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Riboflavin and Cultivars Affecting Genetic Parameters in Maize (Zea mays L.)

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Abstract. The current research was conducted in the fields of the College of Agriculture, University of Anbar (Al-Hamidhiya Research Station) during the spring and fall seasons of 2018. The treatment combinations were randomly distributed in three replicates of randomized complete block design (RCBD) according to split plot arrangement, where four concentrations (0, 100, 200 and 300 mg l-1) of riboflavin (Vitamin B2) occupied the main plots, while the four maize cultivars (5012, Alrabee, Alnoor and Safa) were placed in the sub plots. This investigation was launched to estimate the genetic variation of yield and its contributors in four maize cultivars under four concentrations of sprayed riboflavin. The yield and its components were studied in terms of both, performance and variations, accordingly genetic and environmental variations, in addition to the broad sense heritability were estimated. The highest ratios of genetic to environmental variation were 13 and 9.3 exhibited by grains per row and grain weight, respectively. The same two traits showed the highest values of broad sense heritability (92.79% and 90.00%, respectively). However, Safa cv. was outperformed by revealing the highest 250 grain weight (51.2 g) and a yield of 121.51 g plant-1 in the fall season. The concentrations of sprayed riboflavin significantly affected most of the studied traits in both spring and fall growing seasons. The two practiced factors have significantly interacted in most of the investigated traits. It can be concluded that the yield components are mainly controlled by the heredity factors, thus the adoption of grains per row and grain weight will be more efficient for assessing the yield potential in maize crop.

Keywords: Riboflavin, Cultivars, Zea mays L

INTRODUCTION

Maize (*Zea mays* L.) is the main contributor in the food basket of any family. The fluctuating global production of cereals coincides with environmental conditions tends strongly to be less appropriate, accordingly the threat to global food production is constantly increasing, and global warming may be at the forefront of climate changes that ease vital and large-scale biotic and/or abiotic environmental stresses [1]. This "golden crop" has traditional uses for food, feed and oil production, however new uses were emerged in different countries especially producing biofuel, mainly in Brazil and USA [2]. Although maize is not recently introduced to Iraq, its productivity is still beyond wishes due to poor genetic potential of the local varieties and abiotic stress like salt and high temperatures, especially at the spring season. Furthermore, field practices can either positively or negatively contribute to the final yield in about 30-50% [3]. Therefore, the higher yield is a result of breeding and better understanding of interaction between genetics structure and field practices for crop management. The selection of the desired genotype will not be the only way to raise up the crop productivity, unless we minimize the abiotic stresses to its lower limits. The environmentally safe materials including vitamins can be an effective tool to stimulate plants to use their functional and genetic capabilities. Based on their auxiliary effect, such vitamins serving as antioxidants and possible regulators for various metabolic and physiologic pathways especially in stress conditions that ultimately will

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promote natural growth in plants [4,-6].Riboflavin (vit. B2) is one of the main catalysts for many metabolic enzymes and play a key role in electrons transfer, citric acid.

biosynthesis, fatty acid oxidation, photosynthesis and DNA repairing system [7]. Azooz [8] found that spraying Roselle (*Hibiscus sabdariffa*) with a 100 ppm of riboflavin had increased plant content of carbohydrates and antioxidant enzymes, negatively regulated the plant content of hydrogen peroxide and proline. Hence, riboflavin might be an effective anti-oxidant by optimizing the osmotic pressure and the ionic exchange and promote plant resistance to salt stress. The success of any plant breeding program depends mainly on the size of the genetic variation present in the investigated plant population, thus the first step in any breeding program is the estimation of genetic diversity, that in turn will shape the plant phenotype [9].

The most sought by plant breeders is to increase the grain yield that is directly related to several contributors. Adequate and accurate knowledge of such a reciprocal relationship between grain yield and its components in response to physiological processes can improve the effectiveness of the breeding program via adopting the suitable selection methods [10]. The selection can be applied to the plant population when there are clear genetic variants of the required trait controlled by the additive gene action. The current work is launched to investigate the possible effect of riboflavin concentrations on the genotypic, and hence the phenotypic performance of different maize cultivars grown for two successive seasons.

MATERIALS AND METHODS

A field experiment was carried out for two growing seasons (spring and fall of 2018) at the College of Agriculture - University of Anbar (Al-Hamidhiya Research Station). Treatments were distributed in randomized complete block design (RCBD) with three replicates in split plot arrangement. The main plots contained the four concentrations of foliar feeding riboflavin (0, 100, 200 and 300 mg l^{-1}), while sub plots contained four maize cultivars (5012, Alrabee, Alnoor, and Safa).

