivation in Maharashtra State. These include such as kagdi limbu (thin skinned), Godhadi limbu (thick skinned) and pat limbu (Oblong in shape). Further, they remarked that their exact specific status is yet to be determined. Under West Indian conditions several types of acid lime fruits which differ in size from and degree of seediness are recognised. Spineless forms also occur in India (Reuther et al, 1967). A comprehensive survey work and

classification of citrus fruits of Assam was done by Bhattacharya and Dutta (1956). They isolated and described two distinct types of sour limes viz., Karimganj lime and Abhaypuri lime. The pomological and the quality aspect of these types have been studied in detail. The karimganj lime is superior to Abhaypuri both in respect of production and quality of fruits. In Florida and other citrus districts of America, some prominent superior seedlings have been selected and are now under commercial cultivation (Hume, 1957).

In the Eastern region of India two types of acid limes are mostly grown. Kagzi which is more or less round, highly acidic with characteristic flavour is more popular. The other type called Pati has oblong fruits and less acidic than kagzi (Bhan, 1972). A karimganj lime type is most popular in North-East India, it bears more than one thousand fruits per tree. It is less susceptible to scab, canker and gummosis than Abhaypuri lime (Bhattacharya and Dutta, 1956, and Thapar, 1972). From Andhra Pradesh, it has been reported that acid lime trees bear 3000 to 5000 fruits annually and the seedlings are found to live for 20-25 years even under conditions leading to decline (Swamy et al, 1972). Two better types of kagzi lime seedlings have

been reported from Vidharbha region of the State in respect of fruit size (Anon., 1977). The physico-chemical study of kagzi lime fruits carried out at Parbhani revealed that the percentage of acidity was higher in fruits of Mrig bahar as compared to Ambe bahar (Chakrawar, 1977).

Thus, it is seen that no systematic and large scale efforts were made to survey, isolate, describe and classify the various types of kagzi lime strains available in India.

2.2 Survey work on other fruit crops :

In case of mango, large scale survey works were conducted in different parts of the country by number of workers. In Punjab, a survey was carried out in mango growing regions of the state. Out of six hundred tree seedlings examined, some outstanding types have been studied in detail (Singh and Jawanda, 1962). The most of the present day mango varieties like Dashehari, Langra, Alphonso, Chowsa, Banganpalli, Baneshan, Gulabkhus, Suwarnrekha etc. are originated as chance seedlings and have been selected by the number of workers (Anon., 1967).

The survey work was undertaken in Madhya Pradesh for selection of local reputed varieties. Among these

local popular types, Sundereja was found to be outstanding. (Kashyap and Jyotishi, 1969). Some promising local mango seedlings have also been reported from this region (Anon., 1977).

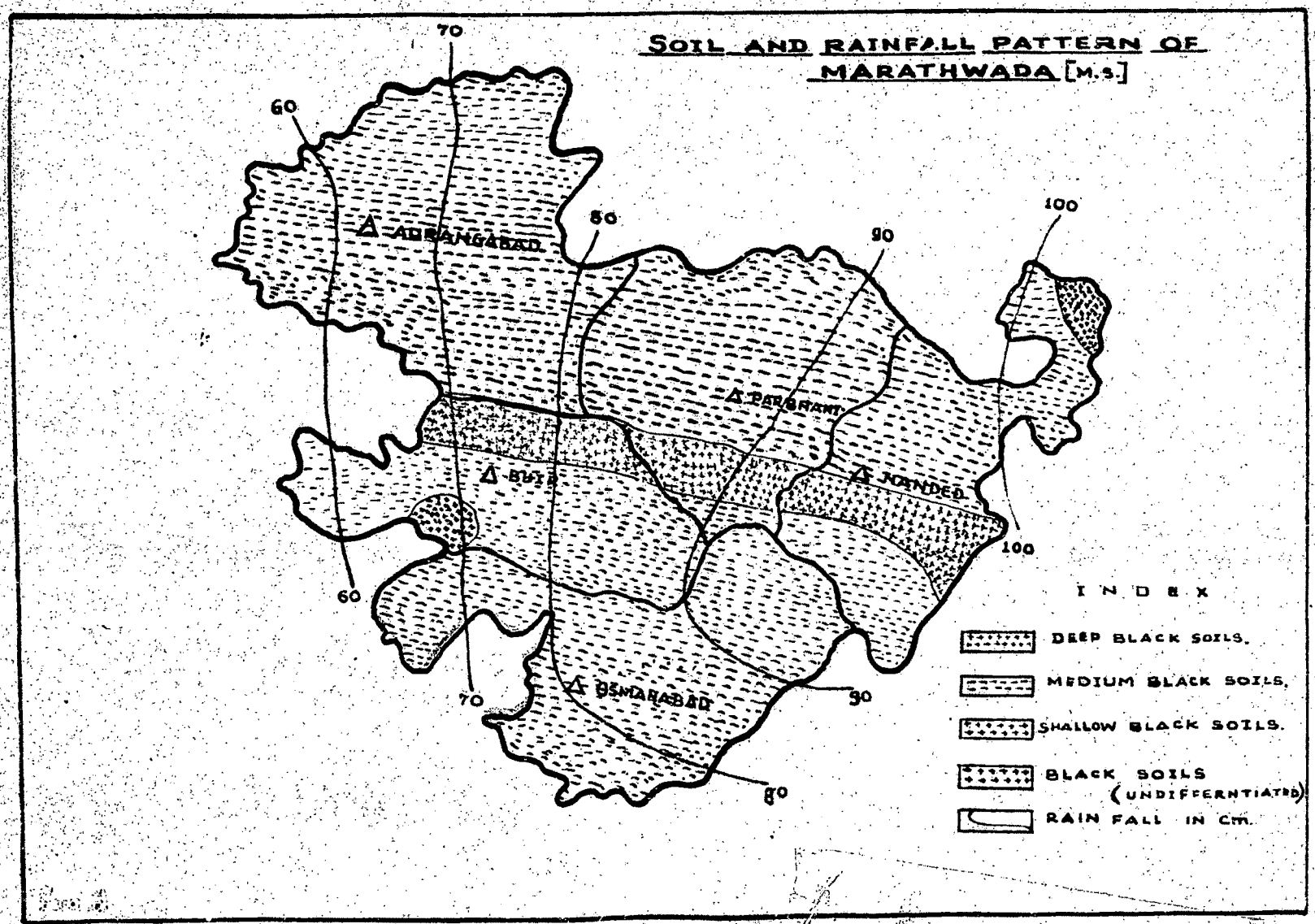
Number of local promising ber seedlings have been studied in Haryana, Punjab and Maharashtra States. Few promising types have been recommended for cultivation (Dhingra, et al, 1973; Gupta, 1977 and Annon., 1977).

At Ganeshkhind Fruit experimental station, Pune, six hundred guava seedlings were studied for yield and quality aspects. On the basis of productivity and quality of individual trees, seedling types like Lucknow 49, Lucknow 46 and Nasik 88 were found most promising (Cheema et al, 1954).

In case of pomogranate, the seedlings raised from Alandi produced one superior type called GBG-1 (Ganesh), which is now a commercial variety in the state (Cheema et al., 1954). An exhaustive survey was undertaken in Ahmadnagar district covering 44 gardens. Detailed observations were recorded on morphological and quality aspects in respect of variations. About 40 superior seedlings of pomogranate were selected and are under further study (Choudhary and Sirsath, 1976).

From the foregoing discussion of review, it appears that very little work has been done in case of sour limes and also in other fruit crops to survey and collect superior strains and establish the germ plasm.

III. MATERIALS AND METHODS


SOIL AND RAINFALL PATTERN OF MARATHWADA [M.S.]
70
60
80
90
100
AURANGABAD
PARBHANI
BEED
JOINTED
OSMANABAD
60
70
80
90
100
INDEX
DEEP BLACK SOILS.
MEDIUM BLACK SOILS.
SHALLOW BLACK SOILS.
BLACK SOILS (UNDIFFERNTIATED)
RAIN FALL IN Cm.

III MATERIALS AND METHODS

The present survey work for selection of superior kagzi lime (Citrus aurantifolia, Swingle) strains/types was undertaken in the Marathwada region comprising of Aurangabad, Bhir, Nanded, Osmanabad and Parbhani districts. The meteorological data for the period January 1977 to January 1978 are given in Appendix-1.

3.1 The general information about the five districts of Marathwada region is given below :

The region comprises of five districts viz., Aurangabad, Bhir, Nanded, Osmanabad and Parbhani. In general, the region falls in between 18^0 to 20^0 north latitude and 75^0 to 78^0 east longitude. The general elevation above sea level varies from 450 to 460 metres. The climate of the region is divided into three seasons viz., moderately warm and wet season from June to September (rainy), cool, dry season from November to February (winter) and hot dry season (summer) from March to May.

