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# EFFECT OF ASCORBIC ACID CONCENTRATION AND HARVESTING DATE ON GROWTH AND YIELD OF THREE CORN VARIETIES (*ZEA MAYS* L.)

**Labed Shareef Mohammed, Kotada Ibrahim Abdulla and Ather Saber Mustafa**
Department of Field Crops, College of Agriculture, University of Tikrit, Iraq

## Abstract

The experiment was conducted at the Field Crops Research Station / Collage of Agriculture / Tikrit University in the fall season 2017 to study the effect of ascorbic acid concentrations and the harvesting date on the growth and yield of corn. The experiment was performed using the factorial experiment with two factors: 3 varieties (Sarah, Fajir and Baghdad) × 3 concentrations of ascorbic acid (0, 100, and 200 mg/$L^{-1}$). The treatments were distributed according to the RCBD to study the growth traits, and using splintered splint plots system with RCBD, after addition of the harvesting date ( 30, 40 and 50 days after pollination ) as a third factor to study the yield and its components. The results showed an increase in the treatment of the addition of 200 mg. $L^{-1}$ in all the traits (plant height, leaf area, and yield and its components). The superiority of variety (Sarah) was in the trait of plant height (227.66 cm), and superiority of variety (Baghdad) was in the number of grain.spike$^{-1}$ (35.08) and the weight of 300 grains (72.85 g). The harvest date after 50 days of pollination was significantly higher in both traits, weight 300 grains (73.41 g) and grain yield (7298.15 kg).

***Keywords***: Corn, Ascorbic acid, Harvesting date

## Introduction

Corn crop (*Zea mays* L.) is one of the most important crops in the world and Iraq for its importance in the nutrition of human in direct use or in terms of its entry into many food products. It is also used to feed animals for entry into the main components of poultry or livestock concentrates due to the high nutritional value attributed to the high content of carbohydrates, proteins and sugars (Bukhsh *et al*., 2010) . The importance of corn has been increased for use in biofuel production, as it is an important source of this fuel, raising its economic value in the world (Kim and Dale, 2004). Although the importance of this crop in Iraq, but it is suffering from the decline of cultivated areas, which was estimated according to the statistics of the Food and Agriculture Organization (FAO) by 76000 hectares in 2016, down to 50% of the cultivated area of ten years ago (FAO, 2018). As well as the decline in the productivity of this crop is an important factor in the decline of cultivation of this crop and low productivity. The cultivation of gypsum soils, which have an area in Iraq to more than 8 million hectares, led to the exit of large areas of cultivated land out of planting especially in this crop because of its low productivity due to the weakness of their building , the low ability to retain water, and the low content of organic matter and nutrients (Khairo, 2016). Therefore, it is useful to use stimulants for plant growth, which complement fertilizers added to the soil to improve the ability of the plant to build the root and shoot systems and raise levels of absorption and utilization of nutrients from the soil, which is positively reflected on vegetative growth and vital events and yield. Vitamins, amino acids and growth regulators come in the forefront of these stimulants, especially ascorbic acid (Vitamin C), which can be used in solutions to soak seeds to improve germination and growth of seedlings. Also, it used to add spray on the shoot system as it works to develop the root and shoot systems and stimulate the work of many enzymes. As well as it helps in building proteins, and its antioxidant role and detoxification of plants caused by environmental stresses, especially drought and lack of moisture, which can occur in gypsum soils for poor water retention. It also works to protect chlorophyll and raise the levels of photosynthesis (Smirnoff and Wheeler 2000 and Sinha, 2003). One of the important factors for corn production is the cultivation of genotypes suitable for the environment, especially localized genotypes, to adapt them to the prevailing conditions in the environment, so it is useful to evaluate them under gypsum soil conditions and under the influence of spraying with ascorbic acid to increase their productivity. The date of harvest for these structures is also a specific factor of productivity because it may cause reduction of productivity, whether at the early harvest due to incomplete fullness and high humidity or delay, which may result in loss of dry matter or quality effect (Nally *et al.*, 2016).

Therefore, this research aims to study the response of local genotypes of corn to cultivate in gypsum soils under the influence of spraying with different concentrations of ascorbic acid and the effect of the date of early and late harvest.

