GENETIC DIVERSITY OF TWELVE SWEET SORGHUM (Sorghum bicolor L. Moench) VARIETIES USING SOME QUANTITATIVE CHARACTERS

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ABSTRACT

Four field experiments were conducted at two different locations (Sabahia and Nubaria Research Stations, Sugar Crops Research Institute, Agricultural Research Center) during two successive seasons 2001 and 2002 using twelve commercial varieties of sweet sorghum (Roma, Sugar drip, Brawley, Rio, Tracy, Honey, Rex, Williams, Willey, Collier, Ramada and Brandes), to evaluate some quantitative characters (morphological, yield and technological characters) in order to find out the relationship among the twelve sorghum varieties throughout the Euclidean distance. The results obtained showed that, there were a significant effect on most of studied characters in both locations and seasons due to varieties.

The relationships among the twelve sorghum varieties showed dissimilarity matrix of the Euclidean distance using quantitative traits between all pairs of varieties ranged from 2.06 between Williams and Willey varieties to 7.25 between Brandes and Collier varieties. The range of Euclidean distance among all varieties found to be wide relatively which indicated that the amount of phenotypic variation among varieties was high dissimilar between the twelve varieties, it can be also noticed that the lowest value was between Williams and Willey while, Collier and Brandes recorded the highest value. The importance of the data in the breeding programs can be summarized in prediction of parental specific combining ability in F_1, occurrence of transgressive segregation in a cross due to genetically distant parents which allow desirable alleles to be combined in offspring and develop an index for parental selection and the hybridization between different varieties expected to increase the hybrid vigour depending on the location.

INTRODUCTION

Sweet sorghum (*Sorghum bicolor* L. Moench) or sorgo is closely related to other sorghum crops belongs to C4 plants with high photosynthetic efficiency and high productivity. It differs from grain sorghum mainly in that its grain yields are low and its stalks are taller and juicier and have a high sugar content.

Sorghum is native to Africa, and many of today's varieties originated there. Sorghum was also grown in India before recorded history and in Assyria

and the western Hemisphere much later (Duke and Wain, 1981 and Duke 1982a)

Sorghum was introduced to the United States from Africa in the early part of the seventeenth century. It was not grown extensively in this country until the 1850s when the forage variety Black Amber (also called " Chinese sugarcane") was introduced from France. Since then many other varieties have been introduced from other countries or developed domestically (Wrights, 1942 and Rohweder *et al.,* 1965).

Sorghum is the only crop that provides grain and stem that can be used for sugar, alcohol, syrup, jaggery, fodder, fuel, bedding, roofing, fencing paper and chewing. It has been used for nearly 150 years to produce concentrated syrup with a distinctive flavour (Schaffert, 1992). Sweet sorghum have also been widely used for the production of forage and silage for animal feed. The oil crisis of 1973 and 1976 renewed interest in the commercial production of sweet sorghum for biological transformation into ethyl alcohol for use as fuel additive (Schaffert, 1982, Ethanol production from sweet sorghum, Hallgern *et al.,* 1992 and Sumantri, 1998).

In Egypt, research on such crop has begun to use it as a sugar resource and to minimize the gap between sugar production and its consumption. Consequently, there are some varieties found to be high in syrup and golden syrup which could reduce the area cultivated with sugar cane. In case of success, an increase of 50000 tons of sugar could be gained (Ghora, *et al.* 2004).

On the other hand, genetic information in sorghum is not as extensive as in Corn, Wheat or Barley. However, genetic studies have been made on stalk juiciness and sweetness and other characters. In addition, genetic relationship among cultivars have been shown to be useful for the analysis of cultivar variability (Smith, 1984 and Cox *et al.,* 1986).

Traditionally, distance estimation and characterization were based entirely on morphological markers and quantitative traits (Goodman, 1977). Furthermore, recent studies have been focused on genetic markers in form of gene products such as isozyme, storage proteins (Oleo *et al.,*1992) and direct DNA markers (EL-Manhaly *et al.,*2004 and Attalah *et al* , 2004). Considering the quantitative traits such as morphological, yield and technological characters, it seemed to be delayed studies as genetic markers. They are often modified by the environment, and coded by unknown marker genes. The usage of such traits on genetic diversity was done on several crops (Spagnoletti and Qualset *et al.,* 1987, Beer *et al.,*1993, Autrique *et al.*,1996, and Abd El-Hameed ,2004). In addition, the

identification of the breeding materials before introducing it in breeding programs is considered to be essential (Van Beuningen and Busch, 1997).

Therefore, the present investigation was established in order to characterize and identify twelve commercial varieties of sweet sorghum at two different locations during two successive seasons using some quantitative traits (morphological, yield and technological characters). The measurement of genetic diversity of the twelve varieties were made by using the genetic distance in such traits.

MATERIALS AND METHODS

Four field experiments were conducted at two different locations (Sabahia Research Station and Nubaria Research Station, Alexandria, Sugar Crops Research Institute, Agricultural Research Center) during two successive seasons (2000/2001 and 2001/2002) in order to, identify and to measure the genetic diversity by using twelve sweet sorghum varieties kindly supported by Sugar Crops Research Institute. The twelve varieties named Roma, Sugar drip, Brawley, Rio, Tracy, Honey, Rex, Williams, Willey, Collier, Ramada and Brandes. A split plot design with four replications was used.

