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WORK PROGRAM

SEPTEMBER

Saturday 13: Johannesburg to Cairo
Sunday 14 : Seminar: Dr Bob Knight – Egyptian Cultivar Evaluation
Monday 15: Visited Ismailia Orchards
Tuesday 16: Visited Ismailia Orchards
Wednesday 17: Visited Sharkia Orchards – Dr. Carlos Balerdi joined us.
Thursday 18: Visited Giza Orchards
Friday 19: Preparation for discussion sessions
Saturday 20: Preparation for discussion sessions and visit to Domestic Market
Sunday 21: Horticultural Research Institute – Several discussion sessions
Monday 22: Ismailia Experimental orchard – Pruning demonstrations
Tuesday 23: Visited Fayoum Orchards
Wednesday 24: Discussion session: Tree and orchard management
Thursday 25: Visited the University Ain Shams and a commercial farm on the dessert road. Dr Balerdi left.
Friday 26: Free day – Trip on the Nile
Saturday 27: Preparation for discussion session
Sunday 28: Dr Richard Cambell joined us. Discussion session: Commercial nursery practices
Monday 29: Ismailia. Discussion on mango production in Egypt
Tuesday 30: Discussion session on Post Harvest procedures for export

OCTOBER

Wednesday 1: Discussion session: World mango cultivars and cultivar development programs
Thursday 2: Visited three desert road farms and a commercial nursery
Friday 3: Preparation for seminar
Saturday 4: Preparation for seminar
Sunday 5: Seminar: A holistic impression and some guidelines for mango cultivation in Egypt
Monday 6: Finalize report
Tuesday 7: Cairo to Johannesburg

INTRODUCTION

I am very optimistic and excited about the mango industry in Egypt. There are several factors in favor of the development of a strong and healthy mango industry. These are:

i. The inherent love for mango fruit by the local inhabitants and the highly lucrative domestic market
ii. The suitability of the climate for mango production and the physical properties of the soils. Although there are some limiting factors, these can be managed. The soil can act as a tool in the tree manipulation program to control plant vigour.
iii. The commitment and enthusiasm of the government, academics, researchers, producers and private concerns in the development of this industry
iv. The availability of the exclusive Gulf market as well as the distance to the European market which can be exploited when and as necessary
v. The availability of a large gene pool locally and interaction with other countries for possible extension of the source. Cultivars suitable for a specific climate, market, with the necessary qualities and high productivity can thus be selected in the future.
vi. Availability of labor who can be trained to do the orchard management
vii. The River Nile

Naturally there are also areas of concern:

i. The extreme occurrence of flower malformation in old and young orchards as well as in nurseries
ii. Saline water and soil conditions
iii. The haphazard way of water and nutrient application
iv. The lack of appropriate tree management strategies in most instances
v. Lack of information for planning and management of new orchards
vi. Lack of precocious commercial cultivars and rootstocks

I am grateful for the opportunity to share some of my experience with you, not to be prescriptive but to stimulate all those involved in this exciting development towards achieving optimal production of marketable fruit. In this endeavor one must be creative and I hope that I may have played some part in stimulating you to strive toward the following objectives:

i) Maintain the urge to produce only high quality and healthy planting material
ii) Establish effective orchards and management practices
iii) Practice applicable post-harvest procedures
iv) Search for and develop the most suitable cultivars that can be adapted to specific Egyptian conditions and markets
v) Encourage close interaction between producers and this program

2. EXISTING ORCHARDS AND CURRENT SITUATION

2.1 ORCHARD MANAGEMENT

Many of the old orchards I visited, can be described as mango jungles. Tall trees with huge canopies and bare lower areas that are difficult to spray and harvest, are the order of the day. This is a situation that will develop in any 20- to 40-year-old orchards planted at about 8 x 8 m and without a tree management program. Renewing these orchards requires major surgery. If this is done in one step, production will suffer severely for a couple of years.

It would be advisable to replant very old, sick and unproductive orchards over a period of time. Do not interplant between old trees but replant certain percentages of the orchard yearly.

There are different strategies that can be used to revive old orchards and make them more productive and manageable. One strategy would be to prune alternate trees or rows more severely and develop new growth at the base of the remaining trees. Over a period of two years these trees can then be pruned back while the severely pruned trees can be developed and shaped.