The field was properly prepared and divided into 48 experimental units, each was in 6 m^2 (2×3 m) of area contained 4 lines. The sowing date was on March 23, 2018 for the spring season and July 27, 2018 for the fall season at a distance of 25×75 cm.

The field was adequately fertilized with DAP (P 48%) at a rate of 160 kg h^{-1} and urea (46% N) at a rate of 300 kg h^{-1} added for two times. Weeding and irrigation was practiced as needed. Then, random samples of ten plants from the two intermediate lines were chosen from each experimental unit to estimate therequired traits.

Investigated traits:

1. The number of days from planting to 50% silking.
2. Leaf area (m^2): Estimated according to [11].
3. The number of grains per row.
4. Weight of 250 grains (g).
5. Grain yield of the individual plant (g). A total yield of ten plants was weighted, and divided by ten for each experimental unit.

The collected data was statistically analyzed according to analysis of variance. The means were compared using the least significant difference (L.S.D) at 5% probability level [12]. Phenotypic, genetic, and environmental and variations were estimated according to [13] based on the following formula.

$$ð^2G = (ð2 \text{ Cultivars} - ð^2E) / r \quad ð^2E = Mse \qquad (1)$$

$$ð^2P = ð^2G + ð^2E \qquad (2)$$

$$P.C.V = \sqrt{ð^2P} / \text{Mean of Cultivars} \qquad (3)$$

$$G.C.V = \sqrt{ð^2G} / \text{Mean of Cultivars} \qquad (4)$$

Where: $ð^2$ Cultivars is the mean square of Cultivars.

$ð^2E$ is the mean square of environment effect.

P.C.V is the Coefficient of phenotypic variation.

G.C.V is the Coefficient of genetic variation.

Broad sense heritability (h^2.b.s%) was estimated for the selected attributes according to the following formula.

$$h^2 bs = (ð^2G / ð^2P) \times 100 \qquad (5)$$

RESULTS AND DISCUSSION

50% Silking (day)

The performance of any plant type varies according to its genetic background, commonly termed genotype. Usually, when the necessary amount of dry matter is available flowering occurs [14]. The results offered in Table (1) clearly indicated the superiority of 5012 cultivar. in the spring season and Safa cv. in the fall season over the other cultivars by giving the minimum days for silking (63.58 and 59.92 days, respectively). As for concentrations of sprayed riboflavin, the concentration of 200 mg l^{-1} was superior by showing the lowest mean of silking days that reached 66.00 and 61.19 days for the spring and fall seasons, respectively, however, it has no significant difference against the higher concentration of 300 mg l^{-1} in the fall season, meanwhile the control treatment had the highest mean of silking days for both seasons. The previous results approved the positive effect of riboflavin in mediating smooth transfer from vegetative to reproductive stage. Generally, the studied cultivars had their positive response to the increased concentration of the sprayed riboflavin in the average number of days for silking as the sprinkler concentrations increased in different proportions and for the two seasons where the overlap was significant and for both seasons, which exceeded Class 5012 with a spray treatment of 200 mg-1 liter and took 63.00 days in the spring season. As for the fall season, the variety exceeded a description with a spray treatment of 200 mg-1 liter by giving the lowest number of days for silking to 58.90 days.The percentage of genetic variances in plant populations was higher than environmental variances Table 1, especially the spring season, which led to giving a relatively high heritability for this trait. This is consistent with what [15,16] stated who assured the negative response of plant varieties regarding silking time to high concentrations of sprayed riboflavin. The results presented in the same table indicated that the maize populations were highly homogeneous in term of phenotypic and genetic variation based on the values of PCV and GCV.

TABLE 1. Genetic variations of 50% silking (day) affected by maize cultivars and riboflavin concentrations in spring and fall seasons of 2018.

