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Evaluation of Some Pecan Varieties Growing under Drip Irrigation System at El-Behera Governorate, Egypt Environmental Condition

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FIVE PECAN (*Carya illinoensis Wang. R koch*) varieties namely: Wichita, Desirable, Burkett, Grazona and Mahan were evaluated in a private farm at EL-Behera governorate, Egypt. All data was used to compare the results of morphological parameters, flowering characteristics, dichogamy phenomenon, fruit set, yield, fruit quality, nut shape, moisture and kernel oil content and biochemical genetic finger print.

The results showed that, Wichita, Grazona and Desirable pecan varieties surpassed the others in morphological growth. Mahan vr. be preferred as it produced the maximum No. of vegetative and female buds with longer male and female inflorescences. While, Wichita has higher No. of dormant, vegetative, male and female buds with longer staminate inflorescences. This study exhibited relatively incomplete dichogamy where Desirable, Grazona and Burkett vrs. were classified as protandrous (type,1) while Mahan vr. was classified as protogynous (type, 2). Desirabie can be a good pollinator for both Burkett and Mahan vrs. . There were more consistent periods of overlap between Desirable and Burkett vrs. which reflected on producing higher fruit set. Mahan was the earliest in fruit set followed by Burkett while, Grazona was the latest. Desirable gained higher nut yield in the 1st season while, Wichita has the highest nut yield in the 2nd season. Mahan vr. has the heaviest nut, and kernel weight and oil content followed by Wichita but Desirable and Burkett have the least weight. Palmetic acid was the main saturated fatty acid while, oleic and linoleic acids were the main unsaturated acids. Mahan kernel oil was the richest in palmetic acid during the two studied seasons and linoleic in the 2nd season but the least oleic acid in the 1st one. Wichita oil has the highest oleic acid in the two studied seasons and linoleic acid in the 1st season.

The genetic polymorphism between the five pecan cultivars was detected by RAPD analysis. Sixteen out of 31 bands detected were polymorphic for the different cultivars. Six markers were found to be specific for Mahan, two markers were specific for Wichita and only one specific marker detected for both Burkett and Desirable.

So we can recommend for Egyptian growers to spread the present five pecan varieties all over the new reclaimed soil for enriching Egyptian food, dietary source of antioxidants, raised local market and export.

The pecan (*Garya illinoensis* Wang. K. koch) is a deciduous tree belongs to walnut family (*Juglanadaceae*) and has low chilling requirements (Pena, 1995). So, it can be productive under Egypt environmental conditions. Pecan nut contains high levels of lipids and significant quantities of proteins, carbohydrates in addition to many minerals and vitamins. The pecan nuts presents bioactive molecules such as sterols, tocopherols and phenolic compounds which present antioxidant activity through the stabilization of free radicals molecules (Kornsteiner *et al*. 2006 and Do-Prado *et al*., 2009). The small acreage of this crop in Egypt is mostly due to scant knowledge of varieties cultivation and growth habit (Andersen, 1995) and the fact that the trees do not bear regular crops from year to year (Thompson and Romberg, 1985). Pecan tree has dichogmous flowering since male and female flowers on a tree mature at different times. So, pecan cultivars classified to type 1 (protandrous) and type 2 (protogynous) Sudheer *et al*. (2005). The flowering system must be understand for choosing appropriate cultivars in the design of productive orchards and plant type 1 with type 2 for maximum pollination and subsequent productivity (Abou-Taleb *et al*., 2004 and Sudheer *et al*., 2005). While, Grauke and Thompson (1996) and Abou-Taleb *et al*. (2010) showed that, the degree of dichogomy depends on the environment which influence in cultivars with different degrees of overlapping.

Genetic markers are basic tool plant breeder's use for cultivar identification, pedigree analysis and assessing genetic diversity. Development of polymerase chain reaction (PCR)-based marker systems, especially randomly amplified polymorphic DNA (RAPD) markers, that proven quite useful in genetic studies (Williams *et al*., 1990). RAPD markers combine the advantages of low technical input with almost unlimited marker numbers. RAPD markers have been used to determine genetic relationships of some plant crops including: blueberry (*Vaccinium* L. sp.) (Levi and Rowland, 1997), Persian walnut (*Juglans regia* L.) (Nicese *et al*., 1998), *Prunus* L. rootstocks (Casas *et al*., 1999), date palm (*Phoenix dactylifera* L.) (Sedra *et al*., 1998), mango (*Mangifera indica* L.) (Schnell *et al*., 1995), and almond (*Prunus dulcis* (Mill.) D.A. Webb) (Bartolozzi *et al*., 1998). Understanding the genetic relationships of frequently used germplasm is vital to any breeding program wishing to increase the genetic diversity of new cultivars. These molecular markers provide an opportunity for direct comparison and identification of different genetic material independent of any influences (Bautista *et al.*, 2003 and Zhao & Pan, 2004).

Therefore, the aim of this study was to evaluate vegetative, flowering characteristics, dichogamy phenomenon and fruit set, yield of nuts, nut shape and kernel content as well as biochemical genetic fingerprint using RAPD markers to estimate genetic similarity among five pecan varieties namely: Wichita,

Desirable, Burkett, Grazona and Mahan growing under drip irrigation system at El-Behera governorate environmental condition.

Materials and Methods

This study was carried out during two successive seasons of 2014 and 2015 to investigate the performance of five pecan (*Craya illinoensis* Wang. R. Koch) varieties in a private farm (Eva farm) located at Tanboul Road (90 kg Cairo-Alex. Desert Road), Behera governorate, Egypt. The studied varieties were eight years old namely: Wichita, Desirable, Burkett, Grazona and Mahan planted at 4 x 5 m apart under drip irrigation system 5000 m^3/Fed about (24m^3/tree/year). The irrigation water salinity is 768 p.p.m. Each variety represented by 3 trees with the same age planted at a complete Randomized Block design. All data were statistically analyzed as Snedecore and Cochran (1990) with Duncan's Multiple Range Test to compare differences between treatments (Duncan, 1955). The soil analysis data was assessed (Table 1) throughout the study.

TABLE 1. Physical and chemical properties of the experimental soil.

