THE VOLCANI INSTITUTE OF AGRICULTURAL RESEARCH

SUMMARIES OF RESEARCH WORK

1967 - 1969

DIVISION OF CITRICULTURE

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DIVISION OF CITRICULTURE

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Activities of the Division

The research activities of the Division were devoted to solving various problems of citrus growing in Israel.

Varieties

Work was continued with Shamouti orange hybrids to develop an early variety which would extend the season. In accordance with the trend of the European market to replace the current orange varieties with types which are easily peeled (mandarins, etc.), studies are in progress with tangelo varieties which were introduced several years ago.

Off-type Fruit

In recent years, growers have noticed the appearance of abnormal fruit of various types, such as round ("Beledi") Shamouti fruit, coarse rind in all citrus varieties, creasing in Valencia, and various other disorders of the rind. Field trials were continued in an attempt to reduce the occurrence of creasing, and a study was made of abnormal rind phenomena. Anatomical studies were carried out of various rind disorders, particularly those involving anatomical changes in fruit rind and in the adjacent branches caused by the impietratura virus.

Rootstocks

Research was continued on new citrus rootstocks which may serve to replace the standard rootstocks in the event of serious virus attacks (such as Tristeza) or under difficult growing conditions (such as salinity). An extensive rootstock experiment conducted to find stocks tolerant to Tristeza showed that we have today a number of stocks which can be recommended for use in the event that an attack by this virus disease does occur. A number of additional observation plots have been planted with rootstocks which will indicate, in time, their tolerance to salinity and boron, and their resistance to collar rot (Phytophthora). A search is being made for dwarfing rootstocks, the purpose being to obtain low trees which can be planted closely and whose fruit can be picked from the ground without the aid of ladders.

Propagation Material

The fact that scion budwood in Israel is infected by various viruses (such as xyloporosis and exocortis) has led to the development of nucellar subvarieties of the country's standard varieties. Due to the large differences discovered between the various nucellars of the same variety, all nucellar progeny in the country is being tested in order to find the best clones to serve as scion budwood. Experiments have also been initiated to shorten the juvenile period of the nucellar scion. In view of the considerable changes taking place in planting policy (for example, the recommendation to renew the planting of grapefruit after many years of opposition, or the demand for mandarin trees due to a change in consumer demands), research was begun to reduce the nursery period of grafted trees, using pre- and post-germination treatments.

Stionic Relations

Work to clarify physiological relations in stionic combinations is being continued in order to enable rapid and reliable evaluation of new rootstocks. Particular attention is being paid to the effect of soil and aeration conditions on tree development.

Nutrition

Research is being continued to develop and establish a method of leaf analysis for the different varieties. This includes the development of standard values, extension of the sampling season, study of the effects of nutritional factors on these values, etc. Work is continuing on development of new methods of determining the nutritional status of the tree through leaf analysis, based on functional aspects of the different elements. This study has been supported by a grant from the United States Department of Agriculture, and is currently being conducted with the support of the Israel Ministry of Agriculture. Also being continued is the study of the effect of different nutrient elements on fruit quality, especially on the incidence of coarseness in Shamouti orange rind, and large fruit size. Extensive experiments are in progress in relatively new citrus-growing districts such as the northern Negev and the inland valleys.

The study of uptake and transport of materials through the foliage, using radioisotopes, is also being continued.

Irrigation and Salinity

Studies on the efficient use of irrigation water were continued during the period reviewed. The relation between the amount and mode of application of irrigation water and yield and fruit quality was investigated. Early grapefruit was found to be especially sensitive to reduced water application. The experiments on citrus tolerance to saline conditions were continued, with the purpose of obtaining an early indication of possible injury. The uptake of chloride by roots and its transfer to the tree was studied in particular, as well as the relation between salinity and growth and yield of the trees.

Pruning

In order to understand the changes which may result from the mechanization of picking in citrus groves, especially where drastic pruning is needed, a study was begun on the response of trees to these cultural practices. The work is directed at determining the physiological responst to pruning, especially with regard to differentiation to fruiting branches or vegetative branches, rate of growth after pruning, etc. The effect of various treatments on the formation of abscission layers on the fruit was studied in connection with "shaker-type" mechanized picking.

Regional Research Projects

Considerable attention was paid to research in the various citrus-growing regions and the specific problems of these areas. The Division maintains a wide spectrum of regionally oriented research, particularly in the Negev, where the work is facilitated by the Gilat Regional Experiment Farm. Work in the Negev included studies of varieties and rootstocks, nutrition, irrigation and salinity. The problem of blemishes on Washington oranges caused by picking of fruit with high rind turgor was elucidated, and recommendations resulting from the research were passed on to the extension workers and growers. During the reported period, a survey was begun of declining groves in the northern Negev in order to determine the reasons for decline and to find ways of correcting the situation in these groves. A high concentration of acid was detected in grapefruit and a study was initiated to reduce the acid content and thus advance the picking season and improve fruit quality.

In the Hula region, pyriform grapefruit fruit, which was thus unacceptable for export, was found to be of prime economic importance. Investigation of this phenomenon uncovered the reasons for its occurrence. The scope of the study was broadened, and today it also deals with increasing the productivity of grapefruit trees in this region.

Following the results obtained in the Hula region, research was begun in the Bet She'an Valley to determine reasons for low productivity there.

In the Gilboa region, the irrigation and fertilizer studies were continued, and research was conducted on the effect of adding gypsum to the soil for the prevention of salinity damage.

Regional irrigation studies are also being conducted in the Western Galilee, Western Jezreel Valley, Carmel Coast, Central Sharon Plain and the Ashquelon region, as well as at Gilat.

The Division is cooperating in the regional research program in the Western Galilee concerning peel blemishes and the phenomenon of round Shamouti fruit.

Personnel activities and study trips

In May 1967, the Division conducted a country-wide symposium devoted to reports of research related to the improvement of fruit quality. Regional meetings to summarize the experiments in the Jordan and Hula Valleys were held in January and February, 1968.

Scientists of the Division lectured at gatherings and field trips organized by the Extension Service and by various growers' associations.

