Review Article

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# Performance of adopted fruit species and cultivars to egyptian-desert agriculture and their major production problems

## Abstract

Desert agriculture represents the future agriculture of Egypt due to the need for expansion in growing much larger areas to meet the high demand of the increasing population. This expansion has been directed far from the narrow areas adjacent to the river Nile. Many new species and fruit cultivars have been adopted based on either previous experience or real knowledge of their performance under arid conditions. Some of these fruit trees originate from moderate or sub-tropical regions and grown under different climate. The general feature of such culture could be described as "the stressful agriculture" since there is many conditions outside the ideal range whether in air, water or soil. Many abiotic or physiological disorders form in the fruit at any time during the season which adversely affect their quality and marketability. Understanding the causes of these disorders could greatly reflect on the farmers profits. Following the proper treatment is very crucial either by applying the avoidance procedures or enhancing the plant tolerance.

**Keywords:** desert agriculture, physiological disorders of new fruit species, proper treatment

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## Introduction

Since the beginning of the nineties, there has been a great expansion in desert agriculture in Egypt. The producers and growers tended to adopt new fruit species and cultivars based on some consultations and local experience. The adoption of such fruit cultivars focused mainly on some deciduous species that have low chilling requirements such as peach,[1] apricot, grape,[2,3] apple, pear, plums, Japanese persimmons in addition to high quality fig and pomegranate cultivars that do not have problems with chilling hours in winter since their requiredchill units are available in the Egyptian desert. When the technology of desert agriculture was professionally applied by following the recommended procedure of establishing drip irrigation networks, by planning and implementing the appropriate water budget, fertigation, modifying the tree growth according to weather conditions and the time of harvest, producers started to adopt new cultivars of evergreen fruits species such as orange, olives, date palm, mangoes, loquats, and avocado. However, growers have been facing many problems[4] that are more specific to arid conditions whether soil types, salinity, nutrient availability, heat and water stress, defoliation, unconcentrated blooming period, lack of pollination, low difference between day and night temperatures which reduces color intensity of grapes[5] and even many frosty nights. These conditions led to many disorders related to abiotic stresses or the interaction between two or more stresses. Moreover, a major loss of yield due to drastic-fruit abscission during flowering, fruit set and even prior to harvest.[6] Furthermore, regreening of Valencia oranges[7] and even the greening at the lower part of navel orange canopy due to warm temperature during the harvest season especially at night which causes higher mobility and activity of nitrogen in the orange tree. Thus, the objectives of this article were to demonstrate the problems associated with desert agriculture of fruits with special emphasize on abiotic ones and to briefly indicate to the possible causes of such problems and physiological disorders.

## Prevailing conditions in Egyptian-desert agriculture

Cultivated soil is mostly alkaline (their pH ranges between 8-8.5 and may reach to 9-10) which limits the availability of some minerals such as iron, zinc, manganese and phosphorus. Many fruits show disorders of zinc and boron deficiency such as the formation of shot berries in grape clusters.[8] Boron deficiency also reduces ovule longevity and fruit set and increases the gummosis in the peel and branches. Bitter pit is also one of the physiological disorders related to calcium deficiency in apples and pears. Low availability of phosphorus due to the high pH reflects on lower carotenes in the juice of citrus fruits.[9]

In some areas, the soil is salty-alkaline which makes it compact and expose the roots to low oxygen stress. Salinity varies among different areas where well-water salt concentration ranges between 600ppm to more than 1500ppm (Personal communications). Calcium carbonate (caliche) is formed in many spots under the soil surface mixed with some iron and covering a large area with different thickness ranging from few centimeters to about one meter. The soil is sandy and not homogenous in many spots and has very low organic matter content. Water table depth does not represent a production problem in many regions. Spring season is relatively short while summer is hot during the day and chilly during the night in most desert areas. There is no sharp difference between summer and fall temperatures or even between fall and most winter temperatures. Frosty might be a problem during some winter nights and beginning of spring especially radiation frost.