3.2 The specific information of the individual districts of the region is given below :

Aurangabad : It is situated in Upper Godavari basin

and the extreme North-West of Marathwada. The temperature ranges from 21 to 36°C (May) and lowers upto 6.8°C (Deceber). Rainfall is unevenly distributed and ranges from 650 to 750 mm per year. Soils are black cotton soils from Deccan trap and very from heavy to light soils.

Bhir : It is situated in Deccan trap area, the Northern part of the district lies in the Godavari basin, while the southern part is in the basin of Manjra. The climate of the district is pleasant and aggeeable during the greater part of the year. The normal temperature ranges from 8.6 to 42°C., maximum temperature rises upto 46°C and lowers upto 4 to 6°C. Rainfall is unevently distributed and it ranges from 508 to 889 mm, normal rainfall is 679.7 mm. Soils are mostly fertile black cotton soils and vary from light to medium black soils in different patches of the district.

Nanded : It is situated in South-West frings of Marathwada and lies in plateau of South India. It is one of the most homogeneous districts in Maharashtra. Climate of the district is dry and subject to extremes of heat and cold. It is very hot in summer and cold in winter. Temperature ranges from 6.80 to 43.8°C.

This district is said to have assured rainfall and it ranges from 596.6 to 1048 mm mostly received from South-West monsoon during June to September.

Osmanabad : It is to the extreme south of Aurangabad division, lies partly in the 'Upper Godavari basin' and partly in the 'Bhima basin'. The major portion of the district is 'Basaltic trap rock' plateau of Deccan. The climate during summer is comparatively cool than other districts. The temperature ranges from 8.8 to 40.8°C. The normal rainfall of the district received from South-West monsoon is 787 mm during June to September. It ranges from 762 to 888 mm. Soils of the district vary from light, medium soils to heavy deep black cotton soils.

Parbhani : Thid district as a whole belongs to the Godavari peninsular basin situated on the Northern side of Maharashtra region. Climate is generally dry throughout the year except during the South-West monsoon season. The maximum temperature in hot season (summer) rises upto 43.2°C and minimum upto 8.6°C in cool dry season (winter). Rainfall is not uniform in all the district. The normal rainfall of the district is 826.6 mm per year, mainly received during June to September. Soils are 'black cotton soils' and vary from

heavy, medium to light to some patches of the district.

3.3 The general information on the cultivation of Kagzi lime in the region :

Such information collected during survey is given below :

The mild sub-tropical climate of the region is best suited for the cultivation of kagzi lime. It is grown on soils varying from light, medium to heavy black cotton soils of the region. But most of the gardens are found on medium black fertile soils. The detailed information on climate and soils of each district is given earlier.

Kagzi lime seedlings raised by seeds from the local strain area obtained from private and Government nurseries. Generally 1 to 1½ year old seedlings (30 to 45 cm ht) are planted during June-July (rainy season), at the distance of 15 to 22' (4.5 - 6 m). November to January planting is also done by the cultivators.

At the time of planting one to two baskets of FYM is applied per plant. Most of the cultivators apply FYM @ 10-50 kg per plant per year. Few cultivators give urea and suphala (mixed fertilizer) @ ½ to 2 kg per plant per year. The irrigations are given at an

interval of 10-20 days mostly with well water by ring or basin system. Weeding is done by manual labourers. Most of the cultivators do not spray insecticides and fungicides for control of pests and diseases. In newly planted orchards the inter-crops like mung, groundnut, gram and vegetables are grown up to bearing of plants. No care is taken about the proper training and pruning of trees.

Under local climate, kagzi lime flowers in 2-3 flushes in a year. However, it produces two distinct bahars (crops) viz., Mrig bahar (June to December) and Ambe bahar (January to June). The fruits of Ambe bahar fetch more price as it is available during summer when the demand is very high. But the yield is more from the Mrig bahar season. The yield varies from 1000 to 3000 fruits (obtained from two bahars) per plant per year. Most of the produce is sold in local and adjacent city markets. Some cultivators send their consignment of fruits to Bombay and Hyderabad cities. On an average cultivator gets an income of Rs. 75 to 250 per plant per year.

Problems in the cultivation of kagzi lime :

Kagzi lime is badly attacked by canker disease, the affected fruits get lower market rates. Secondly there is no specific or standard variety of kagzi lime which can be recommended for large scale cultivation.

Most of the cultivators complaint about very slow growth of the kagzi lime seedlings in the first 2-3 years after planting. The market prices go down whenever there is a glut and cultivators are put to loss, as there is no processing unit in the region to stabilize the prices.

3.4 Experimental procedure :

The districts viz., Aurangabad, Bhir, Nanded, Osmanabad, and Parbhani of the region were selected for survey work. Survey was undertaken during November 1977 to January 1978. The fruits of the Mrig bahar were selected for the present investigation. These districts are abbreviated as follows. The number of locations visited for collection of samples is given below and in Appendix-III.

Sr. No.	Name of the District	Abbreviation used	No. of locations visited
1.	Aurangabad	ABD	15
2.	Bhir	BHR	24
3.	Nanded	ND	15
4.	Osmanabad	OBD	11
5.	Parbhani	PBN	24

The necessary information pertaining to kagzi lime cultivation in the area was collected from the cultivators, Panchayat Samitis and Fruit dealers of the local markets. On the basis of this information 89 kagzi lime locations were selected from the whole region. Names of the cultivators selected for present study are given in Appendix-III.

The selected locations were visited and cultivators were interviewed for the required information as per the proforma given in Appendix-IV. Each and every plant in the garden was observed carefully. The plant bearing highest number of fruits was located first and number of fruits per plant was counted to record the yield. The yield data aree recorded both in terms of number of fruits and its weight per tree was calculated. Plants exhibiting novelty characters like fruit size variations, baramasi, free from canker, highly attractive colour, very thin and thick skinned types were also recorded. In most of the gardens visited, the plants were found in between the age of 10-20 years.

About 15 fruit were collected randomally from the selected plant of each garden. Fruit sample was packed in polythelene bag and brought to laboratory for further study.

Physico-chemical analysis of composite sample of 15 fruits was carried out in three replicates in the laboratory as detailed below and as per the procedure given in A.O.A.C. (1961).

3.5.A Physical characters of fruit :

Weight of fruit : The weight of 15 fruits was determined on a physical balance and average weight per fruit was calculated in grams.

Size and shape index of fruit : The size of the fruit was measured in terms of length and breadth (diamter) in cm with the help of Vernier Calliper. Length was taken as the distance between stem to blossom end, while the breadth (diameter) was measured as the distance between two farthest ends perpendicular to the longitudinal axis. Shape index was calculated (Length/breadth).

Thickness of rind : Thickness was measured by Vernier Calliper at three points after cutting the fruit into two halves and average thickness was calculated in mm.

Percentage and volume of juice : The juice was extracted with the help of hand juice extractor and strained through muslin cloth. The weight of juice was recorded in grams and average juice percentage was calculated. Volume of the juice was measured with measing cylender (ml).

Rind percentage : After extracting the juice rind was separated by hand and weighed. Average percentage of rind was calculated on fresh weight basis.

Percentage of Rag : The rag obtained after straining of juice including septa, albedo was weighed and average percentage was calculated on fresh weight basis.

Number, weight, colour and shape of seed : The total number of seeds was counted. The number of seeds per fruit was calculated, weight of 100 seeds was also recorded in grams. The seed shape and colour was noted for each type.

Colour, shape and surface of fruit : Colour was recorded in terms of degree of yellowness. The surface was noted as smooth, glossy and rough. Shape of the fruit was classified as spherical, round, globose, oval, oblate and oblong. Presence or absence of canker on fruit was recorded.

3.5.B Chemical characters of fruit :

Total soluble solids : T.S.S. of the juice was recorded with hand refractometer (Erma, Japan) in percentage.

Percentage of acidity : Total acidity was determined by titrating a known volume of Juice against N/10 NaOH solution, using phenolphthalein as indicator. The

percentage of acidity was expressed as unhydrous citric acid content. On the basis of mean values of physico-chemical characters and yield the 89 strains have been classified into various groups for the sake of explaination. These have been arranged according to specific criteria.

Statistical analysis of the data :

The simple correlations between physical and chemical characters were worked out. Variability consisting of coefficient of variations, standard deviations and 't' values were calculated for percentage variability and differences among individual characters studied (Panse and Sukhatme, 1954).

