Numerical and Economic Evaluation of Some Papaya Genotypes Trees Grown In Qalyubia Region

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ABSTRACT

The study was undertaken to assess the genetic diversity on the basis of morphological and physiological characterization among 8 papaya genotypes in Qalyubia Governorate, Egypt during three successively seasons (2017, 2018 and 2019). Morphological, physiological and agronomical traits were studied across 8 papaya genotypes to characterize the genetic assessment which includes the following aspects: breeding method, sex form, special characteristics and fruit shape and size, plant height (cm), stem girth (cm), average No. leaves/plant, leaf length and diameter (cm), days from planting to first flowering, days from planting to first fruiting, days from planting to first harvest, number of fruits /tree, fruit weight (kg), yield (kg/tree), physical properties i.e. fruit length and diameter (cm) and fruit dimensions (fruit length/fruit diameter), fresh and dry weights (g) of papaya seed, chemical characteristics (SSC, vitamin C, papain enzyme, total, reducing and non-reducing sugars (%), study showed significant variation among all the genotypes in morphological and physiological traits. The obtained results showed that the availability of the selected papaya genotypes (G4 and G8) made it possible to study the influence of genotypes characteristics on the morphological, fruiting, yield, characteristics of fruits physical and chemical. Genetic diversity studies of available papaya genotypes are necessary to facilitate unambiguous identification of the various germplasms and their protection, and in turn can be provide to farmers and breeders to further improve auspicious papaya that could have a positive effect on the local economy.

Keywords: Carica papaya, evaluation, morphological, attributes genotypes, economy.

Introduction

Papaya, is an evergreen plant small semi-woody trees that considered the best known member of the family Caricaceae (Papaya Carica L.), which native to tropical and semi-tropical regions of both South America and Africa. The Caricaceae family plants belong to 3 genera in South America (Carica, Jasilla, Jacria) and one genera in Africa (Cyclicomorpha) (Sharon et al., 1992; Badillo, 1993, Nakasone and Poull, 1998). Papayas normally grow as single-stemmed trees with a crown of large palmate leaves emerging from the apex of the trunk (Villegas 1997). Papaya flowers are born on inflorescences which appear in the axils of the leaves. Female flowers are held close against the stem as a single flower or in clusters of 2-3 (Chay-Prove et al., 2000). Male flowers are smaller and more numerous and are born on 60-90 cm long pendulous inflorescences. Hermaphrodite flowers are intermediate between the two unisexual forms (Nakasone & Poull 1998). The functional gender of flowers can be altered or reversed, depending on environmental conditions, particularly temperature. Fruit are ready to harvest five six months after flowering. Fruit from female trees are spherical, whereas the shape of fruit from bisexual trees is affected by environmental factors, particularly temperature that modifies floral morphology during early development of the inflorescence (Nakasone & Poull 1998). Dioecious varieties are generally recommended because they have high fruit yield and relatively predictable fruit shape (Drew et al., 1998; Chay-Prove et al., 2000). Economically, Papaya (Carica papaya L) is the most important economic species of this family (Caricaceae) being cultivated widely for consumption as a fresh fruit and use as drinks, jams, jellies, ice-cream, pies and crystalloid fruits (Tawfik, 2007). Papaya fruit is known with its high content of vitamins A and C, and is a good source of calcium. An average of 100g of ripe papaya contains 950 I.U. of Vitamin A and 60.9mg of vitamin C (ascorbic acid). Biochemically, its leaves and fruit are complex, producing several proteins and alkaloids that have important pharmaceutical and industrial applications (El Moussaouii et al., 2001). Globally, Asia is the leading papaya producer continent with 56.27% of the
global production, followed by America (33.12%) and Africa with 10.50% production (FAOSTAT, 2018). In addition, papain is a particularly important proteolytic enzyme that is produced in the milky latex of green, unripe papaya fruits. Commercially, however, papain has varied industrial uses in the beverage, food and pharmaceutical industries including in the production of chewing gums, chill-proofing beer, tenderizing meat. Papain has also been used in the textiles industry, for degumming silk and for softening wool and in the cosmetics industry, in soaps and shampoo (Villegas 1997). Drugs have reparations for various digestive ailments, digestion for helping some people in replacing papain enzymes to the role of pepsin in the stomach and the treatment of gangrenous wounds (Galila, 1995 and Tawfik, 2007). Papaya is considered one of the most promising fruit crops, which their importance concentrated in the easy way to propagate. It ranks the second rank after banana in tropical and sub-tropical regions. It is also, available for fruiting all around the year, and after one year from cultivation (Tawfik, 2005 and Ming et al., 2008). Papaya fruit production in Egypt also relies on imported varieties and farmers’ selected seeds whose quality is not known. So that, we seek little attempts have been made to develop papaya with superior quality attributes and that are adapted locally, with divergent morpho-agronomic traits.

