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FIRST ANNUAL REPORT
TO THE AID-CDR PROJECT NO. DPE-5544-G-SS-7050-00
'GROWING DECIDUOUS FRUIT TREES IN TROPICAL REGIONS LACKING WINTER CHILLING'

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1. Visit to Kenya Jan 6-17 1988

On initiation of the project, a visit of the principle investigator was taken place in order to start the work on the Kenyan part. The aim of this visit was to get a first hand information on the present situation of growing temperate zone fruits in Kenya, to plan the experimental treatments in existing orchards and to initiate a new orchard to be grown and treated as planned from the very beginning of the project.

A suitable location in a grower's orchard was selected in Nyeri. The altitude is about 1800 m on a mild slope. Apple pear and peach trees for planting were sent from Israel in February 1988 and planted. Irrigation system had to be installed when the money for the Kenyan counterpart will arrive. A delay in getting the funds in Kenya was due to the need to replace the Kenyan collaborator in the last minute.

Two other orchards were selected for chemical treatments. One of mostly the Anna cv. near Nairobi and the other of Anna and other apple cultivars in Machakos. The first one was kept in an exceptionally good condition. the following chemicals were sent from Israel for use in the experiments: Nerol 5 oil (product of Pazchem Israel), Mag for defoliation trials, (product of Palindent Israel) and Dormex (distributed by Agan Israel).

In a meeting with ADC officials we were urged to visit and use the deciduous fruit tree experimental orchard in Endebess that was planted 9 years ago. In the next visit we'll visit this orchard (located 9 hours drive from Nairobi) and use it if appropriate for the project.

2. Experiments with peaches in Israel.

Trials with peaches grown in a meadow system in the Volcani Center Farm in Bet-Dagan, were used for this years' trials. Former results showed that rest avoidance is a possible approach for obtaining out-of-season fruit in the coastal plain in Israel (Erez A. 1987. Use of the rest-avoidance technique in peaches in Israel. Acta Hortic. 199:137-144). We dealt especially

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with the problem of poor leafing in winter time. Enclosed a report (Appendix 1) which was delivered in the meeting of the working group in Chiangmai. This work comprises part of the MSc thesis of H. Lerner.

3. Experiments with apples in Israel.

In October 1987 we have initiated a trial on the apple Anna in Kvutzat Shiler near Rehovot southern coastal plain. A group of 10 trees were sprayed on October 27 1987 with $Mg(ClO_3)_2$ at 0.54% and on November 3 1987 with KNO_3 7% followed by the oil-DNOC agent: Nerol 5 at 5%. or with H_2CN_2 as the agent Dormex at 2%. 4 adjacent trees of the pollinizer '28' were treated at the same time. A group of another 10 trees was left as untreated control. Evaluation of leaf drop revealed a complete effect with mild damage to the tips of young twigs. Both rest-breaking chemicals were very effective in inducing vegetative and floral bud break although the combination of KNO_3 7% followed by the oil-DNOC was superior to Dormex at 2%. Full and very heavy bloom was recorded on December 11 1987. No continuous extension growth was obtained as a terminal vegetative bud set after formation of 5 to 8 leaves. Nevertheless, this level of foliage was much better than that obtained with peaches. Resumption of growth occurred in late spring. The control trees retained their leaves through February and no bud break occurred before mid February. The bloom of the pollinizer trees was late compared to that of Anna with only a small overlapping. Very few fruits did set, probably due to this cause. Heavy damage to leaves resulting from infestation with mildew and scab was noted. It was thus concluded that in order to obtain a good bloom coincidence between Anna and its pollinizer the later has to be treated earlier with the defoliant and the rest breaking agent. furthermore, control of mildew and scab should be very rigorous during winter to secure the crop. A net protection over the orchard will secure the yield from a possible hail damage.

Sixty trees of Anna grafted on Hashabi rootstock and 20 trees each of the following new low chilling varieties: 3-11, 60-A and 52-A all grafted on Hashabi were planted in February 1988 in 15 l containers filled with Volcanic tuff and peat moss at a ratio of 3:1 to be used for future trials. Development of the trees was very good in their first year.

4. Attending the third meeting of the working group on " Temperate-zone Fruit Trees in the Tropics and Subtropics" Chiangmai Thailand Dec. 12-21 1988.

