Plant Archives VoL. 19 No. 2, 2019 pp. 4434-4440 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF SPACE BETWEEN PLANTS AND PLANTING DEPTHS ON GROWTH AND YIELD OF MAIZE (*ZEA MAYS* L.)

Emad Khalaf Aziz[1] and Amjed Shaker Hamood Al-Bawee[2]

[1]Department of Field Crops, College of Agriculture, University of Diyala, Iraq.
[2]Department of Biology, College of Education for Pure Science, University of Diyala, Iraq.

Abstract

A factorial experiment within split-plots was applied according to randomized complete block design (RCBD) with three replications. This study has been done in Diyala governorate, Al-Muqdadia, Abi-Sayda, during the summer season 2017. The soil in which *Zea mays* L. were grown was sandy clay loam. The aim of this study is to know the effect of distance and depth on the growth and yield of *Zea mays* "variety 5018". The study has three distances 20, 25 and 30 cm, which occupied the main-plots and three depths 5, 10 and 15 cm, which occupied the sub-plots. The results showed that distance 25cm outplayed in leaves number, it reached 15.60 leaf plant^{-1} as compared with the treatment of 30 cm distance. The two treatments of 25 and 30 cm distance outplayed in ear weight and ankle weight, they reached 223.78, 209.70, 54.08 and 50.17g respectively as compared with the treatment of 20 cm distance. The two treatment of 20 and 25 cm distance outplayed in total yield, they reached 17.71 and 17.17 t h^{-1} respectively as compared with treatment of 30 cm distance. Concerning the planting depths, the results showed a non-significant effect in most attributes. The results showed the presence of significant effects in the interpenetration between different planting distances and planting depths in most attributes.

***Key words*:** Distance between Plants, Planting Depths, *Zea mays* L.

Introduction

Economic improvement all over the world depends to a large extent on agriculture as a main branch of economy. In fact, the aim of planting any economical plant is to get a highest yield and a best quality with less costs. To get this aim, it is necessary to provide a good genetic source of the crop and good environmental conditions during the growth stages of plant. Actually, the need for increasing agricultural products started with the increase in population which is considered as the beginning of the domination of the scientific reasoning and depending experimental devices as an instrument for understanding and studying everything related to this problem, (*i.e.*, the problem of food shortage beside population increase), so there is a tendency to study this case.

Zea mays L. ranks third, following wheat and rice, of the world's production of cereal crops (Al-Yunis, 1993). Its planting varies according to temperature and water availability, thus, it can be grown in different thermal environments and are considered to be tropical and subtropical crops which makes them widespread in many parts of the world (Al-Yunis *et al*., 1987). It is a staple food source for a large number of the world's population and is grown for the purpose of obtaining food-rich grains, as fodder for animals or for artificial purposes. The crop is grown for its high nutritional value for both humans and animals because it contains carbohydrates, proteins, such as vitamin A, Thiamine (B1) and Cobalamine (B12), and its involvement in many food industries such as starch, oil and many others, as well as being essential in the poultry feed industry (Shweile and Jubouri, 1986). The distance between plants plays an important role in the competition between maize and weeds in the field. It has been found that reducing distance between plants help reduce the density of weeds and its spread in the field and increase the yield (Singh and Singh, 2006). The process of developing new hybrid maize requires the study of agricultural treatments, including the appropriate agricultural distance when cultivating these hybrids to