Therefore, the objectives of this study were to evaluate the morphological, physiological and quality characteristics of the fruits of the newly predictable papaya genotypes.

Materials and Methods

The present study was carried out in the three successive seasons of 2017, 2018 and 2019 at a private orchard in Tant Al Jazirah village, Tukh (Qalyubia Governorate) where papaya genotypes are planted. An eight predictable papaya genotypes were been select to evaluate morphological, physiological and agronomical characteristics. Standard recommended agronomic practices were followed for cultivate the crop. The field trials were carried out in randomized complete block design. The sampling plants for this study was selected as an elegant seedling plants in a farm located in Qalyubia governorate near Cairo to evaluate eight fruited local plants of papaya “Carica papaya L”.

A) Morphological characterization

The morphological and agronomical attributes like breeding method, sex form; special characteristics, fruit shape and size per plant were detected. Days to first flowering, days to first fruiting, days to first harvest, number of fruits per tree were measured. Papaya fruits were obtained from orchard and also samples of both leaves and inflorescences were taken to the laboratory of the Horticulture Research Institute to determine their morphological aspects during the seasons of the study; full matured fruits were picked to determine their physical and chemical aspects through both of 2017, 2018and 2019 seasons as follows:

B) Vegetative growth and flowering properties

Monitoring on different of the vegetative growth characteristics like plant height, stem girth of the tested genotypes were recorded also average No. leaves/plant, leaf length and diameter (cm).

C) Fruiting and yield

At harvest time, total fruit number/tree; fruit weight (g) were recorded and average total yield/tree were calculated as kg/tree.

D) Fruit quality

1- Physical aspects of fruits were determined as the fruit length and diameter (cm) and fruit shape index (fruit length/fruit diameter), fresh and dry weights (g) of seed papaya were measured.

2- Chemical properties of papaya fruit: Soluble solids content percentage (S.S.C. %) was determined by using hand refractometer according to A.O.A.C. (1995)

- Total sugars (%); reducing sugars and non-reducing sugars were determined according to the methods described by (Dubois et al., 1956).

-Vitamin (C) as (mg) Ascorbic acid /100 ml. in juice was determined according to A.O.A.C. (1995).
The plant papain enzyme material:
Preparation of papaya fruit pulp.

The extraction of papaya fruit pro tease was carried out according to the method described by (Nitsawang et al., 2006).

General evaluation of the eight papaya genotypes under Qalyubia Governorate conditions

Evaluation of the tested papaya genotypes were calculated on the basis of 100 units which were divided among the various fruit properties according to (Hamed, 2012) with simple modification as follows: 30 units for the yield/plant, 10 units for fruit weight, 10 units for number of fruits/tree, 5 units for each fruit length, diameter and seed weight, 10 units for each SSC and vitamin content and 15 units for total sugar content. Each papaya genotype that gave the best results in any character was given the full mark specified for this character, while each of the other tested papaya genotypes took lower units to their qualities. Economic evaluation of some papaya genotypes as average during three experimental seasons was detected.

Statistical analysis

The obtained data were statistically analyzed using the analysis of variance method according to Snedecor and Cochran (1980). Meanwhile, differences between means of treatments were compared using Duncan’s multiple range tested at probability of 0.05 levels as reported by (Duncan, 1955) during the three seasons of study.

Results and Discussion

Eight papaya genotypes were collected and used for the present experiment. The morphological parameters of the tested genotypes are elaborated in (Table1). The results of the present study revealed variations among papaya genotypes (Papaya Carica L.) in their morphological and the traits which can be used widely in evaluating the separate genotypes of papaya, this results agree with Morshidi, (1996) who stated that the wild population having greater diversity than domesticated populations which includes the following aspects:

| Papaya genotypes | Breeding Method | Sex form | Special characteristics | Fruit shape and size |
|------------------|----------------|----------|-------------------------|---------------------|
| Papaya G1        | Selection      | Dioecious | Small fruit size        | Small Oval          |
| Papaya G2        | Selection      | Dioecious | Big fruit size          | Large Oval          |
| Papaya G3        | Selection      | Dioecious | Small fruit size        | Oval by a bit neck  |
| Papaya G4        | Selection      | Dioecious | Greenish striped fruit when reached ripening. | Spherical to neck |
| Papaya G5        | Selection      | Dioecious | Almost dwarf, orange flesh color, fruit High Papin Enzyme, High sugar flesh | Large Oval |
| Papaya G6        | Selection      | Dioecious | Late repining fruits. | Large Oval |
| Papaya G7        | Selection      | Dioecious | Very sensitive fruit to handling and decayed | Slight Elongated Oval |
| Papaya G8        | Selection      | Dioecious | High sugar flesh, starching smooth yellow skin | Oval to Round |

