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Morphological Variability Among *Moringa oleifera* (Lamark) Populations in Egypt.

K.H. Shaltout[1], H.I. Ali[2], A. Mobarak[3], D.M. Baraka[3], S.H. Aly[3]
1Botany Department, Faculty of Science, Tanta University, Tanta, [2]Forestry and Wood Technology Department, Faculty of Agriculture, Alexandria University, Alexandria, Egypt [3]Botany Department, Faculty of Science, Benha University, Qalubeya, Egypt.

THIS PAPER aims at studying the morphological variation among *Moringa oleifera* Lam. populations in 8 sites in Egypt. Most of the measured tree variables differed significantly among the studied sites. The population of Qanatir Horticulture Research Institute had the maximum size (853.8 m^3 $tree^{-1}$) and diameters of canopy (9.9 m $tree^{-1}$), and stem at breast height level (63.4 cm $tree^{-1}$); while those of Sheikh Zuweid had the minimum size (5.6 m^3 $tree^{-1}$) and height (2.0 m $tree^{-1}$). Many branching modes of the main trunk were observed, where sympodial branching was the dominant in most sites. *M. oleifera* leaves in Botanical Garden of Faculty of Education (Ain Shams University) were the longest (59.6 cm) and those in Sheikh Zuweid were the shortest (24.5 cm). On the other hand, the pods of the trees in Qanatir Horticulture Research Institute were the longest (50.4 cm). In addition, the pods of Botanical Garden of Faculty of Education (Ain Shams University) contained the maximum number of seeds (21.8 seed pod^{-1}), while the heaviest seeds were those of Sheikh Zuweid (270.0 mg $seed^{-1}$). Variations in the morphological attributes of *M. oleifera* (trees, leaves, pods and seeds) may be not only related to environmental conditions, particularly the soil properties, but also to genetic differences within species. A further study on the genetic variation among the populations of this plant should be carried out.

Keywords: Canopy, Flower, Height, Leaves, Pod, Seed, Trunk.

Moringa oleifera Lam. belongs to the family Moringaceae; part of the mustard-oil producing and morphologically diverse Brassicales order (Fay and Christenhusz, 2010). This tree is native to the sub-Himalayan region of northwest India and Pakistan, from where it was introduced into several warm countries in the Tropics (Sengupta and Gupta, 1970; Janick and Robert, 2008). It is evergreen in tropical climates, while it is deciduous in sub-tropical climates (Folkard *et al.*, 1999). It grows best where the average maximum daily temperature range is 25 - 35 °C, but also can survive summer temperature up to 48 °C for a limited period, and can tolerate frosts in winter (Price, 2000). This tree grows on different soil types including sandy and coralline sandy, grey loam, red lateritic, stony and rocky, quartzite clay and loamy clay soils (CALM, 2007 and EPA, 2007).

M. oleifera leaves are a rich protein source that can be advised by doctors, nutritionists and community health cautious persons to solve worldwide malnutrition problems (Thurber and Fahey, 2009). The seeds contain about 38 - 42% oil (Anwar and Bhanger, 2003). This oil is of excellent quality and is used for cooking and cosmetic purposes (Goyal *et al.,* 2007). *M. oleifera* seeds can also be used as an antiseptic in the treatment of drinking water (Obioma and Adikwu, 1997). All parts and components derived from this plant have been used for alleviating various ailments in traditional medicine for centuries in many cultures around the world (HDRA, 2002 and Fahey, 2005).

Since 1924, *M. oleifera* had been introduced and cultivated in Egypt under the name of *M. peterygosperma* (Hekal *et al.,* 1995). Diwan *et al.* (2004) and Hamdy *et al.* (2007) studied many botanical gardens in Cairo and reported that *M. oleifera* was listed as a cultivated species in Orman Botanical Garden. Khalifa and Loutfy (2006) presented a preliminary survey of a part of the cultivated taxa in Egypt and had documented *M. oleifera* in the following localities: Faculty of Science and Faculty of Education Botanical Gardens (Ain Shams University), Orman Botanical Garden, Zoo Garden plant collection and Aswan Botanical Garden. Heneidy (2010) studied the species richness and taxonomic diversity of the Botanical Garden of Faculty of Science (Alexandria University) and indicated that *M. oleifera* is the only representative plant of the Moringaceae family. Recently, Ammar (2015) listed this species among the garden flora that characterizes the Nile Delta. This study aims at studying the morphological attributes of *M. oleifera* trees, leaves, flowers, pods and seeds and indicating the extent of site variation effect on species characteristics.

