SEASONAL CHANGES IN CARBOHYDRATES
AND MINERAL ELEMENTS AS RELATED
TO ALTERNATE BEARING IN
VALENCIA ORANGE

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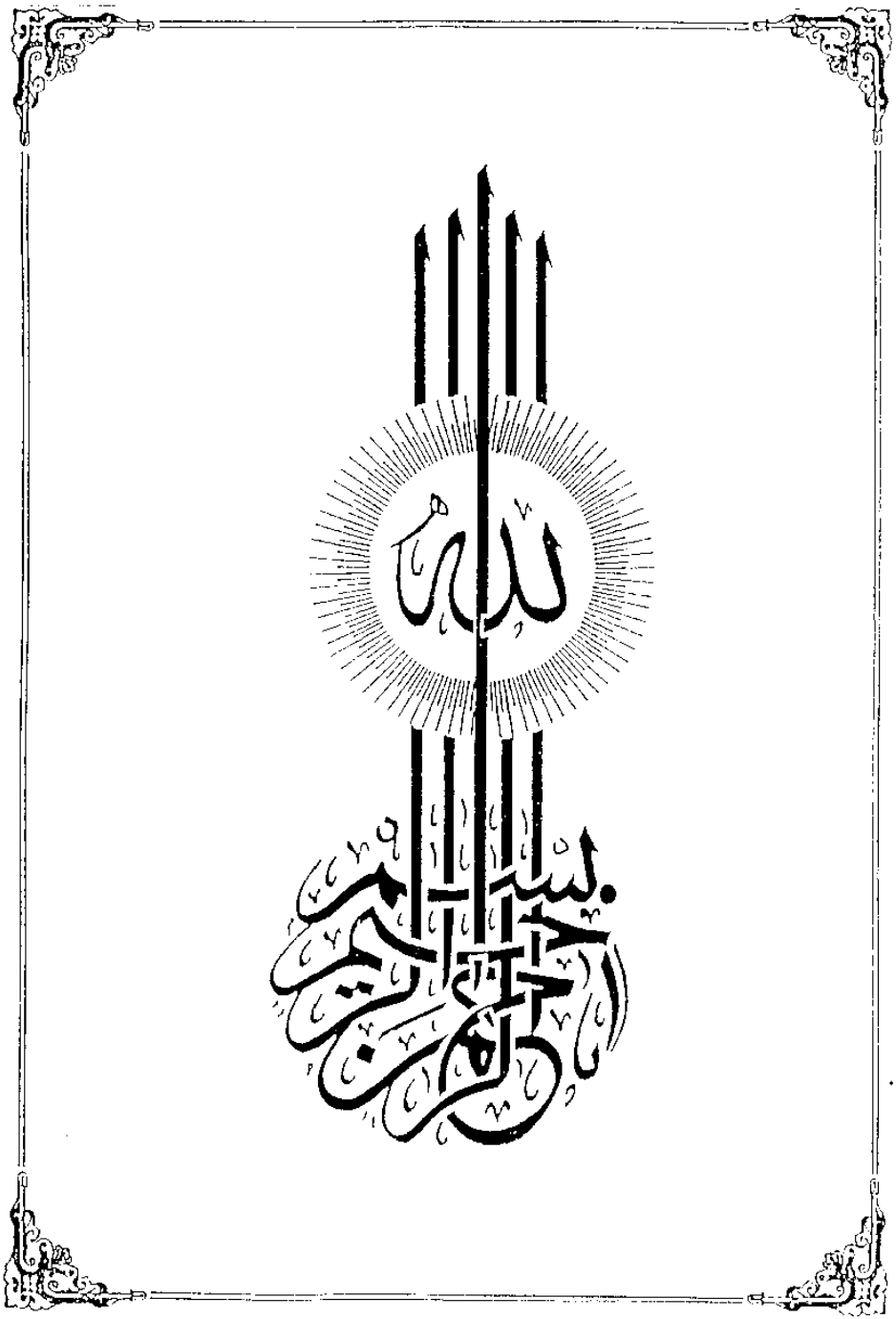

C O N T E N T S

1 - INTRODUCTION

Citrus fruits rank third after grapes and apples, as far as world production is concerned.

In Arab Republic of Egypt, it ranks third after cotton and rice for increased export to foreign countries. The total amount of citrus for export abroad increased from 32000 tons during 1968 to 155000 tons in 1972. The total acreage of citrus is about 137000 feddans according to the latest statistics of the Egyptian Ministry of Agriculture (1969).

Navel oranges is considered to be the most promising fruit for export. The greatest draw back in Navel orange trees is the variability in its strains and accordingly in fruit shape and size.