IV. RESULTS

IV. EXPERIMENTAL RESULTS

The data obtained on physico-chemical characters of fruits, yield and other aspects of 89 Kagzi lime types are analysed statistically. The phenotypic variability was estimated and correlation coefficient was worked out according to standard procedures. The results are presented with three different approaches.

i. Variability studies in various fruit characters and yield.

ii. Studies on the range in various fruit characters.

iii. Correlation studies.

4.1 Variability studies in various fruit characters and yield :

The 89 different strains in Kagzi lime as such appeared to represent a broad spectrum of variability, when their mean performance for different characters was examined. The analysis of variability revealed significant variance owing to strain differences for most of the characters under study.

The estimates of range, the means, the coefficient of variation (%) and standard deviation are presented in Table 1.

Table 1 : Variability in Kagzi lime

Sr. No.	Characters	Range	Mean	S.D.	C.V.(%)	t
1.	Avg.wt. of fruit (g)	31.33 - 97.86	62.70	16.12	27.70	36.47**
2.	Avg.size of fruit (cm^2)	13.94 - 33.64	22.62	4.67	20.64	45.47**
3.	Avg.rind thickness (mm)	1.09-2.61	1.93	0.31	16.06	60.63**
4.	Rind%	17.96 - 28.77	22.59	2.58	11.42	82.24**
5.	Juice %	41.53 - 61.84	52.19	3.95	7.56	123.96**
6.	Av.No. of seeds/fruit	4.13-15.13	10.62	2.73	25.70	36,54**
7.	Acidity%	5.16 - 8.51	6.80	0.72	10.58	90.30**
8.	Yield kg/ fruit	21.93 - 174.66	88.17	35.21	39.94	23.48**
9.	No.of fruits per plant	600-2100	1401.23	363.01	25.90	36.19**

** Significant at 1%

The various characters studied are described below :

Weight of fruit : The data presented in Table 1 indicate that the differences in the sample observations are

significant even though the same species is being grown by the cultivators. The average weight of fruit is 62.70 g with a variation of 25.70 per cent (Table 1). The variability in weight of fruit observed was more and which ranged from 31.33 to 97.86 g. This range indicates that there is wide variation in weight of fruits of 89 types.

Size of fruit :

The variation in size of fruit (Table 1) of different types ranged from 13.94 - 33.64, with a coefficient of variation of 20.64 per cent. As compared to mean size 22.62 cm^2 range indicated that there was a considerable variation in size of fruit and a significant difference between various strains.

Rind thickness : The variability in respect of rind (Table 1) thickness ranged from 1.09 to 2.61 with a coefficient of variation 16.06 per cent. Thus, a significant difference btween various strains was observed in respect of rind thickness.

Percentage of rind : The variability in respect of rind percentage observed was comparatively less though it was significant, which ranged 17.96 - 28.77 with a coefficient of variation 11.42 per cent.

Percentage of juice : In juice percentage the variability was significantly less, which ranged 41.53 to 61.84 with a lowest CV 7.56 per cent. Thus, there was a least variation in the juice percentage of 89 strains.

Number of seeds per fruit : The variability in this character was high, which ranged 4.13 to 15.3 with a CV(%) 25.7. This wide variation among various strains was found significant.

Percentage of acidity : In this character the variation among different strains ranged from 5.16 - 8.51 with a CV (%) 10.58. Thus, the observed variation in respect of percentage of acidity was comparatively less. However, the differences between strains were observed to be significant.

Number of fruits per plant : Wide variation in this character was observed, which ranged 600-2100 with a CV (%) 25.90. However, a significant difference in number of fruits per plant was observed between 89 strains.

Yield of fruits (kg) : The variability was highest in yield of fruits per plant among all the characters studied, which ranged from 21.93 - 174.66, in different strains with a highest coefficient of variation of 39.94 per cent. However, a significant difference in yield was noticed between various strains.

Studies undertaken with 89 types/strains of kagzi lime indicated wide variations in different characters like yield, size and weight of fruit, with a least variations in percentage of juice and acidity.

4.2 Studies on the range in various fruit characters:

The range in the values of different characters of 89 kagzi lime strains have been worked out and is given in Appendix-II. The various characters are classified with a degree of range in order to isolate various types falling under particular group/unit.

Weight of fruit : On the basis of variation in the fruit weight of different Kagzi lime strains, 89 strains have been classified into four groups with a specific range of weight (g). This information has been presented in Table 2 (a).

Table 2 (a) : Classification of various strains on the basis of fruit weight (g)

Sr. No.	Group	Range	No. of strains/ group	Percentage
1.	Small	30 - 50	24	26.96
2.	Medium	50 - 70	35	39.32
3.	Large	70 - 90	20	22.47
4.	Very large	90 -100	5	5.61

It is seen that the various strains can be grouped as small, medium, large and very large fruit on the basis of specific weight. Out of 89 strains, 24 strains fall in small group, 35 in medium, 20 in large and only five in very large group. The percentage of these groups was worked out and it is seen that the maximum (39.32%) strains fall in the group medium, followed by small (26.96%) and large (22.47%) group (Fig. 1,2). It is interesting to note that five strains out of 89 were very large in fruit weight (90-100 g).

The total 89 ptrains have been classified further into small, medium, large and very large groups with specific strains numbers of the five districts.

Table 2 (b) : Group-wise split up of kagzi lime strains

Sr. No.	Small	Medium	Large	Very large
1.	ABD 5,9,10, 14,15	ABD 11,12,13	ABD 2,3,4, 6,8	ABD 1, 7
2.	BHR 12,16, 17,19,20, 21,22,23,24	BHR 1,2,8,9, 10,11,13,14, 18	BHR 3,4,5, 6,7,15	BHR
3.	ND 10,12	ND 3,5,6,8, 9,11,14,15	ND 1,4,7, 13	ND 2
4.	OBD 3,11	OBD 4,5,6,7, 8,9	OBD 1,10	OBD 2
5.	PBN 9,10, 16,20,23,24	PBN 4,5,8, 11,15,17,18, 19,22	PBN 1,3,6, 7,12,13,14, 21	PBN 2

Figure 1 showing fruits are bigger in size and weight with spherical round shape.

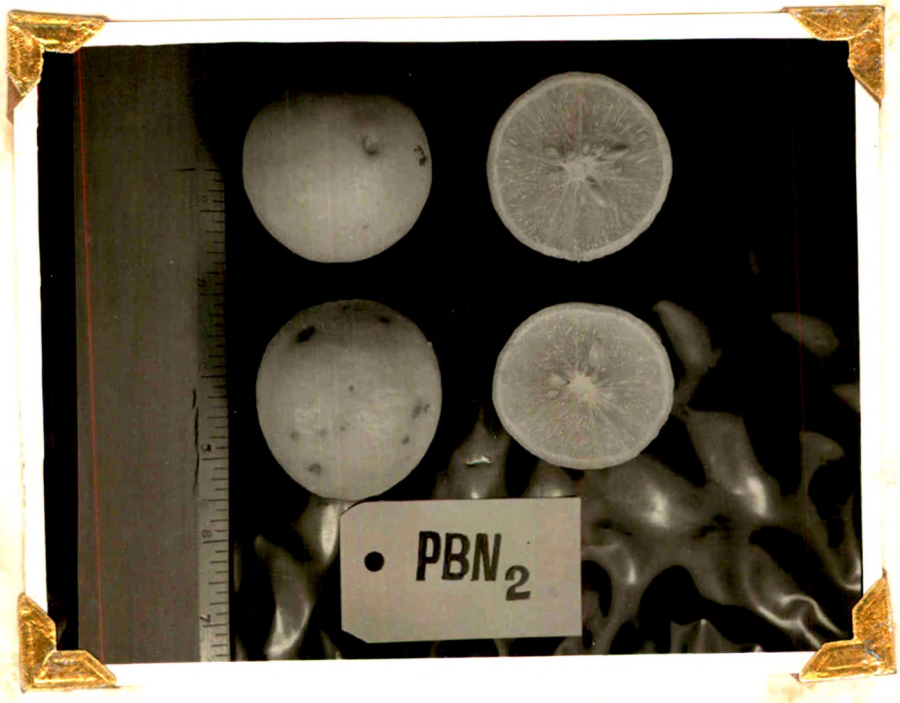


Figure 2 showing fruits are bigger in size and weight with round shape.

The specific details of these strain numbers are given in Appendix-II.

Size of fruit : The size of fruit of 89 strains has been classified on the basis of variation in to four groups with a specific range of size (cm^2). This information has been presented in Table 3 (a).

