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Phenology, growth and yield of some sorghum (*Sorghum bicolor* (L.) Moench) genotypes under irrigated condition at Sinnar

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Abstract

This research was carried out to study the phenology, growth, yield, and to estimate the genetic variability in ten advanced sorghum genotypes at Sinnar Agricultural Research Station Farm, Sinnar, Sudan, during two seasons 2012/13 and 2013/14. Ten advanced sorghum lines provided by the Sorghum Breeding Program, the Agricultural Research Corporation were used in the study. The experiment was arranged in a Randomized Complete Block Design (RCBD) with four replicates. The measured traits were days to 50% flowering, plant height (cm), head exertion (cm), panicle length (cm), number of grains per head, 100 grain weight (g) and grain yield (kg/ha). Analysis of variance indicated highly significant differences ($P < 0.01$) for all characters among genotypes in each seasons and their combined, except for number of grains per head in the second season. On the average, number of days to 50% flowering ranged between (60 -80 days), plant height (97 -140 cm), head exertion (6 – 12 cm), panicle length (18 -25 cm), number of grains per head (1466 – 2242 grain), 100 grain weight (3 - 4 g) and grain yield (1283 -1882 kg/ha). In generally, phenotypic coefficients of variation (PCV) were higher than genotypic coefficients of variation (GCV) in all traits for both seasons and also for combined analysis. The GCV and PCV were high for plant height and head exertion (25.5, 27.0% and 21.9, 35.9 %) respectively. The lowest GCV and PCV were obtained by days to 50% flowering and panicle length (9.3, 10.9 and 11.5, 14.3%) respectively of combined data.

Keywords: Genotypes, growth, Phenology, sorghum, yield.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench, 2n=2x= 20, Poaceae) is one of the main staple food crops for the world (ElNaim *et al.*, 2012). It is an important food crop in Africa, South Asia, Central America and Australia. Sorghum is the fifth major cereal crops in the world after maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), and barley (*Hordeum vulgare* L.). In Africa, sorghum comes second after maize in terms of production (FAO, 2011). According to FAO (2011), the average world production of sorghum amounted to 66 million metric tons per year.

The role of sorghum in the life of the Sudanese people call for not is dwelled upon unduly. Suffice it to know that the name for sorghum in Sudan, “Esh”, means life. Bacon (1948) pointed sorghum as the nutritional backbone of the country. However, rural exodus and increased urbanization resulted in a shift towards more consumption of wheat rendering the statement by Bacon probably not as true today as it was then. In Sudan, sorghum is grown in an area ranged between 4.3 and 7.1million ha with an average of 5.2 million ha (Elzein and Elamin, 2006). The national average grain yield reported is about 600 kg\ha which is very low compared to the world average of 1288kg/ha (Elzein, 2008). Despite the crop's importance and the long experience in its cultivation, sorghum yield is very low (0.4 t/ha, FAO, 2006) compared to its potential. The low productivity can be attributed mainly to the use of traditional low-yielding varieties, limited or no use of fertilizers, poor management practices and prevalence of *Striga* infestation (Ibrahim *et al*., 1995).

The crop is generally suited to hot and dry areas where it is difficult to grow other food grains. These are also areas subject to frequent drought. In many of these areas, sorghum is truly a dual-purpose crop; both grain and Stover are highly valued outputs. In large parts of the developing world, Stover represents up to 50 percent of the total value of the crop, especially in drought years (Abdel rahman, 1998). Sorghum is widely produced in the Sudan by the traditional, semi-mechanized and large commercial farms (Reda, 2014).

In most years, the Sudan has a surplus of sorghum and a balance of millet, but has a great wheat deficit. Sorghum is the staple food for most people living in the Sudan, except for the two northern states where wheat is the traditional staple. It is consumed in a number of ways, most notably as a flat bread or pancake known as "*kisra"* and as a pudding known as "*acida*". Large quantities of sorghum, particularly in the western and southern states are made into beer known as "*marisa*". The total population in Sudan is estimated at 30 million, consuming about 3.1million tons of sorghum annually (2.7 million tones for human consumption and 400,000 tones for animal feed). This represents a daily human consumption rate of about 250 g. of sorghum in one form or another (Mahgoub, 2014).

The phenotypic variability in a given environment can be measured easily, but it reflects non- genetic as well as genetic influence on the phenotypic expression. This research aims are to study the phenology, growth, yield, and to estimate the genetic variability in ten advanced sorghum genotypes.