Since this working group deals with the same topic of our project we asked and were granted the possibility to attend this meeting. We presented there 2 papers. The first on: "Means to improve leafing using the rest-avoidance technique in peaches in Israel" is presented in Appendix 1. A second paper entitled: " Container-grown trees, a new option for intensive culture of temperate zone fruit trees in the tropics". The abstract of this paper is presented below. This meeting was important in advancing the subject to many areas especially in South East Asia where there is an interest in the subject both scientifically and commercially.

Container-grown trees: a new option for intensive culture of temperate-zone fruit trees in the tropics.

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Abstract

Growing deciduous fruit trees in the tropics is limited on the first place by the lack of winter chilling for rest completion of the buds. Although various means do exist to solve this problem, good quality fruits of high chilling requiring cultivars do pose a problem not easily solved. Apart from that, natural calamities like heavy rains, heavy storms or a heat wave may cause severe damage to fruit crops with very little to do to prevent the losses. The reason for that is the complete exposure of the tree to such conditions in the orchard. Protecting the crop although technically feasible, is very frequently too costly to be employed commercially in the conventional orchard. Another type of problems affecting often fruit crops are soil - related ones. Soil is the cheapest medium but generally not the best for growing plants. Physical, chemical and biological problems related to various soil types plagues many of the crops we grow. The means we have to improve the tree performance in many cases are far from correcting the situation resulting in a poor orchard performance.

As long as growing a tree meant producing a large unit requiring a large soil volume, no other alternative did exist. But as small trees became available, another attractive offer is emerging, of growing trees in containers filled with a better medium than soil. The options that growing in containers offer is literally relieving the tree from the two main constrains of climate and soil. The first aim is achievable by turning the plant mobile especially if it is grown in small enough container that may be carried easily. The second aim of liberating the tree from the soil restrains is obtained by using in the container better medium than soil free of physical chemical or biological problems.

The peach excels as a container-grown plant. It was shown to respond positively to pruning methods in producing small and productive trees; It was shown to produce fruiting trees from rooted cuttings thus enabling production of high density orchards on their own roots. The unique bearing habit of the peach enables very early fruiting and thus early return on the investment in the orchard.

For tropical conditions having refrigeration facilities, artificial chilling of the container grown trees will secure good vegetative and reproductive start. The system requires intensive fertigation throughout the growing period.

Examination of growing container-peach trees was started in Israel 6 years ago. To date, small scale commercial orchards are grown for extremely early peach crop in the Jordan valley. Results of trials and potential utilization of the system in the tropics will be described.

5. APPENDIX 1

Means to improve leafing using rest-avoidance technique in peaches in Israel

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Abstract

Under subtropical climate with mild winters and relatively small difference in day length between summers and winters, entering into deep dormant state is more gradual than in the temperate zone and probably faster than in the tropics. Using defoliation at the proper time induces a generally good bud break of floral buds but relatively poor budbreak of vegetative buds. By using rest breaking chemicals we can improve considerably vegetative bud break but the growth obtained is forming a rosette that is typified by the short internodes and the formation of a resting terminal bud. The result is a normal development of the flower and fruit but a shortage of photosynthesizing leaf area to support the developing fruits leading to production of small fruit, poor in sugar and quality. The cause for the secondary dormancy is a combination of the residual dormant state, the short days (down to 10.5 hrs) and the low temperatures in winter in Israel. In the tropical areas, the constant daylength of about 12 hrs and the relatively warm conditions are enough to prevent the rosette formation in peaches. The shorter the daylength and the lower the temperature, the greater the risk of rosette formation.

In the present study we tried to characterize the rosette formation and to try to improve the leaf area of trees forced to grow in autumn by chemical and physical means. We compared the effect of artificial chilling to defoliation followed by rest-breaking chemicals with and without exposure to long days. We checked also the effect of spray with the growth regulators gibberellins and promalin on improving the vegetative growth. We found that only when exposed to chilling the tree could fully overcome the rosette formation. Nevertheless, increase in day length as well as spray with both GA_3 and Promalin improved the total leaf area produced.

Photosynthesis efficiency of autumn and spring leaves was studied as well as the relative importance of the three sources of carbohydrates for the fruits, namely: the reserves in the branches, autumn leaves and spring leaves. It was shown that autumn leaves are of prime importance to the fruit developing in winter and that their photosynthesis capacity is not inferior to that of spring leaves.