## Materials and Methods

An experiment was conducted at the College of Agriculture-University of Tikrit during the autumn season 2017 in gypsum soil with 21% gypsum (210 mg. $kg^{-1}$). The experiment was carried out with RCBD design in a factorial experiment of two factors. The first was cultivars which included three cultivars approved in local agriculture (Baghdad, Fajir, and Sarah. The second factor included three concentrations of ascorbic acid (0, 100, and 200 mg.$L^{-1}$) to study the traits of plant height, ear height, and leaf area. The same design was used for three factors after the introduction of the harvest date factor, which included harvest after 30, 40, and 50 days after the pollination, to study the traits of the yield and its components under the influence of the three factors and interventions.

The planting date was on 15/7/2017 in 6 lines for each treatment with a length of 5 m, 75 cm apart and 25 cm among plants. Phosphate fertilizer (Super Calcium Phosphate) (120 kg.$h^{-1}$) was added at the planting date with the addition of Nitrogen fertilizer (urea 46% N) in (160 kgN.$h^{-1}$) in three batches: The first was in the planting, the second and the third were at the stage of 6 leaves and when flowering in equal quantities. Then spray the ascorbic acid at the stage of

4 leaves with the spray of distilled water with the comparison treatment, with addition of a diffractive material to reduce the surface tension and to facilitate the penetration and spread of the acid solution into the plant tissue.

When the emergence of male and female floral inflorescences and then put paper bags on them when they appeared in 30 plants per treatment, they were pollinated simultaneously. The data of pollination and harvesting were recorded in each treatment after 30, 40, and 50 days after pollination from 10 plants. The traits of plant height, ear height, and leaf area were calculated according to the equation:

Leaf area ($cm^2$) = (length of leaf under the ear leaf)$^2$ × 0.75 (El-Sahookie, 1985)

As well as studying the traits of the yield and its components (number of rows. ear$^{-1}$, number grains. row$^{-1}$ and weight of a 300 grains (gm). The data were analyzed using (SAS) software and the Duncan Multidimensional Test was used to test the significant at (0.05) probability.

## Results and Discussion

Table (1) shows the sources of variation and the mean squares of the study factors in the studied traits that the cultivars significantly affected the plant height, but on significant effect on both leaf area and ear height was found. Ascorbic acid had a significant effect in both leaf area and plant height and did not significantly affect the ear height. Interaction between the cultivars and the concentration of ascorbic acid was not significant in the traits of this study.

**Table 1 :** Analysis of variance of leave area , plant high and ear high characters

| Ear high | Plant high | Leave area | d.f | Source of variance |
|---|---|---|---|---|
| 137.98 | 20.7 | 2438361.5 | 2 | Replication |
| 95.57$^{n.s}$ | 553.2$^{**}$ | 276902.8$^{n.s}$ | 2 | Varieties |
| 319.56$^{n.s}$ | 563.05$^{**}$ | 1170728.5$^{**}$ | 2 | Ascorbic level |
| 219.59$^{n.s}$ | 8.14$^{n.s}$ | 34787.9$^{n.s}$ | 4 | Varieties x Ascorbic |
| 103.03 | 55.00 | 91946.8 | 16 | Error |
| | | | 26 | Total |

The addition of ascorbic acid spraying on corn plants resulted in a significant and continuous increase in leaf area by increasing the concentration of ascorbic acid in the solution and with a significant increase in each addition of acid (6209.3, 6501.3, and 6926.2 $cm^2$) for the treatments (0, 100, and 200 mg.L$^{-1}$) respectively (Table 2) with an increase of 4.7% and 11.5% for acid treatment compared with control treatment. This encouraging of chlorophyll and protein building and thus increase the rates of photosynthesis is important in food processing in plants, which is necessary to expand the leaves requirement because of the increased rates of division and elongation caused by ascorbic acid, which results in increased growth of leaves longitudinal and transverse. These results found by (Darvishan *et al*., 2013 and Ali *et al*., 2015).

The Duncan test for the non-significant interaction of ascorbic acid concentration showed that its highest value was in the interaction between Baghdad variety and the added level of 200 mg. L$^{-1}$ (7125.7 $cm^2$).