Material and Methods

Sixteen field visits were conducted to the eight studied sites (Table 1, Fig. 1) during September 2009 to October 2010. The following morphological parameters were estimated: the height from the ground (m), trunk diameter (m) at ground (DGL) and breast height levels (DBH), number of primary branches per tree, the average diameter of the canopy (m, based on three measures) and tree size (m^3) = Πr^2 × tree height (Shaltout, 2002). Vitality of *M. oleifera* trees was also visually estimated as indicated by the health appearance of the whole plant (branches, leaves, flowers and fruits) and was expressed as a percentage.

In addition, the presence of flowers and pods was recorded. These parameters were determined for 36 individual *M. oleifera* trees representing all sites, except in Sheikh Zuweid, where the determined trees were chosen using restricted random method. Moreover, leaves, pods and seeds collected from *M. oleifera* trees representing each site were randomly mixed to determine the following parameters: leaf length (cm), pod length and circumference (cm), number of seeds in each pod (seed pod^{-1}) and seed weight (mg $seed^{-1}$).

TABLE 1. Features of eight studied botanical sites, where *Moringa oleifera* is cultivated in Egypt. Average temperature (T) and precipitation (P) records are according to www.en.climate-data.org.

Site	Governorate	Latitude (N)	Longitude (E)	Average T (°C)	Average P (mm)
1-Sheikh Zuweid Station	North Sinai	31° 14' 10"	34° 06' 53"	19.7	175
2- Faculty of Science, Alexandria University	Alexandria	31° 11' 23.9"	29° 54' 27.9"	20.6	183
3- Antoniadis Garden	Alexandria	31° 12' 15.0"	29° 56' 56.1"		
4- Qanatir Horticulture Research Institute	Qalubeiya	30° 10' 56.0"	31° 07' 50.7"	20.9	22
5- Faculty of Science, Ain Shams University	Cairo	30° 04' 38.7"	31° 16' 56.3"	21.3	18
6- Faculty of Education, Ain Shams University	Cairo	30° 05' 29.6"	31° 18' 35.5"		
7- Orman Botanical Garden	Giza	30° 01' 49.1"	31° 12' 47.1"	21.2	17
8- Aswan Botanical Garden	Aswan	24° 05' 33.8"	32° 53' 07.4"	26.8	1

Fig. 1 . Map of Egypt indicating the position of the studied sites (☆). Map was prepared using Google Earth program (www.googlemaps.com).

The number of replica for each parameter was 100 in each site and was expressed as mean ± standard deviation. The data of morphological properties were statistically analyzed using One - Way Analysis Of Variance (ANOVA). Duncan multiple range test was used to detect the significant differences between the means. Analysis was performed using IBM SPSS Statics software (SPSS, 2006). Line drawing and photos of *M. oleifera* in different sites were taken for all the aboveground parts of the tree.

Results

Most of the measured tree variables differed significantly among the studied sites (Table 2). The trees of *M. oleifera* at Qanatir Horticulture Research Institute had the

maximum values of trunk diameter at ground (76.1 cm) and breast height levels (63.4 cm), canopy diameter (9.9 m) and tree size (853.8 m^3 $tree^{-1}$); while those of Sheikh Zuweid had the minimum values of trunk diameter at ground level (6.7 cm), canopy diameter (1.6 m), height (2.0 m $tree^{-1}$) and tree size (5.6 m^3 $tree^{-1}$).