Rain is not heavy, sparse and concentrated only during a short duration by the end of December and January. On mild slopes, the root system of many trees does not get sufficient leaching of salts due to the quick runoff of rain. Thus, more salt solution could accumulate around the feeding roots which causes defoliation during a critical period of growth as occurs with "Valencia" orange trees. Spring is usually mild in temperature. However, the trees experience high temperature early in summer which causes many fruit disorders such as sunscald, sunburn, fruit splitting or cracking especially with calcium deficiency as occurs with oranges, pomegranates, mandarins, guava and apricot.[10]

Heat stress during early summer also causes some physiological disorders to differentiated buds of some deciduous fruits such as doubling that is caused by forming double pistils during the heat stress period[10] (Table 1-3). Recently, the formation of sheepnosed fruits of grapefruits and Navelina oranges was reported to be associated with heat stress[11,12] during flower bud initiation and development resulting in an elongated part of the stem end of the ovary. Furthermore, heat stress causes an increased respiration rate of many fruits and the lack to more oxygen in internal tissues which results in internal browning in apricots, peaches and mangoes due to non-aerobic respiration. Furthermore, the drop of relative humidity causes a burst of weak -oil cells in the rind of some mandarins and tangarins especially in large fruits in the southern part of the tree that were more exposed to heat stress. These conditions result in rind pitting and the loss fruit quality at harvest.[13]

On the other hand, activity of pollinating insects is low under such harsh conditions in the field. High temperature kills pollen grains or limits pollen tube germination. This activity is further limited by high-dry wind speed early in spring which increases evapotranspiration during a very critical period of tree growth and increases shriveling, wilting of new leaves and reduce the root's ability to absorb water as occurs with lemon roots when the temperature reaches 37°C or above. In addition, lack of sufficient mature leaves as a source of carbohydrate disturb the balance between source and various sinks which increases the abscission of many flowers, fruits and young leaves[14] (Table 1), (Table 2).

**Table 1** Common abiotic problems or physiological disorders of some fruit trees adopted in Egyptian agriculture

| Fruit species | Introduced or adopted cultivars | Common abiotic problems or physiological disorders |
|---|---|---|
| Peaches | Florida Prince, Florida Sun, Desert Red, Desert Sun, Swelling | 1. Button formation<br>2. Cleft suture<br>3. Endocarp splitting<br>4. Blind wood formation<br>4. Doubling of fruits (especially in Desert Red and Swelling)<br>5. Fruit cracking<br>6. Delayed foliation<br>7. Uneven blossoming<br>8. Flower and postset abscissions |
| Apricots | Canino<br>Amal | 1. Flower bud abscission<br>2. Gummosis<br>3. Lime-induced chlorosis<br>4. Doubling of fruits<br>5. Pit (endocarp) splitting<br>6. Low fruit set<br>7. Blind wood formation |
| Apples | Anna<br>Dorsett Golden | 1. Low fruit set (needs a pollinator such as Dorsett Golden)<br>2. Water core<br>3. Fruit abscission<br>4. Fruit cracking<br>5. Bitter pit<br>6. Blossom end rot<br>7. Sunscald<br>8. Little lateral branching |
| Grapes | Flame Seedless<br>Crimson<br>Red Globe<br>Superior<br>Early Superior | 1. Shot berries formation<br>2. Water berries formation<br>3. Berry shatter<br>4. Poor and nonuniform coloration<br>5. Lime –induced coloration<br>6. Soft spots (due to heat stress) |
| Pomegranates | Wonderful | 1. Fruit cracking and splitting<br>2. Poor coloration<br>3. Sunscald and sunburn<br>4. Chilling injury |

