Variability and Correlation among Morphological, Vegetative, Fruit and Yield Parameters of Snake Melon (*Cucumis Melo* Var. *Flexuosus*)

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*Experiments were conducted at the research farm of the University of Gezira-Wad Medani -Sudan (Latitude 14^0 6, N, Longitude 33^0 38, E, and Altitude 400m absl), in summer season 2004 and winter season 2004-05. The objectives were to study variability in the local germplasm of snake melon (*Cucumis melo *var.* flexuosus*) and correlation among different morphological, vegetative, fruit and yield parameters of snake melon. Five landraces collected in different locations in central Sudan were used in this study. They were subjected to five cycles of inbreeding and selection prior to use in this study. A Complete Randomized Block Design (CRBD), with three replications, was used in the two experiments. Results showed high variability among these inbred lines with respect to earliness (29-45 days), stem length (80.4-152.5 cm), number of secondary branches (7.0-13.5), fruit length (33-90 cm) and leaf pubescence (153-189 hairs/cm^2). Results also concluded that yield parameters were much affected by the variation in both genotypes and seasons. Combined analysis of the two seasons indicated positive and significant association for number of primary branches with number of secondary branches (0.43) and stem length (0.35); and number of secondary branches with stem length (0.35), fruit color with sex ratio (0.37); fruit length with groove width (0.43) and female/male ratio (0.42); groove width with stem pubescence (0.43) and sex ratio (0.41). Sex ratio was found to be highly associated with stem pubescence (0.69). In contrast, negative and significant association was found for edible portion with number of primary branches (-0.27) and stem pubescence (-0.38), and groove width with number of straight fruits (-0.28).*

Because of the complex taxonomy surrounding the many forms of *C. melo* L. mentioned by Pitrat *et al*. (2000) the *C. melo* var. *flexuous* requires unique morphological description. Some of the descriptors have been added to or modified in the melon descriptor list developed by IPGRI in 1983 such as the Technical Guideline for Melon (TG/104/04); The Cucurbit Genetics Cooperative's Descriptor list for Melon (2003); and GRIN's Descriptors (2000). Other sources taken into account are publications including molecular characterization of melon such as Gomez-Guillamon *et al*. (1985), (1998) and JICA (1995). Although it is of high economic importance, no special descriptors have been developed for snake melon.

Sudan is situated within the region where melon is believed to have originated. Within this region, Sudan could be described as unique with regard to melon genetic resources, both wild and cultivated melon (ElTahir and Mohamed, 2004). Snake melon is among the desirable melon groups in the Sudan. Snake melon is consumed locally as green salad, pickles or stuffed with meat and rice. Farmers used to grow snake melon all over the country throughout the year. The yield of the snake melon crop in Sudan has an average of 20ton/ha (Mirghani and El Tahir, 1997). Variability among local accessions of snake melon was found to be high for morphological and agronomic characters, yield and quality attributes. Recently, a consumer preference of snake melon was developed and they tend to prefer slender fruits with deep grooves and light green outer skin colour, a situation which may threaten the biodiversity among the local cultivated landraces of snake melon in the Sudan. Therefore, priority was given for collection, evaluation and conservation of snake melon and its relatives. The main objective of this study was to estimate variability among collected lines of the cultivated snake melon and correlations among the morphological, agronomic, fruit and yield parameters.

Materials and Methods

Experiments were conducted at the research farm of the University of Gezira-Wad Medani -Sudan (Latitude 14^0 6, N, Longitude 33^0 38, E and Altitude 400m absl), summer season 2004 and winter season 2004-05. The soil is typical of the Central Clay Plain which is characterized by its heavy cracking clay (clay content 58%). Five inbred lines of cultivated landraces of snake melons were used in this study. These were Abu-Haraz which was collected in Gezira state, Silate and Umdum collected in Khartoum State, Farm collected in Kassala State, and Kosti collected in the White Nile State; they were named after the places where they were collected. Pure and stable inbred lines were obtained from the collected landraces after five cycles of inbreeding and selection prior to this study. A Complete Randomized Block Design (CRBD) with three replications was used in these experiments.

The land was disc ploughed, harrowed, and then divided into small growing units (7 x 2.5 m^2). Seeds of the different lines were sown on 15^{th} May and 15^{th} October 2004. Fifty plants of each inbred line were grown in each replication. Three tons of old chicken manure was applied to the soil before the first irrigation and two doses of urea (46% N) were applied 15 and 45 days after sowing at a rate of 40 kg urea/fed. at each application. The crop was irrigated at an interval of 5-7 days during the first month and the irrigation interval was prolonged gradually up to 10 days at the harvesting stage. Hand weeding and chemical control of insect pests and fungal diseases were practiced when-ever it was necessary. Ten plants of each line were randomly taken, tagged and subjected to morphological and agronomic characterization. For estimation of yield the whole number of plants and fruits of each line were considered. Parameters measured in this study included the following:

1- Earliness: The time elapsed from planting to the emergence of the first female flower (days).