Seeds of the twelve varieties were sown on first of June in both seasons in Sabahia and Nubaria. The experimental unit was 15 meter square (5m length x 3m width) with 5 ridges, and 20 cm between plants, one plant per hill. The agronomic practices for growing sweet sorghum were used.

At dough stage (112 days from sowing date), ten randomized guarded plants were used to determine the morphological, yield and technological characters in addition to genetic distance of such characters in both locations and seasons.

Harvest was done at the dough ripening stage at which the highest yield of stalks and the highest amount of sugar with good quality were done (Smith & Reeves, 1982; Hurst, 1988 and EL-Maghraby *et al.*, 1992). Sample size was 10 plants/plot.

The following characters were recorded:

1-Morphological characters:

- Stalk height/plant (m)
- Stalk diameter /plant (cm)
- No. of internodes /plant.

2-Yield characters:

- Juice weight / plant (gm)
- Stalk yield after stripping (ton /fed).
- Juice yield (ton /fed).
- Syrup yield (ton/fed).

3-Technological characters:

- Total soluble solids T.S.S. %.
- Sucrose %
- Purity %

4- Genetic Diversity

- Data analysis:

Means across both locations and seasons for each of the quantitative measured variables (morphological, yield and technological characters) were used to compute a similarity distance matrix.

The data was transformed with the STAND procedure from NTSYS-PC ver. 2.1 (Rohlf, 2000). The standardization procedure reduced the effect of different measurement scales of the different characters used in the present investigation. Cluster analysis was conducted on the Euclidean distance. Matrix with un-weighted pair group method based on arithmetic average (UPGMA) to develop a dendrogram using computer program NTSYS-PC ver 2.1 (Rohlf, 2000).

Physical and chemical analysis of the soil surface layer (0-30 cm) was done for the two locations and seasons. (Tables 1&2) according to Piper, 1950.

5- Statistical analysis:

Data were statistically analyzed according to Steel and Torrie (1981) by using least significant differences (L.S.D.) at 0.05 percent level of significance.

Table (1): Physical and chemical properties of the soil surface layer (0.30 cm) during 2000/2001 and 2001/2002 seasons at Sabahia Research Station farm.

Character	2000/2001	2001/2002
Ca^{+2} meq/L	16.83	16.94
Mg^{2+} meq/L	4.23	6.39
Na^{+} meq/L	15.01	14.33
K^{+} meq/L	1.33	1.03
CO_3^{-2} meq/L	0.00	0.01
HCO^{-3} meq/L	2.43	2.48
C^{-1} meq/L	25.18	24.11
SO_4^{-2} meq/L	14.01	14.73
EC dSm^{-1}	4.63	4.58
PH	7.81	8.06
Total N %	0.10	0.11
Organic matter	1.41	1.23
Clay %	41.11	42.13
Silt %	43.1	42.81
Sand %	13.91	13.71
Text class	Clay loam	Clay loam
CaCo3 %	5.3	5.8

Table (2): Physical and chemical properties of the soil surface layer (0.30 cm) during 2000/2001 and 2001/2002 seasons at Nubaria Research Station farm.

Character	2000/2001	2001/2002
Soil pH	7.3	7.41
E.C. ds/m	2.04	1.98
CaCO3 %	34.01	33.41
Organic matter %	0.49	0.53
DEC, mg/100 g soil	13.91	12.41
Na Hco3- ext-Mg/g	2.31	2.03
DTPA-ext. Mg/soil	2.83	2.78
DTPA-ext. Mn, Mg/soil	2.41	2.01
DTPA-ext. Zn, Mg/soil	1.08	1.13
DTPA-ext. Cu, Mg/soil	0.39	0.37
Sand %	54.03	53.01
Clay %	9.73	11.41
Silt %	39.00	39.41
Text class	Sandy clay loam	

RESULTS AND DISCUSSION

The main purpose of the present investigation is to identify twelve commercial varieties of sweet sorghum at two different locations (Sabahia as well as Nubaria Research Stations, Alexandria, Egypt.) during two successive seasons, 2000/2001 and 2001/2002 throughout some quantitative characters (morphological, yield and technological characters) for measuring the genetic diversity to such varieties.

1- Morphological characters:

- **Stalk height:**

The results obtained from this part of study as shown in Tables (3 and 4), indicated that the differences between varieties in stalk height were significant in both seasons and locations as well. In the first season, the highest value was 2.42 m for Roma variety in Sabahia while the same value was to Ramada variety in Nubaria. In second season, the highest value was to Roma (2.38m) in Sabahia and Ramada (2.24m) in Nubaria. Brawely variety gave the lowest values of stalk height for both seasons and locations since it was 1.66 and 1.7 m in Sabahia and Nubaria, respectively at the first season. While it was 1.80 m and 1.67 m in the second one (Table ,3).Such results are in a harmony with those obtained by EL-Taweel (1994) and Bapat *et al.*, (1997).

- **Stalk diameter:**

Significant differences were found in stalk diameter among the studied varieties in both seasons. In 2001, plants of Brandes variety produced the high stalk diameter in Sabahia (2.35 cm) and Roma variety was 2.33 cm in Nubaria. In 2002, Honey variety in Sabahia and Rex variety in Nubaria gave the highest stalk diameter (2.33 and 2.75 cm, respectively). The plants of Sugar drip and Willey varieties gave the lowest values of stalk diameter in the two seasons (1.78 and 1.70) at Sabahia while Tracy variety gave the lowest stalk diameter values in both seasons (1.78 and 1.68 cm) in Nubaria.