TABLE 2 . Mean (M) and standard deviation (SD) of morphological characteristics of *Moringa oleifera* trees in eight sites in Egypt: Sheikh Zuweid Station (SZ), Botanical Garden of Faculty of Science - Alexandria University (XS), Antoniadis Botanical Garden (XA), Qanatir Horticulture Research Institute (QA), Botanical Garden of Faculty of Science - Ain Shams University (SA), Botanical Garden of Faculty of Education - Ain Shams University (ED), Orman Botanical Garden (OR) and Aswan Botanical Garden (AS). DGL: Trunk diameter at ground level, DBH: Trunk diameter at breast height level, PRB: primary branches (branch $tree^{-1}$). ns: Not significant at P ≤ 0.05, *: Significant at P ≤ 0.05, *: Significant at P ≤ 0.001.**

Tree variable	Study site								Overall		F Value
	SZ	XS	XA	QA	SA	ED	OR	AS	M	SD	
No. of trees	10	1	1	17	4	1	1	1	-	-	
DGL (cm)	6.7	34.1	18.5	76.1	73.7	64.3	16.2	83.5	52.0	35.7	17.4***
DBH (cm)	-	29.3	12.9	63.4	44.6	39.2	12.7	49.7	53.8	28.4	1.4^{ns}
Canopy (m)	1.6	6.3	4.7	9.9	8.5	7.6	5.5	6.3	6.9	3.9	20.5***
Height (m)	2.0	8.0	6.5	10.5	12.8	13.0	7.8	12.5	8.3	4.3	76.6***
Tree size (m^3)	5.6	249.3	112.7	853.8	761.4	589.4	185.2	389.5	531.7	475.7	7.4***
No. of PRB	7.3	2.0	19.0	3.9	8.0	19.0	2.0	5.0	6.1	5.8	2.7*
Vitality (%)	94.1	80.0	20.0	86.2	82.3	75.0	90.0	95.0	86.0	13.5	19.8***

M. oleifera trees had sympodial branching in most sites (Plate 1 B - F), whereas monopodial branching was recorded in Sheikh Zuweid only (Plate 1 A). The number of primary branches ranged from two (Faculty of Science - Alexandria University and Orman Botanical Garden trees) to 19 branch tree-1 (Antoniadis Garden and Faculty of Education - Ain Shams University) (Table 2). Different modes of branching were observed as follows: main trunk branched at ground level; dichotomous branching as in the trees of Qanatir Horticulture Research Institute (Plate 1 G), and multiple branching as in Aswan Botanical Garden tree (Plate 1 N). Main trunk divided into 2 branches after a distance from the ground as in the trees of Sheikh Zuweid, Qanatir Horticulture Research Institute and Faculty of Science - Ain Shams University (Plate 1 H - J); and at breast height level as in Qanatir Horticulture Research Institute (Plate 1 K). Lateral branches were crowded and appeared as clusters as in the trees of Faculty of Science (Alexandria University) and Qanatir Horticulture Research Institute (Plate 1 L - M). The branches of the trees in Sheikh Zuweid were the most slender and flexible. Moreover they were downwardly directed with a shrubby appearance (Plate 1 B).

Vitality (%) was estimated as the health appearance of the whole tree (branches, leaves, flowers and fruits). *M. oleifera* trees had shown high vitality percentage in Sheikh Zuweid and Aswan Botanical Garden (> 90%), while the least vitality (20%) was recorded in Antoniadis Garden (Plate 1 C) (Table 2). The measurements of leaf

length, pod length and circumference, seed weight and number of seeds per pod varied significantly among the studied locations (Table 3). *M. oleifera* leaves were compound tripinnate (Plate 2 A, Plate 3). Their mean length reached up to 59.6 cm in Faculty of Education (Ain Shams University) and 24.5 cm in Antoniadis Garden. The flowers were creamy off-white, collected as an axillary panicle inflorescence (Plate 4).

