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# Response of some Yellow Maize Hybrids Growth and Grains Quality for Spraying with Anti-stress Substances under Different Sowing Dates to Face Climatic Changes

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## ABSTRACT

In order to investigate response of some yellow maize hybrids (single cross Gold-21, single cross 168 and single cross Kahraman) growth and grains quality for spraying with anti-stress substances (without, spraying with irrigation water, salicylic acid, potassium silicate and proline acid) under different sowing dates (16th May, 1st June and 15th June) to face climatic changes, two field experiments were conducted at the private field in El-Orman Village, El-Sinbelaween district, Dakahlia Governorate, during the 2023 and 2024 seasons. Every planting date was carried out in a different experiment. Three replications of each sowing date experiment were conducted using a strip-plot design. Early sowing of maize on 16th May produced the highest growth and grains quality traits. Single cross Gold-21 was superior than two other yellow maize hybrids and resulted in the highest growth and grains quality traits. The highest growth and grains quality traits were recorded when spraying maize plants with salicylic acid at 5 g/L in each season. Based on the findings of the research and in light of the climate changes that the whole world is witnessing, as well as Egypt, it could be concluded that early sowing yellow hybrid single cross Gold-21 (SC Gold-21) on 16th May and spraying with salicylic acid at 5 g/L to maximizing grain quality and growth in the El-Sinbelaween district of the Dakahlia Governorate, Egypt's environmental conditions and similar areas.

***Keywords*: Maize, sowing dates, hybrids, spraying with anti-stress substances**

## INTRODUCTION

After rice and wheat, maize, often known as corn (*Zea mays* L.), is the most significant cereal crop in the world, supplying nourishment for both people and animals. In addition to having 7-9% protein and 5% oil, maize grains are high in vitamins A, C, and E, carbs, and vital minerals (Rafiq *et al.*, 2010). They are also a wonderful source of energy because they are high in calories and dietary fiber. Maize starch can be used to make a variety of chemical goods, including adhesives, textiles, and polymers.

Maize is regarded as one of the primary grain crops in Egypt after rice and wheat, it comes in third. In the 2023 season, Egypt's total cultivated area of maize produced 7.130 million tons, with an average yield of 22.52 ardab/fed, reaching approximately 2.261 million feddan (FAO, 2025).

To close the gap between maize production and consumption, care should be taken to increase productivity by optimizing yield per unit area. It is commonly recognized that maize has a high need for other production inputs, such as nutrients. In order to combat climate change while simultaneously increasing maize productivity and grain quality, new yellow maize hybrids can benefit from the best foliar spraying techniques and appropriate sowing dates.

Field crop productivity is greatly impacted by climate change. These effects can manifest as unbalanced precipitation, which has a significant effect on crop yield and reduces the crops' ability to withstand the hard climate. One of the most popular changes in maize farming is changing the sowing date. In many areas, the date of sowing can have a significant impact on grain yield, quality, germination, and comprehension of entire phenological stages. For grain production, early and middle sowings often make the most of sun radiation (Berzsenyi and Lap, 2001). The more a maize hybrid deviates from its ideal sowing date—whether it be early or late—the more yield is lost (Ahmed and Saikia, 2020). Thus, the best way to deal with climate change and maximize maize growth, productivity, and quality is to sow it at the right time based on the local environmental conditions. According to Abbas *et al.* (2020), it took more days to reach 50% tasseling, silking, and maturity for spring early (Jan. 15) and fall late (July 25) planting. To achieve 50% tasseling, silking, and maturity, maize planted between February 5 and July 25 acquired more growing degree days (GDDs). According to Ahmed and Saikia (2020), the growth and development of maize were modified by environmental variables linked to varying sowing dates. All things considered, early or mid-early sowings might be advised for maize production since plants have a longer growth period and develop and flourish in favorable environmental conditions, producing reproductive and vegetative parts and more assimilations. Normal SD led to a longer growing season between plant emergence and maturity, as demonstrated by Abaza *et al.* (2023). An *et al.* (2024) shown that while the grain-filling duration remained reasonably stable, delayed sowing drastically shortened the entire growth period and the sowing-silking period. According to Simon *et al.* (2024), the planting date and climate have a significant impact on the quality of maize. Comparing very early (4°C) and early (6°C) planting dates to optimal or late sowing times, a significant drop in maize grain quality was observed.