**Table 2 :** Means of leaf area ($cm^2$) for three varieties of corn with the effect of spraying levels of ascorbic acid:

| Cultivars mean | Levels of ascorbic acid mg / L $^{-1}$ | | | Cultivar |
|---|---|---|---|---|
| | 200 | 100 | 0 | |
| 6430.0a | 6720.0a-d | 6376.0b-e | 6194.0d-e | Sarah |
| 6459.7a | 6934.0ab | 6341.7cde | 6103.3e | Fajir |
| 6747.6a | 7125.7a | 6786.3abc | 6330.7cde | Baghdad |
| | 6926.2a | 6501.3 b | 6209.36b | Ascorbic mean |

The increase in leaf area by increasing the concentration of ascorbic acid is associated with the increase in plant height by increasing the levels of ascorbic acid. The increase in leaf area and the resulting increase in photosynthesis, food processing, and division and elongation resulted in increased plant height, which increased with acid concentration (215.24 , 221.25 and 230.92 cm) for the treatments of (0, 100 and 200) mg. L$^{-1}$. The increasing of plant high may save more time to increase leaf area more than the comparison plants with the increasing of acid addition from 0 to 100 and then to 200 mg. L$^{-1}$. The effect of ascorbic acid was found by (Atta-Ullah, 2016 and Shahnawas *et al*., 2017).

Baghdad variety superior in plant height and that this superiority is due to genetic variation between the varieties and the extent of their response to Ascorbic acid and the conditions of planting in gypsum soils. The differences in plant height among varieties found by (Aslam *et al*., 2013).

**Table 3:** Means of Plant high (cm) for three varieties of corn with the effect of spraying levels of ascorbic acid:

| Varieties mean | Ascorbic concentration mg.L$^{-1}$ | | | Varieties |
|---|---|---|---|---|
| | 200 | 100 | 0 | |
| 227.66a | 236.56a | 227.23ab | 219.20bc | Sarah |
| 213.45b | 221.03bc | 210.93c | 208.40c | Fajir |
| 226.38a | 235.16a | 225.60ab | 218.13bc | Baghdad |
| | 230.92a | 221.25b | 215.24b | Ascorbic mean |

The studied varieties, concentration of ascorbic acid and their interaction did not affected significantly in the ear height and the number of rows. ear$^{-1}$ (Table 4, 5, 6).

**Table 4:** Means of ear high (cm) for three varieties of corn with the effect of spraying levels of ascorbic acid:

| Varieties mean | Ascorbic concentration mg.L$^{-1}$ | | | Variety |
|---|---|---|---|---|
| | 200 | 100 | 0 | |
| 91.97a | 99.7ab | 90.63b | 85.54b | Sarah |
| 93.36a | 90.35b | 94.14b | 95.61b | Fajir |
| 98.8a | 114.08a | 88.08b | 92.41b | Baghdad |
| | 101.39a | 90.95a | 91.18a | Ascorbic mean |

Table (5) show the analysis of variance, degree of freedom and mean square of statistical analysis of data grain yield and its components.

**Table 5 :** Analysis of variance of grain yield and its component characters.

| Grain yield | 300 grain weight | No. grain row$^{-1}$ | No. row.ear$^{-1}$ | d.f | Source of variance |
|---|---|---|---|---|---|
| 3.640 | 3.640 | 20.734 | 4.9267 | 2 | Replication |
| 37.48$^{ns}$ | 37.48$^{ns}$ | 12.618 $^{*}$ | 0.0445$^{ns}$ | 2 | Varieties |
| 3.75 | 3.74 | 2.308 | 1.2545 | 4 | Error(A) |
| 135.61* | 135.60** | 31.224* | 0.2060$^{ns}$ | 2 | Concentration |
| 1.678$^{ns}$ | 1.678$^{ns}$ | 1.569$^{ns}$ | 0.1377$^{ns}$ | 4 | Varieties x Concentration |
| 1.452 | 1.452 | 7.468 | 1.3218 | 12 | Error(B) |
| 114.52** | 114.516** | 7.516$^{ns}$ | 0.2316$^{ns}$ | 2 | Harvest date |
| 6.83$^{ns}$ | 6.834$^{ns}$ | 1.622$^{ns}$ | 0.2788$^{ns}$ | 4 | Varieties x Date Harvest |
| 1.192$^{ns}$ | 1.192$^{ns}$ | 0.818$^{ns}$ | 0.0392$^{ns}$ | 4 | Concentration x harvest date |
| 2.948$^{ns}$ | 2.948$^{ns}$ | 0.528$^{ns}$ | 0.2555$^{ns}$ | 8 | Varieties x Concentration x Harvest date |
| 5.92 | 5.927 | 5.873 | 1.6298 | 36 | Error (C ) |
| | | | | 80 | Total |