***Author for correspondence :** E-mail: dremad1956@yahoo.com, amjed.biology@gmail.com

reach the optimal plant density, through which the new hybrid can give a high percentage of grain, although this density varies depending on location and prevailing environmental conditions (Widdicombe *et al*., 2002). Determining the depth of agriculture affects seedling emergence and also affects the seedling tolerance of the drought and hence the grain yield in the unit area. The depth of planting differs according to the growth activity of the genome. Some genetic structures have a high ability to the emergence of large depths, while others emerge from simple depths. The depth of agriculture also varies according to the soil texture (Elsahookie, 1990). Recent studies applied in the central region of Iraq showed that corn planting at 15 to 20 cm depth gives a higher harvest and increases the plant's tolerance of drought because of deepening the roots in the soil and their spread because of increasing the root nodes. Studies also show that increasing the depth of agriculture by one cm increases the grain yield by 0.333 tons. (El- Elsahookie and Al-Muttalibi, 1988). The increase in hypocotyl or epicotyl length, as noted in deep seeding, will reduce the probability of the seedlings being capable of overcoming soil strength and render the seedlings more susceptible to attack by pathogens (Parker and Taylor, 1965). Corn Planting on 16 cm depth gave the highest values in grain number per ear, grain weight, grain yield as compared with 4, 8 and 12 cm planting depth (Al-Abodi and Shati, 2014). This study aims at finding the best distance between plants and the best depth of agriculture and the best combination between them which achieves the best growth and yield of maize plant.

Materials and Methods

A field experiment was carried out in the summer season 2017 within an agricultural field in the province of Diyala, Muqdadiya district, Abu Saida, 60 km northeast of the city of Ba'quba, to study the effect of distance between plants and the depth of planting on the growth of maize. A factorial experiment within split-plots was applied according to Randomized Complete Block design (RCBD) with three replications. The area of each experimental unit was (2×2) m^2. Four longitudinal lines were opened in each experimental unit and the distance between a line and another was 50 cm. Three seeds were placed in each hole and then diluted to one plant after germination. 1m distance was left between experimental units to avoid overlap. The study included two factors: the distance between plants which included 20, 25 and 30cm and occupied the main plots and the depth of planting which included three depths 5, 10 and 15cm and occupied the sub-plots. Urea and potassium were added in two batches, the first is after 21 days of germination and the second after 40 days of the first, each with 80 g/plot and 48 g/plot respectively. Calcium superphosphate was added with 160 g/plate at planting. The insect of the corn stalk *Sesamia cretica* was controlled using Diazinon granulator 10% by putting some granules on the developing top of the plant when it is in three to four-leaves stage.

The studied traits: They were calculated on the basis of individual plant as an average of 5 protected plants taken from the intermediate lines of each experimental unit.

Plant height (cm): The height of the plant was measured by a strip beginning from the soil surface to the top of the plant (Kirby and Atkins, 1968, Kambal and Webester, 1965 and House, 1985).

Stem diameter (cm): The circumference of the leg was measured from the center of the first salinity above the surface of the soil using the cloth-made measuring tape and the mathematical relationship between the circumference and the diameter was adopted to extract the diameter. circumference of the stem (cm) = diameter × 3.14 (Quinby, 1963).

The number of leaves (leaf Plant $^{-1}$): The leaves were calculated for each plant from the first green leaf close to the surface of the soil to the top of the plant with the calculation of the leaves that die at the base of the leg or that are buried because of field operations (Kambal and Webester, 1966).

Leaf area (dsm^2 plant^{-1}): (when flowering is complete) according to the equation: square length of leaf under the leaf of the ear × 0.75 if the number of leaves is more than 13 and the square length of leaf under the leaf of ear × 0.65 if the number of leaves is less than 13 (El-Sahookie, 1990).

Number of ears (ear Plant^{-1}): were collected from the plants of each experimental plot and calculated according to the following equation:

Number of ears per plant = Number of ears in each plot in each repeated / Number of plants in each plant in each repeated

Length of the ear (cm): the length of five ears from each experimental unit was calculated and divided on five.

Weight of the ears (gm): We weighed five ears in each experimental unit using the sensitive balance and the weight of each ear was calculated according to the following equation:

The weight of each ear = the weight of five ears for each experimental unit / 5

Components of the product

- **Number of rows per ear (row ear^{-1}):** the rows of the five previous ears were calculated.
- **The number of grains per row (grain row^{-1}):** the number of grains per row in the five previous ears were calculated.
- **Grain weight per ear(g):** The weight of the grains in five previous ears was calculated according to the following equation:

Weight of grains per ear = Weight of grains in five ears / Five ears

Weight of 300 grains (g): 300 grains were collected from each experimental unit and weighed by the sensitive balance.