Plate 1 . Different modes of branching in *Moringa oleifera* from different studied sites. A: Monopodial branching of SZ trees; B: sympodial branching and shrubby appearance of SZ trees; C - F: sympodial branching of XA, SA, ED and OR trees; G: dichotomous branching of main trunk at ground level of QA trees; H - J: dichotomous branching of main trunk after a distance from the ground of SZ, QA and SA trees; K: dichotomous branching of main trunk at breast height level of QA trees; L - M: clusters of lateral branches of XA and QA trees; N: multiple branching of the main trunk at ground level of AS tree. (SZ: Sheikh Zuweid Station, XS: Botanical Garden of Faculty of Science - Alexandria University, XA: Antoniadis Botanical Garden, QA: Qanatir Horticulture Research Institute, SA: Botanical Garden of Faculty of Science - Ain Shams University, ED: Botanical Garden of Faculty of Education - Ain Shams University, OR: Orman Botanical Garden, AS: Aswan Botanical Garden).

Plate 1 - cont

TABLE 3. Mean (M) and standard deviation (SD) of leaf, pod and seed measurements of *Moringa oleifera* in 8 sites in Egypt: Sheikh Zuweid Station (SZ), Botanical Garden of Faculty of Science - Alexandria University (XS), Antoniadis Botanical Garden (XA), Qanatir Horticulture Research Institute (QA), Botanical Garden of Faculty of Science - Ain Shams University (SA), Botanical Garden of Faculty of Education - Ain Shams University (ED), Orman Botanical Garden (OR) and Aswan Botanical Garden (AS). Means with the same letters in the same row are not significantly different (P ≤ 0.05) as evaluated by One - Way ANOVA. *: Significant at P ≤ 0.05, *: Significant at P ≤ 0.001.**

Variable	Study site																Overall		F Value
	SZ		XS		XA		QA		SA		ED		OR		AS				
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	
Leaf length (cm)	38.3^{b}	7.6	36.3^{b}	7.5	24.5^{a}	13.3	52.9^{c}	17.8	56.5^{d}	12.3	59.6^{e}	8.0	50.9^{c}	8.4	35.3^{b}	7.8	44.3	15.9	128.4***
Pod length	29.0	3.9	-		-		50.4	4.3	46.5	6.1	47.6	3.2	46.6	2.5	42.2	4.6	43.7	8.2	327.7***
Pod circumference	5.2	0.7	-		-		4.2	0.3	3.7	0.3	3.7	0.3	3.7	0.5	2.9	0.3	3.9	0.8	305.6***
Seed number (seed pod^{-1})	14.7	3.7	-		-		18.8	3.1	16.7	3.9	21.8	2.6	20.5	1.6	13.7	2.9	17.7	4.2	111.0***
Seed weight (mg seed^{-1})	274.0	0.1	-		-		138.1	0.0	131.0	0.0	101.9	0.0	105.0	0.0	222.7	1.1	162.0	0.1	2.5*

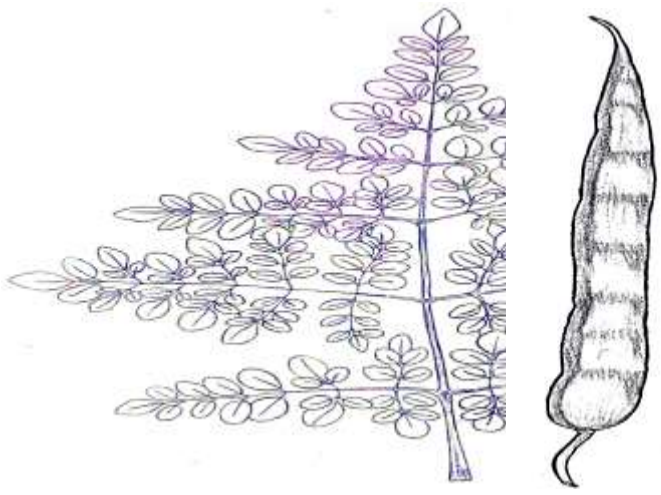

Plate 2 . Line drawing of *Moringa oleifera* (Lam.) A: Leaf, B: Pod, C: Seed (Drawn by Saadia H. Aly).