The increased concentration of ascorbic acid spray on corn plants has increased the number of grains. row$^{-1}$ to 35.53 and a 9.4% increase compared to the comparison treatment that produced 33.42 grain. Note that the factors 100 and 200 mg.L$^{-1}$ did not differ significantly from each other. This superiority may be due to the role of ascorbic acid as a activator vitamin of the processes, which led to the superiority of this treatment in plant height and leaf area (Tables 2 and 3), resulting in increased performance of flowers in the rows of ear formed, as well as the role of acid in increasing the pollination of flowers and thus increase the number of grains. row$^{-1}$. Dolatabadion *et al*. (2010) and Abdel-Adheem (2017) were found exceeded the effect of ascorbic acid up to 200 mg.L, in increasing the number of grains. row$^{-1}$ due to the activation of this acid for vital processes and its role in promoting the formation of flowers and pollination in the ear rows.

The Baghdad variety was superior to the number of grains.row$^{-1}$ (35.08), which was not significantly different from variety Sarah (34.27) grain.row$^{-1}$ (Table 7). This is due to variation in the genotype and the extent to which these varieties respond to the experimental factors (ascorbic acid and date of harvest). The date of harvest did not significantly affect this character, because the ears, seeds, and rows were completed and the date of harvest was not affected.

**Table 6:** Means of No. rows.ear$^{-1}$ for three varieties of corn with the effect of spraying levels of ascorbic acid.

| Varieties x Harvest date | Harvest date (day after pollination) | Ascorbic concentration mg.L$^{-1}$ | | | Varieties |
|---|---|---|---|---|---|
| | | 200 | 100 | 0 | |
| 15.59a | 30 | 16.07a | 15.50a | 15.20a | Sarah |
| 15.51a | 40 | 15.57a | 15.53a | 15.43a | |
| 15.13a | 50 | 15.03a | 15.30a | 15.07a | |
| 15.64a | 30 | 15.73a | 15.63a | 15.57a | Fajir |
| 15.35a | 40 | 15.33a | 15.53a | 15.200a | |
| 15.11a | 50 | 15.20a | 15.40a | 15.63a | |
| 15.41a | 30 | 15.36a | 15.40a | 15.46a | Baghdad |
| 15.51a | 40 | 15.63a | 15.26a | 15.63a | |
| 15.54a | 50 | 16.00a | 15.46a | 115.16a | |
| Mean of harvest date | | | | | |
| 15.55a | 30 | 15.72a | 15.51a | 15.41a | Ascorbic x Harvest date |
| 15.46a | 40 | 15.51a | 15.44a | 15.42a | |
| 15.36a | 50 | 15.41a | 15.39a | 15.29a | |
| Mean of varieties | | | | | |
| 15.41a | Sarah | 15.55a | 15.44a | 15.23a | Ascorbic x Varieties |
| 15.47a | Fajir | 15.42a | 15.52a | 15.47a | |
| 15.49a | Baghdad | 15.67a | 15.38a | 15.42a | |
| | | 15.54a | 15.44a | 15.37a | Concentration mean |

The two-way interaction of the experimental factors was not significant as well as the three-way interaction. However, the Duncan test for the interaction between the concentration of ascorbic acid and the harvest date indicates that the interaction between the harvest date after 50 days after the pollination and the concentration 200 mg . $L^{-1}$ of ascorbic acid produced the highest number of grains (35.89 grains. $row^{-1}$) (Table 7).

The role of ascorbic acid in the activation of biological processes, especially the division, elongation, photosynthesis, and its reflection in the increase of plant height and leaf area was positively reflected in the increase of vegetative system and thus increase the rates of photosynthesis and activate the transfer of dry matter accumulated in the vegetative part to the seeds in ears (Abrahamian and Kantharajah, 2011). Therefore, the use of ascorbic acid led to a significant increase in the weight of 300 grains. The plants treated with a concentration of 200 mg. $L^{-1}$ were recorded (73.59 g) superior to the treatments (0, 100 mg . $L^{-1}$). This is consistent with what Sary *et al*. (2006) found in which he mentioned increasing the weight of the grain by increasing the concentration of ascorbic acid.