Materials and Methods

The experiment was carried out during two consecutive seasons (2012/13 and 2013/14) at Sinnar Research Station Experimental Farm, Sudan (13° 36′N and 33° 32′E). The soil type of the experimental site is heavy clay, belongs to the central clay plain of Sudan. The genetic material used in this study consisted of ten sorghum genotypes provided by the Sorghum Breeding Program of the Agricultural Research Corporation (ARC), Sudan. The genotypes tested included; (Edo26-18-45, Edo26-18-60, Edo13-10-12, Bashayir, Edo34-1-1, Edo26-18-64, Edo34-94-3, Edo4-1-15, plus Butana and Arfa Gadamak-8 were used as checks. The experiment was arranged in a Randomized Complete Block Design (RCBD) with four replicates. Sowing dates were July 18, 2012 (first season) and 2nd July 2013 (second season). Each genotype was sown in four ridges of five-meter length with spacing of 0.80 m between ridges and 0.30 m within ridges. After three weeks from sowing, plants were thinned to three seedlings per hill**.** Nitrogen fertilizer in the form of urea at the rate of 80 kg/ fed was applied, one week after thinning. Weeds were controlled by hand when needed. Irrigation was supplemented at 14 days' interval when necessary. Days to 50% flowering, plant height (cm), head exertion (cm), panicle length (cm), number of grains per head, 100 grain weight (g) and grain yield (kg/ha) were the main traits measured in the study. Parameters, assessments were made in the central ridges of each plot discarding one ridge or more at each side and all data were then based on 4.00 m of ridges length except for days to 50% flowering, which were estimated on the entire ridge. Harvesting and threshing was performed by hand.

Analysis of variance was used for each season separately and the results of the two seasons were combined using the statistical package (SAS) to test -significant differences among genotypes for the phenotypic and genotypic variances and their coefficients, for all traits mean separation was attained according to Duncan Multiple Range Test (DMRT).

Estimation of genetic parameters

Phenotypic and genotypic coefficients of variation of means were computed as follow:

Genotypic and phenotypic variances were computed using the following formulas:

$$\sigma^2 G = \frac{MSg\_MSe}{r}$$

$$\sigma^2 e = MSe$$

$$\sigma^2 P = \sigma^2 G + \sigma^2 e$$

$$= \frac{MSg\_MSe}{r} + MSe$$

Where

$\sigma^2 g$ = genotypic variance, $\sigma^2 P$ = phenotypic variance , $\sigma^2 e$ = environmental variance, MS_g = mean squares of genotype, MS_e = error mean squares, r = number of replications.

Genotypic and phenotypic coefficients of variation

The genotypic and phenotypic coefficients of variation were computed according to Burton and Devane (1953).

Genotypic coefficient of variation (GCV) = $\frac{\sqrt{\sigma^2 g}}{\bar{X}} \times 100$

Phenotypic coefficient of variation (PCV) = $\frac{\sqrt{\sigma^2 p}}{\bar{X}} \times 100$

Where

$\sigma^2 g$ = genotypic variance
$\sigma^2 p$ = phenotypic variance and,
$\bar{X}$ = general mean of trait

The PCV and GCV values are ranked as low, medium and high (Sivasubramanian and Menon, 1973) and are mentioned below:

0 - 10% - Low
10 - 20% - Moderate
>20% - High.

Results and Discussion

Analysis of variance indicated highly significant differences ($P < 0.01$) for all agronomic characters among genotypes in each season and combined except number of grains per head in second season (2013/2014) which showed no significant differences (Tables 1 and 2). These finding indicated the presence of a wide range of genetic variability in the tested genotype. Similar results were obtained by Karnataka, (2010).

During both seasons and their combined over two seasons, there were highly significant differences among tested genotypes in their days to 50% flowering this indicated that there is a wide genetic variability. Days to 50% flowering during the first season (2012/2013), ranged from (64-80) days, the earliest variety was Arfa Gadamak-8, while Edo34-1-1, Edo34-94-3 and Edo4-1-15 were the latest entries. Days to 50% flowering during the second season (2013/2014), ranged from (57-79) days, with variety Arfa Gadamak-8 being the earliest entry while Edo34-94-3 and Edo 34-1-1 were the latest genotype. In combined over two season, the number of days to flowering ranged from 60-80, Arfa Gadamak-8 was the earliest genotype Edo34-1- and Edo34-94-3 were the latest ones. The lines means were (74, 70 and 72) at both seasons and combined respectively, (Tables 1 and 2).