To increase yellow maize growth and productivity per unit area, it is definitely crucial to select hybrids with high yielding ability (Gomaa *et al.*, 2021). Therefore, the

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purpose of this study is to assess a few new, promising hybrids of yellow maize in order to determine which one is most suitable for usage in the study region's environmental conditions. According to Abas *et al.* (2020), the cultivars Maha and the hybrids B73× Ik8 and AGR3×AGR11 had the greatest results in terms of blooming, plant height, and ear leaf area. According to Al-Ani *et al.* (2020), the SC 131 hybrid outperformed the two hybrids under study (TWC 324 and SC 128) and had the largest stalk diameter measurements. The tallest plants and greatest values were recorded by the SC 128 hybrid. According to Abd *et al.* (2021), there was a substantial difference in the number of days from planting to 50% tasseling and silking between parental inbred and their reciprocal and inverse hybrids. Inbred lines and their single crosses shown notable variations in the number of days of sowing to 50% male and female blooming and ear leaf area (Alogaidi *et al.*, 2021). According to Gomaa *et al.* (2021), the plant height of the four maize hybrids under study (SC 2066, SC 2055, SC 3062, and TWC 352) varied, with TWC352 registering the highest values. According to Attia *et al.* (2022), there are notable variations in plant height, total chlorophyll, and flag leaf area amongst maize hybrids. According to the primary findings, the Pioneer 2055 hybrid outperformed the Giza 168 and Giza 352 hybrids in these characteristics. Asefa *et al.* (2024) found that inconsistence performance and flowering were indicated by a highly significant difference between the genotypes and environment interactions for flowering traits (50% days to anthesis and silking). Hasan *et al.* (2025) found that significant variation was observed among the hybrids for all phenological and growth. Therefore, Kaveri-54 is recommended as a promising hybrid for maize cultivation in the Mymensingh region, which will support future breeding efforts aimed at improving growth.

The use of foliar fertilizing in agriculture is certain to increase in the future. It is a commonly used technique to address nutritional deficiencies in plants that result from poor root nutrient delivery. Three primary goals of foliar fertilization are to: 1) address a nutrient shortage, 2) maintain optimal nutrient nutrition, and 3) provide a crop with a nutritional boost at a pivotal point in its life cycle (Ling and Moshe, 2002). According to Gomaa *et al.* (2021), the maximum grain quality of maize was obtained by using potassium silicate foliar spraying three times. According to Wasaya *et al.* (2021), foliar potassium sulfate spray at a 2% concentration worked better than other dosages by enhancing growth characteristics and total chlorophyll. According to El-Nwehy *et al.* (2022), proline at 400 mg/L applied topically boosted maize growth and oil percentage. Mohamad *et al.* (2023) investigated the potential of salicylic (SA) and ascorbic (AA) antioxidants to lessen the adverse impacts of water stress and its consequences on maize yields, growth features, and physiological characteristics. When compared to untreated plants, they discovered that foliar spraying with SA or AA (at 200 ppm) considerably boosted the majority of the attributes under study. According to Asl *et al.* (2024), foliar application of ascorbic acid (AA) and salicylic acid (SA) dramatically raised the protein percentage and chlorophyll content when compared to the control plants. According to Tiwar (2024), proline, a multipurpose amino acid, is essential for reducing abiotic stress in maize. Proline serves as an antioxidant, scavenging reactive oxygen species (ROS) to safeguard cellular constituents, and an osmolytes, preserving cellular hydration and turgor. Under abiotic stress, these two roles play a major role in maintaining cellular homeostasis. Proline production and accumulation in maize are controlled by intricate metabolic and genetic processes.

According to Ashraf *et al.* (2010), salicylic acid (SA) is regarded as a hormone-like substance that plays a significant role in controlling plants' stomata closure, ion uptake and transport, inhibition of ethylene biosynthesis, transpiration, membrane permeability, photosynthesis and growth, nitrate metabolism, flowering, and stress tolerance. According to Khan *et al.* (2010), the application of SA increased plants' resistance to a variety of biotic and abiotic stressors, including heat, drought, and salinity.

In plants, potassium (K) plays a number of vital roles, including photosynthesis, photosynthetic translocation, protein synthesis, ionic balance regulation, stomata and water consumption regulation (Reddya *et al.*, 2004), enzyme activation, and osmoregulation (Mengel, 2007). Additionally, potassium helps plants withstand stressors like pests, diseases, cold, and water stress (Marschner, 2012). Silicon (Si) is the only micronutrient that plants routinely absorb in amounts comparable to those of the macronutrients. The fact that silicon in the soil reduces transpiration in cells with a higher concentration of silicon and helps plants live in water-scarce environments is among the most significant facts (Gao *et al.*, 2006). Potassium silicate has been shown in numerous studies to have beneficial growth effects on maize grain production, its constituents, and grain quality (Gomaa *et al.*, 2021).

The most crucial amino acid for protecting stressed plants is proline, which is soluble in water. To help plants recover from osmotic stress, proline may be used as a signaling molecule to alter physiological processes such as osmotic adjustment, photosynthetic enhancement, increased ion uptake, antioxidant activity, and effects on cell death or explosion and gene expression (Ali *et al.*, 2013).

In order to discourse climate change in the El-Sinbelaween district of the Dakahlia Governorate, Egypt, this study was created to examine how some yellow maize hybrids responded in terms of growth and grain quality to anti-stress spraying under various sowing dates.