Physical properties of soil	
Sand %	83
silt %	10
Clay %	7
Texture	Sandy loamy
Chemical properties of soil	
PH	8.17
EC (ds/m)	1.114
Soluble soled (mg/100g)	
1- Na	3.3
2- K	0.18
3- Ca	1.2
4- Mg	1.2
5- Cl	7.4
6- HCO_3	1.9
7- CO_3	0.0
8- SO_4	3.4
Moisture %	26
Organic matter %	0.35
$CaCO_3$ %	1.7

Environmental conditions of El-Behera governorate during 2014 and 2015 seasons are presented in Fig. 1, 2, and 3 as follows:

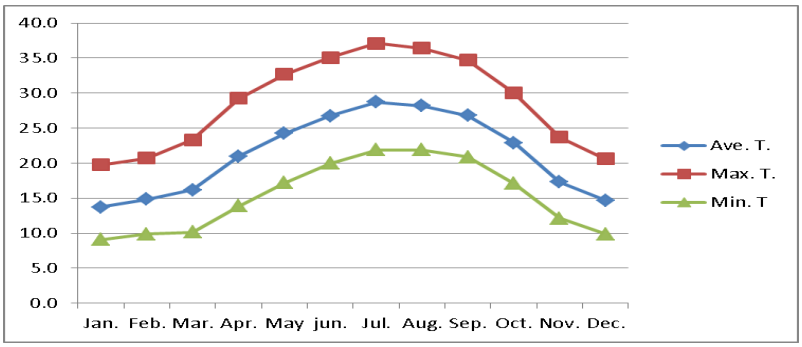

Fig.1. Average monthly temperature (C°) at El-Behera governorate during 2014 seasons.

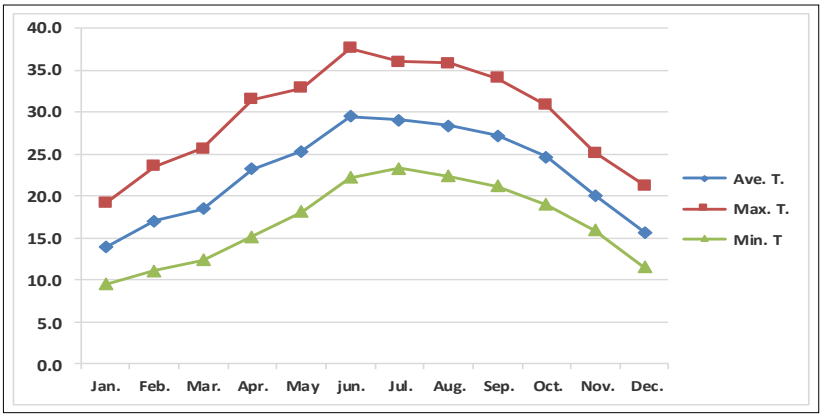

Fig. 2. Average monthly temperature (C°) at El-Behera governorate during 2015 seasons.

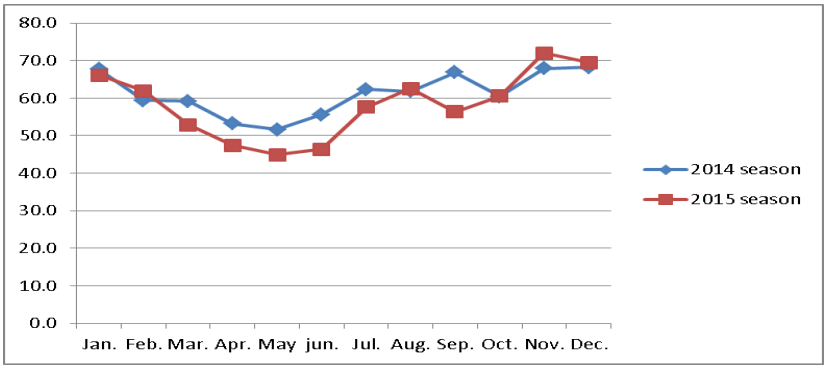

Fig. 3. Average monthly relative humidity (%) at El-Behera governorate during 2014 and 2015 seasons.

The following characters were studied to evaluate these varieties

Morphological parameters

20 twigs of each replicate tree (5/each direction) were selected at random and tagged for measuring twig length (cm), No. of fully developed shoots/twig, shoot length (cm), leaflets/leaf and leaflet area (cm^2) using area meter CL-203. The tree trunk diameter (cm) was measured at uniform height (50cm) using calibrated circumference tape during dormant season. Tree height and canopy width were also recorded (m.) in dormant season with clinometers and canopy width measured across the widest point in axis of raw.

Flowering characteristics

At the time of growth (1st of April), the previously selected twigs were measured for: No. of buds that classified as: dormant – vegetative-staminate (male) – pistillate (female) inflorescence. Average lengths (cm) of staminate and pistillate inflorescence were also measured.

Dichogamy phenomenon and fruit set

First and last dates of pollen shedding and pistil receptivity were recorded and classified to: protandrous (type1) where pollen begins to shed before the stigmas are receptive, or protogynous (type 2) where stigmas become receptive prior to pollen shed. At the end of blooming period, the date of beginning fruit set was determined as well as fruit set percentage was calculated according to the following equation:

Fruit set% = No. of fruitlets x 100/No. of pistillate flowers.

Yield characteristics

Pecan fruits were harvested through the 1st week of October (depending on variety) when the outer inedible hull has split and can be removed easily. After harvest and hull were removed, nuts were dried under room temperature (20-30◦ c) for 3-4 weeks.

The tree yield (kg/tree) and no. of nuts/kg were determined

Kerne l% = kernel weight x 100/ nut weight

Physical characters of nuts

Nut length, width (measured in the plane of the suture at the widest point) and height (measured perpendicular to the plane of suture at the widest point). Nut shape based on nut length to height ratio as classified by Grauke and Thompson (2007) to: Orbicular, Ovate, Obviate, Oval elliptic, Elliptic and Oblong. Apex & based shape (Acute, Acuminate or Obtuse). Cross section form is described as: laterally compressed, Round or Flattened, Dorsal grooves and kernel color was also described. Nut shell touch was classified as rough or smooth. Nut shell hardness was recorded as O = no hardness, 1 = hardness at apex, 2 = hardness to middle and 3=hardness to base of nut (Kaniewski, 1965). Nut weight (gm.) was determined by weighing 50 nuts/ tree as well as kernel weight (gm.). After nuts were cracked using hand-held pecan cracker and shell

weight was calculated. Kernel color was also assessed as golden, golden to light brown, light brown, or brown.

