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EVALUATION OF GRAIN SORGHUM BREEDING GERMPLASM IN EGYPT WITH CONCENTRATION ON KERNEL WEIGHT

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ABSTRACT

Aiming at studying the breeding germplasm population of grain sorghum in Egypt, a sample of 30 lines was randomly selected to make 72 crosses according to line x tester scheme to form three sets. The lines and hybrids samples were referred to as lines and hybrids populations, respectively. The samples were evaluated in three separate experiments, simultaneously planted in two successive seasons.

The descriptive statistical parameters of plant height, days to 50% heading, 1000 kernel weight and grain yield were measured for both lines and hybrids populations. For 1000 kernel weight estimates of minimum value, lighter quartile, median, mean, heavier quartile and the maximum value were 22.00, 24.00, 25.55, 26.23, 27.70 and 35.90 g., respectively, for lines population and 17.00, 23.95, 26.7, 27.88, 31.10 and 42.60 g., respectively, for hybrids population. Results suggested the role of non-additive and effects in the inheritance of kernel weight. The minimum estimates of broad and narrow sense heritability for kernel weight were 92.80 and 58.52%, respectively.

The relationships between kernel weight and each of plant height, heading date and grain yield were studied using phenotypic and genotypic correlations as well as path coefficient analysis.

Key Words: ***Population, Grain sorghum, Kernel weight, Heritability, Phenotypic and Genotypic correlations, Path coefficient***

INTRODUCTION

Egyptian farmers and consumers prefer bold grain size sorghum, which is the principal barrier to sorghum hybrid expansion. Current hybrids despite their high grain yield have small kernel size. Kernel weight is considered the most important quality trait for determining sorghum price, the final income to farmer and continuing his interest in planting sorghum.

The importance of kernel weight as a measure for grain quality has to be discussed. Large grain size has been speculated as indicator for good seed quality for next seasons. The effect of seed size on germination percentage and stand establishment has been studied. Singh and Chapde (1986) stated that weight of seed had no effects on yield components and grain yield in sorghum. However, medium and large seeds had the highest germination percentage at 40-43 C° and 32-42 °C, respectively (Mortloch and Vanderlip 1989). In other study, Mortloch (1989) found that medium seed size showed higher germination percentage over a wide range of environments that differ in heat than other seed sizes, but seed size did not significantly improve establishment in On-Farm trials. So he reported that seed quality effects were insignificant in improving traditional stand establishment. On the other hand, Channakeshava *et al* (1991) observed that medium seed size showed greater plant height, leaf area index and dry matter production during the early stages of crop growth than the small sized seed.

Another important aspect of kernel size is its effect on milling process. Wills and Ali (1983) studied the effect of grain size on grinding the sorghum grain using un-graded and three sizes of grains (<4 mm, <3.35 and <2.8 mm, respectively) and found that the milling recovery was higher for grain <2.8 mm than other grain sizes and the largest size gave the lowest recovery and unbroken kernels. Concerning chemical composition, Subramanian and Jambunathan (1981) stated that the 100 kernel weight showed negative association with protein and a positive association with amylose within fourty-five sorghum cultivars.

Number of kernels per panicle and kernel weight are the main components measured in analysis of sorghum grain yield (Eastin 1972 and Miller 1974). Kernel weight as one of yield components plays a great role in determining grain yield. Several investigators reported close association between grain yield and their principal components (Amir 2004). El-Kady *et al* (1996) reported a significant correlation between grain yield and kernel weight and stated that the selection for large grain size, which is preferable for Egyptian farmers, would increase grain yield. These two yield components are the prime determinants of yield and exhibit a highly significant negative correlation (r= -0.92) in hybrids (Kirby and Atkins 1968 and Miller 1976).

However, the kernel weight showed significant positive association with plant height, days to 50% heading, panicle dimensions and grain yield (Amir 2004).

In the course of the present investigation most of the work was devoted to study the genetic system controlling kernel weight and its relationships with other agronomic characters for exploring grain sorghum breeding germplasm in Egypt.