Table 3 (a) : Classification of various strains on the basis of size(cm^2)

Sr. No.	Group	Range	No. of strains/ group	Percentage
1.	Very small	13-20	27	30.33
2.	Small	20-25	34	38.20
3.	Medium	25-30	21	23.59
4.	Large	30-35	7	7.86

It is seen, that the various strains can be grouped as very small, small, medium and large on the basis of range of the fruit size. Out of 89 strains, 27 strains fall in very small group, 34 in small group, 21 in medium and only 7 in large group. The percentage of these groups was worked out and it is found that the maximum (38.20%) strains fall in small group, followed by very small (30.33%), medium (23.59%) and large (7.86%) group. The total 89 strains have been classified further

in to various size groups. This information has been presented in Table 3 (b).

Table 3 (b) : Group-wise split of kagzi lime strains

Sr. No.	Very small	Small	Medium	Large
1.	ABD 5,10,14, 15	ABD 2,9,12, 13.	ABD 3,4,8, 11	ABD 1,6,7
2.	BHR 1,12,16, 17,18,19,20, 21,22,23,24	BHR 2,8,9, 10,11,14,	BHR 3,4,5, 6,13	BHR 7,15
3.	ND 5,6,10, 12	ND 3,8,9, 11,13,14, 15	ND 2,4,7	ND 1
4.	OBD 3,6,11	OBD 4,5,7, 8,9,10	OBD 1	OBD 2
5.	PBN 8,16,20, 23,24	PBN 3,4,6, 7,9,10,11, 17,18,19,22	PBN 1,2,5, 12,13,14, 15,21	PBN

The specific details of these strain numbers are given in Appendix-II.

Rind thickness : On the basis of variation in rind thickness, which ranged 1.09 to 2.61 mm, these have been classified in to 3 groups with a specific range of rind thickness. This information has been presented in Table 4 (a).

Table 4(a) : Classification of various strains on the basis of rind thickness (mm)

Sr. No.	Group	Range	No. of strains/ group	Percentage
1.	Very thin	1 - 1.5	9	10.11
2.	Thin	1.5 -2.0	41	46.06
3.	Thick	2.0 -2.75	39	43.82

The various strains can be grouped as very thin, thin and thick skinned on the basis of range of rind thickness. Out of 89 strains, 9 strains fall in very thin skinned group, 41 in thin skinned and 39 strains in thick skinned group. The percentage of these groups was worked out and it is seen thatmaximum strains (46.06%) fall in the thick skinned group (Fig.3), followed by thin skinned (43.82%) and very thin skinned group (10.11).

The total 89 strains have been classified further into rind thickness groups with specific strain numbers of the five districts. This information has been presented in Table 4(b).

Table 4 (b) : Groupwise split up of kagzi lime strains

Sr. No.	Very thin	Thin	Thick
1.	ABD 5,10,13,	ABD 6,9,14	ABD 1,2,3,4,7,8, 11,12,15
2.	BHR 1,18	BHR 2,9,11, 12,13,16,20, 21,22,	BHR 3,4,5,6,7, 8,10,14,15,17, 19,23,24
3.	ND ---	ND 2,3,4,6,7, 8,9,10	ND 1,5,11,12,13, 14,15
4.	OBD 11	OBD 1,3,5,6,7, 8,9,10.	OBD 2,4,
5.	PBN 8,9,20	PBN 4,5,10,11, 13,14,15,16,17, 18,21,23,24	PBN 1,2,3,6,7,12, 19,22

The specific details of these strain numbers are given in Appendix-II.

Juice Percentage : Various kagzi lime strains have been classified on the basis of variation in juice content in to three groups with a specific range of percentage of juice. This information has been presented in Table 5 (a).

Table 5 (a) : Classification of various strains on the basis of juice (%)

Sr.No.	Group	Range	No.of strains/ group	Percentage
1	Low	30 - 40	-	-
2.	Medium	40 - 50	26	29.21
3.	High	50 and above	63	70.78

A perusal of the data reveal that the various strains can be grouped as low, and high percentage of juice. Out of 89 strains, 63 strains fall in high, group, followed by medium 26 strains, while in case of low group not a single strain was found. The percentage of these groups was calculated and it is seen that most of the strains (70.78%) fall in the high group, followed by medium group (29.21%).

The total 89 types of kagzi lime have been classified further in various groups as per Table 5(a) with specific strain numbers of the five district. This information has been given in Table 5 (b).

Table 5 (b) : Group-wise split up of kagzi lime strains

Sr. No.	Medium	High
1.	ABD 4,5, 15	ABD 1,2,3,6,7,8,9,10,11, 12,13,14
2.	BHR 3,8,14,16,17,19, 20,23,24	BHR 1,2,4,5,6,7,9,10,11, 12,13,15,18,21,22
3.	ND 5,12,13,14	ND 1,2,3,4,6,7,8,9,10,11, 15
4.	OBD	OBD 1,2,3,4,5,6,7,8,9,10, 11
5.	PBN 1,2,3,7,9,11,15, 22,23,24,	PBN 4,5,6,8,10,12,13,14, 16,17,18,19,20,21

The specific details of these strain numbers are given in Appendix-II

Percentage of acidity : On the basis of differences observed in respect of acidity percentage in various strains, these have been classified into three groups with a specific range of acidity. This information has been presented in Table 6(a).

Table 6(a) : Classification of various strains on the basis of acidity (%)

Sr.No.	Group	Range	No.of strains per group	%
1.	Low	5 - 6	13	14.60
2.	Medium	6 - 7	46	51.68
3.	High	7 - 9	30	33.70

It appears that various strains/types can be grouped as low, medium and high percentage of acidity. Out of 89 strains, 30 strains fall in high acidic group, 46 in medium and only 13 in low acid group. The percentage of these groups was woked out and it is found that maximum (51.68%) strains fall in medium group, followed by high group (33.7%) and low group (14.6%).

The total 89 types of kagzi lime have been classified with a specific strain numbers of the five districts. This information has been given in Table 6(b).

Table 6 (b) : Group-wise split of kagzi lime strains

Sr. No.	Low	Medium	High
1.	ABD 10,	ABD 1,2,3,4,6,8, 11,12,13,14,15	ABD 5,7,9,
2.	BHR 13,14,17, 18	BHR 3,8,10,12, 16,19,20,21,22	BHR 1,2,4,5, 6,7,9,11,15, 23,24
3.	ND 6,15	ND 3,4,7,8,9, 10,11,13,	ND 1,2,5,12, 14
4.	OBD 7,8	OBD 1,3,6,9	OBD 2,4,5,10, 11
5.	PBN 10,13,18, 24	PBN 2,3,8,9,11, 12,15,16,17,19, 20,21,22,23	PBN 1,4,5,6, 7,14

The specific details of these strain numbers are given in Appendix-II.

Fruit shape : On the basis of variation in shape and shape index kagzi lime strains have been classified into six groups with a specific range of shape index. This information has been presented in Table 7(a).

Table 7(a) : Classification of various strains on the basis of shape (shape index)

Sr.No.	Group	Range (L/B)	No.of strains per group	%
1.	Spherical round	0.83 to 0.99	20	22.47
2.	Round	1.0 to 1.02	22	24.71
3.	Oval	1.03 to 1.2	42	47.19
4.	Oblong	1.25 to 2.0	-	-
5.	Oblate	-	2	2.24
6.	Globose	-	2	2.24

The strains (Table 7 a) can be grouped as spherical round, round, oval and oblong on the basis of shape index, while some strains were grouped as oblate and globose. Out of 89 strains, 42 strains fall in oval group (Fig.4,5) with a highest percentage (47.19), followed by 22 in round (24.71%) and 20 in spherical round (22.47%). Not a single sample was obtained of oblong group. Two strains from each oblate and globose types in a 89 samples (Fig.6,7,8,9).

The total 89 strains have been classified further into various groups with a specific strain numbers of the five districts. This information has been presented in Table 7(b).