Kernel content

Moisture and kernel oil percentage were determined. Saturated and unsaturated fatty acids were assessed in samples kept in sealed freezer bags at -18°C until analyzed. Pecan kernel was cracked using Hand–held cracker. Oil content was determined by extracting oil from the dried samples by soxhelt fat extraction using petroleum ether as a solvent at 60-80°C boiling points, fatty acids were identified according to A.O.A.C. (1995).

PCR amplification and electrophoresis

DNA extraction was based on a procedure developed by Porebski *et al*. (1997) for plants containing high polysaccharide and polyphenol components. DNA concentration was determined by running DNA samples of a 1 % agarose gel with known concentrations of DNA, ethidium bromide staining, and visual interpretation of band intensity. The polymerase chain reaction was carried out in a Biometra thermal cycle using primers listed in Table 2. The PCR reaction mix includes the following: 10 ng/µL of DNA, 0.5 U of Red Hot Taq polymerase (AB-gene House, UK) and 10-X Taq polymerase buffer (AB-gene House, UK), 10 mM dNTPs, 50 mM MgC12, 10 uM each of forward and reverse primers Table (2). The PCR profile starts with 95°C for 5 min followed by 35 cycles of denaturation at 94°C for 1 min, annealing at 32 for 1 min, extension at 72°C for 2 mins. A final extension 72°C for 7 mins was included. The amplification products were separated in 2% (w/v) agarose gel with 1 x TAE buffer and visualized by staining with ethidium bromide.

Data analysis

The bands were sized and then binary coded by 1 or 0 for their presence or absence in each genotype. The systat ver. 7 (SSPSS inc.c 1997 spss inc.3/97 standard version) computer programs were used to calculate the pairwise difference matrices (Yang and Quiros, 1993).

TABLE 2. The sequence of the RAPD primers used.

Primer name	**Primer sequences (5'-3')**
OPC-02	GTGAGGCGTC
OPK-03	CCAGCTTAGG
OPK-04	CCGCCCAAAC
OPK-05	TCTGTCGAGG
OPM-13	GGTGGTCAAG

Morphological parameters

Data in Table 3 showed that, in both seasons of study Burkett (26.03 & 26.47cm.) followed by Grazona (22.65 & 22.39cm.) and Desirable (18.63 & 21.77cm.) pecan vrs. significantly have longer twigs than both Wichita and Mahan vrs. Wichita and Grazona vrs (1st season) and Burkett (both seasons) have longer shoots than other varieties. On the other hand, No. of shoots per twig data proved that, Desirable followed by Mahan and Wichita have more shoots per twig through 2015 season whereas, Grazona scored the least records through 2014 season and the statistical analysis confirmed this result. Both Wichita and Mahan pecan varieties were superior in number of leaflets/leaf (Fig. 4) followed by Desirable vr. in a descending order in both seasons. Also, the same previously two mentioned varieties (Wichita & Mahan) were superior in leaflet area (46.28 & 54.13 and 29.83 & 30.4 cm^2) during the two studied seasons respectively. Conversely, the minimum No. of leaflets /leaf was recorded in Desirable vr. (13 & 13 cm^2) in both seasons, respectively.

TABLE 3. Shoot growth parameters of the studied pecan varieties during 2014 , 2015 seasons.

Variety	Twig length(cm)	Shoot length(cm)	No. of shoots / twig	No. of leaflets / leaf	Leaflet area (cm^2)
First season					
Wichita	16.47D	14.00A	3.70B	15.07A	29.83B
Grazona	22.65B	14.07A	1.80C	14.00C	23.79D
Desirable	18.63C	9.30B	5.60A	14.77B	19.71E
Burkett	26.03A	13.27A	1.80C	13.00D	25.77C
Mahan	14.77E	6.50C	3.80 B	15.23A	46.28A
Second season					
Wichita	19.53C	13.47AB	3.70A	15.50A	30.40B
Grazona	22.39B	13.30B	1.60B	14.00C	25.43C
Desirable	21.77B	11.63C	4.07A	14.97B	18.82D
Burkett	26.47A	14.83A	4.30A	13.00D	25.80C
Mahan	15.13D	14.30AB	4.60A	15.90A	54.13A

Means in each season having the same letter/s are not significantly different at 5% level using Duncan's Multiple Range Test.

According to the listed data (Table 4), tree height values ranged from 3.50 & 4.20 m. (Mahan vr.) to be increased to 4.50 & 4.80 m. (Grazona vr.). Also, Wichita (14.75 & 14.97 m) and Mahan (14.80 & 14.90 m) were markedly having much wideness of the tree canopy than Desirable pecan vr. (13.80 & 13.85 m), the other two varieties were in between. Mahan and Wichita have much thickness of tree trunk (55 & 59 and 54.0 & 57.5 cm) than the other studied pecan vrs., whereas, the minimum values (36.00 & 44.00 cm) were recorded in Desirable vr. This was true in both studied seasons.