1- Vegetative measurements of papaya genotype:

Plant height (cm)

Results represented in Table (2) illustrated the plant height (cm) of the studied genotypes, the highest significantly values (295 to 306 cm) were obtained from papaya G4, and G8, followed by papaya G5 and G3 (268 to 282 cm) and (270 to 280 cm) in three seasons of study. On the contrary, the lowest significant values (230 to 244 cm) were resulted from the papaya G1. The other genotypes gave intermediate results among genotypes, in three seasons respectively.

Stem girth (cm)

The results in Table (2) indicated that, papaya G4 gave the thicker stem (19.50, 20.25 and 20.60 cm) followed by papaya G8 (19.15, 19.90 and 20.40 cm) without significant differences in three
seasons. In the contrary, G2 and G1 gave lower values (10.50, 10.80 and 10.65 cm) and (11.5, 11.75 and 11.90 cm) during the three seasons. The rest of papaya genotypes were intermediate between the highest and lowest limited during all three seasons of the experiment under study. These results are matched with Morton, (1987). Stem diameters of adult plants were varied from 10 to 30 cm at the base to 5–10 cm at the crown. The lower internodes are compact and wider and seem to mechanically support the entire weight of the plant.

**Average No. leaves/plant**

Concerning the average number of leaves/plant, results in Table (2) cleared that, the maximum average number of leaves/plant came from papaya genotypes which gave the highest significant values, papaya G8 (30.00, 32.00 and 33.00 leaves/plant) followed by papaya G5 (31.00, 31.00 and 32.00 leaves/plant) in the three seasons. On reverse from that, average No. of leaves/plant was obtained by G4 (29.00) in the first season 2017 and (31.00 and 32.00 leaves/plant) in 2018 and 2019 seasons respectively, followed by the papaya G3 (27.00, 29.00 and 30.00 leaves/plant) during the three seasons of the study. On the other hand, papaya G7 recorded 21.00, 21.00 and 23.00 leaves/plant in the three seasons, respectively. The other genotypes gave intermediate results.

**Table 2: Some vegetative growth properties of papaya genotypes used for the trial in the three seasons (2017, 2018 and 2019).**

| Papaya genotypes | Plant height (cm) | Stem girth (cm) | Average No. leaves/plant |
|------------------|------------------|----------------|-------------------------|
|                  | 2017             | 2018           | 2019                    | 2017           | 2018           | 2019          |
| Papaya G1        | 230.0E           | 235.0D         | 244.0G                  | 11.50E         | 11.75E         | 11.90E        | 23.00F        | 24.00E         | 27.00F         |
| Papaya G2        | 240.0D           | 250.0C         | 257.0E                  | 10.50F         | 10.80F         | 10.65F        | 22.00G        | 25.00D         | 28.00E         |
| Papaya G3        | 270.0B           | 275.0B         | 280.0D                  | 12.75D         | 12.95D         | 12.80D        | 27.00D        | 29.00C         | 30.00D         |
| Papaya G4        | 295.0A           | 300.0A         | 306.0A                  | 19.50AB        | 20.25A         | 20.60A        | 29.00C        | 31.00B         | 32.00B         |
| Papaya G5        | 268.0C           | 275.0B         | 282C                    | 14.35C         | 14.70C         | 14.95C        | 31.00A        | 31.00B         | 32.00B         |
| Papaya G6        | 242.0D           | 250.0C         | 256.0F                  | 16.50B         | 16.70B         | 16.90B        | 24.00E        | 24.00E         | 25.00G         |
| Papaya G7        | 250.0E           | 275.0B         | 282C                    | 19.15A         | 19.90AB        | 20.40AB       | 30.00B        | 32.00A         | 33.00A         |
| Papaya G8        | 295.0A           | 300.0A         | 303.0B                  | 19.15A         | 19.90AB        | 20.40AB       | 30.00B        | 32.00A         | 33.00A         |

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

**Leaf length and diameter (cm)**

Results presented in Table (3) indicated that, the maximum values of leaf length and diameter (cm) were obtained from papaya G4 (58.35, 60.00 and 63.00 cm) and (53.20, 55.50 and 56.00 cm), followed by papaya G6 (55.00, 58.00 and 60.00cm) and (49.00, 50 and 52.80 cm), respectively where it was individual the second rank during the three seasons (2017, 2018 and 2019), respectively for the two parameters in this respect.