These results are in agreement with those recorded by Taha (1990), EL-Maghraby and Gomaa (1992) and Ravi *et al.*, (1997).

- **Number of internodes:**

Results presented in Table (3) showed that, the number of internodes/plant was significantly affected by the varieties in both seasons. Sugar drip variety in Sabahia and Ramada in Nubaria produced the highest number of internodes since it was 13.00 and 12.60, respectively in the first season. In the second one, Honey variety in Sabahia (12.85) and Tracy

variety (13.03) in Nubaria gave the highest number of internodes. The Brawley variety gave the lowest number of internodes in the first season (9.95) while Rio variety was the lowest (8.9) in the second season at Sabahia. In Nubaria Rio gave the lowest number of internodes for both seasons (9.53 and 8.8).

These results are in accordance with that reported by Nallathambi (1997).

As shown in Table (4) and with regard to the differences between varieties using the previous morphological characters, it can be noticed that, the tallest stalk high were produced from Willey (2.18m) and Williams (2.17m) while Brawley variety gave the shortest stalk high (1.71 m). Brandes gave the highest values of stalk diameter (2.13 cm) and Willey variety gave the lowest one (1.80 cm). Sugar drip ,Tracy and R Amada varieties gave the high number of internodes (12.77, 12.13 and 12.03) and Rio variety gave the lowest number (10.29).

Considering the locations, it can be observed that Sabahia location gave the highest values for stalk height since it was 2.06 m while Nubaria location gave the highest values for stalk diameter / plant (11.42 mm) and number of internodes (1.95). In addition, the first season gave the highest values for stalk high (2.00m) and number of internodes (1.94), while there was no significant differences between the two seasons for stalk diameter. Here, it could be stated that, the performance of the varieties showed vary from environment to another (either years or locations or both).

2-Yield characters:

Tables (5 and 6) showed the comparison between varieties, locations and seasons on yield characters of twelve sweet sorghum plants.

- **Juice weight/plant:**

Statistical analysis showed that juice weight per plant was significantly differed in varieties in the two locations and seasons. (Table, 5). In the first season, Tracy variety recorded the highest value of juice weight/plant in Sabahia (184.70 gm) and Honey variety was the highest in Nubaria (196.88 gm). In the second season, Roma variety was the highest in Sabahia (188.50 gm) and Honey variety in Nubaria (186.78 gm). The lowest values of juice weight per plant in the first season obtained from Brawley variety (113.70 gm) in Sabahia and (107.13 gm) in Nubaria. While in the second season, Brawley variety recorded the lowest values in Sabahia (110.80 gm) and (108.88 gm) in Nubaria. Such results are agreed with those obtained by Chetto *et al.*,(1997) and Nallathambi (1997).

- **Stalk yield after stripping:**

The results of stalk yield after stripping in both locations and seasons are given in Table (5). The results showed that the yield of stalk after stripping varied significantly in both seasons. In the first season, the highest stripped stalk yield was obtained from Collier variety in Sabahia (23.45 ton/fed.) and from Willey variety in Nubaria (23.28), while the lowest values was produced from Brandes in Sabahia (18.85 ton/fed.) and in Nubaria (19.44 ton/fed.). In the second season, the highest values of stripped stalks yield were obtained from varieties Williams in Sabahia (23.82 ton/fed.) and Willey in Nubaria (23.49 ton/fed.). The lowest values of such character were recorded from Brandes in Sabahia (18.89 ton/fed.). and from Rio in Nubaria (19.46 ton/fed.).

In general, yield of stalks is an important character and affected by varieties after stripping more than before. These results are in accordance with that reported by EL-Maghraby *et al.,* (1994), Taha *et al.,* (1995), Assran (1996), Almodares *et al.,*(1997), Minghui *et al.,* (1997) and Abou-Shady (1998).

- **Juice yield:**

Table (5) showed that there were significant variations at both locations and seasons in juice yield due to varieties. The highest values of juice yield in the first season were obtained from Williams variety in Sabahia (9.62 ton/fed.) and Willey in Nubaria (9.19 ton/fed.). While in the second season, Collier variety was the highest in Sabahia (9.5 ton/fed.) and Nubaria (9.69 ton/fed.). Whereas the lowest values of juice yield were obtained from Brandes variety in Sabahia (6.27 ton/fed.) and Nubaria (7.06) in the first season. In the second one, Rex variety in Sabahia (6.74 ton/fed.) and Brandes in Nubaria (6.39 ton/fed.) recorded the lowest values.

These results coincided with the findings of Bennett (1982), Sankarapandian *et al.,* (1995) and Abou-Shady (1998).

- **Syrup yield :**

As regard to varieties influence, data indicated that syrup yield was significantly affected by the varieties in both locations and seasons (Table, 5). In the first season, the highest syrup yield was observed from sugar drip variety in Sabahia (1.69 ton/fed.) and Honey variety in Nubaria (1.69 ton/fed.). In the second season, the highest values recorded from Collier variety in Sabahia (1.73 ton/fed.) and Nubaria (1.76 ton/fed.). The lowest values were obtained from Ramada in Sabahia (1.02 ton/fed.). and Brandes in Nubaria (1.19 ton/fed.) in the first season. While in Sabahia, Brandes recorded the lowest value (1.19 ton/fed.) in the second season

and Ramada in Nubaria (1.07 ton/fed.). These results are in the same trend with those recorded by Taha (1990), EL-Taweel (1994) and Abou-Shady (1998).