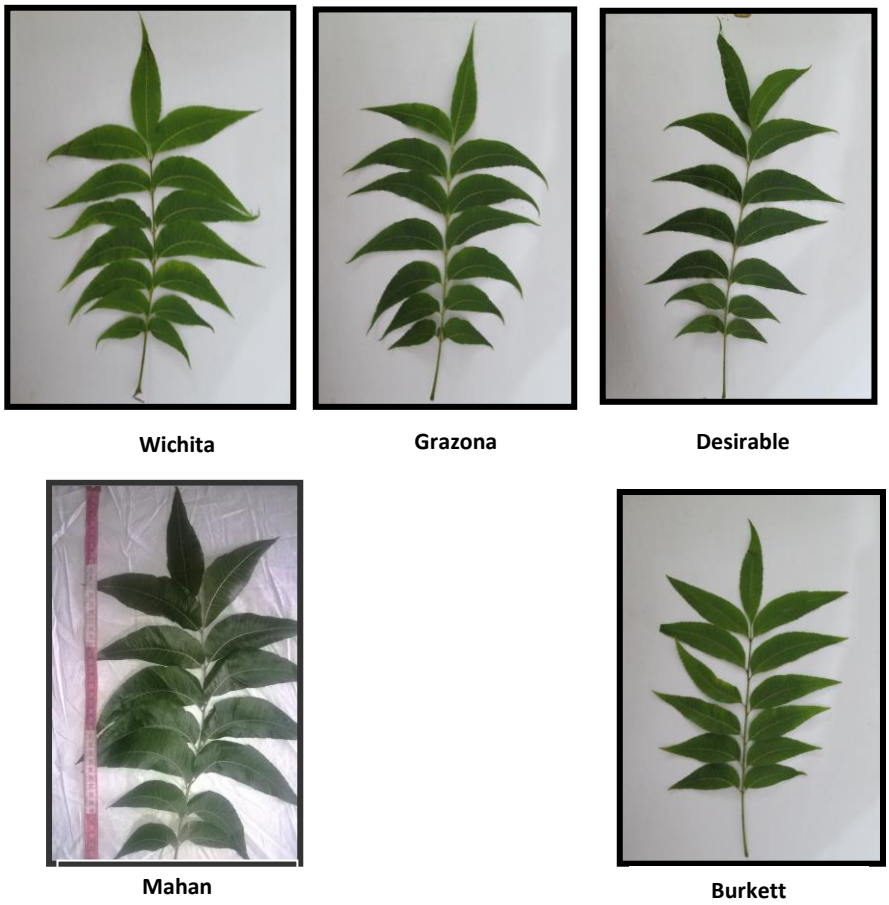

Fig. 4. No. of Leaflets / leaf of the studied pecan varieties.

Generally, the presented data (Tables 3 & 4) showed that, Wichita pecan variety was superior in shoot length, tree trunk diameter and tree canopy width. Grazona was better in twig length, shoot length, tree height and tree canopy width. Desirable surpassed the other varieties in No. of shoots /twigs and No. of leaflets/leaf. Mahan recorded the highest leaflets area and trunk diameter. In addition, Burkett recorded the highest values in twig length and shoot length.

This wide variability that exists in vegetative growth parameters in different studied varieties may be attributed to the differences in some genetically related characters which resulted from hybridization action. These results are in line with those of Awad (2002) and Abou -Taleb *et al.* (2004) and (2010). Also, Thompson (2005) and Attia and Wafaa (2007) noted that, the differences in growth vigor and canopy width may be due to the growth habit. While, Sparks (2009) observed that, temperature alters the time of bud break and subsequent rate of shoot elongation.

TABLE 4. Tree dimensions of the studied pecan varieties during 2014, 2015 seasons.

Variety	Tree height(m)		Canopy width (m)		Tree trunk diameter (cm)	
	2014	2015	2014	2015	2014	2015
Wichita	4.00 B	4.50B	14.75A	14.97A	54.00A	57.50B
Grazona	4.50A	4.80A	14.50 B	14.60B	43.00C	48.00D
Desirable	4.12 B	4.50B	13.80C	13.85 C	36.00D	44.00E
Burkett	3.90 B	4.00C	14.40B	14.60B	46.00B	50.00C
Mahan	3.50 C	4.20C	14.80A	14.90A	55.00A	59.00A

Means in each season having the same letter/s are not significantly different at 5% level using Duncan's Multiple Range Test.

Flowering characteristics

Data in Table 5 indicated that, Wichita followed by Grazona pecan varieties in 2014 season while Desirable followed by Grazona and Wichita in 2015 season achieved the maximum No. of dormant buds/ twig than the other studied vrs. Whereas, Mahan vr. took the other way around as it produced the least No. of dormant buds /twig. Moreover, Desirable scored the maximum No. of vegetative buds / twig (5.60) in the 1st season, however, Grazona had the minimum values (1.80 & 1.60) in both seasons. On the other hand, Mahan variety significantly produced the highest No. of pistillate inflorescences (female) (2.86 & 3.40) /twig through both seasons, while, the minimum values were recorded in Burkett vr. (1.06) in 1st season and Grazona (1.20) in 2nd season. Concerning staminate inflorescences, the records varied from 13.13 & 14.80 (Wichita) to be decreased to 3.40 & 2.73 (Grazona), respectively, in both seasons.

TABLE 5. Bud developmental stages characteristics of the studied pecan varieties during 2014, 2015 seasons.

Variety	No. of dormant buds/ twig		No. of vegetative buds/ twig		No. of pistillate inflorescence/ twig		No. of staminate inflorescences/ twig	
	2014	2015	2014	2015	2014	2015	2014	2015
Wichita	14.27A	13.97B	3.73B	3.77A	1.76C	2.16B	13.13A	14.80A
Grazona	13.80AB	14.15B	1.80C	1.60B	1.60C	1.20E	3.40D	2.73C
Desirable	12.80BC	16.90A	5.60A	4.07A	2.50B	1.86C	9.37B	15.70A
Burkett	11.83C	12.21C	1.85C	4.30A	1.06D	1.50D	6.57C	9.03B
Mahan	9.17D	8.37D	3.80B	4.60A	2.86A	3.40A	3.13D	3.50C

Means in each season having the same letter/s are not significantly different at 5% level using Duncan's Multiple Range Test.

It is also noticeable in Table 6 and Fig 5 that, Burkett (17.17 & 16.50 cm) followed by Wichita (14.39 & 14.33 cm) have longer male inflorescences in the two studied seasons, respectively. But, Desirable (6.17 & 6.67 cm) followed by Mahan (3.83 & 4.33 cm) and Burkett (3.6 & 4.07 cm) significantly have longer female inflorescences throughout 2014 and 2015 seasons, respectively. On the

other hand, the shortest staminate inflorescences (10.56 & 10.28cm) and pistillate inflorescences (2.00 & 1.67cm) were observed in Grazona variety.

TABLE 6. Average length of staminate and pistillate inflorescences of the studied pecan varieties during 2014, 2015 seasons.

Variety	Average length of staminate (male) inflorescence (cm)		Average length of pistillate (female) inflorescence (cm)	
	2014	2015	2014	2015
Wichita	14.39B	14.33B	2.83C	2.50C
Grazona	10.56D	10.28D	2.00D	1.67D
Desirable	10.42D	12.28C	6.17A	6.67A
Burkett	17.17A	16.50A	3.60B	4.07B
Mahan	12.22C	12.39C	3.83B	4.33B

Means in each season having the same letter/s are not significantly different at 5% level using Duncan's Multiple Range Test.

Wichita **Grazona** **Desirable**

Burkett **Mahan**

Fig. 5. Average length of staminate inflorescence (cm) of the studied pecan varieties.