**Table 3: Some vegetative growth properties of papaya genotypes used for the trial in the three seasons (2017, 2018 and 2019).**

| Papaya genotypes | Leaf length (cm) | Leaf diameter (cm) |
|------------------|------------------|--------------------|
|                  | 2017             | 2018               | 2019               | 2017           | 2018           | 2019           |
| Papaya G1        | 44.75F           | 46.00G             | 49.2E              | 34.30G         | 35.00G         | 36.60G         |
| Papaya G2        | 50.30E           | 52.00E             | 55.00D             | 40.00D         | 42.20D         | 43.50D         |
| Papaya G3        | 42.65G           | 45.00H             | 46.70F             | 37.00F         | 38.50F         | 40.35F         |
| Papaya G4        | 53.45C           | 56.00C             | 58.00C             | 44.00C         | 45.10C         | 47.40C         |
| Papaya G5        | 45.30F           | 47.00F             | 47.00F             | 24.25H         | 25.50H         | 28.40H         |
| Papaya G6        | 52.00D           | 53.00D             | 55.1D              | 38.10E         | 40.60E         | 43.00E         |
| Papaya G7        | 55.00B           | 58.00B             | 60.00B             | 49.00B         | 50.00B         | 52.8B          |

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.
However, papaya G3 and G6 gave the lowest leaf length and diameter (42.65, 45.00 and 46.7 cm) and (24.25, 25.50 and 28.40 cm) in the three seasons of study. The other genotypes gave intermediate results between the genotypes.

These results are in line with Ocampo et al., (2006) and Aikpokpodion, (2012), who indicated that papaya shows a wide variation in many traits including fruits, plant stature and leaf characteristics since some of which are exploited in the development of commercial papaya cultivars.

Flowering properties (days from planting to first flower, fruiting and harvest)

Results illustrated in Table (4) showed that days from planting to the 1st flowering required between 93 to 112 days since the longest time for flowering (112 days) was recorded with papaya G7. While the shortest one (93 days) was obtained with papaya G4. The others tested genotypes were intermediate in this concern. Also days from planting to the first harvesting took the same trend of the two previous parameters in this study.

These results are in harmony with those of Ronse Decraene and Smets (1999), Fisher, (1980) and Sritakae et al., (2011) on papaya where the female papaya flowers have five free petals and a rounded superior ovary that is five carpels, hollow and exhibits parietal placentation.

| Papaya genotypes | Days from planting to first flowering | Days from planting to first fruiting | Days from planting to first harvest |
|------------------|-------------------------------------|-------------------------------------|-----------------------------------|
| Papaya G1        | 101                                 | 134                                 | 235                               |
| Papaya G2        | 105                                 | 139                                 | 244                               |
| Papaya G3        | 107                                 | 142                                 | 249                               |
| Papaya G4        | 93                                  | 123                                 | 215                               |
| Papaya G5        | 99                                  | 135                                 | 234                               |
| Papaya G6        | 107                                 | 142                                 | 249                               |
| Papaya G7        | 112                                 | 142                                 | 254                               |
| Papaya G8        | 94                                  | 124                                 | 218                               |

Fruiting and yield

Fruits number/tree

Results presented in Table (5) showed that, the maximum values of fruits number/tree (51.00, 54.00 and 56 fruits/tree) were obtained with the papaya G4 in the first, second and third seasons of the study, followed by papaya G8 (51.00, 52.00 and 54 fruits/tree) with significant differences during the three studied seasons. On the contrary, papaya G6 gave the lowest significant values in this regard (18, 19 and 20 fruits/tree) during the three tested seasons, respectively.

Fruit weight (kg)

Results presented in Table (5) cleared that the comparison and evaluating of the eight papaya selected trees in the first, second and the third seasons of the study revealed that papaya G8 carried the highest fruit weight (1.79, 1.80 and 1.83 kg/tree), followed by G4 with average fruit weight of 1.75, 1.77 and 1.79 kg/tree, respectively. Meanwhile, the lowest average fruit weight was obtained by the trees of papaya G3 (1.00, 1.02 and 1.06) during the first, second and the third season, respectively.

The result of the papaya genotypes yield is shown in Table (5), there were significant differences between all genotypes in the three seasons of the study. The highest yield of papaya trees in 2017, 2018 and 2019 were associated with G8 and G4 (91.29, 95.58 and 100.2 kg/ tree) during 2017 and 2018 and 2019 seasons, respectively. Whereas, genotype number G3 recorded 22.90, 25.50 and 25.44 kg/tree and genotype number G6 gave 27.00, 28.43 and 30.02 kg, as the lowest yield/tree during the three seasons, respectively. The other papaya genotypes gave results in between.