During both seasons and when combined over two seasons, there were highly significant differences among the tested genotypes in their plant height this indicated that there is a wide genetic variability. Plant height during the first season ranged from (85 - 119 cm), the genotype Edo34-1-1 was the tallest genotype, while Edo26-18-60 had the shortest one. Plant height during the second season was a wide range (107.35 – 177.1 cm), Edo34-1-1 the tallest genotype, while Edo26-18-64 the shortest. In combined, plant height ranged from (96.6 – 148.1), Edo34-1-1 the tallest genotype, and the shortest was Edo 26 -18-60. The lines means were (103, 151. and 131.) at both seasons and combined respectively. Most of the entries showed a reasonable plant height compared to the check. With many entries having a plant height shorter than check at both seasons and combined, (Tables 1 and 2). Plant height is an important character because it can describe the proportion of photosynthate allocation between the stem and grain. For grain sorghum purpose, very high plants are not desirable because it will reduce the photosynthate allocation to grain production. In addition, medium height sorghum is generally associated with lodging resistance.

During both seasons and their combined over two seasons, there were highly significant differences among tested genotypes in their head exertion this indicated that there is a wide genetic variability. Head exertion during the first season was a wide ranged from 6.4 to 14.0 cm, the variety Arfa Gadamak-8 showed the tallest head exertion, while Edo-13-10-12 had shortest one. Head exertion during the second season was wide genetic variability, ranged from 4.45 to 10.65 cm, the variety Arfa Gadamak-8 showed the tallest head exertion, while Edo 26-18-64 had shortest one. In combined, head exertion ranged from 5.6 to 12.3 cm, all lines having a head exertion shorter than checks at both seasons and combined. The entries means were (8.8, 6.4 and 7.5) at both seasons and combined analysis respectively, (Tables 1 and 2).

During both seasons and when combined analysis, there were highly significant differences ($P < 0.01$) among the tested genotypes in their panicle length this indicated that there is a wide genetic variability. Panicle length during the first season, ranged from (17.2 - 25.1 cm), and from (81 to 26 cm) during the second season. In combined over two seasons, panicle length of entries ranged from (18 to 25 cm). The genotypes means were (21.4, 16.4 and 22.1) at both seasons and combined respectively. All of the entries having a panicle length tallest than of the check, Arfa Gadamak-8 at both seasons and combined (Tables 1 and 2). Panicle length is one of important component because it is a place for panicle branches containing grains.

During the first season number of grains per head of sorghum genotype ranged from 1172 to 2274, Edo34-94-3, had the highest number of grains per head (2274), followed by Edo13-10-12 (1939), while the check Arfa Gadamak -8 (1172), had the lowest number of grains per head. Number of grains per head during the second season ranged from (1545 to 2208), Edo34-94-3 showed the highest number of grains per head of (2208), while Bashayir, had the lowest number (1545) of grains per head. And from 1466 to 2242 Edo34-94-3, was the highest number of grains per head 2242, followed Edo34-1-1 (1955) while the check Arfa Gadamak -8 had the lowest number

(1466) of grains per head in combined over two seasons. The entries means were (1652, 1800 and 1739) at both seasons and combined respectively. All of the entries showed a number of grains per head more than of the check Arfa Gadamak -8 at the first season and combined in (Tables 1 and 2)**.**

During both seasons and their combined over two seasons, there were highly significant differences ($P < 0.01$) among tested genotypes for 100- grain weight this indicated that there is a wide genetic variability. 100- grain weight during the first season, ranged from 2.66 to 3.56 g, Arfa Gadamak-8 showed more 100- grain weight (3.56 g) compared to other entries, while Edo -13-10 -12 recorded the least weight (2.7 g). During the second season, 100- grain weight ranged from 3.5 to 4.4 g, Edo26-18-60 gave the highest 100- grain weight 4.4 g, while Edo 4-1-15 recorded the lowest weight 3.5 g. In combined 100- grain weight of sorghum entries ranged from 3.2 to 3.9g, Arfa Gadamak-8 gave the highest 100- grain weight 3.9g while Edo34-94-3 gave the lowest (3.2g) weight. The entries means were (3.0, 4.0 and 3.68) at both seasons and combined respectively, (Tables 1 and 2)**.**