Prof. K. Mendel retired on November 30, 1968, as Head of the Division. Dr. A. Bar-Akiva was appointed Head as of December 1, 1968. Prof. Mendel is continuing his research work as a scientist of the Division, and is also continuing to serve as a member of a number of committees in the Ministry of Agriculture.

Dr. A. Cohen participates in the meetings of the Volcani Institute's executive, as a member of the Executive Committee of the Scientific Staff.

Prof. Mendel was invited to participate at the International Citrus Symposium sponsored by the University of California at Riverside, in March 1968. He served as chairman of one of the plenary sessions (the only plenary chairman among the visitors). He delivered two lectures within the framework of the symposium and also lectured at an international session organized by the Extension Service of the University of California.

In connection with the agricultural foreign aid program of the State of Israel, Prof. Mendel traveled to Malagasy in August 1968 as a consultant to the Malagasy Government on the development of the citrus industry there.

As an Israeli representative on the Council of the International Horticultural Association, Prof. Mendel participated in a meeting of the Council convened in Pisa, Italy, in September 1968. He is active in organizing the International Horticultural Congress to be held in Israel in March 1970.

Dr. A. Bar-Akiva participated in the International Citrus Symposium at Riverside in March 1968, and lectured there on new approaches to leaf analysis. He also took part in the European Colloquium on Leaf Analysis and the Use of Fertilizers which was held in September 1968 in Seville, Spain, and delivered a lecture at the Colloquium of the International Potash Institute held in Israel in March 1969.

Mr. A. Goell participated in the International Course on the Use of Radiation and Isotopes conducted by the International Atomic Energy Agency and the Food and Agriculture Organization of the United Nations, in Hanover, Germany, during the months July-September 1968. On his way back to Israel, Mr. Goell visited citrus-growing districts in Italy, Sicily and Cyprus.

ABSTRACTS OF RESEARCH WORK

FERTILIZER AND MINERAL NUTRITION EXPERIMENTS IN CITRUS GROVES OF THE NORTHERN NEGEV*

A. Bar-Akiva, A. Gotfried, Aviva Hadas** and M. Hamou

A fertilizer experiment was conducted in a grove at Yesha in the Besor region, applying various amounts of nitrogen in the absence or presence of phosphorus, on plots of grapefruit, Shamouti orange and Eureka lemon. After four years of treatment, there is a marked response to nitrogen and phosphorus fertilization as revealed in the amount and quality of the yield.

The phosphorus fertilizer applied in addition to the various nitrogen treatments acted occasionally as a substitute for part of the nitrogen, rather than as a supplement.

The effect of phosphorus on fruit quality was reflected mainly in the Shamouti orange: the fruit rind was thinner, juice content was higher and there was a greater degree of ripening.

In an experiment conducted in a young Shamouti grove at Mivtahim, the effect of various chemical and organic fertilizers was studied. Here, also, there was a positive effect of the high nitrogen levels with the addition of phosphorus fertilizer. Due to the short duration of the experiment, it is not yet possible to evaluate the effect of the organic fertilizers.

As for the leaf mineral composition, the nitrogen values reflect the nitrogen treatment only to a minor extent. During the 1967/68 season, the grapefruit leaves had an especially low nitrogen content. On the other hand, the phosphorus values were high in some cases possibly due to the sprays with organic phosphorus insecticides. The potassium level was generally high, and was inversely related to the levels of nitrogen and phosphorus fertilizer applied in the different treatments. Treatment effects on leaf boron content are not yet apparent. The high copper content of lemon leaves, and to a certain extent in the other varieties as well, is probably the result of copper sprays applied to combat brown rot.

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* Joint project of the Div. of Citriculture and the Div. of Soil Chemistry.

** Div. of Soil Chemistry.

THE EFFECT OF POTASSIUM AND MAGNESIUM FERTILIZATION ON CITRUS TREES

A. Bar-Akiva and A. Gotfried

The purpose of the research is to study the methods of application of potassium and magnesium fertilizers to citrus trees and to determine their effect on tree development and fruit yield and quality.

A comparison of different amounts of potassium chloride with potassium sulfate showed that with the former salt the response to potassium was slow even in coarse-textured soils. Potassium in the sulfate form is apparently more rapid in its action. Experiments to overcome the problem of potassium fixation by the soil, using a placement implement, were unsuccessful. Foliar spraying of potassium nitrate was found to be a more efficient treatment.

Aerial methods of magnesium nitrate application were tested. The possibility of combining magnesium with other spray materials was also investigated.

LEAF ANALYSIS AS A GUIDE TO DETERMINING FERTILIZER REQUIREMENTS OF CITRUS TREES

A. Bar-Akiva, Neora Levy and J. Behor

The research was designed to continue the development and establishment of standard values of nutrient elements for the different citrus varieties. The effects of rootstocks, soil conditions, extension of the sampling season, date of fertilizer application and other factors were studied.

For Shamouti, data were collected to determine the critical value of magnesium which is, apparently, higher than the value accepted by us until now. For grapefruit, the critical level of phosphorus was determined, and research was continued to establish more exact standard values for nitrogen. For Valencia, the critical value of potassium was changed.

It was found that in a grove with a proper supply of nitrogen, the date of nitrogen application was unimportant, and leaf tests can direct the grower not only regarding the amount of fertilizer to be used, but also as to the date of its application.

NEW METHODS OF DETERMINING THE MINERAL NUTRIENT REQUIREMENTS OF CITRUS TREES

A. Bar-Akiva, Y. Sagiv, A. Shaked, Ruth Lavon and Y. Fogel

The purpose of the research is to develop a test based on physiological and biological methods which supply information on the activity of various elements in the leaves. Accordingly, a number of metabolic enzymes were tested under laboratory conditions. These included peroxidase for iron analysis, nitrate reductase for molybdenum and nitrogen analysis, and carbonic anhydrase for zinc analysis. The second and third gave promising results in preliminary trials under field conditions in commercial groves.