From Table (6), we can conclude that the highest values of yield characters observed from Collier variety in stalk yield after stripping (23.19 ton/fed.), Roma variety in juice weight /plant (184.9 gm), Williams variety in Juice yield (8.95 ton/fed.) and Collier variety in syrup yield (169 ton/fed.). The lowest values were noticed from Brandes variety in stalk yield after stripping (19.15 ton/fed.), Brawley in Juice weight per plant (110.15 gm), Brandes variety in Juice yield (9.29 ton/fed.) and Brandes variety in syrup yield (1.14 ton/fed.).

As shown in Table (6), it can be noticed that Nubaria location recorded the highest values for all yield characters except Juice yield. However, these values were not significantly differed. On the other hand, there were slight increases between the two seasons of cultivation.

3-Technological characters:

Tables (7 and 8) showed the effect of varieties, locations and seasons on some technological characters of sweet sorghum plants.

- **Total soluble solids (T.S.S %):**

The studied varieties observed a significant effect of total soluble solids (T.S.S) percentage in both locations and seasons (Table, 7). Roma variety recorded the highest percentage of T.S.S. in Sabahia (18.95) and Nubaria (18.95) in the first season and in the second one these values were 18.55 and 18.78 in Sabahia and Nubaria respectively. While, Willey variety recorded the lowest percentage in the two locations and seasons (11.95 in Sabahia and 11.43 in Nubaria in the first season and 11.75 in Sabahia and 11.38 in Nubaria in the second one).

These results are in agreement with those observed by Abbas *et al.*, (1997), Nallathambi (1997) and Abou-Shady (1998).

- **Sucrose percentage:**

Concerning the varieties effect, the results revealed that sucrose percentage differed significantly from one variety to another in both locations and seasons (Table,7). In both seasons the highest value of sucrose percentage in the first season was observed from Collier variety in Sabahia (9.23%) and Nubaria (11.23%). However, in the second season it was (10.83%) in Sabahia and (11.50%) in Nubaria. On the other hand, the lowest value was observed from Brandes variety for both locations and seasons since it was 3.96% in the first season and 3.23% in the second

season in Sabahia and 3.52% in the first season and 3.88% in the second one in Nubaria.

These results are in similar with those obtained by Smith and Buxton 1993, Cosentino *et al.,* 1997) and Ravi *et al.,* (1997).

- **Purity percentage:**

The results presented in Table (7) recorded the values of purity percentage of extracted juice from sweet sorghum stalks under effect of varieties, locations and seasons. Purity percentage of stalk juice was significantly affected by varieties in both seasons. In the first season, Sugar drip variety gave the highest values of purity percentage in Sabahia (48.38%) and Collier variety in Nubaria (59.08%). In the second season, Collier was the highest in purity percentage in Sabahia (61.25%) and Nubaria (61.60).

Consequently, Brandes variety has the lowest values of purity percentage in both locations and seasons. In Sabahia, it was 26.07% and 22.70 % at both seasons respectively. In Nubaria, it was 21.28% in the first season and 25.25% in the second one. A similar results were obtained by Eskandar (2003).

From Table (8), it can be observed that Roma variety recorded the highest value of T.S.S% (18.71), Collier gave the highest value of sucrose percentage (10.69) and purity percentage as well (57.98). In addition, Sabahia location gave the highest values of the technological characters and there were a slight increase between seasons of such characters.

4-Genetic relationship using quantitative traits:

In order to find out the relationship among the twelve sorghum varieties, the Euclidean distance among such varieties was calculated. It was based on the ten quantitative traits scored for all varieties during the two locations and seasons as well. The morphological, yield and technological characters were chosen according to some respects. First, all of traits were closely related to the yield. Second, such traits were easily to score, which make it suitable for morphological analysis. Third, the importance of these traits for breeder and also for breeding programs. Relationships among the 12 sorghum varieties based on the standard values of the quantitative traits (Table, 9). It showed the dissimilarity matrix of the Euclidean distance using quantitative traits between all pairs of varieties ranged from 2.06 between Williams and Willey to 7.25 between Brandes and Collier. The range of Euclidean distance among all varieties relatively wide which indicate that the amount of phenotypic variation

among the varieties found to be high relatively. These values which assumed to reflect the genetic diversity of the two loci controlling the characters.

- **Cluster analysis:**

The dissimilarity matrix have been used to generate a phonogram of the twelve sorghum varieties (Figure , 1). The cluster diagram showed a complicated genetic variation patterns, four groups or clusters were obtained through cluster analysis. Cluster 1 includes four varieties (Roma, Tracy, Collier and Sugar drip) at Euclidean distance about 3, while cluster 2 includes three varieties, two of them were closely related (Williams and Willey) at Euclidean distance 2.06 and Brawley and Rio varieties were separated in the third cluster at Euclidean distance of about 2.50. The last three varieties (Rex, Ramada and Brandes) separated in the four clusters at values of Euclidean distance about 3.3. Again and from the dissimilarity between the twelve varieties as shown in Table (10), it can be observed that the lowest value was between Williams and Willey while, Collier and Brandes recorded the highest value.