Table 7 (b) : Group-wise split up of kagzi lime strains

Sr.No.	Spherical round	Round	Oval	Oblate	Globose
1.	ABD 7,10,13,14	ABD	ABD 1,2,3, 4,6,8,9, 11,12,15	ABD 5	-
2.	BHR 1,12,13, 16,18,21	BHR 2, 11,22,	BHR 3,4,5, 6,7,8,9,10, 14,15,17, 19,20,23	BHR	-
3.	ND 6,8,10,	ND 2,5, 9,11,	ND 1,4,7, 12,13,14,15	ND	ND 3
4.	OBD 1,6,7,	OBD 11,	OBD 2,3,4, 9	OBD 5	OBD 10
5.	PBN 2,11,14, 23	PBN 1,4, 5,8,9, 10,12, 13,17,18, 19,20,24	PBN 3,6,7, 15,16,21,22	-	-

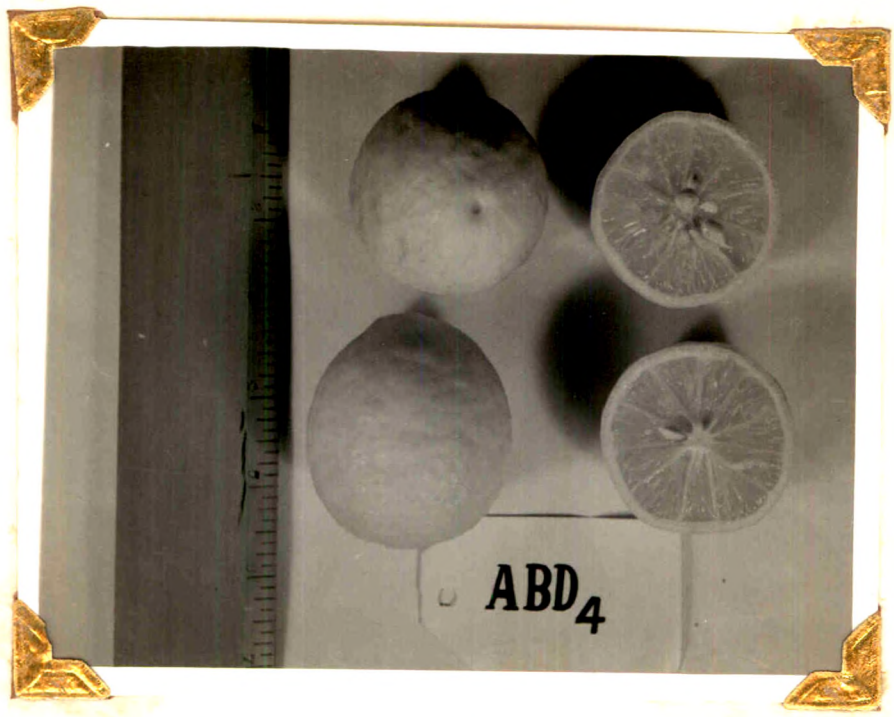


Figure 3 showing fruits are oval in shape and large size

Figure 4 showing fruits are oval in shape and rough, thick skinned

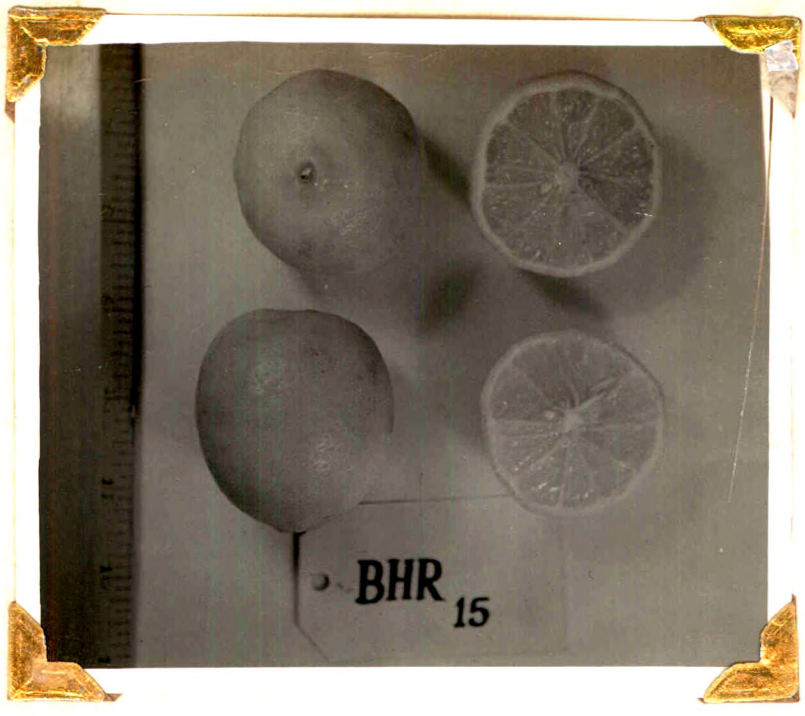


Figure 5 showing fruits are oval in shape with one end depressed.

Figure 6 showing fruits are of oblate shape and canker free.

Figure 7 showing fruits are of oblate shape

Figure 8 showing fruits are of globose shape

Figure 9 showing fruits are of globose shape

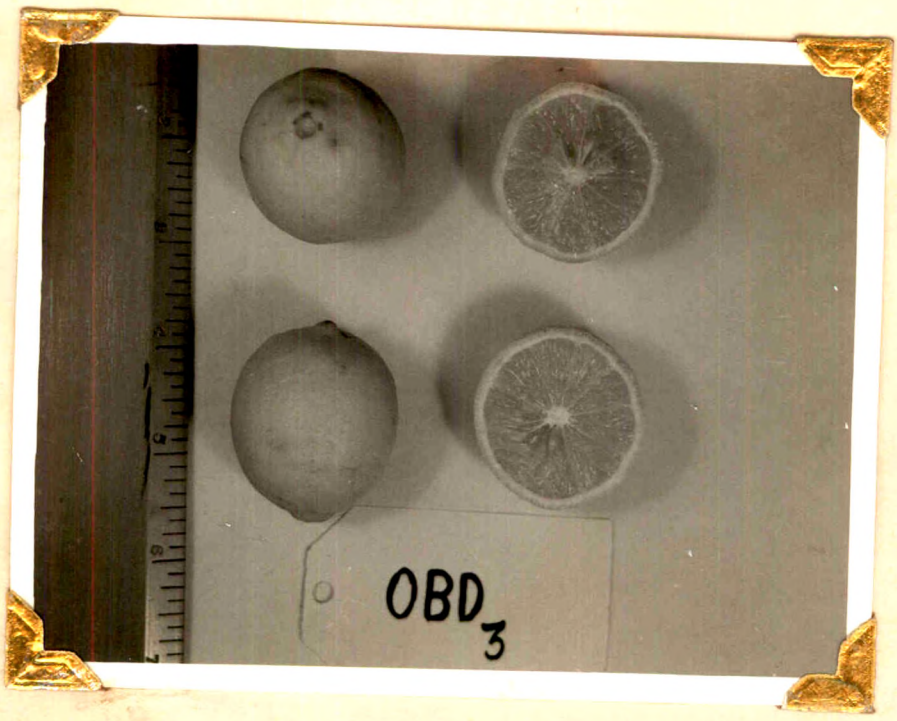


Figure 10 showing fruits having mamilla.

The specific details of these strain numbers are given in Appendix-II.

Yield/plant : On the basis of differences observed in yield (number of fruits/plant) the various samples have been classified into three groups with a specific range of fruit number. This information has been presented in Table 8(a).

Table 8 (a) : Classification of various strains on the basis of yield (number of fruits/plant)

Sr.No.	Group	Range	No. of strains/ group	Percentage
1.	Low	500 - 1000	14	15.73
2.	Medium	1000 - 1500	37	41.57
3.	High	1500 - 2500	38	42.69

The data indicate that various strains can be grouped as low, medium and high yielders. Among the 89 strains maximum (38) strains fall in high yielding group with highest percentage (42.69) followed by medium group (37) strains with 41.57 per cent and low yielder 14 strains with a 15.73 percentage.

The total 89 strains have been classified further into various groups with a specific strain numbers of the five district. This information has been presented in Table 8 (b).

Table 8(b) : Group-wise split up of kagzi lime strains

Sr.No.	Low	Medium	High
1.	ABD	ABD 6,11,13,14	ABD 1,2,3,4,5,7, 8,9,10,12,15
2.	BHR 12,16,17, 18,19,20,22, 22,23	BHR 2,4,6,7,8, 10,11,13,14,15, 24	BHR 1,3,5,9
3.	ND 3,5	ND 2,6,9,11,13 15	ND 1,4,7,8,10, 12,14
4.	OBD	OBD 4,6,7,11	OBD 1,2,3,5,8, 9,10
5.	PBN 7,20,21	PBN 2,4,5,6,9, 13,14,15,16, 22,23,24	PBN 3,8,10,11, 12,17,18,19

The specific details of these strain numbers are given in Appendix-II.

Yield (kg)/plant :

As the range of variation in respect of yield of fruit per plant was wide, the yield in kg per plant was calculated and various types have been classified into three groups with a specific range of weight. This information has been given in Table 9(a).

Table 9 (a) : Classification of various strains on the basis of yield (kg/plant)

Sr.No.	Group	Range	No. of strains per group	%
1.	Low	21-75	31	34.83
2.	Medium	75-125	44	49.43
3.	High	125-175	14	15.73

The data depicted in Table 9 (a) reveal that the various strains can be grouped as low, medium and high yileding on the basis of range of the weight. Out of 89 strains, maximum (44) strains are in medium group with a highest percentage (49.43), followed by 31 strains in low yield with a percentage of 34.83 and only 14 strains (15.73%) were found to be high yielding.