**Table 7:** Means of No. grains $row^{-1}$ for three varieties of corn with the effect of spraying levels of ascorbic acid.

| Varieties x Harvest date | | Harvest date( day after pollination) | Ascorbic concentration mg.$L^{-1}$ | | | Varieties |
|---|---|---|---|---|---|---|
| | | | 200 | 100 | 0 | |
| 33.50a | | 30 | 35.07a | 33.37a | 32.07a | Sarah |
| 34.43a | | 40 | 35.73a | 34.40a | 33.17a | |
| 34.87a | | 50 | 35.80a | 35.30a | 33.53a | |
| 33.46a | | 30 | 34.57a | 33.37a | 32.47a | Fajir |
| 34.25a | | 40 | 35.63a | 33.07a | 34.07a | |
| 33.43a | | 50 | 35.23a | 33.13a | 31.93a | |
| 36.27a | 30 | 35.03a | 34.20a | 33.60a | Baghdad | |
| 35.41a | 40 | 36.10a | 34.96a | 35.17a | | |
| 35.54a | 50 | 36.63a | 35.17a | 34.83a | | |
| Mean of harvest date | | | | | | |
| 33.74a | 30 | 34.89ab | 33.64ab | 32.71b | Ascorbic x Harvest date | |
| 34.70a | 40 | 35.82a | 34.14ab | 34.13ab | | |
| 34.62a | 50 | 35.89a | 34.53ab | 33.43ab | | |
| Mean of varieties | | | | | | |
| 34.27b | Sarah | 35.53a | 34.35a | 32.92a | Ascorbic x Varieties | |
| 33.71b | Fajir | 35.14a | 33.19a | 32.82a | | |
| 35.08a | Baghdad | 35.92a | 34.78a | 34.53a | | |
| | | 35.53a | 34.10ab | 33.42a | Concentration mean | |

Harvest date has a significant effect, and the early harvest after 30 days of pollination led to the incomplete accumulation of dry matter and low grain weight. This treatment gave the lowest weight of 300 grains (69.45 g). The delay of the harvest date beyond 50 days after the pollination caused the increase in the weight of the grain to complete the accumulation and transport of dry matter in the grain and gave the highest value reached (73.41 g) (Table 8). The early date of harvest causes high grain humidity and low dry weight, thus reducing the weight of 300 grains (Siddique and Wright, 2013). The three varieties differed in the weight of 300 grains and the superiority of variety Baghdad at a value of 72.85 g, which did not differ significantly from the variety Sarah. This variation is due to the difference among these varieties in their characteristics associated with their genotypes.

**Table 8:** Means of 300 grain weight (gm) for three varieties of corn with the effect of spraying levels of ascorbic acid.

| Varieties x Harvest date | Harvest date (day after pollination) | Ascorbic concentration mg.$L^{-1}$ | | | Varieties |
|---|---|---|---|---|---|
| | | 200 | 100 | 0 | |
| 68.80c | 30 | 72.23a-i | 67.87i-k | 66.300jk | Sarah |
| 72.78ab | 40 | 73.77a-f | 73.13a-g | 71.43a-i | |
| 74.24a | 50 | 75.23ab | 75.50a | 72.00a-i | |
| 67.95c | 30 | 69.40e-k | 68.77g-k | 65.70k | Fajir |
| 71.42b | 40 | 73.63a-f | 72.43a-i | 68.200h-k | |
| 72.15ab | 50 | 73.77a-f | 72.77a-h | 69.93d-k | |
| 71.61b | 30 | 73.26a-g | 72.60a-i | 68.96f-k | Baghdad |
| 73.11ab | 40 | 74.70a-e | 74.00a-e | 70.63b-j | |
| 73.82ab | 50 | 76.27a | 75.00abc | 70.20c-k | |
| Mean of harvest date | | | | | |
| 69.45b | 30 | 71.63bc | 69.74c | 66.99d | Ascorbic x Harvest date |
| 72.44a | 40 | 74.03ab | 73.19ab | 70.09c | |
| 73.41a | 50 | 75.09a | 74.42a | 70.71c | |
| Mean of varieties | | | | | |
| 71.94b | Sarah | 73.74a | 72.17b | 69.91c | Ascorbic x Varieties |
| 70.51b | Fajir | 72.26b | 71.32b | 67.94d | |
| 72.85a | Baghdad | 74.74a | 73.86a | 69.93c | |
| | | 73.59a | 72.45.b | 69.26c | Concentration mean |