Valencia orange is the standard late variety. The number of Valencia trees slightly exceed those of Navel. It is considered to be the most suitable variety for export because it can be held on the tree for four to five months and even longer, before appreciable deterioration of quality occurs.

The greatest drawback in Valencia oranges is its irregular cropping. A heavy crop in one year is followed by a very light crop for several years. This phenomenon is popularly known as alternate bearing.

The research embodied in this thesis mainly relates to the relationship between alternate bearing in Valencia orange and seasonal changes in mineral elements and total carbohydrates in leaves and shoots. This work was also carried out with the hope to find a way, if possible, to alleviate this habit.

II - REVIEW OF LITERATURE

A. Alternate bearing :

The term alternate bearing was coined by West and Barnard (1939) to describe the irregular bearing of fruit trees from year to year. This phenomenon has been noticed in several crops such as : apples, pears, pecans, mangoes, olives, date palms, loquats, cocoa, avocado, coffee, eight mandarin varieties, Marsh seedless grapefruit (Ahmed, 1960) some orange varieties (Pineapple, Common Hamlin, Blood Red, Valencia late) and grapefruit varieties (Foster, Duncan, and Poona) (Singh et al., 1962).

The depressing effect of heavy crop on the vegetative growth in the "on" year was thought to be responsible for the alternate bearing habit (Hodgson et al., 1939). The same conclusion has been reached by other workers (Sen and Mallick, 1940, Hayes, 1945). However, Naik (1949) did not agree with this conclusion. He found that heavy flowering is followed by reduced growth activity in the next growing season. However, this did not lead to inhibition of blossoming in the next year.

It has been suggested (Singh, 1957) that alternate bearing in Mango is an inherited character which tends to become more pronounced as the tree gets older. However, Sohrab (1959) indicated that alternate bearing is largely physiological and connected with the changes in nutritional balance of the tree, which is produced mainly due to weather conditions. He indicated that in Mango, N defeciency is a main reason for alternate bearing. He stressed the importance of having a large C/N ratio.

The time of harvesting has been indicated as a important factor in determining the extent of alternate bearing expression. The depressing effect of the present crop on the next years crop in Valencia oranges could be reduced by early harvesting (Hodgson et al, 1939). It was also reported (Jones and Cree, 1954) that late harvesting increased the tendency to alternate bearing.

The number of flowers that developed the following year in Satsuma and early Satsuma orange trees was increased when last years crop was harvested early (Iwasaki, 1961). Shoots carrying fruits to full maturity in Sweet orange trees showed a pronounced tendency towards alternate bearing (Randhawa and Sinha, 1963). Early harvesting in

Shamouti orange trees increased flower bud formation in the following season, and the earlier the fruit was harvested, the greater was the stimulus for the succeeding crop. It has been suggested that alternate bearing in Valencia oranges could be prevented by thinning large crop early and small yields later (Hilgeman and Sharp, 1967, Gallasch, 1969).

It has been suggested that biennial bearing in Sweet oranges is caused by the diffusion of a flower inhibitor, possibly a gibberellin-like substance from the fruit into the wood on which it is borne (Moss, 1971).

The presence of flowering hormone and an ample supply of starch have been indicated to be important for flower bud formation in Mango (Singh, 1957).

The balance between leaves and fruits is also important. Iwasaki (1961) recommended that for Satsuma oranges on trifoliate stocks, thinning should be done to leave one fruit for 20 - 25 leaves. Fifteen to twenty leaves/fruit should be the ratio if this variety is grafted on citrus junos stocks. This relation had been also stressed for late Valencia oranges.

5. Fruit thinning :

Several ways have been tried to reduce the alternate bearing habit. Fruit thinning was found to be quite effective (Hodgson et al., 1939). Thinning up to one third of Valencia late oranges crop, early in the on-year, slightly increased fruit size in the same year and considerably increased numbers of blossoms and fruit set in the succeeding year (Cameron, 1950). Thinning Satsuma orange trees increased the size of the remaining fruits in the same year and increased the number of flowers and yield in the following year (Iwasaki, 1961). He also found that removing all the fruits from a branch, increased the number of flowers and also the fruit set the following year. Larger branches and early thinning showed the greatest effect. In a trial to evaluate the importance of time of thinning in Unshiu oranges, it was found that when thinning was done on July 12, August 11, 30 and September, 16, the percentage of flower bud formation on the treated shoots were 42.8, 20.8, 12.5 and 4.0 respectively indicating the importance of doing thinning as early as possible (Ogaki et al., 1965). They noticed that the effect of thinning was also reflected in the untreated bearing shoots.

Fruit set in Washington navel orange was higher in thinned than in unthinned branches (4.4% and 0.9% respectively), and more fruit set occurred on inflorescences with leaves (1.3%) than on those without leaves (0.4%) (Holtzhausen, 1968).

