# Effect of Plant Density and Spraying with Ethephon on Yield and its Components of Sorghum (Var. Bohooth .70)

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## Abstract

A field experiment was carried out during the spring and autumn season 2021 in Al-Kut region - Wasit Governorate, to study the effect of plant densities and ethephon spraying on the yield and yield component of Sorghum (var. Bohooth 70). The experiment was applied according to a randomized complete block design (RCBD) in a split split plots design with three replications. The main plots included three plant densities (80000, 66666 and 50000 plants.ha$^{-1}$), while the sub plots included three stages of ethephon spraying (4, 8 and 12 leaf per plant). Sub-sub plots included three concentrations of ethephon (0, 800, 1600 ppm). The results showed that the lower plant density (50,000 plants.ha$^{-1}$) led to a significant decrease in plant height and the rate of lying, and a significant increase in yield per plant, weight of 1000 grains, and number of grains per head. Spraying ethephon increased the yield per plant, weight of 1000 grains, number of grains per head and yield of grain (t.ha$^{-1}$). On the other hand, there was a significant relationship between the concentration of ethephon and the decrease by plant height and the rate of lying when sprayed at the stage of 4 and 8 leaves. It can be concluded from this study that plant height and lying ratio can be reduced when using low density with ethephon spray during early growth stages for economical grain production..

Keywords: sorghum ,plant density, ethephon. Part of Ph.D. Dissertation of the 1st author.

## 1.Introduction:

Sorghum is one of the most important cereal crops in the world, capable of growing in different environments due to its physiological and morphological characteristics. This crop gives abundant yields in tropical and semi-arid regions [22 and 24]. It is a staple food for people in Asia and Africa and the fifth most important grain crop after wheat, barley, rice and maize [2, 9 and 20]. It is used to feed animals in addition to its use as green fodder or silage. As a result of the scarcity of green forage in Iraq during the summer season, a new variety, Bohooth .70, was registered and approved as the best green forage[23]. However, this variety suffers from the problem of lying due to its height, which may reach more than three meters, which leads to a loss in grain yield. Plant density is one of the most important agricultural practices determining of grain yield, as well as other important agronomic traits. The application of the optimum plant density of the crop results in the optimal use of water, nutrients and, as a result, achieving the best yield, while high densities are associated with increased plant dormancy and deterioration in production [25]. Ethephon (2-chloroethyl phosphonic acid) is one of the plant growth regulators that works to shorten plants by acting as an anti-gibberellin, and breaking the apical dominance imposed by gibberellins and auxins without affecting the lateral meristems. It also plays a role in inhibiting cell division and elongation[8]. When spraying the plant, ethylene is released in the plant parts, which determines the development of the vegetative part, depending on the type of plant, the concentration used and the time of application plants and increase the diameter of the stem. Certain concentrations can improve growth characteristics and regulate plant height, and then increase processed nutrients and their transfer from the source (leaf) to the downstream (seed) to improve the characteristics of the crop and its components[4 and 19].The study aimed at attempting to redistribute the dry matter in favor of plant grains by shortening the plant height, and controlling the vegetative growth of white corn (var. Bohooth .70) by using plant densities and growth inhibitor (the ethephon**).**

## 2.Materials and methods:-

A field experiment was carried out at the Agricultural Research station in Wasit Directorate during spring and autumn seasons of 2021. Soil samples were taken from depths of 0 – 30 cm[10],prior to sowing of crop and analyzed to determine the chemical and physical properties which are shown in Table (1)

Table.1. Some chemical and physical properties of soil field experiment (depth 0 - 30 cm) for the both seasons 2021.

| Measured Character | Value for spring season | Value for autumn season | Measuring unit |
|---|---|---|---|
| pH | 7.8 | 7.9 | |
| Electrical conductivity (EC) | 6.2 | 5.8 | dS $m^{-1}$ |
| Available Nitrogen | 20 | 16 | mg $kg^{-1}$ |
| Available Phosphorus | 13.2 | 11 | mg $kg^{-1}$ |
| Available Potassium | 230 | 250 | mg $kg^{-1}$ |
| Soil texture | Silt Loam | | |