During both seasons were significant differences and highly significant differences at combined, among tested genotypes in their grain yield this indicated that there is a wide genetic variability. During the first season grain yield of sorghum entries ranged from 1000 to 1563 kg/ha. All entries produced grain yield more than check, rather than Edo26-18-45, Edo4-1-15 and Edo 34-1-1 that produced the highest (1562 kg/ha) yield, followed by Butana (1500 kg/ha), while the check Arfa Gadamak -8 (1000 kg/ha) produced the lowest yield. Grain yield during the second season ranged from 1356 to 2461 kg/ha, most of the entries produced grain yield more than checks, Edo34-94-3 produced the highest (2461kg/ha) yield, followed by Edo34-1-1 (2201.6 kg/ha), while the check Butana (1447 kg/ha) produced the lowest yield. In combined grain yield of sorghum entries ranged from 1283.2 to 1933.6 kg/ha Edo4-1-15 was produced highest yield followed by Edo34-1-1 (1882.0 kg/ha), while Edo26-18-64 was produced the lowest yield, 1283.2 kg/ha. The entries means were (1258.75, 1683.83 and 1493.90) at both seasons and combined respectively in (Tables 1 and 2). The variation in yield between the two seasons is due to differences in climatic facters.

Estimates of variance components, genotypic and phenotypic coefficients of variation, are presented in (Table 3). In general, phenotypic coefficients of variation (PCV) were higher than genotypic coefficients of variation (GCV) in all traits under both seasons and combined. These results were in conformity with the findings of (Nguyen Duy Can, *.et al*., 1998 and Khan *et al*. 2005). The GCV and PCV were high for head exertion and number of grains per head (25.6, 34.9 and 15.4, 30.6%) respectively, the lowest GCV and PCV was obtained by days to 50% flowering and 100- grain weight (6.8, 7.5 and 7.3, 10.0 %) respectively, at the first seasons (Table 3). The GCV and PCV were high for 100- grain weight and head exertion (60.5, 61.0% and 25.8, 34.8%) respectively the lowest GCV and PCV were obtained by panicle length and days to 50% flowering (7.8, 11.0 and 8.6, 11.4) respectively at the second season (Table3). The GCV and PCV were high for plant height and head exertion (25.5, 27.0% and 21.9, 35.9 %) respectively the lowest GCV and PCV was obtained for days to 50% flowering and panicle length (9.3, 10.9 and 11.5, 14.3%) respectively, at the combined over two season (Table 3).

The success of any breeding program depends upon the genetic variation in the material at hand. The greater the genetic variability, the higher would be the heritability. Hence the better the chances of success to be achieved through selection.

Study of genetic variability was done according to the standard deviation of genetic variance of each character.

Conclusion

Based on the results of this study, there was significant large genetic variability of agronomic characters among sorghum genotypes. The variations could be effectively manipulated with appropriate breeding methods to develop improved varieties for use by farmers and industries. In general, phenotypic coefficients of variation (PCV) were higher than genotypic coefficients of variation (GCV) for all traits under both seasons and for combine.

Table .1.Mean performance, significant level and rank of some sorghum genotypes evaluated for yield and yield component at two seasons