Table Continued

| | | |
|---|---|---|
| Citrus | Navelina<br>Washington Navel<br>Valencia Oranges<br>Cleopatra mandarins<br>Tangerins<br>Eureka lemon<br>Murcott tangerins | 1. Misshapen Navel (only in Washington Navel)<br>2. Fruit abscission<br>3. Sunscald and sunburn<br>4. Fruit cracking or splitting<br>5. Rind creasing<br>6. Granulation<br>7. Regreening (In Valencia)<br>8. Late coloration<br>9. Sheepnosing<br>10. Nonfruiting in heavy- limed soil<br>11. Rind pitting |
| Olives | Manzanillo<br>Licchino<br>Koraniki<br>Coratina<br>Frantoio | 1. Pit (endocarp) splitting<br>2. Shot berries formation<br>3. Non-uniform ripening<br>4. Low fruit set<br>5. Chilling injury<br>6. Fruit shriveling.<br>7. Monkey-face formation on fruits from boron deficiency<br>8. Soft nose of fruit |
| Mangoes | Kate<br>Kent<br>Langra Panaris<br>Siddique<br>Taymour<br>Zebda | 1. Sunburn & sunscald<br>2. Fruit abscission<br>3. Dichogamy (protogenous)<br>4. Internal Browning<br>4. Jelly pulp formation<br>5. Stem end breakdown<br>6. Frost and chilling injuries |
| Cherimoya | Abdel Razek | 1. Mummy fruits<br>2. Low fruit set<br>3. Late defoliation<br>4. Sunscald<br>5. Non-uniformity of fruit shape<br>6. Dichogamy |
| Figs | Kadota<br>Brown Turkey<br>Conadria<br>Sultani | 1. Irregular ripening<br>2. Cracking and splitting<br>3. Ostiole-end cracking<br>4. Hail and wind damage |

**Table 2** Brief explanation of cause (s) of abiotic problems or physiological disorders mentioned in the above table

| Physiological disorder or problem | Possible Cause (S) |
|---|---|
| 1. Button Formation | Embry Abortion due to frost, excessive GA or boron content |
| 2. Cleft Suture | Excessive carbohydrate partitioning into the fruit due to loss of balance between vegetative and fruit growth. |
| 3. Endocarp Splitting | Irregular irrigation and thinning before the hardening of the endocarp. |
| 4. Doubling of Fruits | Exposure to heat or water stress at the initiation of flower bud differentiation. |
| 5. Fruit Cracking | Loss of cell wall elasticity due to exposure to heat stress plus water stress and calcium deficiency. |
| 6. Delayed Foliation | Need of more chilling hours to satisfy the need of vegetative buds. |
| 7. Uneven Blossoming | High ABA content in bud scales due to late leaf abscission by the end of the season. |
| 8. Flower and Post-set Abscission | Salt stress, high GA and boron content, low leaching, heat and low temperature stresses, blocking of the xylem tissues by nematodes, Inter-competition among sinks. |
| 9. Flower Bud Abscission | Water stress, high leaf vigor during flower bud differentiation which formed a vascular connection with the bearing shoot. |

Table Continued

| | |
|---|---|
| 10. Gummosis | High water table level, tissue wounding in trees of stone fruits. |
| 11. Lime-induced Chlorosis | Unavailable iron due to high lime content. |
| 12. Low Fruit Set | Excessive boron or GA content. |
| 13. Blind Wood Formation | Exposure to chilling or frost stresses after fruit set or desiccation of differentiated flower buds. |
| 14. Embryo Abortion | ExIncread posure to chilling or freezing stress, excess GA or Boron. |
| 15.Water Core | Exposure to heat stress by the outer part of the fruit tissue and formation water gradient activity leading to accumulation of sorbitol-rich solutes at the fruit core |
| 16. Bitter Pit | Calcium deficiency at the styler end of the fruit. |
| 17. Blossom End Rot | Calcium deficiency in fruit tissues. |
| 18. Rind Creasing | Loose, not compact, Albedo cells or thin rind with low vigor. |
| 19. Granulation | Not exactly defined by associated with low fruit load and larger fruit size. |
| 20. Sunscald and Sunburn | Exposure to heat stress. |
| 21. Sheepnosing | Exposure of stigma to heat stress. |
| 22. Misshapen Navel | Increased carbohydrate Partitioning into the fruit at the early stage of cell enlargement in navel oranges. |
| 23. Rind Pitting | Burst of weak oil cells in the rind, drop of relative humidity, lack of potassium. |
| 24. Regreening | High nitrogen content, increased temperature of the bearing branch, Late harvest. |
| 25. Non-fruiting of adult trees | Excessive GA content, High soil pH. |
| 26. Low- Lateral Branching | The presence of calcium carbonate layer as a hard pan around the root system, correlative inhibition due to unbalanced ratio between auxins and cytokinins. |
| 27. Shot Berries in Grape | Deficiency of zinc or boron. |
| 28. Shot Berries in Olive | Lack of cross pollination, rain fall during pollination, formation of a thin oily layer on the stigma resulting from spraying some pesticides. |
| 29. Pit browning | Insufficient oxygen in the internal tissues next to the pit which results in non-aerobic respiration and the formation of ethanol and acetaldehyde. |
| 30. Monkey Face Formation | Boron deficiency in olives |
| 31. Flesh Pitting | Burst of oil glands in the rind, or exposure to chilling stress. |
| 32. Soft Nose of Olives | Possibly due to mineral fertilization from ammonium sources or some organic fertilizers. |
| 33. Olive Fruit Shriveling | Water loss due to heat stress. |
| 34. Water Berries in Grape | Over-cropping or blocking of the vascular system with Tylosis. |
| 35. Berry Shatter | Water or salt stress, compact cluster, mishandling of the cluster laterals, loss of the epicuticular waxes. |
| 36. Poor Coloration of Grapes | Slight difference between day and night temperatures, direct exposure to sun light, low partitioning of carbohydrates from the leaves to berries, potassium deficiency. |
| 37. Soft spots in Grape Berries | Exposure to heat stress. |
| 38. Necrosis of leaf Margins while the of the blade is green | Salt stress |