MATERIALS AND METHODS

The grain sorghum (*Sorghum bicolor* Moench) breeding materials available in Egypt mainly consists of local varieties and exotic lines used as restorer lines and pairs of A and B lines having sterile and fertile cytoplasm, respectively. These materials are about 300 accessions that are used to produce new elite varieties and productive hybrids depending on cytoplasmic male sterility. Twelve pairs of A and B lines and eighteen restorer lines (R-lines) were randomly selected to represent a sample of about 10% of the breeding germplasm population, as shown in Table (1). The sample was divided into three sets: each set contained four A-lines and six R-lines. Twenty-four crosses were composed following line x tester system for each set at Agric. Res. Farm, ARC, Giza in 1999 and 2000 growing seasons. A total of 72 F_1 hybrids were done to represent hybrid population; which could be produced from a sample of line germplasm population.

Table 1. Name and origin of lines used in the present study.

Serial	Line	Origin	Serial	Line	Origin	Serial	Line	Origin
A lines			11	ICSB 88005	ICRISAT	21	GIZA 54	local
1	BKS 18	USA	12	BTX 631	USA	22	NES 1007	USA
2	BKS 48	USA	R lines			23	Dorado	USA
3	BKS 50	USA	13	M 36116	USA	24	CS 3541	USA
4	BKS 51	USA	14	M 36565	USA	25	ICSV 273	India
5	BTX 622	USA	15	ICSV 126	India	26	ICSR 90001	ICRISAT
6	BTX 623	USA	16	ICSV 156	India	27	ICSR 89022	ICRISAT
7	BTX 624	USA	17	ICSV 166	India	28	ICSR 91022	ICRISAT
8	BTX 629	USA	18	ICSV 188	India	29	ICSR 92003	ICRISAT
9	ICSB 1	ICRISAT	19	GIZA 15	local	30	ICSR 93001	ICRISAT
10	ICSB 37	ICRISAT	20	GIZA 113	local			

The three sets were evaluated in three adjacent experiments at Sids during two successive growing seasons (2000 and 2001). Each experiment contained 24 crosses and their 10 parental lines; four B-lines and 6 R-lines which were arranged in a randomized complete block design with three replicates. Each experimental plot consisted of two rows of 6 meters long and 60 cm width, the distance between hills were 20 cm .Two plants per hill were left after thinning. Agriculture practices were done according sorghum recommendations.

Data on a plot mean basis were collected for plant height (PLH), Days to 50% heading (HD), 1000 kernel weight (KW) and grain yield per feddan (GY).

Statistical Analysis

The Genstat 6th edition computer program which was developed by VSN International Ltd, in corporation with practicing statisticians at Rothamsted and other organizations in Britain, Australia and New Zealand was used to perform summary statistics of line and resulted hybrid samples to describe and to test the validity of normal distribution of the reference populations.

Line x tester analysis was performed according to Singh and Chaudhary (1977), respecting the random model to deduce variance components and heritability parameters of the reference population. Variance components were tested for significance according to Robinson *et al* (1955). The genetic correlations and path coefficient analysis were estimated for 72 crosses and their parental lines.

Considering both male and female parents were homozygous lines, an average estimate of narrow sense heritability (h^2_n) on a plot mean basis for one environment was calculated according to Hallauer and Miranda (1981) as follows:

$$h^2_n = \frac{\sigma^2 A}{\sigma^2 A + \sigma^2 D/((f+m)/2) + \sigma^2 /(r((f+m)/2)}$$

where $\sigma^2 A$ is the average additive variance calculated from both male and female lines, $\sigma^2 D$ is dominance variance on individual basis, σ^2 is environmental variance and f , m and r are numbers of female parents, male parents and replicates, respectively.