Plate 3. *Moringa oleifera* leaves in different studied sites. SZ: Sheikh Zuweid Station, XS: Botanical Garden of Faculty of Science - Alexandria University, XA: Antoniadis Botanical Garden, QA: Qanatir Horticulture Research Institute, SA: Botanical Garden of Faculty of Science - Ain Shams University, ED: Botanical Garden of Faculty of Education - Ain Shams University, OR: Orman Botanical Garden, AS: Aswan Botanical Garden.


Pod

Plate 4. ***Moringa oleifera*** **inflorescences in different studied sites. SZ: Sheikh Zuweid Station, XS: Botanical Garden of Faculty of Science - Alexandria University, XA: Antoniadis Botanical Garden, QA: Qanatir Horticulture Research Institute, SA: Botanical Garden of Faculty of Science - Ain Shams University, ED: Botanical Garden of Faculty of Education - Ain Shams University, OR: Orman Botanical Garden, AS: Aswan Botanical Garden.**

The fruits (pods) were dehiscent, elongated capsule which were green when young and turned brown on maturation, opening lengthwise through three angles (Plate 5). Both pods and flowers were recorded together in the trees of both Sheikh Zuweid and Antoniadis Garden (Plate 1 H, Plate 4: XA). Although having flowers, the tree of Faculty of Science - Alexandria University had no fruits at all. The longest pods were those of Qanatir Horticulture Research Institute (50.4 cm pod^{-1}), while those of Sheikh Zuweid were the shortest (29.0 cm pod^{-1}) with a maximum circumference of 5.2 cm pod^{-1} (Table 3).

Plate 5. *Moringa oleifera* pods from different studied sites. SZ: Sheikh Zuweid Station, XS: Botanical Garden of Faculty of Science - Alexandria University, XA: Antoniadis Botanical Garden, QA: Qanatir Horticulture Research Institute, SA: Botanical Garden of Faculty of Science - Ain Shams University, ED: Botanical Garden of Faculty of Education - Ain Shams University, OR: Orman Botanical Garden, AS: Aswan Botanical Garden.

Seeds were three-angled, with three papery wings. The coat color was off-white to creamy light yellow in most sites, while was brown in Sheikh Zuweid

and Antoniadis Garden. In addition, the papery wings were more obvious in the seeds of Sheikh Zuweid and Antoniadis Garden (Plate 6). The pods of Faculty of Education-Ain Shams University contained the maximum number of seeds (approximately 22 seed pod^{-1}). Sheikh Zuweid seeds had the maximum weight (274.0 mg seed^{-1}), while that of Faculty of Education - Ain Shams University had the minimum (101.9 mg seed^{-1}) (Table 3).

Plate 6 . *Moringa oleifera* seeds from different studied sites. SZ: Sheikh Zuweid Station, XS: Botanical Garden of Faculty of Science - Alexandria University, XA: Antoniadis Botanical Garden, QA: Qanatir Horticulture Research Institute, SA: Botanical Garden of Faculty of Science - Ain Shams University, ED: Botanical Garden of Faculty of Education - Ain Shams University, OR: Orman Botanical Garden, AS: Aswan Botanical Garden.

Discussion

The least trunk diameter value (6.7 cm) of Sheikh Zuweid trees may be related to their juvenile age. Growth in trunk diameter is due to the activities of the vascular cambium (situated between phloem and xylem). This growth is

designated as secondary growth or secondary thickening (Panshin and Dezeeuw, 1980). It was very troublesome to measure trunk diameter at breast height level for Sheikh Zuweid trees because they had numerous slender branches which were downwardly directed around this level.