The experiment was applied with a randomized complete block design (RCBD) and according to the split-split-plots arrangement and three replications, the area of each plot was 9 m2. The treatments considered in the study were as follows: planting densities (80000, 66666 and 50000 plant.$ha^{-1}$) (D1, D2 and D3),secondary factor it is the three stages of ethephon spraying to (4, 8 and 12) leave per $plant^{-1}$(S1, S2 and S3) and three concentrations of ethephon (0, 800 and 1600 ppm) (C0, C2 and C3).Sorghum (var. Bohooth .70) was planted on 2th Apr and 20th Jul 2021 during spring and autumn seasons respectively. The phosphate fertilizer was added at one time before planting with the reality of (150 Kg. $ha^{-1}$ P2O5), whereas recommended dose 320 kg. ha-1 of urea (46% N), was applied in three equal doses[11and 18]. Pest control weed and irrigation were carried out as needed determined according of plant needs and environmental conditions [16]. Diazenon was applied to protect the sorghum plant from (Sesamia cretica)[17].Plants from each plot were counted at completely maturity on 21th Jul and 15th Nov during spring and autumn seasons respectively. The data of the following parameters: Higher internode length, lower internode length, plant height, stem diameter and % of lodging.The data analysis were performed using GenStat program and mean comparison were carried out by using the least significant difference (LSD) test at probability levels of 0.05

## 3.Results and Discussion

**3.1-Plant height (cm):-** The results of Table (2, 3) show that there is a significant effect of the plant densities on the plant height. The plant height decreased whenever the plant density decreased. The $D_3$ density gave the lowest value, while the $D_1$ density gave the highest more value for both seasons. This increase due to the plant responds to the change in the plant density through its effect on the amount of light penetrating into the vegetative cover, so the increase in plant height is the result of its response to low light levels and competition for light, and the increase in shading encourages auxins and gibberellins to increase elongation[13], These results are in line with [1 and 7]. Also, the stages of spraying the ethephon had a "significant" effect on the plant height, as the plant height decreased at the early stages of spraying (4 and 8)

and increased at the late stages of spraying 12 leaves for both seasons. The results of tables (2 and 3) also showed the significant effect of ethephon concentrations in reducing plant height, and the decrease increased with increasing ethephon concentrations, because ethephon inhibits the biosynthesis of the naturally produced gibberellin within the cells and tissues of the plant, so it reduces cellular expansion and inhibits cell elongation and thus reduces plant height, Similar result was concluded by [12]. Figures (1 and 2) indicated that the interactions between the stages and concentration of spraying ethephon for both seasons, as plant height decreased when spraying for the early stages with increasing concentration of ethephon. The reason may be due to the difference in the relative response of different levels of ethephon to certain stages when spraying.

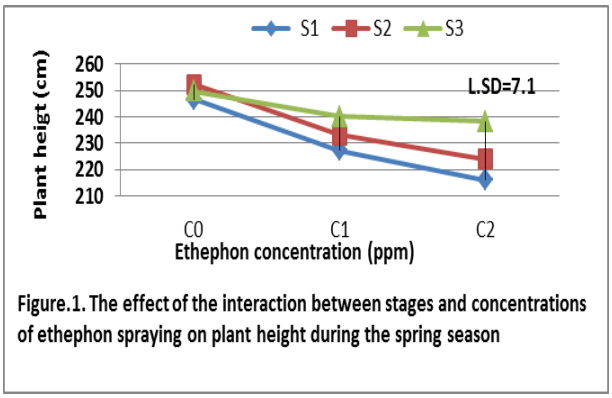


Figure.1. The effect of the interaction between stages and concentrations of ethephon spraying on plant height during the spring season

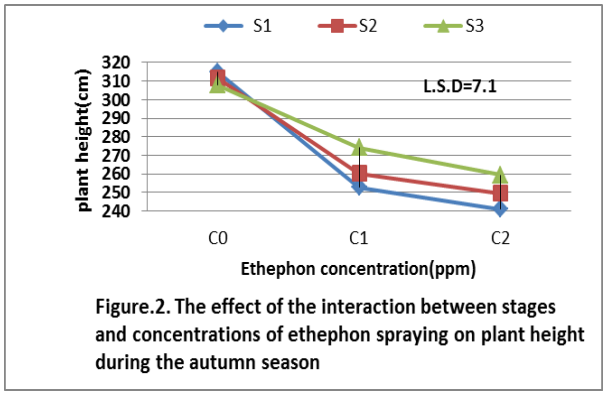


Figure.2. The effect of the interaction between stages and concentrations of ethephon spraying on plant height during the autumn season