These results are in agreement with those found by Yadava et al., (1990), Imungi and Wabule 1990; Abd El-Kareem (1996), OECD, 2005; Chan and Paull 2008; Nakasone and Paull, 1998; Das, 2013; Yogiraj et al., 2014; Ayele et al., (2017) who revealed that the fruit weight was varied substantially and ranged from 0.2 to 12 kg depending on the environment and variety.
Table 5: Fruits number/tree, fruit weight (g) and yield of some papaya genotypes evaluated during three seasons (2017, 2018 and 2019).

| Papaya genotypes | 2017       | 2018       | 2019       | 2017       | 2018       | 2019       | 2017       | 2018       | 2019       |
|------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Papaya G1        | 33.00C     | 34.00E     | 36.00D     | 1.25DE     | 1.23EF     | 1.22D      | 41.25D     | 41.81D     | 43.94D     |
| Papaya G2        | 33.00C     | 35.00D     | 36.00D     | 1.24DE     | 1.20F      | 1.25D      | 40.96D     | 42.00D     | 45.03D     |
| Papaya G3        | 23.00E     | 25.00G     | 24.00F     | 1.00F      | 1.02G      | 1.06E      | 22.97G     | 25.50G     | 25.44G     |
| Papaya G4        | 51.00A     | 54.00A     | 56.00A     | 1.75A      | 1.77A      | 1.79AB     | 89.25B     | 95.58A     | 100.2A     |
| Papaya G5        | 38.00B     | 40.00C     | 41.00C     | 1.20E      | 1.33D      | 1.25D      | 45.60C     | 53.20C     | 51.25C     |
| Papaya G6        | 18.00F     | 19.00H     | 20.00G     | 1.50C      | 1.49C      | 1.50C      | 27.00F     | 28.34F     | 30.02F     |
| Papaya G7        | 25.00D     | 26.00F     | 28.00E     | 1.27D      | 1.25E      | 1.27D      | 31.78E     | 32.50E     | 35.56E     |
| Papaya G8        | 51.00A     | 52.00B     | 54.00B     | 1.79A      | 1.80A      | 1.83A      | 91.29A     | 93.60B     | 98.82B     |

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Physical Characteristics

Fruit length and diameter (cm) and fruit shape index (fruit length/fruit diameter)

Results presented in Table (6) showed the comparison between fruit length of the eight selected papaya genotypes and revealed that, the fruits of papaya G8 and G4 had the longest fruit (23.07, 24.50 and 25.25) and (2.32, 23.40 and 23.90 cm), respectively. While papaya G1 had the shortest fruit (18.35, 18.83 and 19.25 cm), respectively.

Concerning the fruit diameter for the eight selected papaya genotypes, it was found that papaya G4 had the highest significant values of fruit diameter (14.90, 15.20 and 15.60 cm), followed by papaya G8 (14.90, 14.78 and 14.93 cm) during the three tested season of study. On the contrary, papaya G7 and (6) had the lowest fruit width (12.33, 12.65 and 12.91 cm) and (12.71, 12.89 and 13.35 cm) respectively.

Results concerning fruit shape index (fruit length/fruit diameter) Table (6) showed that, the papaya G4 were the highest significant values (1.663, 1.733 and 1.716 cm) followed by papaya G8 and G7. On reverse, the papaya G3 gave the lowest significant values of fruit shape index (1.309, 1.299 and 1.301 cm) in this respect during the three seasons of the study. The other papaya genotypes gave intermediate results between the genotypes.

Table 6: Fruit length; diameter (cm) and fruit shape index (cm) of some papaya genotypes evaluated during three seasons (2017, 2018 and 2019).

| Papaya genotypes | 2017       | 2018       | 2019       | 2017       | 2018       | 2019       | 2017       | 2018       | 2019       |
|------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Papaya G1        | 18.35F     | 18.83F     | 19.25E     | 12.63F     | 12.93E     | 13.61D     | 1.453D     | 1.456F     | 1.529D     |
| Papaya G2        | 20.38C     | 20.33D     | 20.81C     | 12.88DE    | 13.21D     | 13.55D     | 1.582BC    | 1.539E     | 1.536D     |
| Papaya G3        | 19.50E     | 19.75E     | 20.29D     | 14.90A     | 15.20A     | 15.60A     | 1.309E     | 1.299G     | 1.301F     |
| Papaya G4        | 22.32B     | 23.40B     | 23.90B     | 13.42C     | 13.50C     | 13.93C     | 1.663A     | 1.733A     | 1.716A     |
| Papaya G5        | 20.40C     | 20.32D     | 20.83C     | 13.00D     | 13.13D     | 13.54D     | 1.569C     | 1.548E     | 1.538D     |
| Papaya G6        | 20.21CD    | 20.46D     | 20.81C     | 12.71EF    | 12.89E     | 13.35E     | 1.590BC    | 1.587D     | 1.442E     |
| Papaya G7        | 20.13D     | 20.75C     | 20.76C     | 12.33G     | 12.65F     | 12.91F     | 1.633AB    | 1.640C     | 1.608C     |
| Papaya G8        | 23.07A     | 24.50A     | 25.25A     | 14.49B     | 14.78B     | 14.93B     | 1.592BC    | 1.658B     | 1.691B     |