However, I would rather renew an existing orchard in steps over a three year period.

Year 1

Open up the dense tops of the trees (not in the center but from the edges). Remove about 4 branches in the top to allow for light to reach the base of the tree and stimulate the development of new shoots at the base of the tree.

Year 2

Leave the new shoots that developed at the base of the tree to become fruitful. Cut back very long shoots which will hang on the ground. Cut back long shoots of overhanging branches in the top of the trees.

Year 3

Reduce the height of the tree after harvest by cutting back and not by heading.

If you look down the row in the North/South direction there must be an open V between rows for efficient sunlight interception

Year 4

Maintain the shape and production by cutting back about 25% of the branches annually (renewal pruning) and keep the top of the tree narrower than the bottom. To allow sunlight penetration into the tree, remove some lateral branches when the tree becomes too dense. (see Appendix 1-2 Principles of a tree management programme and 1-10b)

In some of the older orchards producers tend to over-irrigate and over-fertilize, especially with nitrogen (see Appendix 1-3 Leaf sample; 1-4 Leaf and soil norms; 1-6 Macro elements in mango trees; 1-7 Water requirements)

2.2 CULTIVARS

Unfortunately I arrived in Egypt when most of the cultivars were past their physiologically ripe state and already in the eat-ripe and even over-ripe stage. However, Dr Robert Knight and Mr. Robert Sandfort had the opportunity to do an

extensive evaluation of Egyptian cultivars. Dr Carlos Balerdi and myself had the opportunity to see some late cultivars in the orchards and most of the cultivars at the market. My personal summary, of the Egyptian cultivars that I saw and tasted, is given in Table 1.

As seen from Table 1, there are cultivars, both green colored and yellow/red ones, with excellent taste. Some of these cultivars performed exceptionally well on the domestic market and even the cheaper ones still fetch very good prices (more than received for many export fruit). Other green cultivars with a bit of an "Indian flavor" are also exported to the Gulf market. I have further seen photos of some excellent selections made by the Horticultural Research Institute. During my discussion I got the impression that lack of precocity, alternate bearing and low productivity are however factors of concern.

TABLE 1 - EGYPTIAN MANGO CULTIVARS

Cultivar	*Season*	*Colour*	*Size*	*Taste*	*Growth Habit*	*Price (EL)*
White Succary	early	light green to yellow	average	average	vigorous	low
Bullocks Heart	early	green	large	average	vigorous	5,50
Hindi Besennara	early	green	large	good	moderate	
Hindi Khassa	early	green	average	sweet	upright, tall	4,50
Taimour	early	green	large	good to excellent bit of an aftertaste	willowy large	for export to Gulf
Alphonse	mid	muddy yellow	good	excellent	upright	5,00
Pairi	mid	yellow with blush	good	good to excellent	pyramidal	
Ewaise	mid/late	yellow	average	excellent	vigorous	8,00 (highest local price)
Mabrouka	mid/late	yellow with blush	large	average	moderate dense	4,00
Zebda	mid/late	green	large	average to good	upright but strong	
Company	late	green	large	average		
Mesk	late	yellow with blush	good	Indian	3,50	
Phigry Kalan	late					4,00

Maybe one will find some selection with say Ewaise-like (or other) features but free from the disadvantages and with good quality. As in some other countries there is also a lack of suitable rootstocks in Egypt.

When Egypt want to sell on world markets (especially Europe which is not too far away), then they will select for appearance and also may be interested in cultivars from Florida, Israel and South Africa. Cultivars for instance with the necessary appearance, storage capability, production ability and free from physiological disorders and other problems (see Appendix – Discussion 4). From Egypt's own selection some super cultivars may come to the fore. In all countries the search for the perfect cultivar(s) is a continuing process.

3. GUIDELINES FOR PLANNING FUTURE MANGO ORCHARDS

3.1 GUIDELINES

These are suggested guidelines that can be applied by producers in new developments.

3.1.1 Cultivars and rootstocks

Decide on the best cultivars for micro climate areas (some cultivars for dry and warmer Upper Egypt, etc). Cultivars for specific markets and for specific times within the existing market or to lengthen the current market span. Cultivars with specific characteristics like improved yield, better quality, regular yield and precocity, compact growth habit and free from internal problems.