The activity of ascorbic acid oxidase was examined as a possible indicator of copper requirement. Results of greenhouse experiments showed that the activity of this enzyme is directly related to the amount of copper supplied to the plants by the rooting medium, as well as to the plants' growth rate. The introduction of a copper sulfate solution into detached leaves stimulated the enzyme's activity inversely to the level of copper in the rooting medium. This means that the degree of response to the introduction of the copper expressed the need or lack of need for this element by the plants. In order to apply the method for use in the grove, a relatively simple technique was developed for determining the enzyme's activity using disks cut from citrus leaves.

THE EFFECT OF NUTRIENT ELEMENTS ON FRUIT QUALITY

A. Bar-Akiva, A. Gotfried, Ruth Lavon and M. Hamou

The purpose of the research is to study the nutritional factors liable to contribute to improving fruit size, rind quality and juice composition.

The study is based on data of a survey conducted in previous years which provided proof of a certain connection between magnesium deficiency, a high potassium level, and an imbalance between the various nutrient elements on the one hand, and the development of large, coarse Shamouti fruit on the other hand.

As a means of correcting the condition, the methods of supplying magnesium to citrus groves were improved, and experiments were initiated to improve the disturbed balance between the various elements by spraying

with different phosphorus salts and other materials liable to have the desired effect.

Only partial success was achieved in the first experiments. This may have been due to the timing of the spray applications and also to the composition of the salts. These aspects are being considered in the current research work.

FERTILIZATION AND MANURING OF GRAPEFRUIT IN THE INLAND VALLEYS*

A. Bar-Akiva and A. Gotfried

The inland vallyes - Jezreel, Bet She'an and Jordan - differ from the other citrus-growing regions of the country in climate and soil. The valleys excel in early ripening fruit but, according to the growers, have a lower productivity than the coastal plain.

The purpose of the experiments is to determine the proper fertilization and manuring treatments for these regions, taking into consideration the above-mentioned factors.

During the first two years that the various treatments were applied, no differences could be detected regarding yield, fruit quality or leaf composition, except for a slight response to phosphorus fertilization in a Jordan Valley grove. In the Gilboa district, the date of picking was found to have a marked effect on yield level in the different groves.

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* With the cooperation of the regional laboratories of the Extension Service.

CITRUS ROOTSTOCKS IN THE NORTHERN NEGEV (GILAT)

Y. Levy and K. Mendel

An experimental grove was planted in the spring of 1958, using grafted trees raised from seeds in a nursery established on the same site. The following varieties are under observation: Shamouti and Washington Navel oranges, Marsh grapefruit, Eureka lemon, Dancy mandarin, and Clementine. Each variety is being tested on sour orange, Cleopatra mandarin and rough lemon. Also included are Eremocitrus and tangelo rootstocks. The sweet lime and sweet orange stocks tested at the Gilat nursery were discarded at an early stage and not planted out.

During the course of the experiment, determinations were made of yield, fruit quality, tree development and the nutrient status according to leaf analysis.

In all the varieties except Shamouti, the development of the rough lemon, as compared to the other rootstocks, was outstanding. In every year, the yield of trees grafted on this rootstock greatly exceeded that of trees grafted on the other stocks.

With most of the varieties, the Cleopatra rootstock was slightly less successful than the sour orange. However, with grapefruit, Cleopatra produced significantly higher yields than did the other rootstocks.

During the past year signs of decline have been detected in Eureka lemon on sour orange rootstock.

WATER CONSUMPTION OF CITRUS TREES IN THE NORTHERN NEGEV*

Y. Levy, A. Goell and H. Bielorai**

The effects of different irrigation frequencies and two depths of wetting were studied in an experiment begun in the spring of 1964. The purpose of the research was to determine the water consumption and the proper irrigation frequency for grapefruit in the Negev region, and to investigate the effect of different soil moisture regimes on fruit quality and yield.

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* Joint project of the Div. of Citriculture and the Div. of Irrigation.

** Div. of Irrigation.

The treatments are as follows:

Treatment No.	Irrigation Frequency (days)
1	40
2	30
3	24
4	18
5	20-24

Fruit quality was affected by the irrigation regime from the first year of the experiment. In the "dry" treatments there was an increase in rind thickness, a reduction in juice percentage, and a rise in the percentage of total soluble solids (TSS) and in the acid content in the juice. The TSS/acid ratio was not affected in most of the years. In the last few years, a marked drop in yield per tree has been observed in the "dry" treatments.

The yield of this young grove has been increasing each year, but Treatment 1 and to a certain extent also Treatment 2 have been causing a reduced rate of increase in fruit production. In 1968/69 the yield ranged from 5.2 tons/1000 m^2 in Treatment 1 to 7.6 tons/1000 m^2 in Treatment 4.

A marked retardation in development of tree size (volume) and trunk circumference was observed in trees of Treatment 1 as compared to the rapid growth in Treatments 4 and 5. In recent years frequent measurements of trunk growth have been made with a dendrometer, and it has been found that tree response to the various irrigation treatments is not uniform. Trees of Treatment 1 are able to continue growing under drought conditions in which Treatment 4 trees do not grow. The study of this phenomenon is continuing in order to clarify whether a form of adaptation is involved.

A STUDY OF THE FACTORS RESPONSIBLE FOR RIND OIL SPOTS (OLEOCELLOSIS, "HARVEST SPOTS") ON WASHINGTON NAVEL ORANGES IN THE NEGEV

Y. Levy

"Harvest spots" are responsible for considerable economic loss from Washington Navel oranges. They are encountered to a high degree in certain regions of the Negev. In 1966, an experiment was begun to find ways of predicting the sensitivity of fruit to rind oil spots and to reduce the damage.

It was found that the spots appear following mechanical injury during picking. This injury ruptures the soil glands, and the released oil brings about a change in color and a depression of the rind at the point of injury.

A technique was developed to study the sensitivity of fruit by using a Magness-Taylor pressure gauge, and a good correlation was found between the pressure required to rupture the oil glands, the sensitivity of the fruit, and the percentage of fruit damaged because of harvest spots.

High sensitivity of the fruit was related to conditions responsible for high rind turgor, such as high soil moisture content, low temperature and high relative humidity.

The pressure gauge was tested in use under regular commercial picking conditions, and it was found that with proper handling of this instrument, the grower is able to prevent the picking of sensitive fruit and thus reduce considerably the percentage of fruit damaged by harvest spots.