Riboflavin concentrations mg l-1	Spring season Cultivars					Fall season Cultivars				
	5012	**Alrabee**	**Alnoor**	**Saf a**	**Mea**	**5012**	**Alrabee**	**Alnoor**	**Saf a**	**Mea**
0	64	71.33	73.67	67.3	69.0	64	71.33	73.67	67.3	58.5
100	63.1	70.33	69	63.6	66.5	63.1	70.33	69	63.6	66.8
200	63	65.33	72.33	63.3	66	63	65.33	72.33	63.3	63.8
300	64.33	70	74.33	300.07	68.83	64.33	70	74.33	300.07	65.2
Mean	63.58	69.25	72.33	65.25	0.97	63.58	69.25	72.33	65.25	
L.S.D 5%		1.343 2.68			0.97 1		0. 92 2.06			1.05
	Heritability	**G2δ**	**E2δ**	**G.C. V**	**P.C.V**	**Heritability**	**G2δ**	**E2δ**	**G.C. V**	**P.C.V**
	79.04	9.58	2.54	4.57	5.15	72.76	3.18	1.19	2.8	3.28

LEAF AREA (M2)

Significant differences were detected among the various treatments Table 2, as 5012 cv. gave the highest mean of leaf area reached 0.5048 m^2, while Alrabee gave the lowest trait mean in the spring season (0.4526 m^2). However, in fall season the highest leaf area (0.4915 m^2) was expressed by Alnoor cultivar. which didn't differ significantly against Safa cultivar. The detected difference may be attributed to the genetic background of the investigated cultivars. These findings are in line with the results of [17] and [18] who reported significant differences between the studied cultivars in leaf area trait.The increased concentrations of riboflavin from 0 to 300 mg l^{-1} has increased the leaf area by 13.89% and 11.65% and in the two seasons respectively. The positive effect of vitamin B2 may be due its crucial role in photosynthesis and electrons transfer especially in oxidation process, furthermore it works as enzymatic catalyst. Riboflavin has an important role in oxins biosynthesis and cell elongation, thus increase the leaf area. As for the interaction between cultivars and the sprayed concentrations of riboflavin, the 5012 cultivar. was superior via giving the largest leaf area with a concentration of 300 mg l^{-1} in the spring season Table 2. Meanwhile, Alnoor treatment sprayed with 300 mg l-1 concentration was the superior in the fall season. The environment has a close variance to the genetic, giving a broad sense heritability of 50.48% and 50.04% for both growing seasons, respectively. These results were in line with what [15,16,19] stated in different plant species. This indicates the positive response of cultivars to the increased concentration of riboflavin. Also, cultivars found to be phenotypically and genetically homogeneous regarding leaf area based on PCV and GCV values, especially in spring season.

TABLE 2. Genetic variations of leaf area (m2) affected by maize cultivars and riboflavin concentrations in spring and fall seasons of 2018.

Riboflavin concentrations mg l-1	Spring season					Fall season				
	Cultivars					Cultivars				
	5012	**Alrabee**	**Alnoor**	**Saf a**	**Mea**	**5012**	**Alrabee**	**Alnoor**	**Saf a**	**Mea**
0	0.4676	0.4403	0.438	0.4424	0.448	0	0.467	0.4403	0.455	0.445
100	0.4949	0.439	0.457	0.448		100	0.4949	0.439	0.457	0.448
200	0.5176	0.4777	0.501	0.502	0.4995	0.4637	0.4827	0.512	0.511	0.492
300	0.5392	0.4697	0.492	0.513	0.5034	0.4597	0.4887	0.523	0.519	0.497
Mean	0.5048	0.4526	0.4726	0.475		0.439	0.4676	0.4915	0.487	
L.S.D 5%		0.033 0.066			0.0076 7		0. 93 2.06			1.05
	Heritability	**G2δ**	**E2δ**	**G.C. V**	**P.C.V**	**Heritability**	**G2δ**	**E2δ**	**G.C. V**	**P.C.V**
	50.48	0.0015	0.0015	8.36	11.77	50.04	0.0064	0.0063	17	24.02