1. Introduction

Foliage cover is the main limiting factor in producing peach crop in winter under mild subtropical climate. It was already shown that by using the rest avoidance technique with the incorporation of three elements namely: a relatively long period of desiccation, defoliation and rest-breaking chemicals, good bud break may be secured (Erez 1987). The flowers appearing, if treatment is timed correctly, in Israel defoliation around end of October (Erez 1987), are normal and fruit set is good with normal development of the fruit. Leaf buds, both terminal and laterals break to a large extend but all form rosettes soon after appearing. This phenomenon testifies to the induction or rather persistence of dormancy in the growing tips that sets a terminal bud after development of a few leaves with very little internode elongation. The phenomenon of poor vegetative development was reported as one of the limiting factors of apple production in Indonesia (Verheij 1985). There lack of lateral vegetative bud break on shoots as well as failure of vegetative bud development from the spur limit the leaf area and causes an imbalance between the fruits of 'Rome Beauty' and the supporting leaves(Verheij 1985). In Israel, these rosettes break, after being exposed to winter chilling in December and January, by early February. But as the fruit of the early cultivars mature in March, the photosynthates produced by the new flush can hardly support this fruit.

The question arose were:

1. Is the formation of the rosette due to the autumn climate of cool nights moderate days with short daylength of ca. 10.5 - 11 hours?

2. Can this phenomenon be overcome by different treatments?

3. What is the quantitative significance of the three possible sources of carbohydrates to the fruit: the reserves in the tree branches, the winter foliage and the spring foliage.

This paper reports on trials done in the last three years to answere these questions.

3. Materials and Methods

3.1. Potted trees:

Potted peach trees were grown as described before (Erez 1988). When chilled artificially, the plants were exposed to continuous 6°C for 21 days. When left outdoors, the trees were sprayed with .36% of $Mg(ClO_3)_2$ (as the agent MAG produced by Palindent Israel) which caused a rapid defoliation(Erez 1985). For breaking rest the combination of KNO_3 at 7% followed by Oil-DNOC at 5% was sprayed once the leaves dropped(Erez 1987a). For producing long day effect added incandescent light at flux density at mean plant height was operated from before dark till midnight.

3.2. Meadow orchard trees

For trials in the orchard, meadow orchard trees (Erez 1982) 8 to 9 years old of the cultivar 'Earligrande' were used. The trees were headed back every year after harvest (April) and the new growth developed produced the next years' crop.

Growth regulators were examined on both 'Earligrande' and 'Maravilha' peach cultivars. The following chemicals were tried: GA_3; GA_{4+7} and Promalin produced by Abbott chemicals. Promalin contains 1.8% of GA_{4+7} and 1.8% of benzyladenine, and benzyladenine by Sigma. Whole small trees in a meadow orchard 8 replicates (single trees) per treatment, were sprayed with a small sprayer at a concentration of 100 or 400 mg/l a.i. The treatments were applied on December 15 (Winter application) and on January 4 (Early spring application). Level of bud break was followed and stage of growth evaluated in 6 grades as follows: 0=No response; 1=Green tip; 2=Growth <1 cm; 3=Growth>1 cm; 4= Half open leaf blade; 5= Full open leaf blade.

Leaf photosynthetic efficiency was determined with the aid of a portable Infra Red Gas Analyzer Licor 6000 product of Licor Corporation England. Leaves checked were fully developed with a normal appearance. Five replicates per treatment were checked on a clear day.

4. Results

4.1. Is the formation of the rosette due to the autumn climate ?

A comparison of the effects of chilling, change in Day length with the outdoors control was performed on potted 'Earligrande' peach trees that were exposed to one of the following three conditions:

1.Defoliated with $Mg(ClO_3)_2$ and sprayed with oil-DNOC and left under natural conditions during November and December in Bet-Dagan.

2. as in 1. but exposed to a longer photoperiod of 18 hrs obtained by added incandescent light from half hour before sundown till midnight.

3. on October 7th, potted trees were transferred to refrigerated cooler at 6°C in 6 hr photoperiod for 24 days. Later the trees were exposed to the natural conditions in Bet-Dagan.

The behavior of the trees was entirely different. The chilled trees grew vigorously inspite of the cool weather and the short days while the other two non-chilled treatments rosetted shortly after budbreak. There were considerable increase due to daylength in level of budbreak and in leaf size (Table 1). Fruit total soluble solids was not different in the two nonchilled treatments but in both it was higher than in the chilled treatment (Table 1). This was probably due to the competition between fruit development and vegetative growth. Also fruit color was inferior in the chilled treatment due to shading.