OBSERVATION PLOTS OF CITRUS IN THE NORTHWESTERN NEGEV

Y. Levy and K. Mendel

Observation plots were planted in order to compare citrus varieties and rootstocks in the different regions of the Negev.

The plantings were made during the years 1951-1955 at the following settlements: Shuval, Ruhama, Re'im, Nirim, Nir Yizhaq, Ze'elim, Gevulot and Eshel HaNasi. In recent years additional plots were included, being planted by the Settlement Department of the Jewish Agency in the Besor district and at Revivim. The observations of the first several years were summarized by Y. Pat and A. Golan. In 1966/67, the supervision of these plots passed into the hands of the Division of Citriculture of the Volcani Institute.

Among the conclusions reached from observations of these plots, the following are worthy of mention:

In most cases, the rough lemon rootstock excelled, including in those regions in which there are high boron concentrations in the soil. The sweet lime stock was retarded at most of the locations, and its development was particularly poor at Nir Yizhaq, Ze'elim and Gevulot.

Cleopatra stock grafted with Washington, Trovita, and Shamouti oranges produced yields similar to or better than those obtained with sour orange, and the fruit was of excellent quality. On the other hand, Valencia yields were not high on this rootstock.

Of interest was the good development and high yield of Shamouti grafted on rough lemon at Re'im, now 19-year-old trees. There are as yet no signs of decline in these trees, and the yield reaches 7 tons/1000 m^2. It should be noted that Shamouti on sweet lime (without inarching) at the same location has also not shown any signs of decline.

REDUCING THE TIME REQUIRED TO PREPARE CITRUS SEEDLINGS

Miriam Ahituv

A nursery period of two to three years is required at present to obtain a citrus tree suitable for planting. This fact makes it extremely difficult for nurserymen to adjust themselves to changes in planting policy, replanting and the replacement of varieties in accordance with market demands.

The research is conducted along the following two lines: the acceleration of germination and the acceleration of seedling growth and advancement of the grafting date.

The work is being carried out at Moshav Bene Deror in a plastic-covered structure with no device for heating.

Acceleration of Germination

In an attempt to increase the permeability of the seed coat of sweet lime seeds, the seeds were treated by soaking them in citric acid and in EDTA. Another treatment - immersion in gibberellin solution - was carried out after the seed-coat treatment had been applied.

There was a marked acceleration of germination after the treatment with acid and EDTA. The additional treatment with gibberellin also contributed to reducing the incubation period. Treatment with EDTA, combined with gibberellin, was found to be the most efficient in hastening germination.

The effect of gibberellin was also expressed by more rapid growth of seedlings, which were relatively very tall, with long internodes and small and narrow leaves.

The same treatments had different effects on sour orange seeds: citric acid retarded germination, whereas gibberellin had no effect.

Tests of the effect of various temperatures (in dark chambers with constant temperature) showed that germination of sweet lime occurs at 30°C. At all other temperatures tested there was a considerable retardation of germination. This retardation continued after the seeds were transferred from a low temperature to 30°C. The length of time of the retardation is related to the temperatures at which the seeds were held prior to the transfer.

Acceleration of Growth

An experiment to stimulate seedling growth, in two media and with three fertilizer levels (the fertilizer used + 20:20:20 + micro-elements), showed that the intensity of growth in pure peat was less than in a mixture of peat and soil. The higher fertilizer levels brought about more rapid growth.

The rootstocks were sown in July, and by January (after 6 months) had reached a height of about 40 cm. At this time they were budded (micro-grafting), and 98% of the grafts were successful.

It seems that sowing in the summer and growing the seedlings in a covered growth-house has a positive effect on subsequent development, without any disturbance resulting from the low winter temperatures.

In a second study in which three growth media were tested (sand, sand + peat, and soil + peat), there was an advantage to the soil + peat mixture

over the other media. In this experiment, the fertilizer level was uniform. The fertilizer was applied to the plants in two ways: directly to the container, and by sprinkling. The results have not yet been evaluated.

Gibberellin (50 ppm) was employed as a growth-stimulating material, being sprayed on the seedlings after germination in five different growth media: sand, soil, soil + 20% "enriched" peat, pure "enriched" peat, and pure regular peat. The most rapid germination was in the sand, followed by the enriched peat, regular peat, soil + peat mixture, and soil, in that order.

After spraying with gibberellin solution, the strongest growth was observed in the soil. The effect of gibberellin decreased in the other media, in inverse relation to the rate of germination. The gibberellin-treated seedlings grown in the soil reached almost double the size of those in the enriched peat.

ROUND FRUIT AND BELEDI IN SHAMOUTI GROVES

A. Cohen

In Shamouti groves one frequently encounters a single branch or a complete tree which carries atypical fruit - round, with or without seeds, and sometimes also Beledi fruit. Concurrently with the development of Beledi fruit, the form of the canopy also changes. This variation has reached large proportions in young groves in certain regions, such as in the Western Galilee.

Observation of this phenomenon over a number of years has led us to the assumption that a marked difference exists in the trend to variation between trees grown from budwood from different sources. It is impossible to assess the trend towards variation on the basis of the tree's external appearance.

The purpose of the study is to confirm the above assumption and to develop a method of detecting the trend towards variation of budwood from the mother-trees, with the intent of guaranteeing choice, stable budwood for new plantings. The research is presently in its initial stage.

FACTORS INFLUENCING GRAPEFRUIT SHAPE AND RIND THICKNESS

A. Cohen and A. Rasis*

When the grapefruit groves in the Hula region reached full productivity, it was observed that the fruit was pear-shaped and had a thick rind. At first, this phenomenon was attributed to the youth of the trees, but in the course of time it became clear that this was not the reason, and that the phenomenon is somehow specific to the region. The purpose of the research was to discover the reasons for this condition and the steps to be taken in order to improve fruit quality.

A comparative study of grapefruit development in various parts of the country indicated that the abnormal fruit shape and rind thickness are due solely to excessive rind growth. It was also found that fruits from regions with low winter temperatures have thicker peels than fruits from regions with higher winter temperatures.