It can be concluded from the listed data Tables 5 & 6 that, Wichita pecan variety has higher number of dormant, vegetative, male and female buds as well as longer male inflorescences. Also, Desirable has the same as Wichita except that it had produced the longest female inflorescences. Conversely, Grazona has less vegetative, male and female buds with shorter male and female inflorescences. However, Hamoda (1982) observed that, No. of pistillate inflorescences was greatly lower than staminate ones may be to overcome the lack of overlapping in reproductive organs maturity. Also Abou-Taleb *et al*. (2010) corroborated that, Wichita and Desirable vrs. have the highest No. of flowers/ pistillate inflorescence.

Dichogamy phenomenon and fruit set

The pattern of stigma receptivity and pollen shedding is very important consideration in selecting a pecan cultivar. Pollen must be shedding at a time when stigma is receptive for pollination to occur. The overlapping of pollen grain shedding and stigma receptivity are presented in Table 7 and Fig. 7. We can clearly observe that, there was a noticeable differences in these varieties in both seasons of study. This may be due to the environmental changes. It is also noted that, number of days in which pollen shed to coincide with stigma receptivity varied between the studied varieties, where there was more consistent periods of overlap between Desirable and Burkett vrs. than the other studied vrs. This reflected on producing higher fruit set percentages (83 & 82.6 %) and (75.6 & 77.6 %) in the two studied seasons, respectively (Table 7 and Fig. 6). Moreover, the present varieties in this evaluation exhibited relatively incomplete dichogamy in both Seasons.

Results in Table 7 and Fig. 7 also declared that, Desirable, Grazona and Burkett vrs. classified as protandrous (type, 1) that pollens shed before the stigmas are receptive. While Mahan vr. classified as protogynous (type, 2) where stigmas become receptive prior to pollen shed. However, Wichita vr. showed as type (1) in the 1st season and type (2) in the 2nd season which is might be due to the effect of environment. Generally, there are overlapping between type (1) and type (2) trees (Sibbett *et al*., 1987). With regard to the beginning of fruit set, data showed that, Mahan (18 and 19/ April) and Burkett (26 and 22/ April) vrs. were the earliest in fruit set through 2014 and 2015 seasons, respectively while, Grazaona vr. was the latest one (12 and 10/ May). Such findings are, supported by Sudheer *et al*. (2005), Grauke and Thompson (2007), Andersen (2008), Abou -Taleb *et al*. (2010) and Gowda (2011) on pecan varieties who stated that, there was a linear relationship between minimum temperature and relative humidity and pollen shedding period where it was extended with increase relative humidity and minimum temperature specially with Wichita cultivar.

TABLE 7. The beginning and end of pollens shedding and stigma receptivity of the studied pecan varieties during 2014, 2015 seasons.

Variety	Begging of fruit set		Stigma receptivity to pollen				Shedding of pollens				Fruit Set (%)	
	2014	2015	2014		2015		2014		2015		2014	2015
			Start	End	Start	End	Start	End	Start	End		
Wichita	4/5	26/4	1/5	8/5	20/4	28/4	25/4	2/5	28/4	7/5	64.50D	66.16C
Grazona	12/5	10/5	3/5	19/5	4/5	13/5	28/4	12/5	30/4	7/5	58.30E	57.00D
Desirable	4/5	25/4	21/4	12/5	23/4	30/4	2/4	30/4	14/4	3/5	83.00A	82.60A
Burkett	26/4	22/4	14/4	21/4	14/4	25/4	10/4	27/4	3/4	30/4	75.60B	77.60B
Mahan	18/4	19/4	16/4	20/4	16/4	21/4	22/4	20/5	25/4	20/5	71.00C	76.30B

Fig. 6. Fruit set of the studied pecan varieties.

Yield of nuts

Data in Table 8 depict nuts yield and No. of nuts/ kg. of 8 years old pecan vrs. Desirable pecan variety gained 6.86 and 7.80 Kg/ tree in the two studied seasons, respectively which is higher than the rest of the studied varieties. Although Wichita vr. had lower nuts yield/ tree (4.25kg) through 2014, it had the highest nuts yield (16.50 kg/ tree) in 2015. No. of nuts/ kg expresses their size, so less number of nuts/ kg means larger size. Mahan vr. had the minimum No. of nuts/kg (64.67 and 64.00 nuts/ kg), so it had the largest nut. The opposite was observed in Desirable during the 1st season (122.0 nuts/ kg) and Grazona in the 2nd one (139.70 nuts/ kg) that means they had the smallest nuts. These results were confirmed by Awad, (2002) and the former studies where Abou- Taleb *et al*., (2010) recorded the highest number of nuts/kg for Burkett and Wichita cvs. While Desirable cv. has the highest yield.These data are partially agreement with Hamoda (1982) and Attia & Wafaa, (2007). Also, Gowda (2011) stated that, nuts yield was differed from season to another.

First season (2014)

Second season (2015)

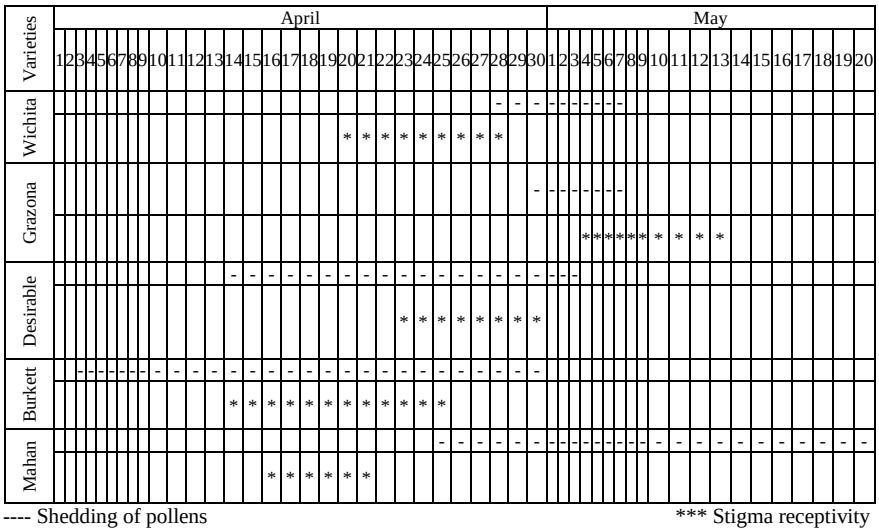

Fig. 7. Pollens shedding and stigma receptivity of the studied pecan varieties.