Rootstocks to have uniformity and adaptable to specific soil conditions, more productive and perhaps some dwarfing characteristics.

3.1.2 Top quality plant material

A great responsibility rests on the shoulders of mango tree propagators in order to supply the industry with quality and healthy plant material. At the same time producers should insist on quality trees by being aware of the specifications to which they are entitled.

(see Appendix – Discussion Session 3 – Commercial nursery practices)

Order trees from a reputable nursery and ensures that the nursery obtains the budwood from selected mother material with an established record of production and quality. I am concerned to see flower malformation in nursery trees. It could be that infected graftwood is being used. The best would be for the nursery to plant hedgerows of selected mother material (3 x 1 m) and prune trees only for graftwood production and not cut graftwood from old orchard trees.

Nursery trees must be free from harmful pathogens.

Producers must examine their trees before planting. If there is any doubt or dissatisfaction discuss it immediately with the nursery manager. Good planting material is your investment for the next 20 to 30 years. Do not buy or produce poor material.

Remove the plastic bags when planting the trees and loosen the mixture with your fingers and unravel roots that are knotted together. Do not leave trees in bags for a long period after receipt. If possible plant early in spring after last cold weather to get the maximum root growth and development of fine roots as well as tree canopy.

3.1.3 Elimination of limiting or adverse soil conditions.

After the orchard has been established any action to correct soil limitations (physical or chemical) will be an emergency measure only and in many instances be virtually impossible.

Chemical adjustments of pH, phosphorus and other elements can be done by means of stock applications during soil preparation. It would be advisable to adjust the pH to the optimum of about 6,5 (H_20). In Egypt with the high calcareous soils there is a need to decrease the soil pH by 1 to 2 units with sulphur powder. It would also be advisable to adjust the normally low phosphate status of the soil to about 35 mg kg^{-1} (Bray extraction) and later only apply maintenance phosphorus as indicated by leaf analysis. Thorough mixing of these chemicals in the top 60 cm of soil is very important. Use the right implements for soil preparation.

3.1.4. Commercial lifespan, break-even point, optimal production and regulation of yield

In planning an orchard for the future you must set certain goals. These goals must be realistic and take economic factors into account and include the following:

- speedily achieving the economic break-even point (±4 years)
- speedily achieving optimum production (±8 years)
- annually maintaining optimal production (16 ton/feddan)

achieving an economical lifespan of about 20 to 30 years which will include a replacement strategy.

It will, however, necessitate the implementation of flower, fruit and tree manipulations.

3.1.5 Planting systems

To achieve the goals of early break-even and optimal production, higher density plantings are necessary.

To establish more intensive plantings without accelerating encroachment the following measures need to be applied:

- plant trees in a rectangular system. In this way there will be an opening between the tree rows to allow light to penetrate and reach the base of the trees
- plant the tree rows as close as possible in a geographical North/South direction. This will have the effect that the two sides of the hedgerow will receive equal amounts of the day's available sunlight
- prevent the tops of the trees becoming broader than the base and forming a light impenetrable canopy, in other words maintain a pyramidal shape.

Planting distances must be logically established and are determined by:

- input from farm management
- soil potential
- growth habit of the specific cultivar
- climate
- rootstocks
- implements

For the current Egyptian cultivars 7 x 3,5 m would be a good average planting distance. With the Florida type of cultivars even 5 x 2,5 m could be considered.

Take care not to plant on a square i.e. 5 x 5 or 7 x 7 m.

(see Appendix – Discussion session 1. Read article: Planting and training systems for citrus and subtropical fruit trees.)
It is recommended that the drip area under the tree row be clear of weeds for the full length and width of the row but be covered by a mulch.
Plant windbreaks to prevent sand damage.