4.2. Can the rosette formation be overcome by different treatments?

Application of promalin or gibberellic acid to 'Maravilha' peaches in autumn showed (Fig 2) that promalin at 100 and 400 mg/l and gibberellic acid at 400 mg/l did advance vegetative budbreak considerably. But the poor leaf development did not increase marketly the leaf area per plant.

Another typical effect of these growth regulators was an advancement of the spring flush. Treatment on January 4 advanced very markedly spring growth (Table 2) leading to a better utilization of the newly formed foliage by the existing and developing fruit.

Another possibility for improving the production potential of the winter foliage was to improve their efficiency. For this purpose, treatments with promalin, benzyladenine Ga_3 and GA_{4+7} were tried. Photosynthesis was determined on a clear day in December on mature leaves (Fig 2).

Promalin containing benzyladenine and benzyladenine alone were shown to improve photosynthetic efficiency as compared to the nontreated control. The two gibberellins were not different in their fixation of carbon from the control. GA_{4+7} produced pale chlorotic leaves as against GA_3 that produced normal green leaves.

4.3. What is the quantitative share of all possible sources ?

The effect of the relative contribution of the three sources for photosynthates supply to the developing fruits was checked in the 'Earligrande' peach trees treated as follows:

1.Trees were defoliated and sprayed with 5% oil with no DNOC. Producing only flowers and no vegetative growth. Spring vegetative growth started in early February was left on the trees.

2. As in 1 but the spring vegetative growth was tipped off when appearing.

3. Trees were defoliated and sprayed with 5% oil and DNOC, bloomed and grew vegetatively with abundant winter foliage of rosettes. Spring vegetative growth started in early February was left on the trees.

4. As in 3 but the spring vegetative growth was tipped off when appearing. This setup produced four combinations of sources: Reserves in the ranches only (Treat. 2); Brunches and spring foliage (Treat. 1); Brunches and winter foliage (Treat. 4); and Brunches winter and spring foliage (Treat. 3) Fruit size, fruit weight fruit color and TSS were all better when winter foliage was present. Spring foliage did not have a marked effect on fruit characteristics (Table 3).

4. Discussion

From comparison of chilled with nonchilled peach trees it was demonstrated that the restricted vegetative growth obtained in winter in the coastal plain of Israel is not caused by the

climatic conditions prevailing as when chilled, growth continued uninterrupted. The cause for the rosette formation is thus due to a secondary dormant state in the vegetative bud inducing a lack of elongation in the terminal bud. It was shown that by increase in the photoperiod leaf area was increased per plant by increase in % of budbreak, by increase in the individual leaf area and by increase in the number of leaves per sprouting bud.

Growth regulators were found to improve leaf area by advancing the break of the terminal bud in the rosette and obtaining an earlier foliage cover in spring. Source efficiency was improved by promalin that increased photosynthetic efficiency. This effect was due to the benzyladenine as was shown when the constituents of promalin were checked individually. This effect of cytokinins on photosynthetic activity agrees with that reported in the literature (Kulaeva 1979, Partier et al 1982)

Evaluation of the relative importance of the various sources supporting the developing fruit, stressed the importance of the reserves in the branches and the contribution of the winter foliage. Spring foliage seem to contribute very little to the almost fully mature fruit. The conclusions of this work is to put special efforts in building a high level of tree reserves in autumn and to improve winter foliage.

This paper presents part of the MSc. thesis of H.L. This work was supported by an AID-CDR grant No.DPE-5544-G-SS-7050-00. Contribution from the Agricultural Research Organization , The Volcani Center, Bet-dagan, 1988 Series.

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Table1:The effect of chilling and photoperiod on foliage development and fruit characteristics in 'Earligrande' peach trees grown in Bet-Dagan Israel.

Treatment	Veg. budbreak (/10 branches)	Leaves/bud (No.)	Leaf area (cm^2)	Fruit color (0-4)	Fruit TSS (%)
Control outdoors	35	3.6±1.7	8.8±1.0	4	7.9±0.2
Long day outdoors	67	3.5±0.2	16.6±0.8	4	8.1±0.2
Artificial chilling	170	4.3±0.2*	17.1±3.4	2	6.3±0.6

*Checked on Dec. 16.

Table 2 : The effect of late winter application of promalin and Gibberellic acid on budbreak of the spring flush in 'Maravilha' peach trees.