The average height of *M. oleifera* trees (8.3 m tree^{-1}) lies within the height range of 6 - 15 m tree^{-1} recorded by Bosch (2004). Moreover, Parrotta (2009) mentioned that *M. oleifera* can grow in height up to 12 m tree^{-1}. The maximum height of the tree of Botanical Garden of Faculty of Education - Ain Shams University (13.0 m tree^{-1}) may be due to growth of *M. oleifera* in a dense garden containing 300 species in only 700 m^2 (Khalifa, 2006); this crowding may affect the light availability, and hence the plants get light through increasing their heights (Shaltout *et al.,* 2010). The least height of Sheikh Zuweid trees (2.0 m tree^{-1}) may be related to their juvenile ages (personal observation and communication). The comparison of height measurements, in this study, with the finding of Raunkiaer (1934), indicated that *M. oleifera* trees ranged from being microphanerophyte (i.e., height of 2 - 8 m) to mesophanerophyte (*i.e*., height of 8 - 30 m), thus gaining the quality of adaptation to different climates.

The trees of Sheikh Zuweid had the minimum canopy diameter (1.6 m), height (2.0 m tree^{-1}) and size (5.6 m^3 tree^{-1}), with slender branches which were downwardly directed with shrubby appearance. The decreased tree size may be a strategy for drought protection (Raunkiaer, 1934), and also to prevent This result agrees with the finding of Navie and Csurhes (2010). Variations in trunk branching (i.e., monopodial) may be genetically controlled (Panshin and Dezeeuw, 1980). Also, the clustering of branches may be caused artificially by man-made cutting for certain purposes (e.g., pruning and elimination of undesired branches). These cuttings were observed in many studied sites. As reported in ICRAF (2001), this species rapidly sends out new growth from the trunk after being subjected to cutting or damage.

The low vitality percentage of *M. oleifera* tree in Antoniadis Garden may be due to planting it on a higher ground level which might minimize adequate water needed for optimum growth (personal observation). On the other hand, the tree of Botanical Garden of Faculty of Education (Ain Shams University) was grown in a highly crowded garden (Khalifa, 2006), hence leading to shortage of nutrients. The basic form of the trunk is supposed to be genetically controlled. However, it can be strongly modified by the environmental influences and cultural practices which affect the vigor, size and shape of the tree crown (Panshin and Dezeeuw, 1980).

The average leaf length of *M. oleifera* in the present study (44.3 cm) was very close to 45.0 cm recorded by Parrotta (2009). The high significant variation in leaf length among the studied sites may be related to the rate of supply of the soil nutrients (Shinozaki and Kira, 1956). The mean pod length was 43.7 cm, which lies within the length range of 30 - 45 cm recorded by Qaiser (1973), 20 -

60 cm recorded by Makkar and Becker (1997), and 30 - 120 cm recorded by Foidle *et al.* (2001) and Parrotta (2009). The pods of *M. oleifera* from Egypt had a medium length like the Mexican pods (20 - 40 cm) of the same species (Hekal *et al.*, 1995). Pod length variation among the studied sites may be attributed mainly to differences in soil properties. The maximum value of circumference in Sheikh Zuweid pods assumed the reverse relation between air temperature and pod circumference. Generally, Palada and Chang (2003) mentioned that variation in leaf and pod properties can be caused by differences within *M. oleifera* varieties.

In most sites, the color of *M. oleifera* seed coat was off-white to creamy light yellow, while it was brown in Sheikh Zuweid and Antoniadis Garden. Seeds with brown coat were recorded by Makkar and Becker (1997), with dark brown coat by Palada (1996) and with brown to black coat by Parrotta (2009). The seeds of *M. oleifera* from Pakistan were covered by coats ranged in color from being black (Anwar *et al.,* 2005; Banerji *et al.,* 2009), off-white (Anwar and Bhanger 2003; Anwar *et al.,* 2006 b), pale yellow to white (Anwar and Rashid 2007) and pale yellow to creamy (Anwar *et al.*, 2006 a).