**3.2-Lodging%:-**The results of Table (2 and 3) show that there is a significant effect of the plant densities on the Lodging% . Lodging% increased with the increase in plant density and vice versa because of the low plant height and the increased utilization of the elements, nutrients and water that contributed to the deposition of dry matter in the stem of the plant, it increased the plants' resistance to Lodging%,[14 and 15].The stages of spraying ethephon also affected significantly in reducing the rate of Lodging for both seasons, where the percentage of Lodging decreased when spraying at the early stages of growth, while the percentage of Lodging increased when spraying ethephon at the late stages of the vegetative growth of the plant, perhaps because the hormonal and enzymatic activity in the early stages of plant growth is higher Ascending levels, the ethephon affects the growth and development of the plant. Tables (2 and 3) indicate the effect of ethephon concentrations on the significant decrease in the % of Lodging, and for both the spring and autumn seasons, the decrease in the Lodging percentage increased with the increase in the concentrations of ethephon ,because the ethephon reduced plant height and increased stem strength as a result of increased production Lignin and cellulose reduce the rate of Lodging[6 and 26]. These results are in line with [4]**.** Figure (3) also explained that the interactions between the plant densities and spraying stages for the autumn season in reducing the Lodging rate. Perhaps the reason is the difference in the relative response to spraying

stages with different plant densi.While figures (4,5) also indicated that the interactions between the stages and concentrations of ethephon spraying in reducing the lying rate for both seasons , perhaps because of the difference in the relative response to the effect of concentrations in different spraying stages.

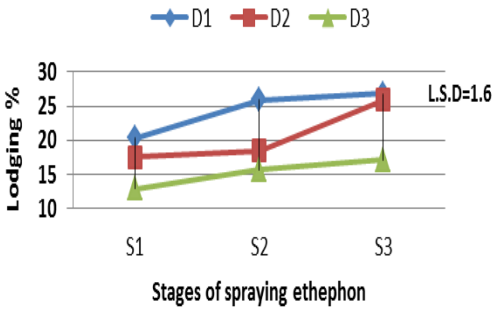


Figure .3. The effect of the interaction between plant densities and stages of ethephon spraying on the % lodging during the autumn season

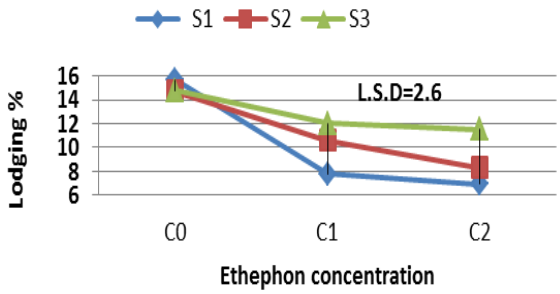


Figure.4. The effect of the interaction between stages and concentrations of ethephon spraying on Lodging% during the spring season

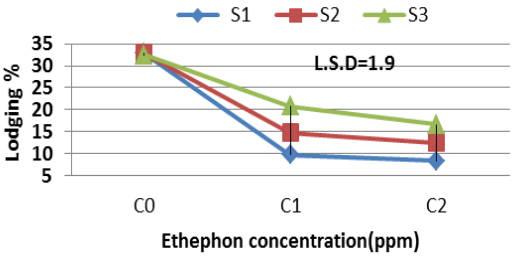


Figure.5. The effect of the interaction between stages and concentrations of ethephon spraying on Lodging% during the autumn season

**3.3 - Grain yield per plant (gm):-**The results of tables (2 and 3) showed the significant effect of the plant density in terms of the yield of one plant, as the yield of one plant increased with a decrease in plant densities for both seasons, Similar result was concluded by,[1 and 21].As for the stages of spraying the ethephon, the stage of 8 leaves gave the highest value for this characteristic, while the stage of spraying at 12 leaves gave the lowest value for both seasons. The response is greater in the early stages of some modifications in the growth characteristics of the plant and the storage of energy produced from the vital processes of the plant and its transfer to the estuaries, which increased the grain yield of one plant. As shown in the table (2 and 3)to increase the yield of one plant when increasing the concentrations of ethephon and for both seasons. Perhaps because the ethephon helped in raising the efficiency of the process of transporting carbon metabolites from the source to the downstream, due to its role in shortening the transport distance as a result of reducing the excessive vegetative growth of the plant[5].Figure (6 ) showed the existence of a significant interaction

between the plant densities and the concentrations of ethephon in increasing the yield of one plant for the spring season, perhaps the reason for the difference in the relative response of the plant yield between the plant densities in the different concentrations of spraying the ethephon.Figure (7) revealed that the significant interaction between the concentrations and stages of spraying ethephon in increasing the yield of one plant for the autumn season, perhaps the reason is that spraying in the stages 4 and 8 leaves, the response to increasing concentrations was more compared to spraying in the late stage 12 leaves.