Fertilizer and irrigation experiments did not contribute to improving fruit shape in the Hula region. All these facts led us to the conclusion that the phenomenon in the Hula region is caused by frost which prevailed in the area in the years 1963/64, and by the low winter temperatures which commonly occur in the region.

Heating the citrus groves is not economical under local conditions, and so it was deemed necessary to search for other means of improving fruit quality. Among the various treatments tested, girdling in the fall was found to be the most effective. Since this treatment has certain disadvantages, the research is continuing in order to develop additional means for improving fruit quality.

* Regional Council of Upper Galilee, Qiryat Shemona.

PHYSIOLOGICAL STUDIES ON THE DECLINE AND AGING OF CITRUS TREES

A. Cohen

One of the main factors responsible for the early decline and aging of citrus trees is unsuitable soil - fine-textured, or an impervious layer in coarser soils.

Trees grafted on sweet lime rootstock decline at an early age in fine-textured soils and also in coarser soils with an impervious layer. On the other hand, trees grafted on sour orange stock develop normally in soils with such a layer, and decline only in fine-textured soils with exceedingly poor aeration, or when an impermeable layer is very close to the soil surface.

The present research was designed to study the reasons for decline and for the different behavior of rootstocks, and to develop methods for preventing the decline.

In the early stages of the work two new facts were discovered: among the important factors causing damage in the above soils are "toxic" materials found in the soil; and roots of sour orange rootstock are sensitive to these materials more so than are the sweet lime roots.

On the basis of these findings, it was proposed that the tolerance of the sour orange stock to these soils, in which trees on sweet lime stock decline, is due to the "hypersensitivity" of the S. O. roots. Because of the extreme sensitivity of the roots, the transfer of "toxic" materials from the roots to the other parts of the tree is limited, and hence damage to the tree is slight. On the other hand, roots of the sweet lime stock absorb and translocate these materials to the entire root system, with the result that the trees are seriously injured.

This theory leads one to the conclusion that drainage of groves planted on sweet lime rootstock will be effective only if the entire root system is drained, while in groves on sour orange stock, partial drainage may suffice.

At the present stage, the research work is concentrating on isola ting and identifying these "toxic" materials. Knowledge of them is essential to the development of methods for their eradication or for elimination of their toxicity. A search is also being conducted for materials or methods which will enhance the sensitivity of the sweet lime roots, making them "over sensitive" in the same manner as are the sour orange roots.

NEW CITRUS ROOTSTOCKS

K. Mendel, Miriam Ahituv and Y. Kalir

The purpose of the research is to find rootstocks to replace the ones usually used at present and which will be resistant to virus (especially tristeza and exocortis) and other diseases and to poor soil conditions.

The experimental rootstock grove at Bet Dagan, planted in 1956, was grafted with budwood from certified mother trees (not nucellar). It was found that most of the trees grafted on sweet orange rootstock developed at least as well as those on sour orange stock. On the other hand, trees on mandarin stock were retarded in their development compared to those on sour orange in the first years, but the lag was overcome after the eighth or ninth year. Sweet lime trees of different origin (India, Israel) declined after a few years. The Troyer citrange and trifoliate orange rootstock produced dwarf trees because the budwood was infected with the exocortis virus.

At first there were large differences between trees grafted on the same rootstock, due to the great variability between individual trees. But these differences disappeared over the years, and the effect of the various rootstocks on yields became obvious.

After the 1967/68 picking, it was possible to summarize the yields as follows:

The highest yields were obtained on the rough lemon stock, the orange group and the "Poorman" stock. Somewhat lower yields were obtained from trees on Sampson tangelo and the mandarin group. Sour orange gave a lower yield than the mandarins, and the lowest yields were obtained from trees on sweet lime.

The Australian variety "Poorman" is of special interest. It seems promising as a rootstock for all varieties in fine-textured soil. It is considerably better than the Cleopatra mandarin, which is currently recommended as a substitute for sour orange in fine-textured soil (if tristeza is present).

The results of the experiment indicated that the Washington Navel should be planted in coarse-textured soil on sweet orange stock. Under such conditions, rapid development of the trees, and high, early, stable yields are assured. All the data obtained from the study are being prepared for computer analysis.

Another experiment with Shamouti on different orange rootstocks, compared to sour orange, has not yet shown (after five harvests) any difference in yield level between the plot with medium-textured soil and that with fine-textured soil.

In the summer of 1968, rootstocks for another experiment were planted. These included primarily Rangpur lime (tristeza- and saline-resistant), Troyer citrange, and a number of sweet orange types. The stocks in this experiment were grafted with nucellar scions. A small plot was also planted to study the effect of the Volkhameriana rootstock on fruit quality of Valencia. This stock has aroused special interest for planting on fine-textured soils due to its resistance to Phytophthora collar rot.

Among the nucellar crosses, a number of citranges - citremon and citrumelo (hybrids of orange, lemon and grapefruit with trifoliate) - have remained. These trees have begun to bear fruit. Their seeds will be examined for their suitability as rootstocks for different citrus varieties. Samples of seed from these trees have been sent to Brazil to test seedling response to tristeza attack.

An experiment has also been started to find dwarf rootstocks for the production of trees whose fruit can be picked without employing various harvesting devices.

THE DEVELOPMENT AND TESTING OF EARLY VARIETIES

K. Mendel

The purpose of the research is the development and testing of early varieties which will advance the picking season. The study is concentrating on early Shamouti, fruit from a cross with other early citrus varieties, and the introduction of early mandarin and tangelo varieties.

From the crosses of Shamouti and other varieties which were carried out in the 1930s, three early Shamouti types were selected. These are currently being studied in semi-commercial experiments in order to determine their yield level and fruit quality. One of the types seems particularly promising as a potential early bearing variety.

A number of years ago early tangelo varieties were brought to Israel from Florida (as seeds), and have since begun to produce fruit. The fruit of two of these varieties is promising, and will shortly be tested on a semi-commercial scale.

A plot has been planted with Clementine seedlings. Considering the nucellar embryony of Clementine, we may anticipate obtaining, from the progeny, new types of early mandarins.