Entry	Days 50% flowering		Plant height (cm)		Head exertion (cm)		Panicle length (cm)	
	2012/13	2013/14	2012/13	2013/14	2012/13	2013/14	2012/13	2013/14
Edo26-18-45	75 B	69 BC	108 BC	140.45 E	8 BCD	5.55 DE	21.40 BCD	22.75 BCD
Edo26-18-60	72 BC	67 BCD	85 E	108 G	7 CD	6.55 CDE	23.40 AB	25.75 A
Butana	72 BC	65 CDE	111 AB	174.7 B	11 B	6.3 AB	20.50 CD	21.30 CD
Edo13-10-12	71 C	60 ED	101CD	127.17 F	6 D	5.6 DE	19.40 DE	21.85 CD
Bashayir,	71 C	67 BCD	114AB	166.15 BC	10 BC	6.95 BCD	21.45 BCD	23.00 ABC
Edo34-1-1	80 A	79 A	119 A	177.1 B	7 CD	4.57 DE	25.10 A	25.55 A
Edo26-18-64	74 BC	68 BCD	87 E	107.35 G	7 CD	4.45 DE	22.65 ABC	24.15 AB
Edo34-94-3	80 A	75 AB	107 BCD	167.3 BC	7 CD	6.9 BCD	23.95 AB	24.05 AB
Edo4-1-15	80 A	74 AB	98D	152.35 DE	11 B	8.5 ABC	19.15 ED	21.65 DE
Arfa Gadamak-8	64 D	57 E	150BCD	156.75 CD	14 A	10.65 A	17.20 E	18.90 E
Range	64 - 80	57 - 75	85 - 119	107.4 - 177.1	6.4 - 14.0	4.5 - 10.7	17.2 - 25.1	18.9 - 25.8
Mean	74	70	103.4	151.2	8.8	6.4	21.42	22.7
SE$\pm$	0.54	1.3	1.38	2.3	0.53	0.4	0.43	0.45
Sig. level	**	**	**	**	**	**	**	**
(C.V. %)	2.9	7.4	5.3	6.0	24.1	23.6	8.0	8.0

Means within the same column followed by the same letter (s) are not significantly different at the probability level of 0.05, and 0.0 (*, **) = significant at the 0.05 and 0.01 probability level respectively, according to DMRT. N.S= no significant at the probability level of 0.05.

Table .1.Cont

Entry	Number of grains per head		100-seed weight (g)		Seed yield (Kg/ha)	
	2012/13	**2013/14**	**2012/13**	**2013/14**	**2012/13**	**2013/14**
Edo26-18-45	1706 ABC	1551 A	4.1 B	3.6 AB	1102.0 BC	1666.7 BC
Edo26-18-60	1506 BC	1741 A	4.4 A	3.8 A	1164.3 ABC	1511.6 C
Butana	1540 BC	1550 A	4.2 AB	3.6 AB	1500.0 AB	1447.2 C
Edo13-10-12	1939 AB	1195 A	3.9 BC	3.3 AB	1180.0 ABC	1592.7 BC
Bashayir,	1484 BC	1545 A	4.1 B	3.6 AB	1351.8 ABC	1671.9 BC
Edo34-1-1	1862 ABC	2047 A	3.70 C	3.3 AB	1562.5 A	2201.6 AB
Edo26-18-64	1810 ABC	1850 A	4.3 AB	3.7 AB	1211.0 ABC	1355.5 C
Edo34-94-3	2274 A	2208 A	3.70 C	3.2 B	1406.5 ABC	2461.0 A
Edo4-1-15	1228 BC	2199 A	3.5 CD	3.3 AB	1000 C	1727.2 B C
Arfa Gadamak-8	1172 C	1758 A	3.6 CD	3.9 A	1109 BC	1626.9 BC
Range	1172 - 2274	1545 – 2208	3.5 - 4.4	3.2 - 3.9	1000 - 1562.5	1355.5 - 2461.0
Mean	1652	1800	4.0	3.68	1258.75	1683.83
SE±	109.2	166.9	0.055	0.09	66.1	101.2
Sig. level	*	N.S	**	**	*	*
(C.V. %)	26.4	32.3	5.3	6.0	21.0	24.0

Means within the same column followed by the same letter (s) are not significantly different at the probability level of 0.05, and 0.0 (*, **) = significant at the 0.05 and 0.01 probability level respectively, according to DMRT. N.S= no significant at the probability level of 0.05.

Table 2. Mean performance, significant level and rank of some sorghum genotypes evaluated for yield and yield component at the combined over two season.