TABLE 8. Fruit set percentage and yield of the studied pecan varieties during 2014, 2015 seasons.

Variety	Yield kg/ tree		No. of nuts / kg.	
	2014	2015	2014	2015
Wichita	4.25D	16.50A	86.00D	68.67D
Grazona	5.45B	6.60C	92.33C	139.70A
Desirable	6.86A	7.80B	122.00A	113.30C
Burkett	4.24D	5.85D	109.30B	130.00B
Mahan	4.75C	5.46D	64.67E	64.00D

Means in each season having the same letter/s are not significantly different at 5% level using Duncan's Multiple Range Test.

Nut shape and characteristics

Referring to the presented data in Table 9 &10 and Fig. 8, Mahan vr. has the longest (6.17 and 6.27) and widest nuts (2.57 and 2.53 cm) as well as nut shape index (2.4 and 2.47) followed by Wichita vr. While Desirable variety has the least dimensions of nuts. Concern the nut height, Grazona has the highest nut height in the 1st season while, Burkett was the highest in the 2nd season followed by Grazona, While Desirable var. was the lowest in both seasons. Mahan and Wichita vrs. have oblong nut shape while Desirable has elliptic nut shape. Grazona and Butkett have orbicular nut shape. Concerning nut apex shape, Mahan and Wichita have acuminate shape while Desirable and Burkett have obtuse apex shape, but Grazona has acute apex shape. Relating to nut base shape, Mahan and Wichita have obtuse shape while Desirable and Burkett have round base but Grazona vr. has obtuse- round shape. About the cross section form of nuts, Mahan, Wichita and Desirable have round cross section while Grazona and Burkett nuts have laterally compressed cross section. Regarding to dorsal grooves of nuts, Mahan and Grazona have wide deep grooves while Desirable has wide grooves but Wichita has narrow deep grooves. It is noticeable that, all studied varieties have rough shell surface except Mahan vr. has smooth shell surface. Relating to shell hardness, we can notice that, Burkett shell has no hardness (O), Desirable shell has hardness at apex (1), Wichita and Grazona shell has hardness to middle (2) as well as Mahan shell has hardness to base of nut (3). About kernel color,Wichita and Desirable vrs. have golden kernel, while Grazona and Burkett vrs. have golden to light brown kernel, but Mahan vr. has brown kernel. Data in Table (10) show that, the average of kernel weight of 5 pecan varieties under study data indicated significant differences among these varieties in both seasons. Mahan variety produced the greatest nut (15.43&15.67gm), shell (5.83&5.53gm) as well as kernel (9.60&10.13gm) weight in both studied seasons, respectively, While Desirable and Burkett have the least nut, shell and kernel weight. especially in the 1st season. In addition, Wichita has the highest percentage of kernel (66.14 &67.80) in the two studied seasons, respectively followed by Mahan vr. while, Grazona and Desirable have the highest percentage of shell in the 1st season (41.99 & 42.11). Exactly the contrary was found by, Awad,

(2002) and Abou- Taleb *et al*. (2010), Desirable nuts were the longest and superior in shape index while, Burkett nuts recorded the lowest shape index but it has the highest nut weight. Also, Burkett and Wichita cvs. have the least nut weight subsequently the highest No. of nuts/ kg. These results of nut dimensions and yield are partially supported by Hamoda (1982), Attia & Wafaa (2007) and Grauke & Thompson (2007).

TABLE 9. Fruit Quality characteristics of the studied pecan varieties during (2014, 2015) seasons.

Variety	Nut length	Nut height	Nut width	Nut Shape index	Dry Nut weight	Shell Weight	Kernel Weight	Shell %	Kernel %
First Season, 2014									
Wichita	5.13 B	2.70C	2.33B	1.90B	11.43B	3.88C	7.55B	33.86C	66.14A
Grazona	4.70C	3.38A	2.30B	1.39D	11.05B	4.64B	6.41C	41.99A	58.00C
Desirable	4.27D	2.51E	1.99D	1.70C	8.24D	3.47C	4.77D	42.11A	57.88C
Burkett	4.53CD	3.30B	2.11C	1.37D	9.21C	3.52C	5.70C	38.11B	61.88B
Mahan	6.17A	2.57D	2.57A	2.40A	15.43A	5.83A	9.60A	37.78B	62.21B
Second Season, 2015									
Wichita	5.47B	2.74C	2.33B	1.99B	14.67A	3.73B	10.94A	32.20D	67.80A
Grazona	4.73C	3.42B	2.17B	1.38D	7.27C	2.80B	4.47D	38.50B	61.48C
Desirable	3.90D	2.22E	1.95C	1.75C	9.07B	3.20B	5.87C	35.28C	64.72B
Burkett	4.97C	3.79A	2.32B	1.31D	7.67C	3.12B	4.55D	40.67A	59.32D
Mahan	6.27A	2.53D	2.53A	2.47A	15.67A	5.53A	10.13B	35.29C	64.71B

Means in each season having the same letter/s are not significantly different at 5% level using Duncan's Multiple Range Test.

TABLE 10. Some nut physical characteristics of the studied pecan varieties grown under Behera Governorate conditions.

Variety	Nut shape	Apex shape	Base shape	Cross section form	Kernel color	Dorsal grooves	Shell surface	Shell hardness
Wichita	Oblong	Acuminate	Obtuse	Round	Golden	Narrow deep	Rough	2
Grazona	Orbicular	Acute	Obtuse-round	Laterally compressed	Golden to light brown	Wide deep	Rough	2
Desirable	Elliptic	Obtuse	Round	Round	Golden	Wide	Rough	1
Burkett	Orbicular	Obtuse	Round	Laterally compressed	Golden to light Brown	Prominent dark Brown speckles	Rough	0
Mahan	Oblong	Acuminate	Obtuse	Round	Brown	Wide deep	Smooth	3

Fig. 8. Nut shape of the studied pecan varieties.

Kernel oil and moisture (%) content

The present data (Table 11) illustrated that, Mahan kernel has the highest oil content (69.5 and 69.15 %) through 2014 and 2015 seasons, respectively. Burkett kernel has the least oil and moisture percentage in 2014 (62.4% and 3.18 %) but has the highest moisture percentage (4.47 %) in 2015.