REJUVENATION OF CITRUS VARIETIES

K. Mendel

The fact that certain virus diseases are not transferred by citrus seeds led to the creation of nucellar sub-varieties of the main varieties growing in Israel. It is known that a great variability exists among the nucellars of the same variety, and the research work is currently devoted to studying this characteristic in the progeny of the various nucellar seedlings (including those produced by the Citrus Department of the Ministry of Agriculture).

The plot planted in 1961 was grafted on sweet lime stock and the trees are developing rapidly. The nucellar trees are much more developed than trees grown from regular budwood which are planted nearby. All the varieties (Marsh grapefruit, and Valencia and Shamouti oranges) are in production and the fruit is being tested regularly. A number of significant differences have been detected between the progeny of the various seedlings, particularly regarding the beginning of fruit production. Especially noteworthy is the fact that the Shamouti nucellars are generally retarded in beginning to bear fruit, both in comparison with the regular Shamouti budwood and also with the nucellars of the other varieties. Thus far, the yield of non-nucellar Shamouti has greatly exceeded that of trees budded with nucellar wood.

In 1967 a new plot was planted with Washington, Valencia and Shamouti nucellars, grafted on sour orange. This planting contains progeny of all the nucellars produced in Israel. A plot of grapefruit nucellars will be planted in the summer of 1969.

Treatments were begun to advance the maturation of the nucellar trees in order to overcome the juvenility phenomena which interfere with the practical use of nucellar scions (spines, coarse fruit, wrinkling, delayed bearing).

THE EFFECT OF GIBBERELLIN ON THE GROWTH AND TAKE OF CITRUS ROOTSTOCKS

K. Mendel and A. Meyrovitch

Gibberellin greatly stimulates vegetative growth and is liable to be useful as a means of hastening the development of slow-growing rootstocks such as sweet orange, sour orange and trifoliate orange. On the other hand, gibberellin retards root development and thus markedly alters the top:root ratio. The question is whether this change may not possibly have a negative effect on the tree's ability to root after transplanting.

An experiment was conducted in a germination bed of trifoliate orange. Some of the seedlings were left in their place and some were transplanted after reaching a height of approximately 5 cm. The treatments included two concentrations of gibberellin. In the second year of the research the seedlings will be transplanted, and the percentage of "take" will be determined.

A parallel experiment involving the same concentrations of gibberellin is being conducted with trifoliate orange seedlings planted in plastic containers in a screenhouse. The purpose of the investigation is to study the quantitative changes occurring in the top:root ratio due to the gibberellin treatments.

THE RELATION BETWEEN VEGETATIVE PROPAGATION OF WASHINGTON NAVEL ORANGE AND BITTERNESS OF THE FRUIT JUICE

K. Mendel

In research conducted in Australia, it was found that the fruit of Washington Navel orange trees propagated from cuttings contained a much smaller amount of limonene (material causing bitterness of the juice) than did fruit of trees propagated by customary methods - that is, grafting on various rootstocks.

Juice bitterness of Washington fruit prevents its use for processing, and the rejected fruit is of no use. The removal of bitterness from Washington fruit is of major importance to the citrus fruit processing industry.

An experiment was begun to check the Australian findings under conditions in Israel. At the present stage, cuttings are being rooted using the mist-propagation technique.

THE ADJUSTMENT OF TREE SHAPE AND SIZE TO INCREASE THE PICKING EFFICIENCY IN CITRUS GROVES

E. Salomon and Miriam Ahituv

Pruning of citrus trees*

The purpose of the research is to reduce the size of Shamouti trees in order to allow easier access when performing various cultural practices in the grove, and also to facilitate fruit picking by mechanical means. Trees of three ages (young, medium and old) were hedge-pruned to three different degrees. In the experimental plots yearly observations are being made of yield level, fruit size and quality, fruit location within the tree canopy, and renewal of growth and fruit-bearing by the pruned branches. It was found that the pruning reduces yield according to the extent of the pruning. This reduction, in the first year after treatment, reached 80% in the old grove and 32% in the medium-aged grove. No marked differences in fruit quality could be detected. The possibility of obtaining an economic yield from a tree of reduced volume is being examined. Hormone treatment of branches is also being tested to reduce growth intensity. Observations are being made of flowering and fruit set on these branches.

The possibility was examined of removing the fruit by mechanical means, to increase picking efficiency. The effect of certain materials which reduce the force required to detach fruit from the tree is being studied. It was found that ascorbic acid and "Ethrel" weaken the retentive force of the fruit. The fruit was damaged by treatment with ascorbic acid, but not with "Ethrel".

* With the cooperation of the Extension Service and the Institute of Agricultural Engineering.

ABSORPTION, TRANSPORT AND CONCENTRATION OF NUTRIENT ELEMENTS IN CITRUS TREES (RESEARCH USING RADIOISOTOPES)

E. Salomon and S. Shapcicki

The purpose of the research was to study the entry, movement and concentration of nutrient elements in citrus trees.

In regard to the specific subject of iron absorption by citrus leaves and determination of its availability, a physiological method was found to determine the efficiency of different iron treatments given to correct chlorosis stemming from iron deficiency.

Results of the research showed that one of the factors responsible for inactivity and immobility of iron in citrus leaves is that it is strongly bound to the macromolecular components of the tissue. Treatments which reduced the degree of bonding increased the physiological availability of the iron absorbed by the leaves.

A reliable method was found for determining the degree of physiological deficiency of iron in leaves.

USE OF GYPSUM TO PREVENT SALINITY DAMAGE IN CITRUS (AT HEFZI BAH AND YIZRE'EL)*

A. Goell, A. Edri, N. Alperovitch** and E. Mor**

The experiment includes three treatments of gypsum application to grapefruit groves planted on soil with a higher-than-normal content of sodium and chloride.

To date no significant differences have been detected regarding canopy growth or yield between the various treatments. Similarly, no real differences were found in fruit quality or size at time of picking.

The mineral content of the leaves was not affected by the different gypsum treatments.

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* Joint project of the Div. of Citriculture and the Div. of Soil Salinity and Alkalinity.