Ankle weight (g): ankles of five ears from each experimental unit were weighed by using the sensitive balance.

Plant yield (g): the product of each plant in each experimental unit was calculated according to the following equation:

The product of one plant = Number of rows per ear × Number of grains per row × Weight of one grain.

Total yield (t ha^{-1}): was calculated by multiplying the average product of each plant by plant density (number of plants per hectare) according to the following equation:

Total yield (t ha^{-1})= average product per plant × plant density per hectare

Chlorophyll index (SPAD) in leaves: chlorophyll in leaves was measured after 80 days of planting using the manual digital measuring device SPAD-502 meter in the field directly (Felix *et al*., 2000).

Result and Discussion

It is noticed from table 1, that the treatment of the distance 25cm significantly exceeded in the average number of leaves, giving the highest average of 15.60 leaf Plants^{-1} as compared with the treatment of 30cm, which gave a lower average of 14.71 leaves with an increase reached 6.05%. No significant differences were found in the treatment of the distance 20cm in the average number of leaves, it gave an average reached 15.08 leaf plant^{-1} compared with the two treatments of 25cm and 30cm respectively. There were no significant differences in most vegetative indicators of plant height, stem diameter, leaf area and the number of ears in the plant in different distances. The positive effect of reducing the distance between plants in increasing the number of leaves may be due to the fact that the narrow distances give longer plants compared with those cultivated at large distances, this occurs due to increasing the competition between plants for sunlight, nutrients and water which causes an elongation in the cells and an increase in the flexibility of the cell walls and the number of leaves or it may be due to the intensity of the light, which is less in the case of high density of plants, which leads to a decrease in the Photo oxidation process of oxytin and thus increasing the level of oxyin in plant tissues, which increases the elongation of cells in the cultivated plants at close distances and as a result a rarity of the lateral growth (Mohammed and Elrais, 1982) or it may be due to the availability of moisture which allowed the plant to grow and benefit from it, which was positively reflected in plant growth and then increasing the number of leaves (Jallow *et al*., 2009). As for the effect of the depth of agriculture, the results showed no significant differences in most vegetative growth indicators of plant height, stem diameter, number of leaves, leaf area and number of ears per plant. The results showed that there were significant differences in the binary interaction between different distances and depths in the plant height since the binary interaction 30×5 cm gave the highest average of 283.73 cm compared with the binary interaction 20×5 cm, 20×10 cm and 30×15 cm, which gave less average reached 240.66, 245.20 and 260.26 cm with an increase reached 17.89%, 15.71% and 9.01%, respectively.

The results showed that there were no significant differences in the binary interaction between different distances and depths in the height of the plant, the binary interactions 20×15 cm, 25×5 cm, 25 × 10 cm, 25×15 cm and 30×10 cm gave an average reached 269.20, 278.13, 277.86, 271. 13 and 268.66 cm, respectively. While the results showed no significant differences in the binary interaction between different distances and depths of planting in all indicators of vegetative growth represented by the diameter of the stem, the number of leaves, leaf area and the number of ears in the plant. It is noted from table 2, that the distances 25 and 30 cm were significantly higher in the average weight of the ear, giving the highest average 223.78 and 209.70 g respectively, compared with the distance 20 cm, which gave the lowest average of 180.10 g, 24.25% and 16.43% respectively. This is explained by the fact that the decrease in the number of plants in the unit area led to a significant increase in most of the components of the crop, while the increase in the number of plants in the unit area led to increasing competition among them in access to their food, water

Table 1: Effect of distance between plants and the depth of agriculture and their overlap in the indicators of vegetative growth of maize plant.