This is consistent with what was found by Abdel-Adheem (2017) of the difference in the weight structures under study in this trait under the influence of the concentration of ascorbic acid. The Two-way and Three-way interactions were not significant in this trait. The non-significance of the F values in these interactions and the variance of the Duncan test for the treatments among the means showed that the interactions of variety Baghdad × Harvest date (50 days), harvest date (50 days) × concentration 200 mg.$L^{-1}$, and variety Baghdad × concentration 200 mg.$L^{-1}$ gave the highest values in this trait (73.82, 75.09 and 74.74 g) respectively (Table 8).

The effect of the two spray treatments 100 and 200 mg. $L^{-1}$ did not differ on each other in the grain yield. The treatment of spraying 200 mg. $L^{-1}$ in this trait exceeded the treatment of non-spraying with a significant superiority (7.092 ton.$h^{-1}$) (Table 9). The superiority of spraying treatment of 200 mg. $L^{-1}$ in grain yield is due to the spraying of this concentration caused the superiority of the plants of this treatment significantly higher in the traits of growth and yield components result of the increase in the rates of photosynthesis, division and elongation, the collection and transfer of stored materials to seeds, and increase the number of grains (Darvishan, 2013). The varieties did not differ significantly in this trait, While the early harvesting caused a significant reduction in the yield. Harvesting treatments after 40 and 50 days after pollination exceeded the early treatment (30 days after harvest) with values of (6.536 , 7.148 and 7.292 ton.$h^{1}$) for the three treatments respectively (Table 7).

**Table 9:** Means of grain yield (ton.$h^{-1}$) for three varieties of corn with the effect of spraying levels of ascorbic acid.

| Varieties x Harvest date | Harvest date (day after pollination) | Ascorbic concentration mg.$L^{-1}$ | | | Varieties |
|---|---|---|---|---|---|
| | | 200 | 100 | 0 | |
| 6.590 b | 30 | 6.594 c-f | 6585.0cdef | 6.592 c-f | Sarah |
| 7.165 a | 40 | 7.249 abc | 7.205 a-d | 7.041 a-d | |
| 7.378a | 50 | 7.454a | 7.381 a | 7.299 ab | |
| 6.502b | 30 | 6.600 c-f | 6.554def | 6.352 ef | Fajir |
| 7.106a | 40 | 7.219 a-d | 7.144 a-d | 6.956a-e | |
| 7.214a | 50 | 7.362 a | 7.225 a-d | 7.055 a-d | |
| 6.517 b | 30 | 6.629b-f | 6.643 b-f | 6.280 f | Baghdad |
| 7.173 a | 40 | 7.289 ab | 7.211a-d | 7.019 a -d | |
| 7.302a | 50 | 7.436a | 7.285 ab | 7.184 a-d | |
| Mean of harvest date | | | | | |
| 6.536 b | 30 | 6.607c | 6.594 c | 6.408 c | Ascorbic x Harvest date |
| 7.148a | 40 | 7.252ab | 7.187ab | 7.005 b | |
| 7.292a | 50 | 7.417 a | 7.297ab | 7.179ab | |
| Mean of varieties | | | | | |
| 7.194 a | Sarah | 7.099a | 7.057ab | 6.977ab | Ascorbic x Varieties |
| 6.941 a | Fajir | 7.060ab | 6.974ab | 6.787b | |
| 6.997a | Baghdad | 7.118a | 7.046ab | 6.827ab | |
| | | 7.092a | 7.026b | 6.864c | Concentration mean |

These results on the effect of the harvest date in the yield were found by Vera (2004). This decrease in grain yield in early treatment resulted from low weight of seeds, which is due to the main reason for the decline in grain yield in contrast to the other two treatments, which increased the accumulation of dry matter and increased grains weight in the ear and thus increase in grain.

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