** Div. of Soil Salinity and Alkalinity.

A COMPARISON OF DIFFERENT IRRIGATION METHODS USING WATER WITH TWO SALINITY LEVELS IN A VALENCIA GROVE (AT NUSSEIRAT, GAZA STRIP)

A. Goell and Y. Barr*

In the spring of 1968, two Valencia groves and two water sources for irrigation (1050 and 600 mg Cl/liter) were selected for tests with three irrigation methods: small basins (as commonly used in the area), sprinkling (every row), and drip irrigation.

Irrigations with the highly saline water were carried out in six replications, and those with the less-saline water in three replications. Water was applied every 14 days in the basin and sprinkler-irrigated plots; the trickle (drip) system was operated at more frequent intervals and discharged smaller quantities of water at each irrigation.

Results of the first season showed that in sprinkler-irrigated trees there was a serious leaf drop from that part of the tree wetted by the sprinklers, with water of both salinity levels. Analysis of these "low" leaves revealed a very high concentration of sodium and chloride, compared with the contents in the higher leaves on the same trees, or compared to "low" leaves on basin-irrigated trees.

There were no significant differences in yield or fruit quality due to the irrigation method or to the salinity of the water.

A cross-sectional trench about 1 m from the tree, dug at the end of the irrigation season, showed that the drip irrigation method affected rootlet distribution in the soil adjacent to the nozzles.

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* Faculty of Agriculture, Hebrew University of Jerusalem. The project is financed by the Faculty of Agriculture.

AUXILIARY EXPERIMENTS TO DETERMINE THE CONSUMPTIVE USE OF WATER BY CITRUS*

A. Goell, A. Edri, N. Yechieh and E. Shmueli**

Experiments were continued at Sa'ar, Gevat, 'En HaMifraz, Ma'agan Mikha'el, Shefayyim and Porat (fourth and fifth years of the experiments). Three rates of water application were tested, at identical intervals between irrigations. At Talme Yafe, two water quantities were tested, each applied by two methods: irrigation of every row, and alternate irrigation of every second row. At 'En Harod an additional irrigation treatment was included with a higher frequency of water application (smaller intervals between irrigations). At Emeq Hefer the experiment was continued with one water quantity applied by four irrigation methods: every row, alternate irrigation of every second row, irrigation of every second row without alternation, and permanent installation of sprinklers above the canopy.

Generally, water application affected vegetative growth of the trees in the summer and, as a result, influenced the yield. In most of the groves, it was found that the amount of water applied had an effect on the size distribution of fruit. In certain cases, the lowest rate of water application raised the percentage of the smaller fruit sizes in the total yield of packed cases. In groves having larger fruit (due to low yields or young trees), the higher water application rate increased fruit size so that much fruit was rejected, and consequently the total number of packed cases per unit area was reduced.

In most of the locations, fruit quality was affected by the treatments. The "dry" treatment increased the sugar and acid content of the juice, as well as the relative rind thickness. Increasing the irrigation frequency at 'En Harod produced larger, juicier fruit with a high sugar/acid ratio at the beginning of the season (early ripening). At Talme Yafe it was found that the various methods of irrigation differed very little in their effect on tree growth, yield level and fruit quality.

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* Joint project of the Div. of Citriculture and the Div. of Irrigation.

** Div. of Irrigation.

THE WATER REQUIREMENT OF A MATURE CITRUS GROVE IN THE COASTAL PLAIN (BET DAGAN)*

A. Goell, N. Yechieh and A. Mantell**

The seventh and eighth seasons of the experiment were completed according to a program which included four frequencies of irrigation (every 14, 21, 30 and 40 days) to a depth of 90 cm, and irrigation every 21 days to a depth of 60 cm, in a Shamouti grove on sour orange planted in 1930.

Yield differences between the various treatments were not significant. Regarding fruit size distribution, there was a slight rise in the percentage of small fruit on the trees irrigated every 40 days. The trend for this "dry" treatment to produce fruit with higher sugar and acid contents and increased relative rind thickness continued to be evident.

The research was concluded on April 1, 1969.

THE WATER REQUIREMENT OF A CITRUS GROVE ON COARSE-TEXTURED SOIL IN THE COASTAL PLAIN (SITRIYYA)*

A. Goell, N. Yechieh and A. Mantell**

The fourth and fifth seasons were completed of an experiment in which the following two series of treatments were tested: irrigation to a depth of 60 cm every 14, 20, 26 and 32 days; and irrigation to a depth of 90 cm every 20, 26 and 32 days.

In the group of treatments irrigated to 60 cm, the lower frequencies of water application retarded tree growth and to a certain extent also reduced the rise in yield from year to year. Trees irrigated at the same frequencies but to a depth of 90 cm were larger and the yield increased accordingly.

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* Joint project of the Div. of Citrivulture and the Div. of Irrigation.

** Div. of Irrigation.

Fruit quality was affected only slightly by the irrigation regimes, and fruit size distribution was likewise not markedly altered by the treatments.

EFFECT OF IRRIGATION WITH SALINE WATER ON CITRUS IN FINE-TEXTURED SOIL (NEWE YARAQ)*

A. Goell, N. Yechieh and J. Heller**

The experiment continued for the fourth and fifth seasons according to a program testing two irrigation methods (irrigation of every row, and alternate irrigation of every second row), using water at two levels of salinity (130 and 250 mg Cl/l), at three frequencies of irrigation (21, 30 and 42 days in the case of the first irrigation method and 15, 20 and 30 days in the case of the second method). In addition, water containing 500 mg Cl/l was used in irrigations of every row at a frequency of 30 days.

The effects of reduced irrigation frequency were expressed in a reduced rate of canopy growth and to a lesser extent in the yields. There was an increase in sugar and acid content of the fruit juice and in relative rind thickness as the irrigation frequency decreased.

The effect of irrigation method was expressed by a smaller seasonal water application and a lower yield when alternate irrigations were given to every second row as compared to irrigation of every row at the same frequency.

The salinity of the irrigation water began to have an effect during the early stages of the research, and was expressed as an increase in the chloride content of the leaves. In the last two years there were differences in yields between plots irrigated at the same frequency and by the same method, but with water of different quality. There was a decided trend towards yield reduction in plots irrigated with water containing 250 mg Cl/l.