The data in Table 4 indicated to the change occurring between 1992 and 2012 expressed as percent increase or reduction relative to 1992 data in three main parameters, mainly the harvested area, yield per hectare, and total production. It was shown that there has been a reduction in apple harvested area over the twenty years period[15] (it was shown by who?? Can you mention the reference source please? However, there was a remarkable increase in the other fruit crops with a maximum increase in olive harvested area (153.72%) followed by apricots (109.61%). Many growers and producers were enthusiastic about producing high- quality apples with limited chilling requirements since the cultivated apple varieties were local with poor quality. Growing "Anna" apples in arid areas in the desert faced many problems such as lack of pollinator, limited vegetative growth due to stressful conditions especially the increase of calcium carbonates and the formation of caliche. On the other hand, there is an increasing demand on olives especially for oil production. Many new olive cultivars have been productive with normal cultural practices especially some Greek and Spanish ones (Personal Experience) (reference).

With regard to productivity, expressed as the yield per hectare, the data in Table 3 indicated that all the above mentioned fruits have been increasing in productivity. The highest increase was achieved in olive productivity followed by apples while the lowest one was found with apricots. Olive tree growers focused on regulating flowering and increasing fruit set especially by using pure urea spray and by using some growth regulators during full bloom such as putrescine and auxins. They also met the requirement of the olive tree of some micronutrients especially boron that enhances fruit set and ovule longevity when sufficient in the tree. Apricot trees, on the other hand, suffer from some physiological problems such as the formation of the blind wood, bud abscission and doubling of fruits due to heat and water stresses during flower bud differentiation. Trends of total production in 2012 as compared with 1992 indicated that there was a marked increase in all studied fruits. Again, the highest increase in total production was found with olives where it increased about four times followed by the production of banana then peaches and nectarines. Meanwhile, the lowest increase was obtained with fig production.

The data in Table 5 show a comparison between area harvested, yield, and production of main citrus species grown in Egypt between 1992 and 2012. The data revealed that there was a marked increase in citrus harvested area in all species except lemons and limes. The greatest increase in harvested area was in grapefruit followed by the tangerines.

However, there was a remarkable reduction in the yield per hectare of minor citrus estimated by 28.91% and in grapefruit productivity by 10.72%. Meanwhile, there was a large increase in orange productivity by 30.62% over the twenty-year period, while in various tangerines such increase was estimated to be 98.36% from 1992 to 2012. With regard to production in tones, the data in Table 5 showed that there was a drastic increase in citrus production from 1992 to 2012 except with lemon and limes since their production was reduced by 2.70%. The greatest increase in production was achieved in tangerines production by 159.84% followed the minor citrus production increase by 106.40%, then grapefruits that increased by 98.68% over the twenty years.