The total 89 strains have been classified further into various groups with specific strain numbers of the five districts. This information has been given in Table 9 (b)

Table 9 (b) : Group-wise split up of kagzi lime strains

Sr.No.	Low	Medium	High
1.	ABD 10,14,15	ABD 2,5,8,9,11, 12,13	ABD 1,3,4,6,7
2.	BHR 8,12,13,14, 16,17,18,19,20, 21,23,24	BHR 1,2,4,5,6, 7,9,10,11,15	BHR 3
3.	ND 3,5,6,9,12	ND 2,4,7,8,10, 11,13,14,15	ND 1
4.	OBD 6,11	OBD 3,4,5,6,7,8, 9,10	OBD 1,2,
5.	PBN 5,7,9,16,20, 21,23,24	PBN 4,6,10,11,13, 14,15,17,18,19, 22	PBN 1,2,3,8,12

The specific details of these strain numbers are given in appendix-II.

The total soluble solids of the juice of various strains were determined. This value was found to range 8.27 - 9.96 in various strains (Appendix-II).

The observations like seed colour, seed size, and weight of 100 seeds were recorded in various strains. There was considerable variation in colour, shape and weight of seeds of various strains. The colour of the seed was found to very from white to light yellow, dark yellow and brown. Shape of seed like round, avoid, and flat were observed. The weight of 100 seeds was found to vary 8.84 to 15.48 grams (Appendix-II).

Some peculiar/noval types of Kagzi lime :

Out of 89 strains studied, some peculiar strains like Baramasi, mamilate, canker free and attractive coloured were observed and are described below :

The results given in Table 10 are interesting. It is seen that the fruits of Baramasi type differ in respect of shape, thickness of rind, percentage of acidity and number of fruit per plant. The fruit shape of this type is invariably round and the fruits are thin skinned. The acidity is comparatively less as compared to normal kagzi lime, but the most important point in the favour of Baramasi type is the high yield obtained

Table 10 : Physico-chemical composition of Baramasi types

Character \ Strain No	PBN 8	PBN 10	PBN 11	PBN 12	OBD 1
Fruit wt (g)	65.00	51.93	53.50	76.80	71.00
Size (LXB)	22.42	20.24	20.70	27.19	25.35
Shape	round	round	spherical round	round	spherical round
Juice (%)	52.20	53.27	49.93	51.82	56.71
Thickness of rind (mm)	1.09	1.56	1.92	2.03	1.80
No. of seeds/ tree	9.66	8.80	7.40	6.40	9.80
Acidity (%)	6.50	5.73	6.48	6.73	6.50
Yield No. of fruits/plant	2100	1900	1800	1900	1950
Remark	canker free	-	-	canker free	-

almost through out a year. Out of 89 types surveyed, some types were observed to be very distinct in respect of fruit colour. The strain numbers OBD 10, PBN 1, PBN 10, PBN 14 were observed to have very bright-yellow attractive colour with glossy appearance.

During survey attempt was made to locate kagzi lime types free/tolerant to canker disease. The strain numbers, ABD 5, ABD 13, BHR 1, PBN 1 PBN 8 and PBN 12 were observed to be canker free at the time of sampling and also reported

V. DISCUSSION

V. DISCUSSION

Kagzi lime is one of the important citrus species, widely grown in India for various purposes. It is commercially propagated by seeds in India, as it comes true to type because of high degree of nucellar embryony. Even though the phenomenon of nucellar embryony is common in Kagzi lime, seedling variations do occur (Hume,1957) Therefore, selection of superior strains from existing variation is one of the easy and best methods of crop improvement.

Few survey works carried out in South India, Central India and North-East India indicate that there are several forms of limes under cultivation. Their exact specific status, pomological characters and physico-chemical composition of fruits is yet to be determined. Therefore, at present we do not have standard/specific cultivars which can be recommended. At present cultivators are switching over to the cultivation of Kagzi lime on large scale, as the mandarins and sweet oranges are being wiped out due to die-back Complex. So, there is a heavy demand for the supply of better types of kagzi lime. In view of the above necessity survey was undertaken in the Marathwada region of the Maharashtra State.

The foregoing discussion brings out two important points, firstly there is a great scope to survey and locate the superior strains of kagzi lime and secondly to build up germplasm for the improvement of kagzi lime. The salient features of important findings discussed below:

1. Variability studies in different Kagzi lime strains:

The phenotypic variation among the different strains plays vital role in crop improvement programme. The present study elucidates this aspect.

The survey work comprising of 89 strains of Kagzi lime appeared to represent a broad spectrum of variability when their mean performance for different characters was examined. The differences in the sample observations are significant even though the same species is grown by the cultivators.

The results indicate that the variability was more in yield (Kg)/plant, which ranged from 21.93 to 174.66 kg in different strains with a highest coefficient of variation of 39.94 per cent, this was followed by number of fruits/plant, weight of fruit (g), number of seeds/fruit, size of fruit (cm^2), rind thickness (mm), percentage of rind, percentage of acidity and juice respectively. Studies undertaken with 89 types/strains of Kagzi lime indicated the wide variation in different characters like

yield, size and weight of fruit with least variations in percentage of juice and acidity.

Bhattacharya and Dutta (1956) reported that the yield of Karimganj lime to be found higher than Abhaypuri lime under Assam conditions. The variation in the yield of Kagzi lime trees varied 1500 to 5000 fruits annually (Bhan,1972 and Swamy et al, 1972).

According to Siddappa (1952) the average weight of various Kagzi lime types varied from 26-60 grams, percentage of juice from 45-58 and acidity 6.27 to 7.69. Bhattacharya and Dutta (1956) reported 6.67 per cent and 6.81 per cent acidity in two types of sour limes.

Under West Indian conditions several types of acid lime fruits have been reported which differ in size, form (round, oval and oblong), degree of seediness and thickness of rind as thin and thick (Anon; 1932; Cheema et al; 1954 and Reuther et al; 1967).

2. Studies on the range in various fruit characters :

The results clearly indicated that large scale variation exists both in quality of fruits and productivity of plant. Therefore, it was decided to classify the various strains with a specific unit. On the basis of

variation in the fruit weight, 89 strains have been classified into four groups viz; small, medium, large and very large fruit (Table 2). It is interesting to note here that only five strains out of 89 were heavy in fruit weight (90-100 g).

The size of fruit is very important from the marketing point of view. Therefore, the various strains have been classified into four groups with a specific range of size (Table 2b) into very small, small, medium and large sized (30-35 cm^2). Only seven strains were found to be large sized out of 89.

The rind thickness of various strains ranged 1.09 - 2.61 mm. Therefore, these have been classified as very thin, thin, and thick skinned (Table 4 a). The character rind thickness is important both from the point of pickle and juice purpose. Most of the types having thin rind give high percentage of juice, while thick skinned types are suitable for pickle purpose. A thin and thick types of kagzi lime fruits have been reported earlier (Anon; 1932 and Cheema et al; 1954). Cheema et al; (1954) found thin skinned (Kagdi limbu) and a thick skinned (Godhadi limbu)under cultivation in Maharashtra State. Thus, supporting the above findings.

The extent of variation in juice percentage was found minimum in various strains. Out of 89, 63 strains

are classified in high percentage of juice and 26 are of medium group. It is observed that the percentage of juice was significantly more from thin skinned types over thick skinned.

Percentage of acidity is most important economical character of the fruit. From the present study a distinct variation in the percentage of acidity was recorded. Out of 89 strains, 30 strains had high acidity (7-9%). This character can be exploited on commercial scale for manufacture of citric acid from only promising strains. The strain AED 7 (8.51%), AED 5 (8.40%) and PBN 1 (8.29) numbers had highest percent of acidity (Appendix-II).

A distinct and wide variation in shape of fruit in various strains of Kagzi lime has been noted (Appendix-II It is interesting to report here that in the present study, fruits of spheridal, round, round, oval, oblate and globose shape were obtained from the 89 samples. Most of the strains were oval and round in shape. In this region in 1932, four distinct types 1) round, small thin skinned, ii) round large thin skinned, iii) round large thick skinned, iv) long thick skinned (Godhadi limbu) have been reported on visiaul observations (Anon, 1932).

From Assam, two types round (Kagzi) and Pati (oblong) have been reported by Bhattacharya and Dutta (1956)

and Bhan (1972). Thus, large variations in shape of fruit exists in cultivated kagzi lime species.