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* Joint project of the Div. of Citriculture and the Div. of Irrigation.

** Div. of Irrigation.

SALT TOLERANCE OF CITRUS

A. Goell, A. Altman* and S. Batzri

The purpose of the research is to find plant indicators for evaluating the salt status of the tree. The work is being conducted along several lines: determining the chloride content of leaves of different ages and relating it to leaf area; determining the chloride content in the juice and in the seed; studying visual and anatomical phenomena of salinity in the tree, such as leaf curling; and following the drop of leaves, flowers and young fruit, as an effect of salinity.

It was found that none of the indicators studied can serve, by themselves, to determine the upper permissible limit of chloride accumulation in the plant, but the combined use of some of them is quite efficient for this purpose.

The mechanisms responsible for chloride absorption by roots of citrus rootstocks which differ in their relative salt tolerance were found to be quite similar in the first stages of absorption. Accordingly, there is no explanation available yet for the differences observed in leaves of mature trees on the same rootstocks. The mechanism of absorption by citrus roots is markedly different from that of annual plant roots, and the role of passive absorption was found to be of relatively greater importance in the citrus roots.

The relation between vegetative growth and chloride accumulation and distribution in the plant was studied using seedlings of different rootstocks and in branches of several varieties grafted on a number of rootstocks. A relation was found between chloride accumulation on the one hand, and various interferences to parameters of vegetative growth, such as branch length, size of the root systems, and dry weight, on the other hand. It was also found that the growth rate of citrus seedlings was retarded by high salinity and that the "dormant" intervals between growth flushes became longer as salinity was increased.

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PEEL BLEMISHES ON GROWING CITRUS FRUIT

Hannah Safran and Bracha Artzi

Histological and histochemical examinations were made of fruit peel damaged by various forms of blemishes, spots and stains, sunscald, and silver spots caused by hail and abrasion, spraying, or unknown agents. These disorders were compared to the sound peel. Data were collected regarding the environmental conditions which may contribute to the appearance of the defects.

It was found that the impietratura virus affects not only the shape of the fruit and causes a gum-like exudation in the albedo, but also causes necrosis of the xylem of the fruit stem and of the branch carrying affected fruit. This necrosis appears about the same time as the symptoms are observed on the fruit and before the dropping of the most affected fruit in July-August. The disease's appearance is limited in time and does not interfere with the future normal growth of the branches. Apparently the virus remains in the canopy of affected trees and penetrates into the new flush and the newly set fruit without causing any visual damage to branches or foliage.

It was confirmed that in fruits with a coarse peel the albedo's thickness is twice that in normal fruit, and there is an additional layer of oil glands below the glands normally found in the hypodermis.

PHYSIOLOGICAL AND METABOLIC REACTIONS IN CITRUS UNDER UNFAVORABLE GROWING CONDITIONS

Hannah Safran

Citrus trees may have tyloses, which are internal secretions of a gum-like substance in the vessels of the xylem. Tyloses may appear in all woody parts of the citrus tree. Among the factors responsible for their appearance are injury, penetration of fungi, leaf drop, etc. The role of the tyloses is thought to be a barrier between the affected and the healthy tissues.

The appearance of tyloses in roots of declining trees was examined. Most of the vessels of those trees were found to be closed, while in roots of healthy trees only single tyloses could be located, mostly in the vicinity of a wound.

EFFECTS OF SOUR ORANGE, SWEET LIME AND ROUGH LEMON IN SOME INTERSTOCK COMBINATIONS UNDER THE SHAMOUTI SCION

Hannah Safran

The investigations of the performance of Shamouti grafted on sour orange, rough lemon and sweet lime as scion and as interstock, on loam to sandy-loam soil in the groves of Bet Dagan, were continued.

Ten years from grafting, it is possible to conclude the following:

Sour orange as a rootstock and as an interstock provides the tree with the greatest degree of vigor. The combination of Shamouti/sour orange/rough lemon produces the strongest trees with higher yields than those obtained from any of the other combinations (including Shamouti on sour orange alone). The intensity of growth and productivity on rough lemon stock is medium, less than that on sour orange and greater than that on sweet lime. Of the trees containing sweet lime in the combination, 15% have died, and the rest are undeveloped. Productivity is directly proportional to the volume of the canopy, and the yield differences between the various combinations are growing from year to year.

Sweet lime as a rootstock and as an interstock is seriously affected by xyloporosis, even without direct contact with Shamouti. Shamouti exhibits no signs of this disease, but obviously carries the virus without indicating its presence. Rough lemon in all combinations is only slightly affected by xyloporosis; when in direct contact with Shamouti it invariably develops the typical ring at the union.

The results of the first nine years of the research have been published.

CREASING IN THE PEEL OF VALENCIA FRUIT

Hannah Safran and S. Shapcicki

In an attempt to prevent creasing on Valencia fruit, fertilizer experiments were conducted by foliar spraying with potassium nitrate, The experiments have been carried out for three years, and the following conclusions have been reached:

a. The damage from creasing was reduced by 10-50%. However, foliar spraying with potassium nitrate cannot prevent its appearance, even in cases of slight damage.

b. A 4% concentration spray applied at the end of June was the most efficient.

c. In most cases, the effect of two sprayings did not justify the additional expense.

d. The sprayings affect only the first yield after application of the treatment.

e. The method of spraying has no influence on the absorption of the material.

f. In most cases, there was no increase in the potassium content of leaves after three successive annual sprayings.

g. There was a drop in leaf magnesium content as a result of the spraying.

Long-term observations are being continued as to the effect of 30 different rootstocks on the degree of creasing of Valencia fruits.

Research is continuing on the development of the phenomenon during the course of the season, and concomitantly climatic data are being collected.

In order to examine to what degree the tendency to carry affected fruit is inherited, trees in one plot were grafted with budwood from trees showing different stages of the disorder.

Experiments have been initiated to study the effect of gibberellin sprays, alone and in combination with potassium nitrate applications. In a preliminary trial, carried out at the beginning of January, after the color break, no abnormal development of the color was observed.

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