The importance of such data in the breeding programs is: Prediction parental specific combing ability (SCA) in the first generation (F1) (Souza and Sorells, 1991).Occurrence of transgress segregation in a cross due to genetically distant parents which allow favorable alleles to be combined in offspring (Cowen and Frey, 1987 and Tsegaye *et al.,* 1998).Develop an index for parental selection and the hybridization between different cluster varieties expected to increase the hybrid vigour and allelic diversity which can be used in breeding programs (Van Bruningen and Busch, 1997)

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Table (3): Means of morphological characters for twelve Sorghum varieties at Sabahia and Nubaria locations in 2001 and 2002 seasons

Varieties	Stalk height/plant				Stalk diameter/plant				No. of internodes /plant			
	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Roma	2.42	2.38	1.88	1.85	1.85	2.00	2.28	2.25	11.08	11.38	10.08	10.60
Sugar drip	1.87	2.08	1.87	1.79	1.78	2.28	1.80	1.90	13.00	12.83	12.33	12.80
Brawley	1.66	1.80	1.71	1.67	1.83	1.85	1.80	1.80	9.95	10.00	10.53	10.68
Rio	1.79	1.80	1.86	1.86	1.88	1.75	1.95	2.25	2.33	8.90	9.53	8.08
Tracy	2.35	2.28	1.87	1.92	1.88	1.78	1.78	1.68	11.68	11.35	12.43	13.03
Honey	1.95	1.99	1.80	1.82	2.20	2.33	1.90	2.00	10.63	12.85	11.18	11.13
Rex	1.90	1.90	1.80	1.82	2.13	1.73	2.03	2.75	10.93	10.10	11.58	12.13
Williams	2.18	2.28	2.08	2.13	1.85	1.90	1.88	1.88	11.55	12.25	11.75	11.90
Willey	2.18	2.20	2.29	2.06	1.98	1.70	1.83	1.70	11.25	11.20	11.93	11.50
Collier	2.30	2.35	2.05	1.97	2.08	2.13	2.06	2.13	11.48	12.18	11.33	12.18
Ramada	1.92	2.06	2.30	2.24	1.95	2.30	1.88	1.70	12.15	11.55	12.60	11.80
Brandes	2.11	1.85	1.93	1.95	2.35	2.00	1.85	2.30	11.00	10.83	11.12	11.03
L.S.D. at 0.05	0.0873				0.08934				0.3089			

Table (4): Effect of varieties, Locations and seasons on some morphological characters in twelve varieties of sweet sorghum.

Varieties	Stalk height /plant (m)	Stalk diameter/ plant cm	No. of internodes/ plant
Roma	2.13 ef ± 0.291	2.09 c ± 0.217	10.78 c ± 0.623
Sugar drip	1.90 c ± 0.169	1.94 c ± 0.236	12.77 l ± 0.511
Brawley	1.71 a ± 0.080	1.82 a ± 0.111	10.29 b ± 0.722
Rio	1.82 b ± 0.109	1.96 c ± 0.231	9.21 a ± 0.542
Tracy	2.10 c ± 0.251	1.83 a ± 0.148	12.13 h ± 0.795
Honey	1.89 c ± 0.137	2.11 e ± 0.128	11.45 f ± 0.293
Rex	1.85 bc ± 0.102	2.04 d ± 0.261	11.18 e ± 0.244
Williams	2.17 f ± 0.197	1.88 b ± 0.023	11.86 g ± 0.475
Willey	2.18 f ± 0.129	1.80 a ± 0.155	11.47 f ± 0.582
Collier	2.17 f ± 0.179	2.09 de ± 0.161	11.79 g ± 0.496
Ramada	2.13 ± 0.171	1.96 c ± 0.253	12.03 h ± 0.655
Brandes	1.96 d ± 0.118	2.13 e ± 0.262	11.01 d ± 0.415
L.S.D. at 0.05	0.04403	0.04508	0.15589
Locations			
Sabahia	2.065 b ± 0.243	1.288 b ± 0.224	11.23 a ± 1.107
Nubaria	1.938 a ± 0.196	1.951 a ± 0.231	11.427 b ± 1.20
L.S.D. at 0.05	0.1155	0.0199	0.1716
Seasons			
1st season	2.002 b ± 0.244	1.948 a ± 0.203	11.269a ± 1.079
2nd season	1.899 a ± 0.215	1.291 b ± 0.250	11.390 a ± 1.153
L.S.D. at 0.05	0.05318	0.2503	N.S

Table (5): Means of yield characters for twelve Sorghum varieties at Sabahia and Nubaria locations in 2001 and 2002 seasons.