2- Sex ratio: Refers to female/male flowers ratio of a plant.

Morphological characteristics such as:

3- Leaf pubescence: Determined by counting number of hairs at the lower surface of the leaf in a disc (1 cm^2) under the microscope.

4-Stem pubescence: Determined by counting number of hairs at the surface of the stem in a disc (1 cm^2) taken at the middle of the stem under the microscope.

5- Leaf colour: Leaves of the different plants were described as dark green, green and light green.

Vegetative characteristics such as:

6- Stem length measured in (cm.) from the soil surface to the tip of the main stem.

7- Number of primary branches: Refers to the number of branches originated from the first node on the main stem.

8- Number of secondary branches: Refers to the number of secondary branches which originated from other nodes rather than the first node of the main stem.

Yield and yield components such as:

9- Fruit length: Determined by measuring the length (cm) of the dorsal side of the fruit.

10- Number of fruits per vine. Determined at the end of the season as total number of fruits harvested from the line divided by the number of plants of the line

Fruit characteristics such as:

11- Fruit colour: It was described using a four categories scale: green, light green, pale green and whitish with the aid of a color chart.

12- Number of straight fruits per vine Shape of fruit was recorded using a three categories scale: straight, semi-curved and curved.

13- Number of ribs: Determined by counting the number of ribs on the outer surface of the fruit.

14- Groove width: measured in cm at the middle of the fruit.

15- Flesh thickness: Measured in cm at the middle of the fruit.

Data were analyzed with MSTAT to calculate ANOVA and correlation coefficients for these traits (Table 1 & 2).

Table 1.

Character	Range of variability	Probability		
		Genotype (A)	Season (S)	Genotype x season (A x S)
Earliness (days)	29-45	0.000	0.28	0.050
Stem length (cm)	80.4-152.5	0.001	0.04	0.006
Number of primary branches	2.8-3.5	0.230	0.35	0.140
Number of secondary branches	7.0-13.5	0.002	0.05	0.213
Number of fruits/vine	5.8-7.2	0.030	0.02	0.050
Fruit length (cm)	33- 90	0.000	0.2	0.034
Groove width (cm)	1.9-2.3	0.000	0.15	0.013
Flesh thickness (cm)	0.6-2.8	0.000	0.01	0.200
Sex ratio (female/male)	0.3-0.5	0.060	0.002	0.010
Leaf pubescence (No of hairs/cm^2)	153-189	0.070	0.02	0.045

Results

Highly significant differences were found among the different lines in the two seasons for earliness (P<0.000), stem length (P= 0.001), number of secondary branches (P= 0.002), number of fruits per vine (P= 0.03), fruit length (P< 0.000), groove width (P< 0.000) and flesh thickness (P< 0.000) as presented in Table 1. The range of variability was high for earliness (29-45 days), stem length (80.44-152.5 cm), number of secondary branches (7.0-13.5), fruit length (33-90 cm), number of fruits per vine (5.8-7.2), groove width (1.9-2.3 cm) and flesh thickness (0.6-2.8 cm). In contrast, no significant differences were found among the different lines for number of primary branches, sex ratio and leaf pubescence. Moreover, differences among seasons were found to be significant for stem length (P=0.04), number of secondary branches (P= 0.04), number of fruits per vine (P= 0.02), flesh thickness (P= 0.01), sex ratio (P= 0.002) and leaf pubescence (P= 0.02). Furthermore, the genotype x season interaction was significant for earliness (P= 0.05), stem length (P= 0.006), number of fruits per vine (P= 0.05), fruit length (P= 0.034), groove width (P= 0.01), sex ratio (P= 0.01) and leaf pubescence (P= 0.045). The color of fruits of the different lines ranged from light green to green.

Stem pubescence of the different inbred lines ranged from few to very few hairs. However, the number of straight fruits was in the range of 20-3, the inbred line 'Farm' recorded the highest number of straight fruits while the inbred line 'Kosti' recorded the lowest number of straight fruits

Association among the different parameters in the summer season, revealed positive and significant correlation of number of primary branches with secondary branches (0.43) and stem length (0.35); number of secondary branches with stem length (0.35) and total number of fruits per vine (0.31) these results were in a line with those obtained for sweet melon by Taha *et al.* (2003). For morphological characteristics, groove width was found to be associated with sex ratio (0.41) and stem pubescence (0.43); sex ratio with stem pubescence (0.69). Fruit length was found to be highly associated with groove width (0.43) and sex ratio (0.42). Fruit color was found to be highly associated with sex ratio (0.37), the darker the fruit the higher the number of female flowers.