RESULTS AND DISCUSSION

Since the random sample of sorghum lines is a representative for the lines population of Egyptian breeding materials, the sample consists of all crosses between them would be a representative sample of speculative population consists of all hybrids that can be produced from the lines population. All crosses from the deduced sample during the course of this investigation have to be N^2 or 900 crosses. It is incredible task to make all these crosses so that the sample was classified into three sets by using line x tester scheme that produced 72 crosses, which was assumed to be a representative sample of the F_1 hybrids population. Results shown in Table (2) described lines population and hybrids population for days to 50% heading, plant height (cm), 1000 Kernel weight (g.) and grain yield (ard/feddan).

Table 2. Statistical description for some agronomic traits of Egyptian grain sorghum populations.

Trait	Population	Minimum	Lower quartile	Median	Mean	Upper quartile	Maximum	Variance	C.V	Skewness	Kurtosis	Chi^2 of deviance from normal distribution
Days to 50% heading	Lines	54	60.5	64	64.94	68.5	85	42.31	10.02	0.60*	0.09 ns	8.89ns
	Hybrids	54	63.5	67.5	67.79	72	82	36.11	8.87	0.08 ns	-0.46 ns	2.31 ns
Plant height (cm)	Lines	62	93.5	105.5	111.8	131	278	733.4	24.2	0.4ns	-0.5 ns	9.94 ns
	Hybrids	101	147.5	168	180.5	194	322	3046.1	30.6	1.0**	0.3 ns	39.36 **
1000 Kernel weight (g.)	Lines	22	24	25.55	26.23	27.7	35.9	8.66	11.22	1.32**	1.76**	7.75 ns
	Hybrids	17	23.95	26.7	27.88	31.1	42.6	35.08	21.24	0.61**	-0.37 ns	28.56**
Grain yield (ard / feddan)	Line	3	6	7.9	10.83	14.7	27.1	44.29	6[illegible]43	1.00**	-0.26 ns	35.14**
	Hybrids	3.7	14	16.2	16.76	20	29.3	28.12	31.64	-0.08 ns	-0.20 ns	8.39 ns

* and ** are significant at 0.05 and 0.01 probability levels, respectively.

The earlier line reached 50% heading after 54 days from sowing. The lower quartile for this trait at which the delimiting line of the earlier quarter was 60.5 days while the median showed 50% heading after 64 days. The later quartile headed at 68.5 days while the latest line headed at 85 days. The average number of days to 50% heading for lines is 54.83 days that is greater than median value, indicating that number of earlier lines is greater than the number of later lines and therefore, the asymmetrical distribution for this trait was clarified. This conclusion is supported by the significant skewness parameter. However, the greater number of earlier than later lines suggested that in lines population the frequency of genes controlling earliness is more (>0.5) than that of genes controlling lateness. Nevertheless, the non-significant kurtosis and chi^2 of deviance from normal distribution assures the normality of the lines population. Variance and coefficient of variation estimates were 42.31 and 10.02, respectively. This variance is mainly due to additive variance and error variance since the lines are approximately complete homozygous.

Parameters describing the hybrids population for number of days to 50% heading were 54.0, 63.5, 67.5, 67.79, 72.0 and 82.0 days for the minimum, earlier quartile, median, mean, later quartile and the maximum, respectively. This population showed non-significant parameters that validates its normal distribution, i.e., hybrids are normally distributed, concerning this trait.

The hybrids population showed variance and coefficient of variation estimates of 36.11 and 8.87, respectively, for days to 50% heading. Because of the homozygosity of the parental population of the heterozygous F_1 hybrids population, the differences may originally due to non-additive genetic effects or specifically to dominance effects assuming absence of epitasis and linkage effects. The hybrids population inherits normality from its parental population. Comparing with the lines population, while the minimum number of days to heading was 54 days for both lines and hybrids and the maximum value were 85 and 82 days, respectively, indicating that non-additive gene effects for earliness displaying heterosis towards earliness in the hybrid combinations between later lines. On the contrary, the means of hybrids population and lines population were 67.79 and 64.83 days, respectively, suggesting non-additive effects towards lateness; it is the opposite of the former deduction. However, regarding variance unexpected result was shown; the variance of the hybrids population was less than that of lines population. This may be due to the small size of the hybrid sample or to that opposite direction of non-additive gene effects masked the non-additive variance for this trait.