Varieties	juice weight/plant				stalk yield afters stripping (ton/fed)				Juice yield (ton/fed.)				syrup yield (ton/fed.)			
	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Roma	184.5	188.5	187.13	179.83	22.04	22.46	22.47	22.02	8.00	8.41	8.17	8.13	1.53	1.60	1.71	1.72
Sugar drip	129.58	126.38	137.58	119.75	22.12	21.94	22.43	21.93	8.88	8.77	8.58	7.76	1.69	1.57	1.73	1.63
Brawley	113.7	110.8	107.13	108.88	20.34	20.25	20.33	19.99	7.66	7.66	7.61	7.28	1.28	1.42	1.63	1.52
Rio	166.2	170.88	146.88	158.98	20.30	19.65	19.62	19.66	8.20	6.92	7.28	7.24	1.52	1.42	1.52	1.48
Tracy	184.7	183.38	167.75	175	22.35	21.8	23.08	22.81	8.53	8.19	8.02	8.36	1.43	1.63	1.52	1.43
Honey	183.88	176.88	190.88	166.78	23.43	23.29	22.64	22.60	8.99	9.66	8.18	8.34	1.71	1.75	1.69	1.62
Rex	127.45	135.75	108.36	111.45	20.40	19.83	20.23	19.84	7.36	6.74	7.24	7.46	1.08	1.20	1.25	1.28
Williams	175.55	180.25	164.63	161.6	23.40	23.82	22.98	22 85	9.62	10.09	8.20	7.92	1.69	1.81	1.85	1.6
Willey	181.6	145.25	173.5	171.28	22.11	21.73	23.28	23.49	8.38	8.48	9.19	9.57	1.43	1.64	1.76	1.7
Collier	165.43	165	178.25	184.63	23.45	23.13	22.96	23.19	9.33	9.56	8.59	9.69	1.61	1.73	1.66	1.76
Ramada	136.5	132.12	174.56	167.88	19.29	19.9	20.05	19.62	6.41	7.69	7.09	7.68	1.02	1.38	1.2	1.07
Brandes	128.37	119	143.75	132.9	18.85	18.89	19.49	19.83	6.27	7.19	7.06	6.39	1.04	1.19	1.15	1.17
L.S.D. at 0.05	17.746				0.22051				0.3862				0.02684			

Table (6): Effect of varieties, Locations and seasons on some yield characters in twelve varieties of sweet sorghum.

Varieties	Juice weight / pant gm	Stalk yield after stripping (ton/fed.)	Juice yield (ton/fed.)	Syrup yield (ton/fed.)
Roma	184.91 f ± 5.98	22.25 f ± 0.276	8.18 d ± 0.182	1.64 g ± 0.083
Sugar drip	128.3 b ± 7.76	22.10 e ± 0.318	8.49 e ± 0.467	1.65 g ± 0.067
Brawley	110.15 a ± 6.55	20.23 d ± 0.273	7.55 c ± 0.173	1.46 d ± 0.135
Rio	160.73 cd ± 11.19	19.71 b ± 0.487	7.41 bc ± 0.536	1.48 e ± 0.047
Tracy	177.71 ef ± 11.05	22.51 g ± 0.651	8.27 d ± 0.312	1.50 f ± 0.084
Honey	184.60 f ± 7.56	22.99 l ± 0.432	8.79 f ± 0.618	1.69 l ± 0.049
Rex	120.74 b ± 13.25	20.07 c ± 0.316	7.20 b ± 0.378	1.20 c ± 0.088
Williams	170.51 de ± 10.19	23.23 j ± 0.414	8.95 f ± 0.986	1.68 e ± 0.084
Willey	167.91 de ± 40.65	22.65 h ± 0.784	8.90 f ± 0.520	1.63 g ± 0.128
Collier	173.33 ef ± 10.56	23.19 j ± 0.324	9.29 g ± 0.443	1.69 l ± 0.065
Ramada	152.75 c ± 19.95	19.71 b ± 0.359	7.22 b ± 0.859	1.17 b ± 0.152
Brandes	130.50 b ± 10.47	19.15 a ± 0.455	6.73 a ± 0.492	1.14a ± 0.070
L.S.D. at 0.05	8.95497	0.11127	0.18720	0.01354
Location				
Sabahia	154.57 a	21.43 a	8.20 b	1.47 a
Nubaria	155.78 a	21.52 a	7.96 a	1.51 b
L.S.D. at 0.05	4.14554	0.107349	0.09077	5.91204
Seasons				
1st season	156.48 a	21.56 b	8.035 a	1.47 a
2nd season	153.87 a	21.40 a	8.13 a	1.51 b
L.S.D. at 0.05	0.83040	0.03976	0.21553	5.69056

Table (7): Means of technological characters for twelve Sorghum varieties at Sabahia and Nubaria locations in 2001 and 2002 seasons

Varieties	Total soluble Solids (T.S.S %)				Sucrose %				Purity %			
	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria	Sabahia	Nubaria
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Roma	18.95	18.55	18.95	18.78	7.63	7.38	7.85	7.70	40.24	41.45	39.80	41.90
Sugar drip	17.45	17.38	17.15	17.08	8.43	8.25	8.35	8.18	48.38	48.73	47.50	47.88
Brawley	16.40	16.23	16.38	17.18	7.20	7.28	6.93	7.05	43.93	42.28	44.85	41.03
Rio	17.48	18.25	18.00	17.98	8.58	8.85	9.75	7.40	48.88	54.18	48.50	41.20
Tracy	17.98	17.85	17.80	17.25	9.03	8.63	8.98	9.18	50.20	50.68	48.28	52.75
Honey	15.58	14.63	15.18	15.20	4.43	4.45	4.68	3.33	29.15	30.35	30.45	21.95
Rex	16.12	16.10	15.28	14.83	7.65	7.28	6.85	6.50	47.40	44.85	45.23	43.85
Williams	13.80	14.10	12.88	13.38	3.80	3.70	3.55	4.58	27.53	27.58	26.25	34.20
Willey	11.95	11.75	11.43	11.38	4.28	4.88	4.48	5.83	35.75	39.15	41.50	51.23
Collier	18.23	18.33	18.33	18.38	9.23	10.83	11.23	11.50	50.60	61.25	59.08	61.00
Ramada	15.15	15.38	14.38	15.30	7.70	6.50	7.20	7.70	63.07	50.16	42.28	50.33
Brandes	14.95	15.28	15.53	15.56	3.90	3.25	3.52	3.88	26.07	22.70	21.28	25.25
L.S.D. at 0.05	0.216104				0.149707				1.02576			