Distance between plants (cm)	Depth of planting (cm)	Plant hight (cm)	Stem diameter (cm)	Number of leaves ($leaf.plant^{-1}$)	Area of leaves ($dsm^2\ plant^{-1}$)	Number of ears ($ear.plant^{-1}$)
20	5	240.66 b	2.26	15.33	43.91	1.04
	10	245.20 b	2.22	14.80	47.25	1.12
	15	269.20 ab	2.34	15.13	54.52	1.14
25	5	278.13 ab	2.33	15.93	53.92	1.20
	10	277.86 ab	2.39	15.40	52.16	1.26
	15	271.13 ab	2.40	15.46	47.98	1.26
30	5	283.73 a	2.28	14.86	55.41	1.41
	10	268.66 ab	2.22	14.66	54.07	1.38
	15	260.26 b	2.38	14.60	52.23	1.12
L.S.D. (0.05)		22.60	NS	NS	NS	NS
Average effect of distance between plants	20	251.68	2.27	15.08 ab	48.56	1.10
	25	275.70	2.37	15.60 a	51.35	1.24
	30	270.88	2.29	14.71 b	53.90	1.30
L.S.D. (0.05)		NS	NS	0.75	NS	NS
Average effect of planting depth	5	267.51 a	2.29	15.37	51.08	1.21
	10	263.90 a	2.28	14.95	51.16	1.25
	15	266.86 a	2.37	15.06	51.58	1.17
L.S.D. (0.01)		17.98	NS	NS	NS	NS

and light, resulting in a decrease in most components of the crop (Al-Hameed and Adra, 2011, Sharifi *et al*., 2009). This may also be due to the increase in the vegetative growth indices of plant height and number of leaves (Table 1), thus increasing the photosynthesis products that go to the new breeding sites, in the productive stage of the plant, including flowers, to increase the fertility rate, which is reflected in the weight of ear in the plant (Foyer and Paul, 2001). Table 2 shows no significant differences in the average length and weight of ears, the number of rows in ears, the number of grains per row and the weight of grains per ear at different planting depths. The binary interaction between different distances and depths of planting significantly affected the average length and weight of ears and weight of grains per ear, the binary interaction 20×15 cm, 25×10 cm, 25×15 cm and 30×5 cm, gave the highest average in the length of ear which reached 22.02, 20.85, 20.97 and 21.20 cm, respectively, compared with the treatment of 20×5 cm and 20×10 cm, which gave the lowest mean which was 16.69 and 18.06 cm, respectively, with an increase reached 31.93%, 39.36%, 24.92%, 15.44%, 25.58%, 16.05%, 27.02%, 17.38% and respectively. While there were no significant differences in the same attribute in the binary interaction 25×5 cm, 30×10 cm and 30×15 cm, which gave an average of 19.52, 19.78 and 19.86 cm, respectively. The binary interaction 30×5 cm also exceeded significantly in the weight of ear, giving the highest mean of 240.26 g compared with the binary interaction 30×15 cm, 20×5 cm and 20×10 cm, giving a lower average of 190.76, 135.51 and 169.27 g respectively. While the binary interaction 30×15 cm significantly exceeded in the same attribute, giving the highest average of 190.76 g compared with the interaction of 20×5 cm, which gave an average of 135.51 g, while there were no significant differences in the weight of ear in binary interaction 20×10 cm and 20×15 cm 25×5 cm, 25×10 cm, 25×15 cm and 30×10 cm, giving an average of 169.27, 235.53, 222.51, 222.54, 226.30 and 198.08 g, respectively.

The results showed that the interaction between 20×15 cm and 30×5 cm exceeded in the weight of ears which gave a highest mean reached 184.45 and 185.51 g in comparison with 30×15 cm, 20×10 cm and 20×5 cm which gave the lowest average 142.28, 131.10 and 101. 41 g, respectively. Also, the binary interaction 30×15 cm significantly exceeded in the weight of grains per ear, giving a higher average of 142.28 g compared with the binary interaction 20×5 cm which gave a lower average reached 101.41 g. Table 2, showed no significant differences in the weight of grains per ear in the interactions 20×10 cm, 25×5 cm, 25×10 cm, 25×15 cm and 30×10 cm, giving an average of 131.10, 167.35, 170.59, 157.83 and 150.66 g, respectively. This may be due to the separate effect of both distances and depths, which increased in overlapping. The results showed that there were no significant differences in the binary interaction

Table 2: Effect of distance between plants and the depth of agriculture and their overlap in some quantitative components of the yield of maize.