Parameters for plant height of lines population were 62, 93.5, 105.5, 111.8, 131.0 and 278 cm for the minimum, shorter quartile, median, mean, taller quartile and the maximum value, respectively. This population showed non-significant deviations from normality. But the mean of plant height of this population was non-significantly greater than the median value besides the positive value of skewness was also non-significant, indicating excess in number of lines that were shorter than the mean without deforming the curve of normal distribution. On the other hand, parameters of hybrids population for plant height were 101.0, 147.5, 168.0, 180.5, 194.0 and 322 cm for the minimum, shorter quartile, median, mean, taller quartile and the maximum value, respectively.

The distribution of hybrids plant height significantly differed from normality as proved by Chi^2 of deviance; this deviation is mainly due to significant skewness towards excess in number of hybrids that were shorter than the population mean. This result can be illustrated from the excess in number of shorter parents. Three differences between lines and hybrids population arose when precise comparison was done. There is a large shift in all the hybrids population parameters towards taller plants that can be attributed to dominance effects of genes controlling plant height. The second difference was the varied distributions of both populations, while lines population followed normal distribution the hybrids population displayed significant deviance from normality and showed real skewness. The number of shorter hybrids was more than that of taller ones so that hybrids population showed asymmetry. This difference can be due to the excess in number of short lines.

The third difference is in the variance parameter where it was larger in hybrids population than in lines population, indicating the important role of the non-additive variance. The first and third points suggest that the dominant genes are in one direction towards taller plants. Abd El-Mottaleb (2004) observed that 42 out of 49 F_1 hybrids displayed significant heterosis that surpassed their highest parent in plant height.

The estimates of lines population for grain yield were 3.0, 6.0, 7.9, 10.83, 14.7 and 27.1 for the minimum, low quartile, median, mean, higher quartile and the maximum plant productivity, respectively. Dispersal parameters were 44.29 and 61.43 for variance and coefficient of variation, respectively. This population showed significant and positive skewness indicating an excess in number of lines which have lower productivity than mean. This significant skewness was enough to deform the distribution from normality. However, the over-number of low productive lines suggested that the average frequency of genes controlling high grain yield is less (<0.5) than that of genes controlling low grain yield. The descriptive parameters of hybrids population were 3.7, 14.0, 16.2, 16.76, 20.0 and 29.3 ard/fed for minimum, low quartile, median, mean, higher quartile and the maximum plant productivity, respectively. Apparently, all these parameters were higher in magnitude than their counterparts in the lines population, suggesting that non-additive genetic effects increase grain yield in the hybrids. Unexpected dispersed parameters were shown; they were 28.12 and 31.64 for variance and coefficient of variation, respectively that were remarkably lower in magnitude than that recorded for lines population. This result may be due to sample size. The hybrids population proved the normal distribution since the chi^2 of deviance was non-significant. The skewness that was observed in the lines population disappeared in the hybrid population.

Estimates of lines population for 1000 kernel weight were 22.00, 24.00, 25.55, 26.23, 27.70 and 35.90 g. for the minimum, lighter quartile, median, mean, heavier quartile and the maximum 1000 kernel weight, respectively. Dispersal parameters were 8.66 and 11.22 for variance and coefficient of variation, respectively. This population showed significant positive skewness, indicating an excess in number of lines that have lower 1000 kernel weight than mean. Most exotic R-lines and A-lines have small seed size. However, the over-number of lines having small kernel weight suggested that the average frequency of genes controlling heavier kernels is less (<0.5) than that of genes controlling low kernel weight. Another aspect of this population is that it showed significant kurtosis, indicating relatively excess in number of lines near the mean and far from it with a depletion of flanks of the distribution. This suggests that there is a possibility to find new recombinants showing extreme kernel weight towards both directions. Nevertheless, the significant skewness and/or kurtosis could not prove abnormality distribution since the chi^2 of the deviance was non-significant (Table 2).