Yield per plant is a complex character being the result of the effect of number of factors inherent both in the plants as well as in the environment. The increase in yield has been reported with increase in number of fruits per plant and increase in weight of fruit. Therefore, it was thought desirable to classify the yield of various strains with a specific range/unit. On the basis of this approach the strains were grouped as low, medium and high yielding (Table 8a). Thirty-eight strains out of 89, were high yielders in terms of number of fruits/plant, while only 14 strains were observed to be high yielding when weight of fruit per plant was considered (Table 9 a). Thus, the knowledge of the fruit weight and number of fruits per plant can jointly predict the total yield of the plant (Appendix-II). Bhattacharya and Dutta (1956) observed that Karimgan lime yields 1000 fruits per tree in a peak season. Bhan (1972) reported yield of Kagzi lime from 1500 to 2000 fruits/tree. From Andhra Pradesh, Swamy et al, (1972) observed that acid lime trees bear 3000-5000 fruits annually. Thus, the variation observed in the present study in respect of yield can be supported by the findings of these workers.

During the survey work of the present study, some noval types like Baramasi, highly attractive colour tupes and canker tolerant types have been spotted out. It is interesting to report here that five strains (Table 10) of Baramasi types have been located and their yield and quality aspect of the fruit were studied. These are superior in yield, optimum in quality and give the fruits almost through out the year. Such strains should be exploited on commercial scale to establish their superiority over normal types. Baramasi types are specially suited for Kitchan gardening purpose. The colour and appearance are important factors, which decide the market value of the fruit. It is sure that highly attractive, glossy, smooth surfaced Kagzi lime fruits fetches better price in the market. Such types (OED10, PBN1, PBN10 PBN14) have been spotted during the sufvey work.

The canker disease is a serious problem in the cultivation of Kagzi lime. In view of this problem some types (ABD 5, ABD 13, BHR 1, PBN 1, PBN 8, PBN 12) have been located as canker tolerant. However, it is suggested that their resitance to canker disease dhould be studied further to confirm the above observation.

3. Correlation studies in Kagzi lime strains :

Corrélation studies between various characters of

fruit and yield indicated some definite positive/ negative relationships (Table 11).

There is a definite relationship between weight of fruit and size of fruit, as the size of fruit increases it accompanies increase in weight of fruit, as well as the juice percentage and thickness of rind. Siddappa (1952) reported that size or the weight of acid lime does not bear any definite relationship to percentage of juice or its acidity. Gowda and Shanker (1971) reported that increase in weight of citrus fruit accompanies with an increase in diameter of fruit. There is no definite relationship between number of seeds per fruit and weight of fruit. However, Hittalmani and Rao (1976) reported that there was a positive correlation between seed number and weight of fruit during the developmental stages of Kagzi lime fruit. There was no distinct relationship between size of fruit and percentage of acidity. But a highly significant and definite relationship between size of fruit and the thickness of rind observed. The increase in size of fruit accompanies increase in the thickness of rind. There was a highly significant negative correlation between percentage of rind and percentage of juice. It is obvious that when rind percentage increases automatically the juice percentage decreases. The correlation between size of fruit with number of seeds/fruit did not give

positive relationship. The yield of a plant is a most economical factor from commercial point of view. The correlation studies indicated highly significant and positive relation between yield (kg) and number of fruits per plant. The increase in number of fruits per plant and by weight accompanies increase in yield per plant.

In summing up, the foregoing discussion it can be said here that the various strains can suitably be classified and utilized for juice purpose, manufacture of citric acid and pickle purpose on the basis of physico-chemical composition of fruit. The collection of 89 types will enrich the germ plasm of Kagzi lime for further improvement of this crop as per the needs of the cultivators of the state.

VI. SUMMARY

VI. SUMMARY

The study entitled "Survey for the selection of superior Kagzi lime strain/types in the Marathwada region" was carried out during 1977-78 in five districts of Marathwada region and Department of Horticulture, M.A.U. Parbhani. The results obtained are briefly summarised as under :

1. The analysis of variability of 89 Kagzi lime types revealed significant variance owing to strain differences for most of the characters under study. It indicated a wide variations in yield size and weight of fruit, with a least variations in percentage of juice, acidity and rind thickness.

2. The various fruit characters and yield of 89 types are classified on the basis of variation into definite groups (unit) in order to isolate and specify the types under particular group.

i) The fruit weight of different types has been classified into four groups within the range of 30-100 grams.

ii) The size of fruit has been classified into four groups within the range of 13.0 to 35.0 cm^2.

iii) The find thickness of fruit has been classified

into three groups within the range 1·0 - 2.75 mm. The strain numbers ABD 3 (2.61) ABD 1 (2.55) PBN2 (2.42) are very thick skinned and may be suitable for pickle purpose.

iv) The 89 strains have been classified on the basis of juice percentage into three groups having a range of 30 to 60.

v) The percentage of acidity of various strains has been classified into three groups within the range of 5 to 9%. The strain numbers ABD 7 (8.51) ABD 5 (8.4), PBN 1 (8.29) had highest acidity percentage.

vi) On the basis of variation in shape and shape index the types have been classified into five groups like spherical round, round oval, oblate and globose.

vii) Yield in terms of number of fruits and weight of fruit per tree of various samples has been divided into three groups as high yielding, medium and poor. The strain numbers ABD 3, PBN 1, PBN3, PBN 8, ND 1 were observed highly productive.

3) During survey, some peculiar and novel types were located. Out of 89 strains, ABD 1, PBN 8,10,11,12 are of Baramasi types. Baramasi types are found in shape, thin skinned, abundent juice and very high in yield per plant.

4) The strain numbers OBD 10, PBN 1, PBN 10 and PBN 14 had very attractive, yellow bright colour with glossy appearance.

5) The strain numbers ABD 5, 13, BHB 1, PBN 1, 8 and 12 were observed to be canker free and as also reported by the cultivators.

6) Definite relationships betwen weight of fruit and size of fruit, percentage of juice and rind thickness size of fruit and thickness of rind, number of fruits/ weight of fruits to yield per plant have been found out.

It may be concluded here that out of 89 types of Kagzi lime, some strains are productive, high in acidity content, suitable for juice and pickle purpose. The Barmmasi types are found productive and economical to the cultivators. It is indicated that this germ plasm should be studied further for the improvement of Kagzi lime.

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* Originals not seen

APPENDIX

APPENDIX-I

Weekly Meteorological DATA collected during the period January 1977 to January 1978

Weeks No.	Dates	Mean Temperature $0^{o}C$.		Mean relative humidity percentage		Rainfall in mm	No. of rainy days
		Maximum	Minimum	Morning	Evening		
1	2	3	4	5	6	7	8
			January 1977				
1.	1-7	30.2	11.1	62	25	-	-
2.	8-14	31.7	12.1	61	20	-	-
3.	15-21	31.0	14.1	56	30	-	-
4.	22-28	31.0	14.0	60	30	-	-
			February 1977				
1.	29-4	31.4	10.8	50	18	-	-
2.	5-11	31.9	11.1	47	20	-	-
3.	12-18	34.2	14.7	54	28	-	-
4.	19-25	35.7	18.4	69	34	19.4	2
			March 1977				
1.	26-4	35.8	19.1	55	18	1.0	1
2.	5-11	37.0	18.0	27	17	-	-
3.	12-18	39.2	22.2	24	15	-	-
4.	19-25	40.0	21.7	41	14	1.0	1
5.	26-1	39.5	22.8	41	16	4.2	1

APPENDIX-I (Contd.)

1	2	3	4	5	6	7	8
			April 1977				
1.	2 - 8	40.5	23.6	43	17	-	-
2.	9 - 15	38.7	21.8	47	14	-	-
3.	16- 22	39.4	23.3	40	15	1.4	1
4.	23 - 29	39.9	25.1	39	18	-	-
			May 1977				
1.	30 - 6	40.3	25.1	33	16	-	-
2.	7 - 13	41.5	26.1	42	16	-	-
3.	14 - 20	41.4	27.0	50	13	-	-
4.	21 - 27	39.2	27.0	50	25	2.2	1
5.	28 - 3	40.0	26.0	60	21	2.0	1
			June 1977				
1.	4 - 10	41.0	27.0	60	21	3.0	1
2.	11 - 17	38.0	24.8	70	35	22.0	2
3.	18 - 24	35.0	23.1	86	50	50.4	6
4.	25 - 1	32.9	23.7	81	53	30.8	3
			July 1977				
1.	2 - 8	35.3	23.5	77	49	4.2	3
2.	9 - 15	34.4	24.0	82	45	36.0	3
3.	16 - 22	34.4	23.6	86	55	27.2	6
4.	23 - 29	30.6	23. 2	88	66	21.2	5
5.	30 - 5	32.1	22.6	80	52	21.2	1

APPENDIX -I (Contd.)