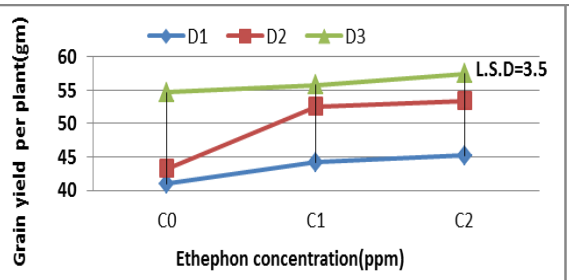


Figure .6. The effect of the interaction between plant densities and ethephon concentrations on Grain yield per plant during the spring season

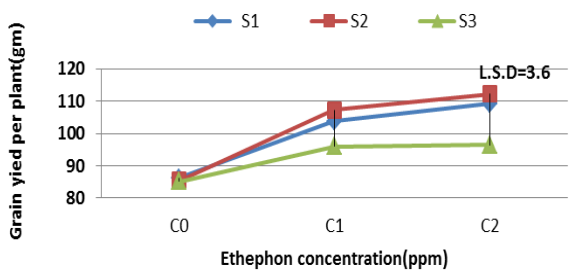


Figure.7. The effect of the interaction between stages and concentrations of ethephon spraying on Grain yield per plant during the autumn season

**3.4-The weight of 1000 grains:-** The results of Table (2 and 3) indicated that there was a significant effect for each of the plant densities, stages and concentrations of ethephon spraying, and the bilateral overlap of the plant densities with the concentrations for the autumn season, while the spring season did not record any significant effect of the experimental factors and their interactions.The plant densities significantly affected this trait, as the weight of 1000 grains increased significantly as the plant density decreased. The reason for the decrease in the grain weight at high plant density is the competition between plants for mineral nutrients, light and water, this result agrees with[25]. The stages of spraying the ethephon had a "significant" effect, as the spraying at the stage of 12 leaves gave the lowest value for the weight of 1000 grains, while the highest value was at the stage of 8 leaves.Table (3) indicates that there is a significant effect of ethephon concentrations on this trait for the autumn season, as an increase in ethephon concentration led to an increase in the weight of 1000 grains, as the percentage of increase in weight using the concentrations was (800 and 1600ppm) compared to the control treatment (5% and 8.2%), respectively. Perhaps the reason is that spraying the ethephon led to an increase in the efficiency of the photosynthesis process and the transfer of photosynthesis products from the source to the downstream[5], These results are in agreement with those of [12].Figure (8) also showed the existence of a significant interaction between plant densities and ethephon concentrations in the weight of 1000 grains, perhaps the reason for the difference in the relative response of plant densities with different spray concentrations.

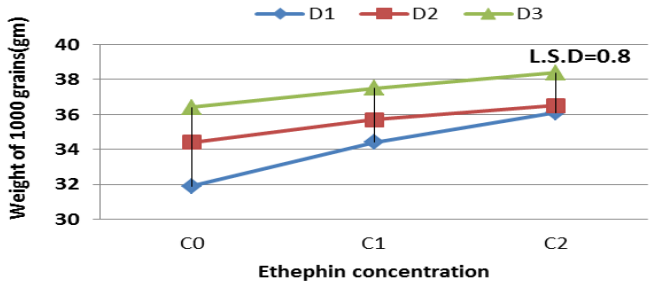


**Figure .8. The effect of the interaction between plant densities and ethephon concentrations on The weight of 1000 grains during the autumn season**