The hybrids population gave 17.00, 23.95, 26.7, 27.88, 31.10 and 42.60 g. for the minimum, lighter quartile, median, mean, heavier quartile and the maximum 1000 kernel weight, respectively. Beginning from the median value, there are excesses in magnitude of the parameters than their counterparts in the parental population. These results suggest that the non-additive gene effects work towards increasing kernel weight and the genes controlling heavier kernel weight may be dominant. Contrasting manner could be observed for parameters of the lower quartile since the kernel weight of the hybrids in this section had lower kernel weights than their counterpart parameters derived from lines population. This leads to increase the range in the hybrids population. Two possible interpretations may participate to illustrate these results. Since the heterosis increased grain yield and their closed associated character, kernel number per head which is negatively correlated with 1000 kernel number, the latter trait decreased as correlated response in some hybrids. Specially, the competition between kernel number and kernel weight on the nutrition's sink begins earlier to form kernel number at head initiation and spike number detecting and ending after successful fertilization; at the end the kernel weight takes share in the competition through the seed filling period. It is unfair competition for kernel number sake. This suggestion needs further investigation. The second illustration is that the dominance genes affecting kernel weight work towards both increasing kernel weight by some genes and/or decreasing it by other genes. Whatever, the significant positive and/or negative values of heterosis for grain sorghum hybrids were reported (Abd El-motaleb, 2004 and Amir, 2004).

Because the range was increased, all other dispersal parameters of hybrids population were also amplified, comparing with lines population, to be 35.08 and 21.24 for variance and coefficient of variation, respectively. These results indicated the important role of the non-additive genetic variance in the genetic system controlling 1000 kernel weight. The excess of hybrids that have light kernel weight than the hybrids that have heavy kernel inherited from increased number of lines that have light kernel weight, thus the skewness parameter was significantly positive. On the other hand, the kurtosis parameter of hybrids showed non-significant negative value thus population curve took plateau shape, but this deforming of distribution is not enough to differ from normality. These results were due to widening of the range of 1000 kernel weight.

Data in Table (3) are mean squares for 1000 kernel weight of grain sorghum in three sets of line x tester crosses in two growing seasons; 2000 and 2001. Highly significant differences among parents or hybrids were obtained in each set and each year, indicating that the reference populations contain enough variability for further breeding programs to either producing new lines or hybrids with bold grains.

Table 3. Analysis of variances for 1000 kernel weight of three sets of line x tester crosses grown in 2000 and 2001 seasons.

Source of Variance	df	Set 1		Set 2		Set 3	
		2000	2001	2000	2001	2000	2001
Replicates	2	0.2154	0.143	0.5477	0.4127	4.2213	3.6942
Genotypes	33	21.2636**	17.3614**	68.7059**	55.9369**	30.344**	24.7348**
Crosses *Vs* Parents	1	80.1569**	65.905**	376.0276**	302.4217**	58.5885**	47.6439**
Parents	9	25.8776**	21.0634**	120.1506**	98.4866**	38.124**	31.4834**
Crosses	23	16.8976**	13.8022**	35.2136**	28.5703**	26.0716**	21.098**
Male effects	5	25.3262**	20.8869**	95.8852**	78.1516**	12.0387**	9.4748**
Female Effects	3	45.9196**	37.2648**	19.0298**	15.4197**	125.8048**	101.0474**
Male X Female Effects	15	8.2836**	6.7481**	18.2265**	14.6733**	10.8026**	8.9825**
Pooled Error	66	0.1121	0.101	1.556	1.300	2.436	1.966

*** and ** are significant at 0.05 and 0.01 probability levels, respectively.**

The contrast between crosses and their parents was highly significant indicating that the average non-additive effects are active. This result agrees with the difference between lines and hybrids population means for 1000 kernel weight, indicting that the average effects of non-additive gene action is towards increasing kernel weight. Partitioning crosses sum of squares showed highly significant mean squares for both male and female effects, indicating the presence of additive gene action in the hybrids population and both A-lines and R-lines.