Table (8): Effect of varieties, Locations and seasons on some technological characters in twelve varieties of Sweet sorghum

Varieties	(Total soluble solids T.S.S %).	Sucrose %	Purity %
Roma	18.71 k ± 0.467	7.64 g ± 0.241	40.85 d ± 1.55
Sugar drip	17.26 g ± 0.336	8.30 f ± 0.288	48.12 h ± 1.99
Brawley	16.54 f ± 0.450	7.11 e ± 0.294	43.02 f ± 2.07
Rio	17.93 l ± 0.474	8.64 l ± 0.888	48.19 h ± 5.05
Tracy	17.72 h ± 0.345	8.95 j ± 0.292	50.48 l ± 1.95
Honey	15.14 c ± 0.424	4.22 c ± 0.598	27.98 b ± 4.03
Rex	15.58 e ± 0.637	7.07 e ± 0.502	45.33 g ± 1.88
Williams	13.54 b ± 0.549	3.91 b ± 0.437	28.89 c ± 3.34
Willey	11.63 a ± 0.351	4.86 d ± 0.648	41.91 e ± 6.17
Collier	18.41 j ± 0.332	10.69 k ± 0.941	57..91 j ± 4.62
Ramada	15.05 c ± 0.532	7.28 f ± 0.546	48.38 h ± 3.88
Brandes	15.31 c ± 0.444	3.64 a ± 0.361	23.76 a ± 2.33
L.S.D. at 0.05	0.10905	0.07554	0.51761
Location			
Sabahia	16.16 b	6.79 a	42.18 a
Nubaria	15.97 a	6.92 b	41.97 a
L.S.D. at 0.05	0.04931	0.04706	0.27843
Seasons			
1st season	16.05 a	6.88 a	41.41 a
2nd season	16.08 a	6.84 b	42.73 b
L.S.D. at 0.05	0.07527	0.04410	0.18442

Table (9): Euclidean distance matrix of 12 sorghum varieties using 10 quantitative traits.

Varieties	Roma	Sugar drip	Brawley	Rio	Tracy	Honey	Rex	Williams	Willey	Collier	Ramada	Brandes
Roma	0.00											
Sugar drip	3.54	0.00										
Brawley	4.79	3.58	0.00									
Rio	3.74	4.59	2.88	0.00								
Tracy	2.62	2.66	4.56	4.37	0.00							
Honey	3.13	4.04	5.10	5.13	4.24	0.00						
Rex	4.36	3.77	3.03	3.66	4.58	4.83	0.00					
Williams	3.77	4.13	5.44	5.92	3.86	2.57	5.52	0.00				
Willey	4.54	4.29	5.23	5.81	3.70	4.01	5.67	2.06	0.00			
Collier	2.84	3.39	5.87	5.19	2.70	4.77	5.44	4.92	5.11	0.00		
Ramada	4.05	3.78	3.95	4.24	3.39	5.05	2.55	4.79	4.50	4.98	0.00	
Brandes	5.31	5.59	4.47	5.07	5.93	4.78	3.04	5.20	5.70	7.25	3.5701	0.00

Table (10): The ranked mean orders of ten quantitative characters for twelve studied varieties at two season and two localities.

Stalk height	Stalk diameter	No. of internodes	T.S.S%	Sucrose %	Purity %	Juice weight	Stalk yield	Juice yield	Syrup yield
Willey	Brandes	Sugar drip	Roma	Collier	Collier	Roma	Williams	Collier	Honey
Williams	Honey	Tracy	Collier	Tracy	Tracy	Honey	Collier	Williams	Collier
Collier	Collier	Ramada	Rio	Rio	Ramada	Tracy	Honey	Willey	Williams
Ramada	Roma	Williams	Tracy	Sugar drip	Rio	Collier	Willey	Honey	Sugar drip
Roma	Rex	Collier	Sugar drip	Roma	Sugar drip	Williams	Tracy	Sugar drip	Roma
Tracy	Rio	Willey	Brawley	Ramada	Rex	Willey	Roma	Tracy	Willey
Brandes	Ramada	Honey	Rex	Brawley	Brawley	Rio	Sugar drip	Roma	Tracy
Sugar drip	Sugar drip	Rex	Brandes	Rex	Willey	Ramada	Brawley	Brawley	Rio
Honey	Williams	Brandes	Honey	Willey	Roma	Brandes	Rex	Rio	Brawley
Rex	Tracy	Roma	Ramada	Honey	Williams	Sugar drip	Ramada	Ramada	Rex
Rio	Brawley	Brawley	Williams	Williams	Honey	Rex	Rio	Rex	Ramada
Brawley	Willey	Rio	Willey	Brandes	Brandes	Brawley	Brandes	Brandes	Brandes