TABLE 11. Kernel oil content and moisture percentage of the studied pecan varieties during 2014, 2015 seasons.

Variety	Oil %		Moisture %	
	2014	2015	2014	2015
Wichita	65.4BC	68.26A	4.58B	3.41B
Grazona	66.45B	66.50B	4.13C	3.07C
Desirable	64.16CD	68.70A	4.84A	3.47B
Burkett	62.40D	66.12B	3.18D	4.47A
Mahan	69.50A	69.15A	3.25D	3.56B

Means in each season having the same letter/s are not significantly different at 5% level using Duncan's Multiple Range Test.

Table 12 showed the fatty acids composition of the oil extracted from kernel of the studied pecan varieties during 2014 and 2015 seasons. As for kernel Palmetic acid, the differences between studied varieties didn't reach the significant except for Burkett vr. which scored the least values in the 2nd season. Also, Oleic acid was the main unsaturated fatty acid followed by linoleic acid. Wichita oil has the highest oleic acid (70.15% and 68.5%) in the two studied seasons as well as linoleic acid in the 1st season (23.15%). Whereas, Mahan oil has the least oleic acid in the 1st season (65.6%) but the highest linoleic acid in the 2nd season (22.0%).

Generally, Herrera (2005), Abou- Taleb *et al*. (2010) and Gowda (2011) stated that, linoleic acid is responsible for oxidation and rancidity in pecan kernel. Linoleic acid varies widely in different varieties and from year to year. Unsaturated fats in pecan are protected against oxidation by the high concentration of γ-Tocophenel and ploymeric flavones. The proportion of oleic, Linoliec and linolenic fatty acids determined the oxidative stability, viscosity and melting/crystallization behavior of pecan oil. These properties were similar or superior to extra – virgin olive oil and unrefined sesame oil (Herrera 1985 and Toro- Vazquex *et al*., 1999).

TABLE 12. Fatty acids composition (weigh %) of pecan kernel of the studied pecan varieties during 2014, 2015 seasons.

Saturated fatty acids						
Varieties	**Palmetic C 16:0**		**Stearic C 18:0**		**Arthodonic C 20:0**	
	2015	**2014**	**2015**	**2014**	**2015**	**2014**
Wichita	5.12A	5.40AB	2.01C	2.97A	0.45B	0.33A
Grazona	5.29A	5.10AB	2.77A	2.57BC	0.19CD	0.17B
Desirable	5.00A	5.30AB	2.38B	2.71B	0.56A	0.17B
Burkett	4.92A	4.80B	2.77A	2.56C	0.25C	0.19B
Mahan	5.36A	5.50A	2.50B	2.30D	0.13D	0.15B

Unsaturated fatty acids								
Varieties	**Gadoleic C 20:1**		**Oleic C 18:1**		**Linolinec C 18:3**		**Linoleic C 18:2**	
	2015	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**
Wichita	1.20AB	1.01A	70.15A	68.50A	2.19C	2.11BC	23.15A	20.60A
Grazona	1.01B	0.99A	68.27B	68.50A	2.44B	2.20B	19.90C	21.00A
Desirable	1.10AB	1.19A	68.60B	68.10A	2.30BC	1.90CD	20.80BC	21.70A
Burkett	1.33A	1.12A	65.60C	64.50C	2.68A	1.70D	22.40AB	21.00A
Mahan	1.00B	1.00A	65.60C	65.50B	2.19C	2.50A	23.10A	22.00A

Means in each season having the same letter/s are not significantly different at 5% level using Duncan's Multiple Range Test.

PCR amplification and electrophoresis

In order to study the genetic difference among the five pecan varieties, DNA samples were subjected to RAPD analysis. All of the 5 primers produced reproducible PCR products with a clear pattern for each variety and showing informative and easily scrabble RAPD profiles. In this study, a total of 31 alleles were detected among the five pecan varieties (Table 13 and Fig. 9). Only 16 of them were polymorphic markers (51.6 %). The highest number of bands (9 bands) was generated by using the primer OPK-04, while the lowest one was 3 bands and generated with primer OPK-03. The highest polymorphism percentages belonged to marker OPK-04 (88.8 %) followed by OPK-05 (60 %) then OPC-02 (57.14%) while the lowest belonged to marker OPK-03 (zero %). Ten out of the 16 polymorphic RAPD markers were found to be genotype-specific (62.5 %). Therefore, this RAPD marker can be used as associated markers for the pecan genotype. Six RAPD specific markers distinguish Mahan (five positive markers, OPK-04 (695, 709, 736, 1304 and 1329 bp) and one negative marker for OPC-02 (700 bp) primer followed by Wichita (two negative marker, OPC-02 (382 and 587 bp), then for Burkett and Desirable only one specific marker OPC-02 (323 bp) and OPK-04 (321 bp), respectively (Table14). Mahan showed the higher oil percentage (69.50). Desirable showed the higher yield percentage (6.8 in the first season and 7.8 in the second season). The presence of unique RAPD markers among the various pecan genotypes to indicate the utility of the approach for fingerprinting purposes. RAPD fingerprinting has a number of potential applications including the determination of cultivar purity, efficient use and management of genetic resources collection, particularly identification of mislabeled accessions (Ahmad, 1999). This result was in agreement with those obtained by Conner and Wood (2001). They indicated that, the genetic relatedness between 43 cultivars was estimated using 100 RAPD markers. The RAPD data was used to design the dendrogram of the five pecan genotypes Fig. (10).

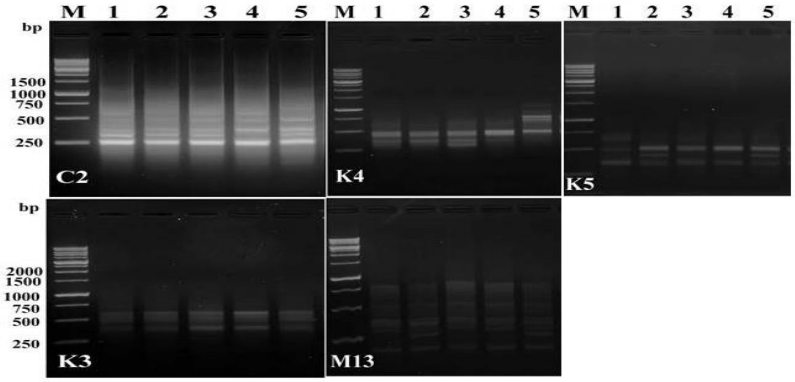

Fig. 9. RAPD profile demonstrating polymorphism among the five pecan varieties. M refers to DNA marker of 1Kb ladder. Lanes 1-5 represent (Wichita, Grazona, Desirable, Burkett, and Mahan, respectively).