Entry	Days 50% flowering	Plant height (cm)	Head exertion (cm)	Panicle length (cm)	Number of grains per head	100-seed weight (g)	Seed yield (Kg/ha)
Edo26-18-45	72 CDE	124.0 CD	6.7 CDE	22.0 BCD	1629 AB	3.6 AB	1384.1 BC
Edo26-18-60	70 DEFG	96.6 DE	8.0 ABC	24.5 A	1625 AB	3.8 A	1337.8 C
Butana	69 EFG	142.7 B	10.0 B	20.9 CD	1546 AB	3.6 AB	1473.6 BC
Edo13-10-12	66 FG	114.2 D	6.0 CE	20.6 DE	1568 AB	3.3 AB	1386.2 BC
Bashayir,	70 EFG	139.9 BC	8.5 ABC	22.2 BCD	1515 B	3.6 AB	1511.7 AB
Edo34-1-1	80 A	148.1 A	5.6 E	25.3 A	1955 AB	3.3 AB	1882.0 A
Edo26-18-64	71 DEF	96.9 DE	5.6 E	23.4 ABC	1831 AB	3.7 AB	1283.2 D
Edo34-94-3	78 AB	136.8 BCD	7.0 C	24.0 AB	2242 A	3.2 B	1933.6 A
Edo4-1-15	77 ABC	125.1 CD	9.7 AB	20.4 DE	1715 AB	3.3 AB	1363.6 C
Arfa Gadamak-8	60 H	145.8 AB	12.3 A	18.0 E	1466 B	3.9 A	1368.1 CD
Range	60 – 80	97 - 148	6 - 12	18.0 - 25.3	1466 - 2242	3.2 - 3.9	1283.2 - 1933.6
Mean	72	131.2	7.5	22.1	1739.1	3.68	1493.9
SE±	1.32	1.9	0.56	0.47	147.2	0.09	95.3
Sig. level	**	**	**	**	*	**	**
(C.V. %)	5.7	6.0	29.8	8.5	30.7	6.0	23.7

Means within the same column followed by the same letter (s) are not significantly different at the probability level of 0.05, and 0.0 (*, **) = significant at the 0.05 and 0.01 probability level respectively, according to DMRT. N.S= no significant at the probability level of 0.05.

Table 3. Estimates of genotypic, phenotypic variance, genotypic and phenotypic coefficients of variation of some sorghum genotypes at two seasons (2012/13, 2013/14) and their combined data.

Parameters	Genotypic variation ($\sigma^2 g$)			Phenotypic variation ($\sigma^2 p$)			GCV (%)			PCV (%)		
	2012/13	2013/14	Combined	2012/13	2013/14	Combined	2012/13	2013/14	Com-bined	2012/13	2013/14	Combined
Days 50% flowering	24.8	35.7	43.4	29.8	62.4	60.4	6.8	8.6	9.3	7.5	11.4	10.9
Plant height (cm)	113.3	626.6	1025.8	143.8	709.3	1150.8	10.3	16.9	25.5	10.4	18.0	27.0
Head exertion (cm)	5.2	3.2	3.0	9.7	5.8	8.1	25.6	25.8	21.9	34.9	34.8	35.9
Panicle length (cm)	5.2	3.2	6.5	8.2	6.5	10.1	10.6	7.8	11.5	13.4	11.0	14.3
Number of grains / head	64930	12527.9	15051.6	255760.8	458403.7	361806.5	15.4	6.3	7.2	30.6	38.4	35.2
100- grain weight (g)	0.05	5.9	0.4	0.09	6.0	0.6	7.3	60.5	18.0	10.0	61.0	22.0
grain yield (Kg/ha)	17183.6	59706.5	52194.2	87184.2	223619.0	197511.4	10.4	14.2	15.3	23.5	27.4	29.0

GCV: Genotypic Coefficients of Variation: PCV: Phenotypic Coefficients of Variation.

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دراسة الشكل الظاهرى ، النمو و الإنتاجية لبعض سلالات الذرة الرفيعة فى السودان

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المستخلص

أجريت الدراسة في محطة بحوث سنار لموسمين 2012/13 و 2013/14، بهدف دراسة الشكل الظاهرى ، النمو، الإنتاجية و التباين الوراثي لعشرة سلالات من الذرة الرفيعة. و استخدم تصميم القطاعات الكاملة العشوائية بأربعة مكررات. شملت الدراسة سبعة صفات و هى : عدد الايام لى 50 %من الإزهار، ارتفاع النبات (سم)، مسافة ورقة العلم (سم)، طول القندول (سم)، عدد الحبوب في القندول، وزن المائة حبة (جرام) والإنتاجية الكلية (كيلوجرام/هكتار). أظهرت نتائج التحليل الإحصائي أن هنالك فروق معنوية عالية بين سلالات الذرة لكل الصفات التي تمت دراستها للموسمين و التحليل المركب فيما عدا عدد الحبوب في القندول للموسم الثاني. وقد كان معامل الاختلاف في الشكل الظاهري اكبر من معامل الاختلاف في التركيب الوراثي لكل الصفات في الموسمين و التحليل المشترك.