The non-additive effects expressed as male x female mean squares were also highly significant in the three sets and the two seasons, indicating the major role of non-additive variance of sorghum kernel weight. These results are in the same line with that reported by Amir (2004) and Abd El-Mottaleb (2004).

Variance components were estimated according to Singh and Chaudhary (1977) and presented in Table (4). Both additive and non-additive variances were highly significant in the three sets and the two seasons of evaluation. They worked together forming the genetic variance. The broad sense heritability varied between sets and years and ranged from 92.80 to 99.47% indicating the great role of genetics in kernel weight variance. On the other hand, the narrow-sense heritability ranged from 58.52 to 68.14%, indicating that the additive effects of genes have a great role in kernel weight inheritance. In addition, the difference between broad and narrow sense heritability values, which is due to non-additive variance indicated also that the non-additive effects have the remaining great part for increasing kernel weight. Average degree of dominance values presented in Table (4) reveal that genes controlling kernel weight show over-dominance on average since all estimated values were more than the unity. On the contrary, the estimates of heterosis of individual crosses (unpublished data) suggested over-dominance, complete dominance and partial dominance for kernel weight. This result agrees with that recorded by Amir (2004) and Abd El-Mottaleb (2004) and therefore, the presence of non allelic gene interactions or epistasis can be suggested.

Table 4. Genetic parameters for 1000 kernel weight of three line x tester sets of crosses grown in 2000 and 2001 seasons.

Item	Set 1		Set 2		Set 3	
	2000	2001	2000	2001	2000	2001
Additive Variance	0.869**	0.712**	1.714**	1.402**	1.540**	1.222**
Dominance Variance	0.47**	0.56**	0.89**	1.11**	0.44**	0.54**
Broad sense heritability%	99.47	99.42	96.46	96.36	92.82	92.80
Narrow sense heritability%	61.14	61.28	58.52	58.90	68.14	67.11
Average degree of dominance	1.77	1.76	1.80	1.78	1.35	1.38

Phenotypic and genotypic correlations among some agronomic traits estimated from both lines population and hybrids populations are presented in Table (5). All phenotypic correlation values between kernel weight and each of number of days to heading, plant height and grain yield were highly significant; other interrelationships among these four traits were also significant. Moreover, all the estimated genetic correlations were highly significant, and the correlation between grain yield and heading date was significant. The genetic correlations tended to be less in magnitude than phenotypic correlations except those values representing the correlations between 1000 kernel weight and each of heading date and plant height, where the genetic correlation was higher than phenotypic correlation.

Table 5. Phenotypic (below diagonal) and genotypic (above diagonal) correlations among some agronomic traits of sorghum.

Trait	HD	PLH	GY	1000KW
HD	1	0.3665**	0.2439*	0.4628**
PLH	0.3770**	1	0.4839**	0.6091**
GY	0.4908**	0.6178**	1	0.3007**
1000 KW	0.2597**	0.4794**	0.3031**	1

*** and ** are significant at 0.05 and 0.01 probability levels, respectively.**

The path coefficient technique clarifies the association causes *via* partitioning the correlation into direct and indirect effects. The effects of heading date and plant height on kernel weight were presented graphically in Figure (1). The path coefficient estimates, which are the standardized partial regression, were 0.508 and 0.277 for plant height and heading date, respectively. Remarkably, plant height positively affected kernel weight with a greater degree than heading date. Both studied traits, which were positively and genetically associated (0.366, P <0.01), indirectly affected kernel weight, each through thc other.

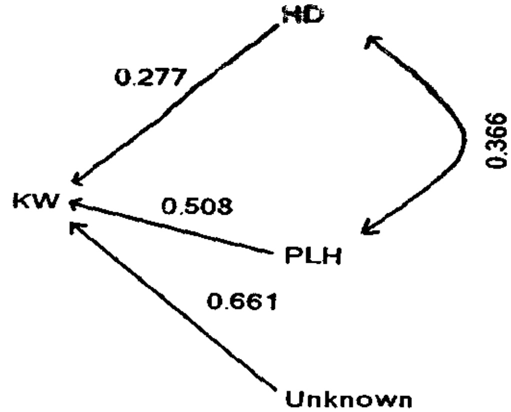

Figure 1. Genetic path coefficient and correlation of heading date (HD) and plant height (PLH) affecting kernel weight (KW).