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Fresh and dry weights of papaya genotypes seeds

Results presented in Table (7) declared that the heaviest fresh and dry seeds were obtained from papaya G8 (135.3, 145.1 and 140.7 g) and (15.17, 15.25 and 15.52 g), while the second rank was papaya G6 (116.6, 123.2 and 119.6g) and (13.00, 13.97 and 13.71 g) during the three seasons, respectively. Meanwhile, papaya G3 gave the lowest fresh and dry weights of papaya seeds (81.71,
89.95 and 86.31g) and (11.68, 12.62 and 12.83g) during the three studied seasons respectively (2017, 2018 and 2019). The other papaya genotypes gave results in between papaya genotypes.

These results are in agreement with those found by Nakasone et al., (1973), Shah and Shanmugavelu (1975a), Pal et al., (1980), Yadava et al., (1990) and Abd El-Kareem (1996) who concluded that there were significant differences in physical traits among cultivars. In addition, environmental effects on relatively less physical characteristics values were also proved by early findings of Kuhne and Allan (1970), Aziz et al., (1976), Chan (1979), Allan et al., (1987) and Fioravanço et al., (1994).

Table 7: Fresh and dry weights of seeds (g) in some papaya genotypes evaluated during three seasons (2017, 2018 and 2019).

| Papaya genotypes | Fresh seed weight (g.) | Dry seed weight (g.) |
|------------------|------------------------|---------------------|
|                  | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 |
| Papaya G1        | 108.1E | 109.3E | 109.1G | 12.54CD | 12.71EF | 12.88D |
| Papaya G2        | 105.4F | 109.1E | 110.7F | 13.15B | 13.56C | 13.65B |
| Papaya G3        | 81.71H | 89.95G | 86.31H | 11.68E | 12.62F | 12.83D |
| Papaya G4        | 116.6B | 123.2B | 119.6B | 13.00B | 13.97B | 13.71B |
| Papaya G5        | 111.2C | 118.6C | 117.7C | 12.67C | 13.55C | 13.61B |
| Papaya G6        | 89.73G | 91.64F | 111.1E | 12.42CD | 12.96D | 13.15C |
| Papaya G7        | 109.5D | 115.6D | 113.0D | 12.33D | 12.85DE | 13.22C |
| Papaya G8        | 135.3A | 145.1A | 140.7A | 15.17A | 15.25A | 15.52A |

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Fruit chemical characteristic and papain enzyme:

Fruit SSC (%)

From Table (8) it can be noticed that SSC (%) in the studied papaya fruits genotypes ranged from 14.13 % in first season (2017) in papaya G8 and 15.37 % and 15.18 in the second and third seasons of papaya G4 respectively. The other papaya genotypes results were in between.

Table 8: Fruit SSC (%), ascorbic acid (vitamin C) mg/100 juice and papain enzyme of some papaya genotypes evaluated during three seasons (2017, 2018 and 2019).

| Papaya genotypes | SSC (%) | VC mg/100g | Papain enzyme |
|------------------|---------|------------|--------------|
|                  | 2017    | 2018 | 2019 | 2017    | 2018 | 2019 | 2017    | 2018 | 2019 |
| Papaya G1        | 12.68CD | 13.52C | 13.65CD | 15.25D | 15.25D | 15.48E | 68.18G | 70.92H | 72.69G |
| Papaya G2        | 12.78CD | 13.26C | 13.77C | 13.81F | 15.87C | 16.53C | 76.50F | 79.25F | 81.03E |
| Papaya G3        | 13.03C | 13.41C | 13.49D | 10.17H | 10.27G | 10.45H | 86.25C | 89.25C | 79.21F |
| Papaya G4        | 13.36B | 15.18A | 15.37A | 16.08C | 15.40D | 15.97D | 108.7A | 110.3A | 90.90B |
| Papaya G5        | 12.21EF | 12.33D | 12.56E | 16.72B | 16.90B | 19.08B | 76.92F | 78.50G | 80.86E |
| Papaya G6        | 12.48DE | 12.23D | 12.71E | 14.43E | 14.43E | 14.66F | 81.92E | 85.25E | 86.73D |
| Papaya G7        | 12.06F | 12.51D | 12.80E | 13.34G | 13.34F | 13.57G | 82.75D | 86.67D | 87.86C |
| Papaya G8        | 14.13A | 14.29B | 14.48B | 19.32A | 19.41A | 19.55A | 88.75B | 91.75B | 93.40A |