**3.5- The number of grains per head (grain.head$^{-1}$) :-**The results of Table (2 and 3) explained that the high plant density $D_1$ gave the lowest number of grains per head, while the low plant density, $D_3$, gave the highest value for this trait, for both the spring and autumn seasons. Perhaps the reason for the superiority of $D_3$ low density in the number of grains in the head is due to the increase in the efficiency of the carbon metabolism process and the regulation of its transfer from the source to the storage sites in the reproductive stage, which was positively reflected in the increase in fertility and knots and the increase in the number of grains in the head, and this is consistent with,[1].The stages of spraying the ethephon also affected the number of grains per head significantly, as it gave the highest value when spraying at the stage of 8 leaves, while the spraying treatment at the late stage gave 12 leaves per plant the lowest mean for this characteristic. The efficiency of transferring carbon metabolites from the source to the floral origins to complete the fertilization process and not to abort the eggs[5].Tables (2 and 3) showed the significant effect of ethephon concentrations on the number of grains per head. The treatment of spraying ethephon with a high concentration of 1600 ppm gave the highest value, while the comparison treatment gave the lowest number of grains per head for both seasons. Perhaps because of the contribution of the ethephon in the process of transporting carbon metabolites from the source to the storage sites, as well as its role in shortening the transport distances [5].Figure (9) showed the presence of a significant interaction between concentrations and stages of ethephon spraying in the number of grains per head in the autumn season, perhaps the reason for the difference in the relative response to the difference in concentrations in different stages of spraying**.**

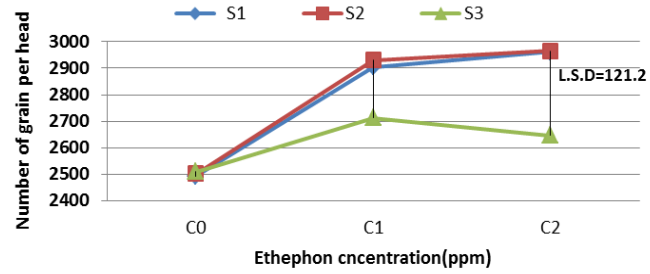


**Figure.9. The effect of the interaction between stages and concentrations of ethephon spraying on number of grains per head during the autumn season**

**3. 6-Grain Yield (ton.ha$^{-1}$):-**Tables (2 and 3) show that there is a significant effect of the plant density in both seasons, as the high density $D_1$ gave the highest value of grain yield amounting to (3.482 and 7.27) ton. ha$^{-1}$ - for the spring and autumn seasons, respectively, while the low plant density $D_3$ gave the lowest grain yield amounted to (2.801 and 5.401) (ton.ha$^{-1}$)for the two consecutive seasons. The reason for the increase in grain yield (ton.ha$^{-1}$) at high density $D_1$ is the increase in the number of plants per unit area that compensated for the decrease in the yield of one plant. These results are in line with,[1].Tables (2 and 3) also indicated that there was a significant effect of the stages of spraying the ethephon for both seasons, as the spraying treatment in the stage of 8 leaves gave the highest value of grain yield amounting to (3.336 and 6.581) tons.ha1 for the spring and autumn seasons, respectively, while the stage of 12 leaves gave the lowest grain yield. It reached (3.031 and 5.987)(ton.ha$^{-1}$)for both seasons in succession, because early spraying with the ethephon may push the plant to move to the stage of proliferative growth in a shorter time. Also, the concentrations of ethephon had a significant effect on the characteristic of grain yield, as the high concentration of ethephon (1600 ppm) gave the highest value of grain yield for the spring and autumn seasons, while the comparison treatment gave the lowest grain yield. And 11.4%, respectively. In the autumn season, the increase rate was 16.1% and 19.3%, respectively. The explanation for this is that the increase in grain yield is the result of an increase in the important yield components, such as the yield of one plant, the number of grains per head, and the weight of 1000 grains, and this result agrees with[3 and 12]**.**Figure (10,11) shows the existence of a significant interaction between the plant densities and the concentrations of ethephon, the effect of the spring and autumn seasons. Perhaps the reason is the difference in the relative response of the concentrations in the different plant densities in their effect on the yield. Figure (12) showed the presence of a significant interaction between the concentrations and stages of spraying ethephon in increasing the grain yield in the autumn season, perhaps the reason for the difference in the relative response to the increase in grain yield with an increase in the concentration of ethephon.