However, the unknown factors affecting kernel weight showed a path coefficient estimate of 0.661, and were more effective than the two studied traits. The coefficient of determination of the unknown factors were 0.44 meaning that 44% of the variance of kernel weight is due to unstudied traits and 56% of this variance can be illustrated by both heading date and plant height. Unfortunately, any increment in kernel weight would be accompanied by undesired tall and late plants.

The genetic correlation estimate between kernel weight and grain yield (0.3007) reveals that the coefficient of determination was only 9% meaning that the variance of kernel weight is responsible for a low part of the grain yield variance.

Regarding individual traits, most of the sorghum breeding germplasm in Egypt are lines that show earliness in flowering, short plants, low grain yield and low kernel weight. Bold kernel weight displayed significantly positive associations with undesired tall and late plants as well as a small coefficient of determination with grain yield. The genetic system of kernel weight is controlled by both additive and non-additive genetic effects with epistasis and non-allelic gene interactions. Thus a successful hybrid with bold grains must be composed of two bold grain lines. Long period breeding programs aiming to develop new lines that have bold grains and break the association with undesired traits are essential for future. This dream may change the lines population characteristics and increase number of lines that have bold grains and high yield potentiality.

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تقييم الأصول الوراثية للذرة الرفيعة للحبوب في مصر مع التركيز على صفة وزن الحبة

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معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، جمهورية مصر العربية

كان الهدف هو دراسة عشيرة الأصول الوراثية للذرة الرفيعة والمستخدمة كمواد تربية بمعهد بحوث المحاصيل الحقلية، تم اختيار عينة عشوائية ممثلة من عدد ٣٠ سلاله واستخدمت لتكوين عدد ٧٢ هجين طبقا لطريقة السلالة × الكشاف موزعة علي ثلاثة مجموعات هجين كل مجموعة مكونة من ٢٤ هجين. اعتبرت عينات السلالات والهجن إنها ممثلة لعشائرها. وتم التقييم في ثلاثة تجارب بواقع تجربه لكل مجموعة وتكرر التقييم في موسمي زراعة متتاليين (٢٠٠٠، ٢٠٠١). قدرت القياسات الإحصائية اللازمة لوصف العشائر لصفات طول النبات، عدد الأيام حتى طرد ٥٠%، محصول الحبوب للفدان ووزن الألف حبة.

كانت التقديرات الإحصائية لصفة وزن الألف حبة كالتالي ٢٢,٠٠، ٢٤,٠٠، ٢٥,٥٥، ٢٦,٢٣، ٢٧,٧٠ و ٣٥,٩ جم للسلالات و١٧,٠٠، ٢٣,٩٥، ٢٦,٧٠، ٢٧,٨٨،٣١، ٣١,١٠، ٤٢,٦٠ للهجن لكل من الحد الأدنى، والربيع الأول، والوسيط، و المتوسط، والربيع الثالث والحد الأقصى على التوالي. واقترحت النتائج أهمية الدور الذي تلعبه التأثيرات الغير مضيفة علي وزن الألف حبة بالنسبة للهجن. وكان مقدار التباين ٨,٧٧ و ٣٥,٠٨ بالنسبة لعشائر السلالات والهجن علي التوالي مؤكدة علي دور التأثيرات الغير المضيفة. وكانت اقل قيم لدرجة التوريث بالمعني العام والضيق لصفة وزن الحبوب ٩٢,٨٠ و ٥٨,٩٠% علي التوالي. كما تم دراسة العلاقة بين وزن الحبوب وكل من ارتفاع النبات وتاريخ التزهير ومحصول الحبوب للنبات باستخدام طرق الارتباط الوراثي والمظهري ومعاملات المرور.

المجلة المصرية لتربية النبات: ١٠ (١): ٧٥-٨٨ (٢٠٠٦)