**Table 3** Changes over twenty years in harvested area, yield per hectare and produced quantity in Egypt of major fruit crops that have been expanded cultivation in the desert areas

| Fruit Species | Years | Area harvested (H) | Yield (Hg/Ha) | Production quantity (Tonnes) |
|---|---|---|---|---|
| Apple | 2012 | 21145 | 255965 | 541239 |
| | 1992 | 23158 | 112616 | 260797 |
| Apricot | 2012 | 6127 | 161208 | 98772 |
| | 1992 | 2923 | 153380 | 44833 |
| Banana | 2012 | 25073 | 450595 | 1129777 |
| | 1992 | 14218 | 278870 | 396497 |
| Date Palm | 2012 | 42500 | 345882 | 1470000 |
| | 1992 | 27450 | 219910 | 603652 |
| Grapes | 2012 | 66262 | 208085 | 1378815 |
| | 1992 | 57921 | 113614 | 658061 |
| Olives | 2012 | 57551 | 97838 | 563070 |
| | 1992 | 22683 | 41878 | 94991 |
| Oranges | 2012 | 118731 | 234682 | 2786397 |
| | 1992 | 98596 | 179668 | 1771457 |
| Peaches and nectarines | 2012 | 26611 | 107171 | 285194 |
| | 1992 | 16800 | 62500 | 105000 |
| Figs | 2012 | 28716 | 87169 | 171062 |
| | 1992 | 17595 | 59570 | 153373 |

Source: FAO Stat. 2014

**Table 4** Percentage changes in the harvested area, yield per hectare, and the total production of the same data shown in Table 2 when comparing 1992 and 2012 values

| Fruit species | % Change in harvested Area | % change in yield/hectare | % change in production |
|---|---|---|---|
| Apple | -8.69 | 127.29 | 107.53 |
| Apricot | 109.61 | 5.10 | 120.31 |
| Banana | 76.34 | 61.58 | 184.94 |
| Date Palm | 54.83 | 57.28 | 143.52 |
| Grapes | 14.40 | 83.15 | 109.53 |
| Olives | 153.72 | 133.63 | 492.76 |
| Oranges | 20.42 | 30.62 | 57.29 |
| Peaches & Nectarines | 58.40 | 71.47 | 171.61 |
| Figs | 63.21 | 31.66 | 11.53 |

**Table 5** Changes in major- citrus species grown in Egypt, over twenty- year period, in harvested area, yield and production

| Citrus 2012 | Area harvested (Ha) |
|---|---|
| Fruit, Citrus* | 421 |
| Grapefruit (inc. pomelos) | 158 |
| Lemons and limes | 13769 |
| Oranges | 118731 |
| Tangerines, mandarins, clementines, satsumas | 42060 |
| **Citrus 1992** | **Area harvested (Ha)** |
| Fruit, Citrus* | 145 |
| Grapefruit (inc. pomelos) | 71 |
| Lemons and limes | 17047 |
| Oranges | 98596 |
| Tangerines, mandarins, clementines, satsumas | 32109 |
| **Citrus 2012** | **Yield (Hg/Ha)** |
| Fruit, Citrus* | 122565 |
| Grapefruit (inc. pomelos) | 171013 |
| Lemons and limes | 218263 |
| Oranges | 234682 |
| Tangerines, mandarins, clementines, satsumas | 210500 |
| **Citrus 1992** | **Yield (Hg/Ha)** |
| Fruit, Citrus* | 172414 |
| Grapefruit (inc. pomelos) | 191549 |
| Lemons and limes | 181188 |
| Oranges | 179668 |
| Tangerines, mandarins, clementines, satsumas | 106118 |
| **Citrus 2012** | **Production (tonnes)** |
| Fruit, Citrus* | 5160 |
| Grapefruit (inc. pomelos) | 2702 |
| Lemons and limes | 300527 |
| Oranges | 2786397 |
| Tangerines, mandarins, clementines, satsumas | 885365 |
| **Citrus 1992** | **Production (tonnes)** |
| Fruit, Citrus* | 2500 |
| Grapefruit (inc. pomelos) | 1360 |
| Lemons and limes | 308871 |
| Oranges | 1771457 |
| Tangerines, mandarins, clementines, satsumas | 340733 |

Source: FAO statistics, 2014.

*Citrus Fruit Including inter alia: bergamot (Citrus bergamia); citron (C. medica var. cedrata); chinotto (C. myrtifolia); kumquat (Fortunella japonica). Some minor varieties of citrus are used primarily in the preparation of perfumes and soft drinks.

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## Conflict of interest

The author declares no conflict of interest.

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