Distance between plants (cm)	Depth of Agriculture (cm)	Ear length (cm)	Ear weight (g)	Number of rows per ear (row.ear^{-1})	Number of grains per row (grain.row^{-1})	Weight of grains per ear (g)
20	5	16.69 b	135.51 c	14.57	30.26	101.41 c
	10	18.06 b	169.27 bc	15.58	34.12	131.10 bc
	15	22.02 a	235.53 ab	16.00	39.33	184.45 a
25	5	19.52 ab	222.51 ab	16.78	35.66	167.35 ab
	10	20.85 a	222.54 ab	16.61	39.61	170.59 ab
	15	20.97 a	226.30 ab	17.22	38.33	157.83 ab
30	5	21.20 a	240.26 a	16.40	34.40	185.51 a
	10	19.78 ab	198.08 ab	17.27	35.93	150.66 ab
	15	19.86 ab	190.76 b	15.66	35.53	142.28 b
L.S.D. (0.05)		2.65	46.47	NS	NS	39.78
Average effect of distance between plants	20	18.92	180.10 b	15.38	34.57	138.98
	25	20.44	223.78 a	16.87	37.86	165.25
	30	20.28	209.70 a	16.44	35.28	159.48
L.S.D. (0.05)		NS	26.83	NS	NS	NS
Average effect of depth of agriculutre	5	19.13	198.42	15.91	33.44	151.42
	10	19.56	196.63	16.48	36.55	150.78
	15	20.95	217.53	16.29	37.73	161.52
L.S.D. (0.05)		NS	NS	NS	NS	NS

between the different distances and planting depths in the average number of rows per ear and the number of grains per row.

It is noted from table 3, that the distances 25 and 30 cm significantly exceeded in ankle weight, they gave the highest average 54.8 and 50.17 g respectively, compared with the distance 20 cm which gave the lowest average 39.54 g with an increase reached 36.77% and 26.88% respectively. The treatments of the two distances 20 and 25 cm significantly exceeded in the total yield, they gave the highest average 17.71 and 17.17 tons respectively in comparison with the treatment of the distance 30 cm, which gave an average reached 13.54 tons, the ratio increased by 30.79% and 26.80, respectively. This increase may be due to the increase in the number of leaves and the exposure of most leaves to the light which helped to increase the process of photosynthesis in the plant and then convert the products to the orgasm sites in the grain (Table 1, Sharifi *et al*., 2009). It is also believed that the reason for increasing the weight of ankle is due to the increase in the average weight of the ear in the wide distance because of the lack of competition between the plants (Table 2). In addition, the grains are formed as a result of the induction process occurring in the leaves and the catalyst moves after a series of changes and specialties and an increase in the transfer of processed carbs, particularly starch from different parts of the plant to the grains (Mohammed and Elraiss, 1982). All of that led to increasing the total yield, as well as the addition of nitrogen and phosphate fertilizers during the implementation of the research led to a clear response to all the studied traits, as well as to the fact that increasing the distance of planting allows the roots to absorb nutrients and water more efficiently, which increased the efficiency of carbonation and reflected on the yield because of its efficiency in increasing the number of materials produced in the source and its transfer to the estuary (Cavero *et al*., 2000, Chapman and Edmeades, 1999). Table 3 also shows that there were no significant differences in the average weight of 300 grains and the single plant yield and the chlorophyll index in the leaves at the different planting distances. Moreover, table 3 showed no significant differences in the average weight of 300 grains, the ankle weight, the yield of a single plant, the total yield and the chlorophyll index in the leaves in the different planting depths. The binary interaction between the distances and the different depths of planting significantly affected the average weight of 300 grains, the ankle weight, single plant yield and the total yield. The binary interaction 30×5 cm gave the highest mean in the weight of 300 grains which was 114.84 g, compared with the treatment of the binary interactions 20×5 cm, 20×10 cm, 25×10 cm, 25×15 cm, 30×10 cm and 30×15 cm, which gave the lowest average of 94.42, 94.27, 98.24, 101.09, 91.43 and 91.28

Table 3: Effect of distance between plants and the depth of agriculture and the overlap between them in some components of the yield of maize.