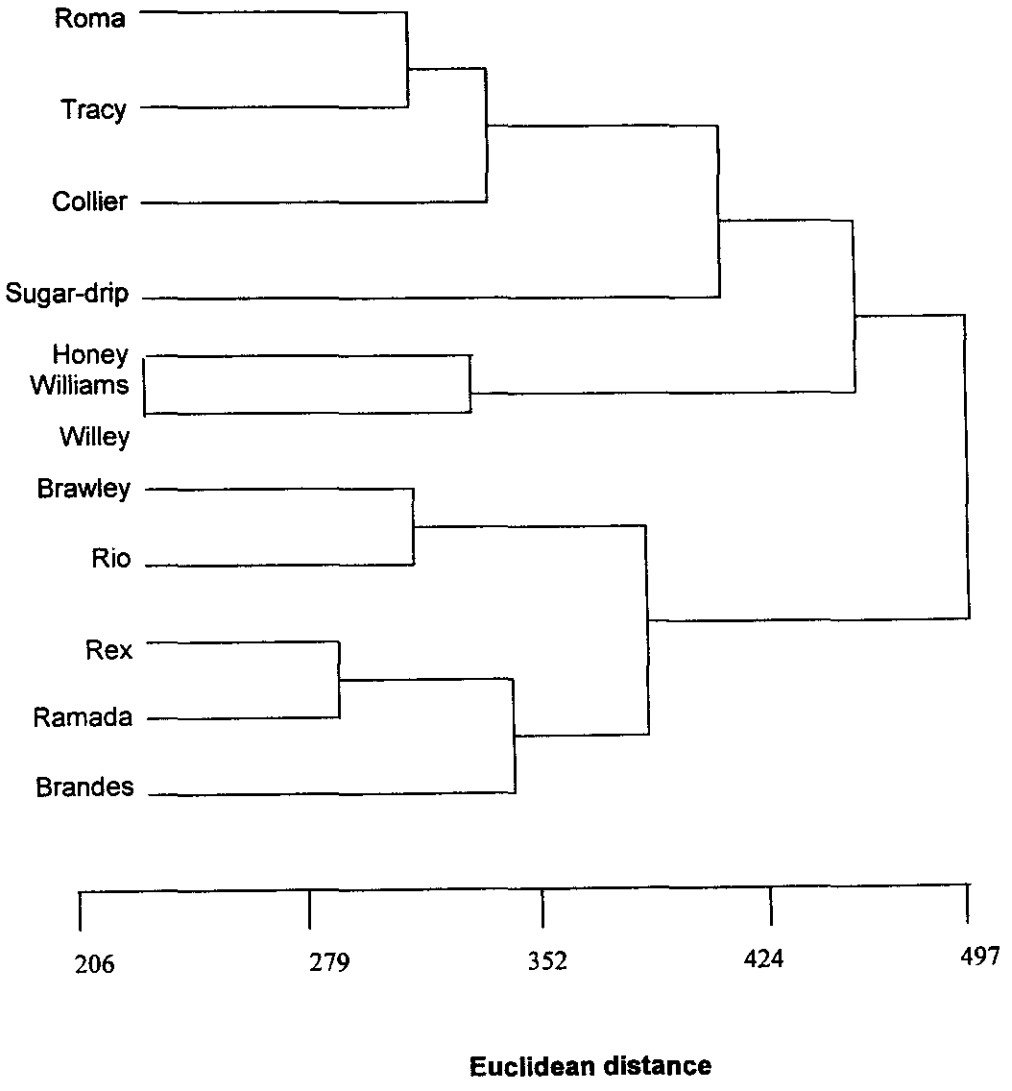

Figure (1): Dendrogram of twelve sorghum varieties using Euclidean distance for ten quantitative traits

الملخص العربى

استخدام بعض الصفات الكمية لتحديد التباعد الوراثى لاثنى عشر صنفا من الذرة السكرية

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** قسم الفسيولوجى والكيمياء- معهد بحوث المحاصيل السكرية

اجريت اربعة تجارب حقلية فى موقعين مختلفين (محطة البحوث الزراعية- بالصبحية ومحطة البحوث الزراعية بالنوبارية- معهد بحوث المحاصيل السكرية مركز البحوث الزراعية) خلال موسمى زراعة 2001 & 2002 حيث استخدم اثنى عشر صنفا تجاريا من الذرة السكرية (روما & شوجار درب & براولى & ريو & تراسى & هولى & ركس & ويليامز & ويلى & كولير & رمادا & براندز).. وذلك باستخدام بعض الصفات الكمية (صفات مورفولوجية & صفات محصولية & صفات تكنولوجية) لتحديد العلاقة بين تلك الاصناف عن طريق مايسمى بمعامل التباعد **Euclidean distance**

وقد اوضحت النتائج المتحصل عليها وجود تأثير معنوى راجع الى الاصناف فى معظم الصفات المدروسة فى كلا الموقعين والموسمين وان دراسة العلاقات بين الاثنى عشر صنفا المستخدمة اظهرت عدم تماثل فى معامل التباعد وذلك بين كل زوجين من الاصناف المدروسة.. فعلى سبيل المثال فقد تراوح معامل التباعد بين 2.6 لصنفى ويليامز وويلى حيث سجل هذان الصنفان اقل قيمه تباعد.. وعلى الجانب الاخر فقد اعطى صنفى كولير وبراندز اعلى قيمه تباعد (7.25).

مثل هذه النتائج يمكن الاستفادة بها فى برامج التربية حيث يمكن استبعاد الاصناف التى تحمل اقل قيمه تباعد (متشابة) فى التهجينات.. اما تلك التى تحمل اعلى قيمه تباعد (مختلفة) يمكن ادخالها فى برامج التربية للحصول على قوة الهجين والجمع بين الصفات المرغوبة بهدف التحسين وانتاج اصناف تلائم البيئات المختلفة فى الزراعة المصرية سواء كانت فى الاراضى الجديدة او المستصلحة (رملية) او الأراضي الطينية.