3.1.6 Tree shape and manipulation

Mango trees can be pruned, the technique and time will depend on climate and cultivar. (see Appendix – Discussion session 1 nos 2, 8 and 12 for more background)
During the first three years after planting the main concern is to get volume and increase tree complexity. This is to fill the allocated space as soon as possible and create bearing units. Because the mango tree initially grows very slowly do not try to shape the tree by drastic pruning. Through tipping stimulate the development of laterals and remove flowers especially during the first growing season. After planting wait until trees reach about 70 cm and then cut out the growing point at about 60 cm height.
When the necessary volume has been attained start shaping the tree into an informal pyramidal shape (keep the top narrower than the bottom). This can be done by cutting back one or more nodes. Make the cut behind the ring to stimulate lateral development from the leaf axils. If the cut is made in front of the ring, several laterals will develop and this is unsatisfactory. Long branches can also be cut back to more horizontal laterals. Upright growing shoots can be removed completely to make the tree less dense. Pruning is not a once-off process and should rather be done annually and in some cases even more than once a year depending on what you want to achieve. If done frequently it is never a severe operation and not very time consuming.
The time of pruning is certainly the most important factor. Early cultivars can be pruned after harvest and still mature bearing shoots for the next crop. In the case of late cultivars, complete pruning after harvest will result in a severe decrease in yield. Pruning in late winter will stimulate flower development on the older wood. In mangoes it is also possible to work out a system of renewal pruning whereby only 30% of the shoots are cut back yearly and the others remain to bear the crop. In cultivars with a small-fruit problem, pruning can also be done to remove undesirable fruit by cutting back the whole shoot to the desired length to accommodate the shape of the tree.
After harvest, prune away all the old bearing shoots to behind the ring. Pruning will help to regulate bearing and keep bearing wood close to the main stem.

3.1.7 Nutrition and irrigation

Correct nutrition and irrigation applications are very important for fruit production and quality and for the health of the tree. On many of the farms that I visited, over-application of nitrogen and water was the general practice.
Over-application of nitrogen will stimulate vigorous growth, which will reduce reproductivity, and when applied at the wrong phenological stage, has the effect of

decreasing the internal quality of the fruit. Over-application of nitrogen will result in bigger and stronger leaves, which will compete successfully for calcium with the fruit (which in many cases are very weak competitors for calcium). Over application of nitrogen and water at the wrong stage will stimulate a strong flush to the detriment of fruit set and fruit retention.
To be able to apply the correct amounts and have feedback on previous applications it is important to annually have leaf samples analyzed. The right time to do this is to sample young mature leaves from fruit bearing twigs during May.
Soil analyses from time to time (every three years, for instance) are also necessary. For this one needs leaf and soil norms as summarized in Table 2.

TABLE 2 - LEAF AND SOIL NORMS

a) Soil norms

pH (H_2O)	6-7	(optimal 6,3-6,5)
P (Bray)	30-40mg/kg	
Al	0-30 mg/kg	(high Al concentrations are phytotoxic)
Ca : Mg	2,5-5mg/kg	

b) Leaf norms

Elements	*South Africa*	*Australia*	*Israel*	*Florida*	*Optimal*
N (%)	1,25-1,41	0-1,5	1,2-1,6	1,0-1,5	1,3
P (%)	0,08-0,1	0,08-0,18	0,09-0,12	0,09-0,18	0,12
K (%)	0,9-0,98	0,3-1,2	0,4-0,8	0,5-1,0	0,9
Ca (%)	2,0-2,8	2,0-3,5	2,0-3,5	3,0-5,0	3,0
Mg (%)	0,2-0,35	0,2-0,4	0,25-0,35	0,15-0,47	0,3
S (%)		0,2-0,6			0,4
B (ppm)	30-100	70-200		24-54	50
Fe (ppm)	70-100	50-100	70-100	38-120	70
Mn (ppm)	60-200	60-500		92-182	90
Zn (ppm)	20-100	20-150	20-40	101-119	40
Cu (ppm)	10-20	10-20		28-35	20

Furthermore, one needs guidelines as to the correct amounts necessary to maintain the tree's nutritional status (see Appendix 1: Tree and orchard management guideline articles 5 and 6). My recommendation is to fertilize trees according to what they really need and on the basis of their yield. Mango trees need about 6 g N, 0,8 g P, 7 g K, 6 g Ca and 0,8 g Mg per kg yield, annually.