Distance between plants (cm)	Depth of Agriculture (cm)	Weight of 300 grains (cm)	Weight of ankle (g)	Yield of one plant (g)	Total yield (ton.ha^{-1})	Chlorophyll index in leavs (SPAD unit)
20	5	16.69 b	135.51 c	14.57	30.26	101.41 c
	10	18.06 b	169.27 bc	15.58	34.12	131.10 bc
	15	22.02 a	235.53 ab	16.00	39.33	184.45 a
25	5	19.52 ab	222.51 ab	16.78	35.66	167.35 ab
	10	20.85 a	222.54 ab	16.61	39.61	170.59 ab
	15	20.97 a	226.30 ab	17.22	38.33	157.83 ab
30	5	21.20 a	240.26 a	16.40	34.40	185.51 a
	10	19.78 ab	198.08 ab	17.27	35.93	150.66 ab
	15	19.86 ab	190.76 b	15.66	35.53	142.28 b
L.S.D. (0.01)		2.65	46.47	NS	NS	39.78
Average effect of distance between plants	20	18.92	180.10 b	15.38	34.57	138.98
	25	20.44	223.78 a	16.87	37.86	165.25
	30	20.28	209.70 a	16.44	35.28	159.48
L.S.D. (0.01)		NS	26.83	NS	NS	NS
Average effect of depth of agriculutre	5	19.13	198.42	15.91	33.44	151.42
	10	19.56	196.63	16.48	36.55	150.78
	15	20.95	217.53	16.29	37.73	161.52
L.S.D.		NS	NS	NS	NS	NS

g, respectively.

While there were no significant differences in the binary interference of the same trait in the binary interactions 20×15 cm and 25×5 cm giving an average of 107.62 and 102.74 g respectively. The results showed that the interactions 20×15 cm, 25×5 cm, 25×10 cm, 25×15 cm and 30×5 cm exceeded in the ankle weight, giving the highest average 50.25, 54.58, 51.28, 56.38 and 53.81 g, respectively, compared with the treatments of 20×5 cm and 20×10 cm, which gave the lowest average of 33.59 and 34.80 g, respectively. While there were no significant differences in the binary interactions 30×10 cm and 30×15 cm of the same trait which gave an average of 48.96 and 47.74 g, respectively. While the results showed the superiority of the binary interaction 30×5 cm in the characteristics of the total yield, giving the highest average of 251.07 g, compared with the interaction 20×5 cm and 20×10 cm and 30×15 cm, which gave the lowest average 137.56, 167.37 and 169.54 g respectively. While there were no significant differences for the same attribute in the interactions 20×15 cm, 25×5 cm, 25×10 cm, 25×15 cm and 30×10 cm, giving an average reached 226.53, 204.36, 216.99, 222.86 and 189.06 g respectively. The results showed that the binary interactions 20×15 cm superimposed in the total yield, giving the highest average of 22.65 t ha^{-1}, compared with the binary interactions 20×5 cm, 25×5 cm, 30×10 cm and 30×15 cm, which gave the lowest average 13.75, 16.34, 12.60 and 11.30 t ha^{-1}, respectively. While there were no significant differences, for the same attribute, in the binary interactions 20×10 cm, 25×10 cm, 25×15 cm and 30×5 cm, they gave an average reached 16.73, 17.35, 17.82 and 16.73 t ha^{-1}. The results showed no differences in the binary interference between the distances and the different depths of planting in the average of chlorophyll index in the leaf.

References

Al-Abodi, H.M. and R.K. Shati (2014). Response of Maize to Duration of Irrigation, Depth and Method of Planting. *The Iraqi J. of Agr. Sci.,* **45(7):** 672-684.

Al-Muttalibi, S.M. and M.M. Elsahookie (1989). Impact of irrigation interval and planting depth on growth and yield of maize IV. Yield of plant, field Efficiency and water use efficiency. *The Iraqi J. of Agric. Sci*., **20 (1):** 279-310.