GRAINS NO. PER ROW

Cultivars was affected significantly the trait of grains per row Table 3 as Safa cultivar. expressed the highest mean of grains per row in both seasons being 26.58 and 35.45 grains, respectively, with a percentage increase reached 2.5%, 5.4%, and 9.7% against Alnoor, Alrabee, and 5012 cultivars in the fall season, respectively. From the same Table it can be noted that there was a significant increase in the number of grains per row in response to the increase of the sprayed concentration, where the concentration of 200 mg l^{-1} revealed the highest mean (35.63 grain), meanwhile it didn't differ significantly with the maximum concentration of riboflavin (300 mg l^{-1}) in the fall season.The positive effect of riboflavin in increasing grains number per row Table 3, could be resulted from the better leaf area and efficient photosynthesis process that improved the biosynthesis of carbohydrates necessary for the normal development of grain initials and contributed effectively to its filling [5]. However, riboflavin has no significant effect on the trait in the spring season. The interaction between the used cultivars and the concentrations of sprayed riboflavin was significant in the spring season. In the same contest, the interaction treatment of Safa cv. with 200 mg l^{-1} riboflavin was superior with an increase of 20.34% over the treatment of 5012 cv. with a concentration of 100 mg l^{-1} . The general performance of the investigated cultivars was in line with the increased concentration, where the higher sprayed concentrations imitated in a higher grain number per row. Genetic variations among maize populations were more than environmental variations (6.5 and 12.9 times in spring and fall season, respectively) that significantly affected grains number per row and explains the high heritability of the studied trait Table 3. These results agreed with previous findings reported by [15, 16]. According to PCV and GCV values, cultivars had phenotypically and genetically homogenous plants corresponding the investigated trait.

TABLE 3. Genetic variations of grain per row affected by maize cultivars and riboflavin concentrations in spring and fall easons of 2018

Riboflavin concentrations mg l-1	Spring season					Fall season				
	Cultivars					Cultivars				
	5012	**Alrabee**	**Alnoor**	**Saf a**	**Mea**	**5012**	**Alrabee**	**Alnoor**	**Saf a**	**Mea**
0	23.6	25.53	25.73	25.67	25.13	30.2	32.27	34.57	33.43	32.62
100	23.43	26.2	26.3	26.27	25.55	30.67	32.2	33.17	33.6	32.41
200	24.93	24.87	26.33	28.2	26.08	34.27	34.57	35.33	38.37	35.63
300	24.93	24.27	25.3	26.2	25.17	31.8	34.1	35.63	36.4	34.48
Mean	24.22	25.22	25.92	26.58		31.73	33.28	34.68	35.45	
L.S.D 5%		0.649 1.34			N.S		0.758 N.S			1.18
	Heritability	**G2δ**	**E2δ**	**G.C. V**	**P.C.V**	**Heritability**	**G2δ**	**E2δ**	**G.C. V**	**P.C.V**
	86.72	3.87	0.5931	12.7	13.64	92.79	10.43	0.809	9.56	9.92

WEIGHT OF 250 GRAIN (G)

The grain weight is one of the important yield contributors, particularly in maize where grains develop and fill quickly after fertilization. Three quarters of the dry weight of the grains accumulates at the end of the dough phase, and reaches the peak at physiological maturity [20]. The results of Table 4 showed the positive response of cultivar 5012 to score the highest mean of 250 grain weight reached 52.61 g, while Alnoor showed the lowest trait mean in the spring season (41.84 g).In the fall season, Safa cv. was superior as it showed the highest mean of the studied trait (48.89 g) that didn't significantly varied with the Alrabee and 5012 cultivars, however Alnoor cv., exhibited the lowest trait mean of 45.45 g Table 4. The reported differences may be attributed to the genetic diversity existed among the studied genotypes. These findings were consistent with what was stated by [21] that the sprayed riboflavin increased the grain weight because riboflavin has a stimulating effect in different biological processes and increasing the manufactured materials, which will reflect on grain weight. The maximum concentration of 300 mg l^{-1} produced the highest mean of 250 grain weight reached 47.25 and 51.20 g for the spring and fall seasons, respectively Table 4. The same table indicates a significant difference between the studied cultivars and the practiced concentrations as 5012 cv., achieve the best positive response with 300 mg l^{-1} of sprayed riboflavin giving the maximum weight of 250 grains of 53.33 g and an increase of 31.77% compared to Alrabee cv. in the spring season. As for the fall season, Alrabee cv. treated with 300 mg l^{-1} of riboflavin revealed the highest weight of 250 grains (53.72 g), with an increase of 25.62% over the control treatment of 5012 cultivars. Genetic variations were bigger than environmental one (4.1, 9.0 times in the spring and fall seasons, respectively), which was reflected in high heritability of 80.05% and 90.00%, in the two seasons, respectively. Based on the values of PCV and GCV (Table 4), the results indicated that cultivars were phenotypically and genetically homogeneous in grain weight, especially in the fall season. Similar results were stated by [22].

TABLE 4. Genetic variations of 250 grain weight (g) affected by maize cultivars and riboflavin concentrations in spring and fall seasons of 2018.