Treatment	Vegetative development (0-5*)	
Control	0	C
Ga_3 100	2.6	B
Ga_3 400	4.3	AB
Promalin 100	2.7	B
Promalin 400	4.9	A

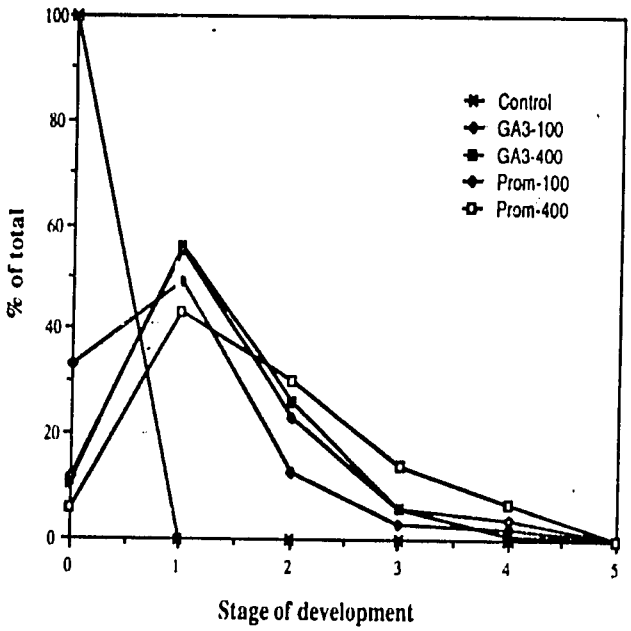
*Evaluation in 6 grades: 0=No response; 1=Green tip; 2=Growth <1 cm;

Table 3: The effect of the different sources of supply for winter grown fruit of the 'Earligrande' peach on its fruit characteristics.

Source	Color (0-4)	Diameter (mm)	Weight (g)	TSS (%)	Acids (meq./100 ml)
Branches	3.0±.2	47.2±0.9	54.1±6.2	6.1±.6	5.5 ±0.4
Branches+WF*	4.0±.2	53.0±4.3	68.9±4.4	7.7±.2	7.4 ±0.3
Branches+SF*	3.0±.1	48.1±1.1	61.4±2.5	6.4±.4	4.7 ±1.1
Branches+WF+SF*	3.6±.1	52.8±1.7	68.4±4.3	7.7±.5	7.8 ±0.2

*WF = Winter foliage; SF = Spring foliage.

Fig 1 :The effect of early winter application of promalin and Gibberellic acid on budbreak of the spring flush in 'Maravilha' peach trees. (Evaluated in 6 grades* on 30/12)



*Evaluation in 6 grades: 0=No response; 1=Green tip; 2=Growth <1 cm; 3=Growth>1 cm; 4= Half open leaf blade; 5= Full open leaf blade.

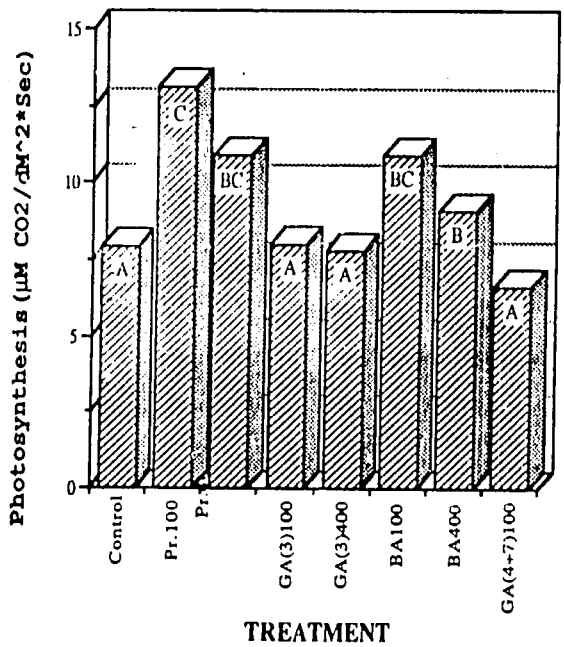



Fig. 2: The effect of promalin (Pr) gibberellins and benzyladenine (BA) on photosynthesis activity of 'Earligrande' winter leaves. Growth regulator concentration is shown in mg/l. The leaves were treated on and the measurements were carried out on December in a clear day.