1	2	3	4	5	6	7	8
			August 1977				
1.	6 - 12	32.0	22.7	85	57	38.8	4
2.	13 - 19	32.8	22.0	82	48	1.2	1
3.	20 - 26	29.0	22.4	88	77	60.8	5
4.	27 - 2	28.5	22.1	91	75	143.8	7
			September 1977				
1.	3 - 9	31.5	21.5	87	55	-	-
2.	10 - 16	31.0	21.2	78	54	34.2	1
3.	17 - 23	33.1	20.3	84	40	0.6	1
4.	24 - 30	34.1	22.0	77	38	1.2	1
			October 1977				
1.	1 - 7	32.2	22.0	89	63	55.0	3
2.	8 - 14	33.6	17.8	72	30	-	-
3.	15 - 21	34.0	16.1	66	22	-	-
4.	22 - 28	33.1	15.4	66	27	-	-
			November 1977				
1.	29 - 4	34.0	19.2	64	32	-	-
2.	5 - 11	33.4	17.4	55	26	-	-
3.	12 - 18	30.6	18.4	72	42	-	-
4.	19 - 25	28.3	19.7	80	61	-	-
5.	26 - 2	29.0	20.3	91	62	-	-

APPENDIX.I (Contd.)

1	2	3	4	5	6	7	8
			December 1977				
1.	3 - 9	28.4	14.2	82	41	-	-
2.	10 - 16	28.0	9.1	81	24	-	-
3.	17 - 23	28.3	10.3	76	25	-	-
4.	24 - 30	27.6	10.1	78	30	-	-
			January 1978				
1.	1 - 5	28.1	12.1	66	41	0.8	1
2.	8 - 14	26.7	11.4	85	39	1.0	1
3.	15 - 21	30.8	12.6	67	26	-	-
4.	22 - 28	28.7	13.8	79	41	16.4	2
5.	29 - 4	30.8	16.8	71	33	0.4	1

Source - Meteorological Laboratory, Marathwada Agricultural University, Parbhani.

APPENDIX-III

List of Cultivators

1. Aurangabad District :

Strain No.	Name of the cultivator	Place
ABD 1	Shri Haribhau Rambhau Nirve	Uthwat
ABD 2	" Deorao Patil	Jodmanegaon
ABD 3	" Kishanrao Dhole	Pasud
ABD 4	" Dupa Maroti Dure	Jikthan
ABD 5	" Vishwanath Ganpatrao Gore	Takli
ABD 6	" Laxmanrao More	Katpur
ABD 7	" Kishan Venkayya Goriyanthyal	Jalna
ABD 8	" Vithoba Nagre	Saukhed
ABD 9	" Bihariseth Bhakkad	Jalna
ABD 10	" Pandurang Trimbake	Golegaon
ABD 11	" Narayan Deore Somdhane	Hankar Deolgaon
ABD 12	" Govind Siduappa	Varkhed
ABD 13	" Yeshwantrao Anandrao	Masegaon
ABD 14	" Bapusaheb Baburao Kakde	Kandari
ABD 15	" Shivaji Dyanoba Kakde	Kandari

2. Bhir District

BHR 1	Shri Fakirbua Mali	Mazalgaon
BHR 2	" Sopan Mukundaro Gutte	Nananj
BHR 3	" Narsoba Phad	Kandherwadi
BHR 4	" Eknath Tulsiram Munde	Saradgaon
BHR 5	Smt. Sarubai Munde	Dabi

APPENDIX -III (Contd.)

2. Bhir Dist. (contd.)

Strain No.	Name of the cultivator	Place
BHR 6	Shri Nandlal Marwadi	Adgaon
BHR 7	" Laxamanrao Patil	Jawla
BHR 8	" Ganpatiappa Balde	Malkapur
BHR 9	" Apparao Dhondiba Munde	Pangri
BHR 10	" Murlidhar Arjun Gutte	Nananj
BHR 11	" Biru Mane	Malkapur
BHR 12	" Laxman Rajaram Yadav	Jadit Jawla
BHR 13	" Baburao Annaseheb Mule	Waghora
BHR 14	" Ashroba Balde	Waghora
BHR 15	" Namdeaorao Bhise	Ujani
BHR 16	" Gyandeorao Maske	Palwand
BHR 17	" A.P. Bhople	Bhir
BHR 18	Smt. Sonabai Ghode	Bhir
BHR 19	Shri G.A. Mane	Bhir
BHR 20	" R.M. Garam teacher	Bhir
BHR 21	" Maszid Samsthan	Parli-Vaijnath
BHR 22	" A.M. Munde	Pangri
BHR 23	" Sk. Pharidsaab	Khurdi
BHR 24	" Sheshrao Dhondiba Jagtap	Karchundi

3. Nanded District :

ND 1	Shri Bhagwanrao Govindrao Choudhari	Mudkhed
ND 2	" Sambhaji Tukaram Lone	Lahangaon
ND 3	" Manik Pundlik Bhise	Jodgawala
ND 4	" Sahebrao Jaywantrao Patil	Rajwadi

APPENDIX-III (Contd.)

3. Nanded Dist. (Contd.)

Strain No.	Name of the cultivaror	Place
ND 5	Shri Ganeshrao Govindrao Kadam	Chidgiri
ND 6	" Madhavrao Ramchandra Lokhande	Dharmapuri
ND 7	" Sheshrao Deorao Chavan	Loha
ND 8	" Deorao Patil	Karwadi
ND 9	" Baburao Jaywantrao Patwari	Talegaon
ND 10	" Afsar Patel	Talegaon
ND 11	" Dajiba Nagorao Mungal	Ejali
ND 12	" Tapaji Manika Mungal	Ejali
ND 13	" Namdeorao Suryawanshi	Talni
ND 14	" Eknathrao Pawar	Naleshwar
ND 15	" Sk. Pharid Sk. Baban	Bembra

4. Osmanabad District

OBD 1	Shri	Manikrao Kedar	Rajwadi
OBD 2	"	Pundlikrao Kendre	Patoda
OBD 3	"	Udhav Sakharam Kachwe	Kokangaon
OBD 4	"	Venkatrao Sonerao Kadam	Tambatsinghi
OBD 5	"	Bhagwanrao Bhadade	Mavalgaon
OBD 6	"	Venkat Apparao Bhadade	Mavalgaon
OBD 7	"	Pandharinath Patil Khendre	HanmantJawlga
OBD 8	"	Raosaheb Yeshwantrao Khakre	Malegaon
OBD 9	"	Tuljaraosingh Thakur	Shivankhed
OBD 10	"	Vilas Trimbakrao Kendre	Patoda
OBD 11	"	Namdeorao Patil	Kolwadi

APPENDIX-III (Contd.)

5. Parbhani District :

Strain No.	Name of the cultivator	Place
PBN 1	Shri Haribhau Babarao	Ghatangra
PBN 2	" Gyanba Santram Dahiphale	Shendga
PBN 3	" Baliram Sambhaji Munde	Badwani
PBN 4	" Eknath Bhaurao Phad	Dhabwadi
PBN 5	" Namdeo Manaji Latpate	Kodri
PBN 6	" Nandkumar Marotrao Dake	Malewadi
PBN 7	" Palsaheb Chaoudhari	Suralwadi
PBN 8	" Dinkarrao More	Deothana
PBN 9	" Bhagwanrao Lad	Talni
PBN 10	" Vishwanathrao Deshmukh	Deothana
PBN 11	" Mahadeorao More	Deothana
PBN 12	" Prahlad Khillare	Deothana
PBN 13	" Vikram Rakhmaji Jadhav	Bhosar
PBN 14	" Laxaman Yogaji Awtar	Deolgaon
PBN 15	" Rangnathrao Tulsiram Jawle	Asola
PBN 16	" Sheshrao Namaji Jawle	Asola
PBN 17	" Laxman Sambhaji Mungal	Margalwadi
PBN 18	" Tukaram Vishwanath Margal	Margalwadi
PBN 19	" Paraji Patloba Phad	Dhongarpimpla
PBN 20	Dept. of Hort. (old orchard) M.A.U. Parbhani.	Parbhani.
PBN 21	Dept. of Hort. (new orchard) M.A.U. Parbhani.	Parbhani.
PBN 22	Shri Govindrao Nanabhaj Dhumal	Shevga
PBN 23	" S.G. Deshpande	Partur
PBN 24	" Gangaram Lad	Manwat.

APPENDIX - IV

Proforma of the General observations recorded during survey work

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1. Name of the village :
2. Name of the cultivator :
3. Soil conditions of Kagzi lime orchards :
4. No. of plants in the orchard :
5. Average No. of fruits per plant :
6. Quantity of fertilizers and manures applied :
7. Condition of the plant: (Healthy/unhealthy)
   : Age of the plant
8. Presence or absence of canker disease :
9. No. of fruits/sample :
10. Remarks of the cultivator and popularity of kagzi lime. :