The best time to apply nitrogen is during the post harvest period and from fruit set onwards but not during the last period of ripening. Be careful with nitrogen applications during the summer months.
In sandy soil slow releasing nitrogen like poultry manure can be used advantageously but must be worked into the fertilizer program. Potassium must be applied annually in sandy soils and especially early with flower bud development. Zink and boron sprays must be applied two to four times a year during early flush and boron even with flowering. Special iron formulations can be applied through soil applications.
In the sandy soils of Egypt a lot can be done to manipulate the tree through water stress at the right phenological stage (see Appendix – Discussion session 1, article no. 7)
Irrigation should only wet the drip area of the tree. A micro- or drip system that succeeds in doing this effectively can be used. Sound irrigation scheduling should be applied. Waterlogged conditions must be avoided. Fertigation as a means of supplying nutrients more frequently can be considered.

3.1.8 Growth control and chemical manipulation

There are several "tools" available to control the growth of a mango tree:

i) Nitrogen: Do not stimulate vigour by applications at the wrong time and by over application
ii) Water stress: Schedule water applications in such a way that no over-vigorous flushing during fruit set takes place
iii) Pruning: Cutting back to keep the trees compact
iv) Soils: Sandy soils which have low vigour potential can be used very effectively to manipulate growth
v) Rootstocks: Especially precocious and highly productive ones. A good fruit load is still the best way to control tree growth.
vi) Chemicals: Growth retardants can be applied to young trees before bearing or used as directed sprays onto vigorously growing flushes.

3.1.9 General tree health

Flower malformation is a very serious problem in Egypt. It must be controlled by pruning infected flowers at least 30 cm behind the infection. Infected parts must be collected in a bag, taken out of the orchard and immediately burnt.
A big problem in Egypt might be that nursery trees are already infected through the use of infected grafting material. Clean healthy mother material is necessary to get the industry free of flower malformation.
Micro-element deficiencies must be controlled by efficient spray programs or even soil applications as necessary. Correction of soil pH before planting will however help a lot to make this problem more manageable. Maybe Calsimax sprays can be given (five times) from flowering to harvest to increase the calcium in the fruit (research necessary).
Tree dieback was also seen and several reasons might be given for this problem:

- waterlogging

- micro nutrient deficiencies
- saline conditions
- infections

3.1.10 Pollination, fruit set and fruit retention

There is evidence to indicate that some cultivars are completely or partially self-infertile. This will result in degeneration of the embryonic tissue. This could be a yield limiting constraint especially in mono-embryonic cultivars.

It is recommended that beehives be placed in orchards to enhance cross pollination and thus improve yield. These hives must be brought into the orchard when the flowers are already opening. Hives must be placed in warm, sunny and wind protected areas. Competing weed flowers must be removed. The mango flowers are not very beneficial or attractive to bees and it might be necessary to spray every second row with an attractant (Aniseed oil 50 ml plus 7,5 kg sugar per 100 L water)

Zinc and boron deficiency might decrease fruit set and must be adequate. A strong vegetative flush will also compete with the young fruitlet. Certain sprays, such as, 3% KNO_3 given during flowering are said to help fruit retention. Other synthetic growth promotor sprays are sometimes applied after flowering to enhance fruit retention.

3.2 POST-HARVEST PROCEDURES

Finding the correct maturity indicator(s) is important to determine picking time. Cultivar specific colour charts currently seem to be the most appropriate. Current research is focussed on non-destructive methods of determining fruit maturity.

Hot water treatments of 5 minutes at 47C is the most appropriate combination although not for the sensitive cultivars.

The modern trend is to pack mangoes in boxes without lids and recently a netting material has been used to cover the opening.

Inspection and feedback on export fruit is very important. Mangoes are currently exported at two temperatures, namely 11C for greener fruit and 8C for riper fruit. (see Appendix – Discussion session 3)

4. CONCLUSIONS

1. Flower malformation must be eradicated and starting with clean healthy mother material is a precondition for achieving this goal. Get hold of all the necessary information to achieve this goal.
2. Nutrition and irrigation practices need improvement through dissemination of existing information and through research.
3. Tree management practices must be implemented. Time of pruning needs research.
4. Certain strategies must be implemented when planning new orchards
5. Select and import precocious, high yielding cultivars adapted to specific micro-climates
6. Select, import and evaluate rootstocks adapted to Egyptian conditions
7. Do not interplant citrus and mangoes
8. Draw up standards for nursery trees
9. Give attention to fruit quality, harvest, packing and storage principles
10. Do soil preparation especially to correct pH and phosphorous status of the soil