Each pod contained approximately 15 - 22 seed pod^{-1}; it was close to the range of 12 - 35 seed pod^{-1} recorded by Makkar and Becker (1997) and Foidle *et al.* (2001); but lower than that of 20 - 25 seed pod^{-1} recorded by Hekal *et al.* (1995) and the mean of 26 seed pod^{-1} recorded by Parrotta (2009). The average seed weight was 162.0 mg $seed^{-1}$, which was higher than that of 130.0 mg $seed^{-1}$ recorded by Anwar and Rashid (2007); but lower than that of 300.0 mg $seed^{-1}$ recorded by Anwar and Bhanger (2003) and Parrotta (2009). Varieties within *M. oleifera* may vary in pod and seed characteristics (Palada and Chang, 2003). The significant differences of seed weight between sites may be related to variability of climate factors, soil properties (nutrients and drainage) and cultivation practices. The heavy weight of Sheikh Zuweid seeds may be due to suitable irrigation, which agrees with the study of Anwar *et al.* (2006 b) which recorded that the seeds assayed from an irrigated region in Pakistan were significantly heavier, when compared with those of drought regions. This was confirmed by the study of Triboi-Blondel and Renard (1999) which reported that seed weight decreased under conditions of water stress.

Conclusion

The study of morphological properties of *M. oleifera* indicated some variations in the features of species attributes (trees, leaves, pods and seeds), which may be due to genetic differences within species, environmental conditions (*e.g*., climate and soil properties) and cultivation practices. This research is a starting effort in the description of *M. oleifera* morphology in Egypt. Thus, it is recommended to assay this species in other numerous sites, as possible, in order to follow the extent of their morphological as well as genetic variations.

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تباين الشكل الظاهرىلجماعات نبات البان (مورينجا أوليفيرا) فى مصر

كمال شلتوت،حسين محمود، أحمد عبد الله، دينا بركة، سعدية حامد
قسم النبات – كلية العلوم – جامعة طنطا ،قسم تكنولوجيا الخشاب – كلية الزراعة –جامعة الاسكندرية ، قسم النبات – كلية العلوم – جامعة بنها

يهدف البحث الحالى إلى دراسة اختلاف الشكل الظاهرى لجماعات نباتالبان فى ثمانية مواقع بمصر. أظهرت النتائج وجود اختلافً معنوي بين المواقع فى معظم الصفات المدروسة. كانت أشجار معهد بحوث البساتين بالقناطر هي الأكبر من حيث الحجم (٨٥٣,٨ م^{3} شجرة$^{-1}$)، وقطر كلٍ من التاج (٩,٩ مشجرة$^{-1}$) والجزع الرئيسى عند مستوي إرتفاع الصدر (٦٣,٤ سمشجرة$^{-1}$)؛ بينما كانت أشجار محطة الشيخ زويد هى الأقل من حيث الحجم (٥,٦ م^{3} شجرة$^{-1}$) والإرتفاع (٢,٠ م شجرة$^{-1}$) . تم ملاحظة عدة أشكال لتفرع الجزع الرئيسى للأشجار حيث كان التفرع كاذب المحور هو السائد فى معظم المواقع. وبخصوص التباين فى الورقة، كانت أوراق البان فى الحديقة النباتية لكلية التربية - جامعة عين شمس هى الأطول (٥٩,٦ سم ورقة$^{-1}$)، بينما تلك التى فى حديقة أنطونيادسكانت هى الأقصر (٢٤,٥ سم ورقة$^{-1}$). ومن ناحيةأخرى؛ كانت القرون فى معهد بحوث البساتين بالقناطر هى الأطول (٥٠,٤ سم قرن$^{-1}$). وقد إحتوت القرون فى الحديقة النباتية لكلية التربية - جامعة عين شمس على العدد الأكبر من البذور (٢٢ بذرة قرن$^{-1}$ تقريباً)، بينماكانت بذور محطة الشيخ زويد هى الأثقل وزناً (٢٧٤,٠ مجم بذرة$^{-1}$). وعموماً؛قد لا يعزى التباين الظاهرى للأجزاء المختلفة لهذا النبات (السوق، الأوراق، القرون والبذور) إلىالتباين فى الظروف البيئيةفقط (خاصةًخواص المناخ والتربة)؛ ولكن أيضاً من الممكن أن يكون راجعا لتباين فى التنوع الوراثى بين جماعات هذا النبات، ومن هنا نوصى بدراسة التباين الوراثى بين جماعاته قى الأماكن والبيئات المختلفة فى مصر.