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Vitamin (C mg/100 ml Juice)

Results in Table (8) showed that V.C in the fruits of papaya genotypes under this study recorded the highest significant values (19.32, 19.41 and 19.55 mg/100 ml) for papaya G8 in 2017, 2018 and 2019 seasons, respectively. On the contrary, the lowest values (10.17, 10.27 and 10.45 mg/100 ml) was recorded with papaya G3. The other genotypes results were in between.
Papain Enzyme

Results in Table (8) showed that papain enzyme was the highest in fruits of papaya G4 (108.7, 111.3 and 90.90) as compared with the other tested papaya genotypes. While the standard of papain enzyme was in lowest values (68.18, 70.92 and 72.69) in fruits of papaya G1 this is clear in the tested three seasons respectively, the other studied papaya genotypes were intermediate in this concern.

Total, reducing and non-reducing sugars (%)

The results presented in Table (8) showed that, the highest statistical values of total sugar (%) were in papaya G4 (18.13, 18.21, 18.30 %) followed by papaya G8 (16.37, 16.75 and 17.30 %) during the three seasons of the study, respectively. On reverse, the lowest values (12.89, 12.65 and 12.23 %) were observed with papaya G5 in both three seasons. The other genotypes gave intermediate results between papaya genotypes. Concerning the reducing and non-reducing sugars, the highest significant values were obtained from papaya G2 (13.24, 12.99, 13.93 %) and (7.87, 7.76 and 7.72 %), during the three seasons, respectively. The lowest value of reducing sugars and non-reducing sugars (%) was associated with papaya G5 (12.89, 12.65 and 12.23%) and (1.80, 1.85 and 1.33 %) in the three seasons of the study, respectively. The other papaya genotype results came in between during the three seasons.

These results are in agreement with those found by Nakasone et al., (1973), Shah and Shanmugavelu (1975b), Madrigal et al., (1980), Pal et al., (1980) and Abd El-Kareem (1996) where significant differences were found among cultivars. In addition, environmental effects on relatively less chemical constituent values were also shown by early findings of Kuhne and Allan (1970), Aziz et al., (1976) and Fioravanço et al., (1994).

In conclusion, due to the different genetic constitution there are remaining some morphological differences among the papaya genotypes. The shape and size of fruit will vary with sex forms i.e. female that will be round and ovular fruits are found in hermaphrodite plant. The present search provides the guidelines for the selection of parents based on agronomic traits with special reference to qualitative features for papaya improvement program.

Table 9: Total sugars, reducing-sugars and non-reducing sugars (%) of some papaya genotypes evaluated during three seasons (2017, 2018 and 2019).

| Papaya genotypes | Total sugars (%) | Reducing sugars % | Non-reducing sugars (%) |
|------------------|------------------|-------------------|-------------------------|
|                  | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 |
| Papaya G1        | 13.88D | 14.10F | 14.15E | 11.13C | 10.95D | 11.05D | 2.75E | 3.15E | 3.10E |
| Papaya G2        | 15.56C | 15.52D | 15.63D | 13.24A | 12.99A | 13.93A | 2.32F | 2.53F | 1.70H |
| Papaya G3        | 15.71C | 16.30C | 16.52C | 10.43E | 9.98H | 10.17H | 5.28B | 6.32B | 6.35B |
| Papaya G4        | 18.13A | 18.21A | 18.30A | 10.26F | 10.45G | 10.58G | 7.87A | 7.76A | 7.72A |
| Papaya G5        | 12.89F | 12.65H | 12.23G | 11.09C | 10.80E | 10.90E | 1.80H | 1.85H | 1.33G |
| Papaya G6        | 14.02D | 14.35E | 14.21E | 10.69B | 10.63F | 10.73F | 3.33D | 3.72D | 3.48D |
| Papaya G7        | 13.20E | 13.25G | 13.71F | 11.19C | 11.26C | 11.49C | 2.01G | 1.99G | 2.22F |
| Papaya G8        | 16.37B | 16.75B | 17.30B | 12.69B | 12.88B | 13.09B | 3.68C | 3.87C | 4.21C |

Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Numerical evaluation:
Total score for yield and fruit quality (100 Unit)