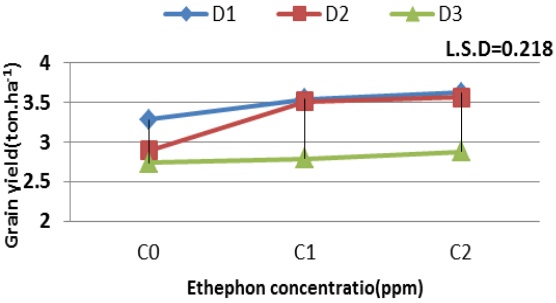


Figure .10. The effect of the interaction between plant densities and ethephon concentrations on grain yield during the spring

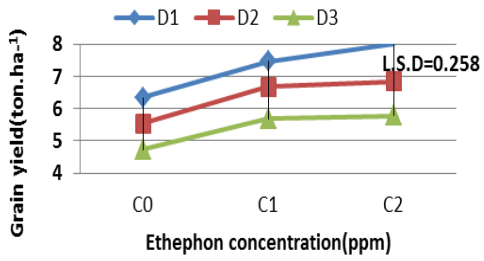


Figure .11. The effect of the interaction between plant densities and ethephon concentrations on grain yield during the autumn season

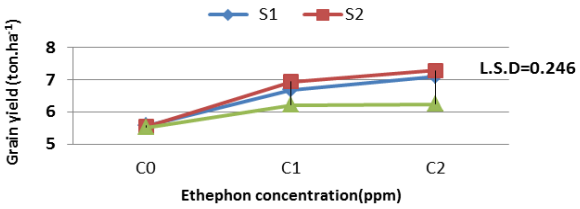


Figure.12. The effect of the interaction between stages and concentrations of ethephon spraying on grain yield during the autumn season

**Table.2. The studied traits for the spring season of 2021**

| treatments | D1 | D2 | D3 | L.S.D | S1 | S2 | S3 | L.S.D | C0 | C1 | C2 | L.S.D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| plant height(cm) | 256.1 | 234 | 219 | 7.02 | 229.9 | 236 | 243 | 3.8 | 250 | 233.5 | 226 | 4.4 |
| % of lodging | 15.5 | 12 | 6.1 | 3 | 10.1 | 11.2 | 13 | 1.7 | 15.1 | 10.1 | 8.9 | 1.5 |
| Grain yield per plant (gm) | 43.5 | 49.8 | 56 | 2.3 | 50.2 | 51.9 | 47.1 | 2.9 | 46.3 | 50.9 | 52 | 2.1 |
| The weight of 1000 grains | 26 | 26.4 | 26.4 | N.S | 26.1 | 26.3 | 26.5 | N.S | 26.6 | 26 | 26.2 | N.S |
| The number of grains per head(grain.head $^{-1}$) | 1680 | 1910 | 2126 | 239.8 | 1931 | 1989 | 1796 | 140.6 | 1751 | 1957 | 2009 | 137.1 |
| Grain Yield (ton.ha-$^{1}$) | 3.482 | 3.321 | 2.801 | 0.116 | 3.237 | 3.336 | 3.031 | 0.165 | 2.97 | 3.28 | 3.353 | 0.142 |

**Table.3. The studied traits of the autumn season of 2021**

| treatments | D1 | D2 | D3 | L.S.D | S1 | S2 | S3 | L.S.D | C0 | C1 | C2 | L.S.D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| plant height(cm) | 285 | 275.6 | 263 | 3.8 | 269.5 | 274 | 280.3 | 3.7 | 311.4 | 262.2 | 249.9 | 4.4 |
| % of lodging | 24.3 | 20.6 | 15.2 | 0.7 | 16.9 | 20 | 23.3 | 1.1 | 32.7 | 15.1 | 12.5 | 1.1 |
| Grain yield per plant (gm) | 90.8 | 95.2 | 108 | 3.2 | 99.7 | 101.7 | 92.6 | 2.4 | 85.7 | 102.4 | 106 | 2.1 |
| The weight of 1000 grains | 34.1 | 35.5 | 37.4 | 0.4 | 35.7 | 36.1 | 35.2 | 0.6 | 34.2 | 35.8 | 37 | 0.5 |
| The number of grains per head(grain.head $^{-1}$) | 2655 | 2674 | 2878 | 94.8 | 2786 | 2800 | 2623 | 79 | 2501 | 2849 | 2858 | 68.9 |
| Grain Yield (ton.ha-$^{1}$) | 7.27 | 6.35 | 5.401 | 0.22 | 6.453 | 6.581 | 5.987 | 0.168 | 5.54 | 6.609 | 6.871 | 0.136 |

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