Ogaki (1968) found that fruit thinning was the most effective single treatment in encouraging Satsuma orange trees to return to annual bearing.

As mentioned in the first section, the time of harvesting could be used as a mean to reduce the alternate bearing habit. (Hodgson et al., 1939, Jones and Cree, 1954, Iwasaki, 1961, Randhawa and Sinha, 1963, Hilgeman and Sharp, 1967, and Gallasch, 1969).

Growth regulators sprays have been tried as a means of reducing the alternate bearing habit.

Hield et al. (1964) worked on the effect of NAA on fruit thinning in citrus in the on-years. He found that only a slight increase in yield occurred in the following year. However, Hilgeman et al. (1964) comparing between NAA and hand thinning, reached the conclusion that both

methods were equivalent. They stressed that more than 50% of the fruits on the tree in late June must be removed to break the biennial bearing cycle of Kinow mandarins.

Kelleg and Minessy (1964) studied the effect of 2,4,D on June drop, pre-harvest drop, fruit quality and alternate bearing habit of the Baladi mandarin and Washington Navel oranges. They found that spraying with 20 - 40 ppm 2,4,D in May is effective in reducing the alternate bearing habit.

C. Mineral elements and carbohydrates level :

Many trials to associate alternate bearing to the chemical composition of several parts of the tree have been made.

It was stressed (Sinha and Randawa, 1961) that moderate amounts of N, P, K, Ca, and carbohydrates were favourable for flowering and fruit set in Sweet orange. The levels of all mineral elements were quite low in bearing shoots compared with the non-bearing shoots. It was found that fruiting twigs of "Baladi" mandarin contained more carbohydrates in the first four months of the season of an "on" year, than vegetative twigs and vice versa for "off" year trees (Zidan et al., 1961).

Moreover, more N was reported to accumulate in the twigs prior to the spring flush in the "on"-year tree than in the off-year (Zidan and El-Domi, 1972). A significantly high C/N ratio in the bark as well as a general rise in the carbohydrate content of the shoots during the period of flower bud initiation and differentiation was also reported (Sen et al., 1963).

Flower bud differentiation was favoured by high shoot contents of carbohydrates and nitrogen (Ogaki et al., 1963). The maximum amount of total N content in Unshiu tree fruits and shoots was reached in June for the "off"-year tree, whereas it was attained in August for the "on"-year tree and annual bearer.

Carbohydrates and nitrogen analysis showed similar trends in bearing and non-bearing shoots of mandarin (Citrus reticulata, Blanco) but the concentrations of N, Ca, P and K were consistently higher in non-bearing shoots. (Randhawa and Kar, 1967).

The percentage of N and P in Valencia orange leaves was lower in "on" year than in off-year (Jones et al., 1968).

The absolute amount of nitrogen [illegible] orange increased gradually [illegible] during the Winter period and showed a rather decrease with the flush and bloom in the spring. Meanwhile, such decrease went on steadily until the leaf abscised (Reuther and Smith, 1950).

C/N ratio in Sweet orange young leaves was lowest just before the initiation of the spring flush and bloom (Singh and Randhawa, 1961).

A study of the reducing and the non reducing sugars, starch, soluble N and protein N content of leaf, bark and wood of Mango shoots showed a significantly high C/N ratio in the bark during November and December. A general rise in the carbohydrates content of the shoots from November to January was also noted (Sen et al., 1963).

In Satsuma oranges, N and Carbohydrates increased from December to February (Ogaki et al., 1955). The lowest soluble carbohydrates content on 10 - 12 old lemons trees was reached during the Summer months when the new shoots grew intensively. (Dzasi, 1965). Moreover, sugar content was highest in the Winter, and starch accumulation was greatest in the Summer and smallest in the Winter.

Maximum content of N in Unshiu tree fruits and shoots was reached in June for the off-year trees and in August for the "on"-year trees and annual bearer (Chapot et al., 19[illegible]). N content in shoots of mandarin decreased with age and the C/N ratio increased especially during the Winter months. (Randhawa and Kar, 1967); (Jones et al., 1970).

Ca and Mg accumulated while N, K and to a lesser extent P was reduced during fruit development in Valencia orange (Folsher et al., 1967). This phenomenon was used to distinguish between direct and indirect correlations usually reported for elements and their relationship to yield and fruit quality. Multiple regression functions could be calculated for the predicition of rind thickness, juice content, acidity and even T.S.S. values for the matured fruits from N, P and K levels of 6 weeks old leaves (Folsher et al., 1967).

The level of N and P in leaves of Washington Navel oranges decreased from April to July, i.e. from dormancy breaking during flowering and until set. They rose rather sharply during late summer and then more gradually to a maximum in early or mid-Winter. The K values rose gradually