Al-Sahuki, M.M. (1990). Maize production and improvement. Ministry of Higher Education and Scientific Research - University of Baghdad. (*in Arabic*)

Al-Younis, A.A., M.A. Mohamed and Z. Abdel-Yass (1987). Cereal crops. Ministry of Higher Education and Scientific Research - University of MosuL. College of Agriculture. (*in Arabic*)

Al-Younis, A.A. (1993). Production and Improvement of Field Crops. Ministry of Higher Education PO Box 469. (*in Arabic*)

Cavero, J. I., I. Farre, P. Debaek and J.M. Faci (2000). Simulation of maize yield under stress with the epic phase and crop wat Models. *Agron. J.*, **92:** 679-690.

Chapman, S.C. and G.O. Edmeades (1999). Selection improves drought tolerance in tropical maize population. *Crop. Sci.*, **39:** 1315-1324.

Felix, L., J. Grabosky and N. Bassuk (2000). Use of the Minolta SPAD-502 to determine chlorophyll concentration in *Ficus benjamina* L. and Populus deltoids Marsh leaf tissue. *Hort Sci.*, **35(3):** 423-424.

Hamid, E.A. and L. Adra (2011). Effect of plant density and nitrogen fertilization on some yellow maize growth indicators (Basel II hybrid) and its productivity. *Journal of Damascus University for Agricultural Sciences.*, **27 (1):** 65 -81. (*in Arabic*)

House, L.R. (1985). A Guid to Sorghum Breeding. 2nd ed. International Crop Research Institute for the Semi-Arid Tropics. ICRISAT. Patancheru. P.O. Andhra Pradesh, 502324, India.

Jallow, R.A., A.T. Fissah, R.Z. Al-Beiruty and S.H. Shakir (2009). Effect of seed size and depth of planting on field germination percentage and its relation to maize grain yield and components of maize. *Iraqi J. Agric.,* (Special Issue). **14(7):** 25-36.

Kambal, A.E. and O.J. Webester (1965). Estimates of general and specific combining ability in grain sorghum. *Crop. Sci.,* **5:** 521-53.

Kambal, A.E. and O.J. Webster (1966). Manifestation of hybrid vigor in grain sorghum and the relation among the components of yield, weight per bushel and height. *Crop. Sci.*, **6:** 513-515.

Kirby, J.C. and R.E. Atkins (1968). Heterotic response for vegetative and mature plant characters in grain sorghum, (*Sorghum bicolor* L). Moench. *Crop. Sci.,* **8:** 335-339.

Mohammed, A.A.K. and A. Al-Rayes (1982). Plant Physiology, Part II, France. (*in Arabic*)

Parker, J.J. and H.M. Taylor (1965). Soil Strength and Seedling Emergence Relation. 1. Soil Type, Moisture Tension and Planting Depth Effect. *Agr. J.*, **57:** 289-291.

Paul, M.J. and C.H. Foyer (2001). Sink regulation of photosynthesis. *J. Expt. Bot.*, **52:** 1383-1400.

Quinby, J.R. (1963). Manifestation of hybrid vigor in sorghum. *Crop. Sci.*, **3:** 288-291.

Sharifi, R.S., M. Sedghi and A. Gholipouri (2009). Effect of population density on yield and yield attributes of maize hybrids, *Research J. of Bio. Sci.,* **4(4):** 375-379.

Singh, R.P. and R.K. Singh (2006). Ecological approaches in weed management National Symposium on Conservation and Envi. October 26-28, 2006, 301-305.

Shuwailiya, A.H. and A. Al-Jubouri (1986). Production of Cereals and Legumes. Ministry of Higher Education and Scientific Research. Dar El Tkany For Printing and Publishing. (*in Arabic*)

Widdicombe, W.D. and K.D. Thelen (2002). Row Width and Plant Density Effects on Corn Grain Production in the Northern Corn Belt, *Agron. J.*, **94:** 1020-1023.