Riboflavin concentrations mg l-1	Spring season					Fall season				
	Cultivars					Cultivars				
	5012	**Alrabee**	**Alnoor**	**Saf a**	**Mea**	**5012**	**Alrabee**	**Alnoor**	**Saf a**	**Mea**
0	51.12	40.47	40.52	41.26	43.27	42.66	44.13	42.99	44.03	43.45
100	52.86	42.21	41.15	46.09	45.57	46.37	48.13	44.43	50.53	47.37
200	53.13	43.15	42.73	47.82	46.7	48.05	49.32	45.04	50.68	48.27
300	53.33	44.12	42.97	48.61	47.25	51.4	53.72	49.34	50.33	51.2
Mean	52.61	42.48	41.84	45.94		47.12	48.82	45.45	48.89	
L.S.D 5%		1.92 3.84			2.54		1.48 3.24			2.36
	Heritability	**G2δ**	**E2δ**	**G.C. V**	**P.C.V**	**Heritability**	**G2δ**	**E2δ**	**G.C. V**	**P.C.V**
	80.05	20.87	5.2	10	11.17	90	27.92	3.1	5.92	6.98

GRAIN YIELD (G)

The plant breeders have growing eager to increase the grain yield by adopting old and/or new techniques especially for diagnosing genetic structure expected to produce higher yield. Table 5 indicates the superiority of 5012 cultivar. by giving the highest plant yield of 108.61 g, although it has no significant differences against Safa cultivar., on the other side Alrabe. produced the lowest trait mean (89.43 g) in the spring season. The superiority of 5012 was due to its superiority in the grain weight. In fall season, Safacv. was superior by exhibiting the highest trait mean (121.51 g), and its superiority was attributed to the highest values of grain weight and grain number per row, while Alrabee cv. gave the lowest mean of plant yield (95.85 g). The varied response of the explored cultivars is due to their different genotype. This result was in consistent with previous findings [23,24].

The increase in the concentrations of sprayed riboflavin up to 300 mg l^{-1} resulted in the highest attribute of 101.05 and 115.97 g for the two growing seasons, respectively Table 5, with 3.15% and 6.5% fold of increase in spring and 10.30% and 11.63% in fall season against the lowest concentrations 100 and 0 mg l^{-1}. The two factors had no significant interaction in spring season, where cultivars response was in the same direction of the tested riboflavin concentrations, but in fall season Safa. exposed the highest mean of plant yield (130.80 g) under the effect of the highest concentration, with an increase of 45.93% over Alrabee. as control. This is in line with [25] findings that high sprayed concentrations of riboflavin positively affected the plant yield.

The genetic variances were about three times the environmental counterpart in almost both seasons Table 5, that greatly affected the grain yield according to the genetics and environmental susceptibility. These findings explain the good heritability of grain yield of 74.21% and 75.83% in the two seasons, respectively. This is consistent with what [15,16,26] attained. The results of the previous Table indicated that plants were phenotypically are genetically homogeneous in grain yield based on the values of P.C.V and G.C.V.

In any case, the heritability was high in most of the investigated traits in both seasons, and the phenotypic variability is mainly due to the genetic differences existed between the tested cultivars of maize, at the same time low environmental effect was detected [27,28].

TABLE 5. Genetic variations of grain yield (g) affected by maize cultivars and riboflavin concentrations in spring and fall seasons of 2018.

Riboflavin concentrations mg l-1	**Spring season**					**Fall season**				
	Cultivars					**Cultivars**				
	5012	**Alrabee**	**Alnoor**	**Saf a**	**Mea**	**5012**	**Alrabee**	**Alnoor**	**Saf a**	**Mea**
0	103.2	86.33	90.53	99.38	94.88	100.2	89.63	108.53	117.1	103.8
100	108.2	88.94	92.08	100.9	97.96	102.5	96	109.3	112.7	105.1
200	111.0	90.49	92.21	102.4	99.05	106.67	97.87	119.07	125.3	112.2
300	111.9	91.99	95.25	104.9	101.0	112.73	99.9	120.43	130.8	115.9
Mean	108.6	89.43	92.51	101.9		105.52	95.85	114.33	121.5	
L.S.D 5%		8.07 N.S			5.72		6.28 12.55			6.36
	Heritability	**G2δ**	**E2δ**	**G.C. V**	**P.C.V**	**Heritability**	**G2δ**	**E2δ**	**G.C. V**	**P.C.V**
	74.21	263.9	91.68	16.53	19.19	75.83	174.2	55.51	12.6	13.85

CONCLUSION

It can be concluded that the two investigated factors, riboflavin and maize cultivars have significantly affected most of the investigated traits, in term of genotypic, hence phenotypic performance. Generally, the yield components are mainly controlled by the heredity factors, however the adoption of grains per row and grain weight will be more effective for evaluating the yield potential of maize crop.