TABLE 13. Total number of scorable alleles and the allelic polymorphic among pecan varieties.

Primer name	Total no. of alleles	Polymorphic alleles	Polymorphism %
OPC-02	7	4	57.14
OPK-03	3	0	0
OPK-04	9	8	88.8
OPK-05	5	3	60
OPM-13	7	1	14.2
Total	**31**	**16**	**51.6**

TABLE 14. Pecan cultivar specific RAPD markers.

Cultivar	RAPD markers	Total markers
Mahan	OPC-02 (700 bp)	1
Wichita	OPC-02 (382 and 587 bp)	2
Burkett	OPC-02 (323 bp)	1
Desirable	OPK-04 (321 bp)	1
Mahan	OPK-04 (695, 709, 736, 1304 and 1329 bp)	5
Total		**10**

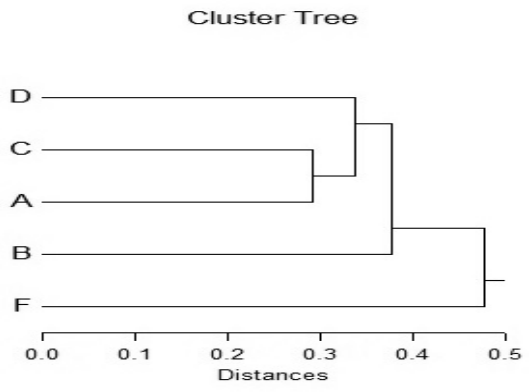

Fig. 10. Dendrogram of the five pecan genotypes as revealed by data.

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تقييم بعض أصناف البيكان تحت نظام الري بالتنقيط و الظروف البيئية لمحافظة البحيرة

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تم تقييم ودراسة خمسة أصناف بيكان هي: ويشيتا – ديزيرابل– بيركيت– جرازونا - ماهان، في مزرعة خاصة أراضي رملية تحت نظام الري بالتنقيط، و تم أخذ البيانات المتمثلة في مواصفات النمو الخضري للأشجار، البراعم الخضرية والزهرية والنورات المذكرة والمؤنثة – ظاهرة الدايكوجمي و العقد ، المحصول وصفات جودة وشكل الثمار؛ محتوى الثمار من زيت البيكان، البصمة الوراثية للأصناف تحت الدراسة.

أظهرت النتائج أن أصناف ويشيتا - جرازونا - ديزيرابل تميزت في النمو الخضري عن الأصناف الأخري في (عدد وطول الأفرع ومساحة الوريقات وقطر جذع الشجرة وارتفاع الشجرة وحجمها) بينما صنف ماهان تفوق في عدد البراعم الخضرية وعدد البراعم الزهرية المؤنثة مع نورات زهرية مذكرة ومؤنثة أطول، تميز صنف وايشيتا في عدد البراعم الساكنة والخضرية والزهريةالمذكره والمؤنثه مع نورات مذكره اطول .اظهرت الدراسه وجود ظاهرة الدايكوجمى في الأصناف تحت الدراسة بصورة جزئية حيث صنفت أصناف ديزيرابل - جرازونا وبيركت على أنها مبكرة الطلع (النوع الأول) بينما صنف ماهان كان مبكر المتاع (النوع الثاني) و يعتبر الديزايرابل ملقح جيد لكل من صنفي بيركيت و ماهان و تميز صنفي ديزيرايل وبيركت بفترة أطول من التوافق بين فترة استعداد المياسم للتلقيح وبين انتشار حبوب اللقاح والذي أدي الي انتاج أعلى % لعقد الثمار للصنفين. صنف ماهان كان أكثر الأصناف تبكيرا في عقد الثمار يليه صنف بيركت بينما كان صنف جرازونا أكثر الأصناف تأخيرا في عقد الثمار.

ديزايرابل أعطي أعلى محصول ثمار ، بينما صنف وايشيتا أعطي أعلى محصول مجفف في الموسم الثاني ، ثمار البيكان للصنف ماهان كانت كبيرة بينما ثمار صنفي ديزيرابل وجرازونا كانت صغيرة .

تميز صنف ماهان بكبر وزن الثمرة والقشر واللب ونسبة الزيت في اللب يتبعه صنف ويشيتا لكن صنفي ديزيرابل وبيركت حصلوا على أقل الأوزان السابقة. يعتبر حمض البالمتيك هو الحامض الدهني المشبع الرئيسي في زيت ثمرة البيكان بينما أحماض أوليك واللينوليك كانا الأحماض الدهنية الرئيسية الغير مشبعة. احتوى زيت ثمار صنف ماهان على أعلي نسبة الحامض البالمتيك أثناء سنتي الدراسة وأعلى نسبة في حامض اللينوليك في الموسم الثاني وأقل نسبة في حامض أوليك في الموسم الأول للدراسة، بينما صنف ويشيتا فقد احتوى على أعلى نسبة في حمض أوليك في موسمي الدراسة وحمض اللينوليك في الموسم الأول فقط.

من أجل تقييم التنوع الجيني بين خمس سلالات من البيكان. نجحت خمس بادئات عشوائية RAPD في إستهداف تضاعف تتابعات متنوعة محددة من المادة الوراثية، نتج عنها ١٦ تتابع متضاعف متباين بين السلالات من ٣١ تم تحديدهم

.وقد تم تحديد واسمات مميزة متخصصةلاصناف البيكان المتماثلة محل الدراسة.سته منهم مميزين لصنف ماهان واثنتين لصنف ويشيتا و واحده فقط لكل من بيركيت و ديزايربل .

لذلك فيمكن توصية مزارعي البيكان بنشر زراعة هذه الأصناف في كل مزارع الاستصلاح الحديثة بهدف تحسين مستوى الانتاجيه بالاضافه الى تحسين خصائص الجوده للزيت والحصول على محصول اقتصادى له خواص جوده تنافسيه فى الاسواق العالميه.