Results regarding the general evaluation of different papaya genotypes, Table (10) showed that papaya G8 and G4 seemed to be the superior’s genotypes in yield and fruit quality as they attained the uppermost score units (98.22 & 96.61 unit) as compared with of the other papaya genotypes in average tested seasons. Whereas, the papaya G4 and G8 were the superior in all the traits of the evaluation, since the papaya G4 took the highest units in four measurements (yield, fruit number/tree, SSC and total sugars), while the papaya G8 took the highest units in five measurements (fruit weight, fruit length, fruit diameter, seed weight and vitamin C) in the three evaluation seasons.
The tested genotypes could be arranged in descending order based on total score (70) for fruit quality as follows: G8 (68.36), G4 (66.61 unit), G2 (55.66 unit), G5 (55.07 unit), G1 (53.94 unit), G6 (51.60 unit), G7 (50.87 unit) and G3 (50.19 unit) in average tested seasons. In harmony with the present results those obtained by Hamed (2012) and Ibrahim et al., (2014) date palm cultivars.

Table 11: General score evaluation of the eight evaluated papaya genotypes average three seasons (2017, 2018 and 2019) under Qalyubia governorate conditions.

| Characteristics                  | Units specified | Tree (G.1) | Tree (G.2) | Tree (G.3) | Tree (G.4) | Tree (G.5) | Tree (G.6) | Tree (G.7) | Tree (G.8) |
|----------------------------------|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Yield                            | 30              | 13.37      | 13.47      | 7.78       | 30.00      | 15.79      | 8.98       | 10.51      | 29.86      |
| Fruit weight                     | 10              | 6.83       | 6.81       | 5.68       | 9.80       | 6.97       | 8.28       | 6.99       | 10.00      |
| Fruit number/plant               | 10              | 6.40       | 6.46       | 4.47       | 10.00      | 7.39       | 3.54       | 4.91       | 9.75       |
| Fruit length                     | 5               | 3.87       | 4.22       | 4.09       | 4.78       | 4.23       | 4.22       | 4.22       | 5.00       |
| Fruit diameter                   | 5               | 4.43       | 4.48       | 4.17       | 4.62       | 4.49       | 4.41       | 4.29       | 5.00       |
| Seed weight                      | 5               | 3.88       | 3.86       | 3.06       | 4.27       | 4.13       | 3.47       | 4.01       | 5.00       |
| SSC                              | 10              | 9.08       | 9.07       | 9.09       | 10.00      | 8.45       | 8.52       | 8.51       | 9.77       |
| Vitamin C                        | 10              | 7.89       | 7.93       | 5.30       | 8.14       | 9.04       | 7.47       | 6.91       | 10.00      |
| Total sugar                      | 15              | 11.57      | 12.82      | 13.32      | 15.00      | 10.37      | 11.69      | 11.02      | 13.84      |
| Total scour fruit quality        | 70              | 53.94      | 55.66      | 50.19      | 66.61      | 55.07      | 51.60      | 50.87      | 68.36      |
| Total unit yield/palm            | 100             | 67.30      | 69.13      | 57.97      | 96.61      | 70.86      | 86.25      | 61.38      | 98.22      |

Economic study

Economic evaluation of the eight papaya genotypes grown in Qalyubia Governorate as average during three experimental seasons was shown in (Table 11). It is cleared that net income for the eight papaya genotypes can be arranged discerningly as follows: G1, G2, G3, G4, G5, G6, G7 and G8. The minimum value of net income was for G3 (41.700 LE) and G6 (49.700 LE) while the maximum value for G4 (189.500 LE) and G8 (188.600 LE).

Table 11: Economic evaluation of eight papaya genotypes under Qalyubia governorate conditions.

| Papaya genotypes | Average fruit yield (kg/tree) | Average fruit yield (ton)/fed. | Price / kg | Total income | Operation cost of management | Net income |
|------------------|-------------------------------|--------------------------------|------------|--------------|-------------------------------|------------|
| Papaya G1        | 42.33                         | 8.89                           | 10.00      | 88.900       | 10.000                        | 78.900     |
| Papaya G2        | 42.66                         | 8.96                           | 10.00      | 89.600       | 10.000                        | 79.600     |
| Papaya G3        | 24.64                         | 5.17                           | 10.00      | 51.700       | 10.000                        | 41.700     |
| Papaya G4        | 95.01                         | 19.95                          | 10.00      | 199.500      | 10.000                        | 189.500    |
| Papaya G5        | 50.02                         | 10.50                          | 10.00      | 105.000      | 10.000                        | 95.000     |
| Papaya G6        | 28.45                         | 5.97                           | 10.00      | 59.700       | 10.000                        | 49.700     |
| Papaya G7        | 33.28                         | 6.99                           | 10.00      | 69.900       | 10.000                        | 59.900     |
| Papaya G8        | 94.57                         | 19.86                          | 10.00      | 198.600      | 10.000                        | 188.600    |

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