REFERENCES

1. A. Pande and S. Arora, Cell & Cell. Life Sci. J. **2**, 000112 (2017).
2. M. H. Shenawa and A. O. Alfalahi, The Iraqi J. Agric. Sci. **50**, 31-41 (2019).
3. M. Tollenaar, A. Ahmadzadeh and E. A. Lee, Crop Sci. **44**, 2086 – 2094 (2006).
4. A. Muhammad and A. Al-Rayes, *Physiology of Plants* (Dar Al Kotub for Printing and Publishing, 1989). p, 984.
5. A. Abu Al-Yazid, Egyptian Agriculture Network, World of Agriculture (2011).
6. P. Abrahamian and A. Kantharajah, American J. of Plant Sci. **2**, 669-674 (2011).
7. M. Fischer and A. Bache, Nat. Prod. Rep. **22**, 324-350 (2005).
8. M. M. Azooz, Ind. J. Plant Physiol. **13**, 325–333(2008).
9. D. Bello, A. M. Kadams, S. Y. Simon and D. S. Mashi, Am-Euras. J. Agric.and Environ. Sci. **2**, 297- 302 (2007).
10. S. A. Mohammadi, B. M. Prussian and N. N. Singh, Crop Sci. 43,1690-1697 (2003).
11. M. M. Elsahookie, J. Agron. and Crop. Sci. **154**, 157-160 (1985).
12. M. M. Elsahookie and K.M. Wehaib, *Applications in Experimental Design and Analysis*, (Ministry of Higher Education and Scientific Research, University of Baghdad, Baghdad, 1990). p, 488.
13. R. G. D. Steel and J.H. Torrie, *Principles and Procedures of Statistics* (McGraw-Hill, Book, Co. Inc., London, 1980). p, 560.
14. B. J. Glover, *Understanding Flowers and Flowering* (Oxford University Press, U.K., 2007), p. 227.
15. V. Mallinath, B. D. Biradar B.M. Chittapur, P. Salimath, M. Yenagi, and S.S. Patil, J. Agric. Sci. 17, 463-467 (2004).
16. S. K. Chavan and R. C. Mahajan, J. Agric. Sci. **23**, 23-323 (2007).

17. S. M. Kazem and R. R. Arak, Kufa J. for Agric. Sci. **8**, 151-163 (2016).
18. S. M. Al-Nasiri, F. A. Siddiq and M. A. A. Al-Janabi, Tikrit J. of Agric. Sci. **16**, 1-13 (2016).
19. H., Sharma, D. K. Jain and V. Sharma, Ind. J. Agric. Res. **40**, 310- 312 (2006).
20. R.L. Vanderlip, *How a Sorghum Plant Developed* (Kansan State University, Kansan, p, 20 (1993).
21. P. Szulk, T. Michalski and H. Waligora, Communication in biometry and Crop Sci. **11**, 90-97 (2016).
22. Ch. M. Rafiq, M. Rafique, A. Hussain and M. Altag, J. Agric. Res. **48**, 35-38 (2008).
23. C. R. Kunwar, B. Katual, S. Thapa and J. Shrestha, J. Maize Res. and Development **2**, 94-99 (2016).
24. 24. A. Qahar and B. Ahmad, J. Agric. **32**, 239-252 (2016).
25. N. M. Abood and Z. A. Abdulhamed, J. Plant production, Mansoura Univ. **8**, 1093-1101 (2017).
26. H. A. Al-Khazali, "Genetic parameters variations of some maize and sorghum traits, under the effect of plant densities", M.Sc. Thesis, University of Baghdad. p, 100, 2013.
27. R. Yogi, R. S. Meena, R. K. Kakani, A. Panwar and R. K. Solanki, Int .J. Seed Spices **3**, 41-43 (2013).
28. Z. A. Abdulhamed, A. H. Noaman, Y. A. Mohammed and N. M. Abood, J. of Physics Conf. Series **1294**, 092040 (2019).