Discussion

Melon (*Cucumis melo* L.) is a polymorphic species especially for fruit characters such as ripening, shape and flesh color. This variability was used by several botanists to subdivide melon into different major groups (Perin *et al.*, 1999). The most recent classification of melon is that given by Pitrat *et al.* (2000). Among these groups snake melon was characterized as monoecious, very long fruit, light green to dark green skin, white flesh, not sweet mature fruit and white seed. Results obtained from this study indicated that phenotypic differences of some characteristics were highly attributed to differences among the genotypes, these included earliness and yield components. Moreover, yield components were also found to be affected by differences due to season. The interaction between the genotype and the season also affected variability in some characteristics such as earliness, sex ratio, stem length, number of fruit per vine, fruit length, groove width and leaf pubescence. These results indicated that both genotype and environmental differences affected snake melon yield and quality and therefore selected lines grown under favorable growing conditions will resulted in high yield and good quality

Table 2.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X10	X_{11}	X_{12}	X_{13}
X_1	-	.10	.13	.19	-.11	-.10	-.20	-.27*	-.051	.23	-.38*	.07	-.01
X_2		-	-.27*	-.18	-.087	-.021	.37**	-.11	.01	.18	-.29*	.83	-.34*
X_3			-	.43**	.03	.084	.42**	.18	.17	.27*	.34*	.07	.07
X_4				-	.28*	.11	.41**	.15	.09	.31*	.43**	-.28*	.13
X_5					-	-.03	.15	.31*	.04	.29*	.12	-.29*	.04
X_6						-	.08	-.03	.08	.04	.17	.072	.09
X_7							-	.18	.24	-.16	.69**	-.12	.16
X_8								-	.34**	.35**	.15	-.27*	.25
X_9									-	.35**	.21	-.05	.31*
X_{10}										-	.166	-.03	.14
X_{11}											-	-.14	.08
X_{12}												-	-.24
X_{13}													-

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.
A, Cannot be computed because one of the variables is constant.

X! = Edible portion X6= Leaf pubescence X10= Stem length
X2= Fruit color X7= Sex ratio (female/male) X11 = stem pubescence
X3= Fruit length X8=Primary branches X12= Straightness (number of straight fruits per vine)
X4= Groove width X9= Secondary branches X13= Total number of fruits per plant
X5= Fruit color

Some morphological characteristics such as stem pubescence, leaf pubescence were included in this study and they were found to be associated with insect resistance in melon, as mentioned before by IPGRI (2003). Moreover, the ratio of female/male flowers is crucial as it affects pollination especially in monoecious plants such as snake melon. Furthermore, the natural pollination of the different crops in the irrigated sectors in the Sudan is threatened by the application of insecticides. Therefore, breeding hermaphroditic snake melon to enhance pollination was proposed to have good chance for successful and complete pollination which in turn results in a high yield with quality fruits. On the other hand, correlations among fruit length, groove width and straight length can be discussed with the linkage of number of straight fruits per plant with sex type. These associations indicated that hermaphroditic flowers could produce short fruits with broad grooves whereas total number of fruits per vine increase even in the absence of pollinators.

A study of correlation among the vegetative and fruit characteristics in snake melon is almost lacking. The findings of this study revealed association of number primary branches with both stem length and number of secondary branches; fruit length with stem length; groove width with stem length; stem pubescence with both groove width and number of female to male flowers ratio; and fruit thickness with fruit length and fruit color with stem pubescence that can be used in selection breeding of snake melon. Nevertheless, some efforts were exerted to identify this association in sweet melon (*Cucumis melo* var reticulatus), closely related to snake melon by Perin *et al.* (1999) and Taha *et al.* (2003). The latter showed positive and significant association in sweet melon between number of fruits per vine with number of primary branches, number of primary branches with number of secondary branches. These findings were similar to those found for snake melon in this study. Results of correlation among the different growth and yield parameters in snake melon were similar to those found in muskmelon. They also reported strong positive correlation of netting with total soluble solids and flavor. This might explain why snake melon fruits are not sweet and with flat flavor as they are lacking the netting callus on the outer fruit surface. On the other hand, similarity in association among the different characters between sweet and snake melon could indicates also having the same evolution, hybridization and morphological similarity among the different botanical varieties of the species *Cucumis melo* L.

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