## MATERIALS AND METHODS

During the two consecutive summer seasons of 2023 and 2024, two field experiments were conducted at the private field in El-Orman Village, El-Sinbelaween district, Dakahlia Governorate. The purpose of this study was to determine how some yellow maize hybrids' growth and grain quality responded to anti-stress spraying at various sowing dates in response to climate change.

Every maize sowing date, May 16, June 1, and June 15 was carried out in a different experiment. Three replications of each sowing date experiment were conducted using a strip-plot design. Each sowing date experiment had fifteen treatments, including five foliar spraying treatments with anti-stress chemicals and three new hybrids of yellow maize.

Single cross Gold-21 (SC Gold-21), single cross 168 (SC 168), and single cross Kahraman (SC Kahraman) were the three new yellow maize hybrids to which the vertical plots were given. The Maize Research Department of the Field Crops Research Institute, Agricultural Research Center, Giza, Egypt, provided the three yellow maize hybrids that were employed in this study.

The following five foliar spraying treatments with anti-stress substances were used in the horizontal plots: 5 g/L of salicylic acid per spraying, 5 $cm^3$/L of potassium silicate per spraying, 2.5 g/L of proline acid per spraying, foliar spraying with irrigation water, and no foliar spraying (control treatment). El-Nasr Pharmaceutical Chemicals Co. in Egypt produces salicylic and proline acids, which are used as anti-stress agents. El-Gomhouria Company for Trading Pharmaceutical Chemical & Medical supplies them. Abo-Ghanema produced the commercial fertilizer Potassium Sil Ghanem "Liquid silicon" (potassium silicate as an anti-stress agent) for the chemical and fertilizer industries.

The volume of the foliar solution was 200 liters/fed, and two times after 35 and 50 days of sowing, the experimental plots were sprayed by hand using a sprayer till the saturation point. The concentration of tween-20 utilized as a wetting agent was 0.02%.

The size of each experimental unit was 12.0 $m^2$ (1/350 fed) and consisted of five ridges, each measuring 60 cm in width and 4.0 m in length. Egyptian clover (*Trifolium alexandrinum* L.) was the winter crop that came before it in the first and second seasons.

Using the procedure outlined by Page *et al.* (1982), soil samples were randomly selected from the experimental field area at a depth of 0 to 30 cm from the soil surface prior to soil preparation during the growing seasons. The results are displayed in Table 1.

**Table 1. Features of the trial sites' physical and chemical soils over the two growing seasons in 2023 and 2024.**

| Soil analysis | 2023 season | 2024 season |
|---|---|---|
| A: Mechanical analysis | | |
| Sand (%) | 28.79 | 28.26 |
| Silt (%) | 29.55 | 30.94 |
| Clay (%) | 41.66 | 40.80 |
| Texture | Clayey | Clayey |
| F.C. (%) | 32.50 | 32.45 |
| P.W.P (%) | 16.00 | 16.00 |
| Available water (%) | 16.25 | 16.50 |
| Bulk density (g $cm^{-3}$) | 1.16 | 1.15 |
| B: Chemical analysis | | |
| pH | 8.05 | 8.18 |
| EC (m. mohs/cm at 25°C) | 2.42 | 2.54 |
| $CaCO_3$ (%) | 1.95 | 1.90 |
| Organic matter (%) | 1.98 | 1.93 |
| Available N (ppm) | 25.42 | 24.40 |
| Available P (ppm) | 14.60 | 13.74 |
| Exchangeable K (ppm) | 316.20 | 308.40 |

Table 2 displays the El-Sinbelaween district's monthly temperature (in degrees Celsius) and relative humidity (in percentages) during the two growing seasons of 2023 and 2024.

**Table 2. Monthly averages of the experimental site's highest and lowest temperatures (°C) and relative humidity (%) throughout the course of two growing seasons.**

| Season | Temperature (°C) | | | | Relative humidity (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2023 | | 2024 | | 2023 | | 2024 | |
| | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| May | 29.9 | 19.6 | 30.5 | 21.0 | 83.5 | 39.8 | 84.5 | 41.5 |
| June | 34.0 | 22.9 | 34.0 | 22.2 | 83.4 | 38.1 | 84.0 | 41.9 |
| July | 35.2 | 25.0 | 35.3 | 26.0 | 84.6 | 40.2 | 84.3 | 42.0 |
| August | 36.1 | 25.4 | 36.0 | 25.8 | 84.6 | 41.7 | 83.7 | 42.4 |
| September | 33.9 | 24.4 | 33.8 | 24.4 | 84.4 | 42.9 | 83.4 | 40.6 |

After two ploughs, leveling, compacting, and ridging, the experimental field was thoroughly prepared before being split up into experimental units (12.0 $m^2$). 150 kg/fed of calcium superphosphate (15.5% $P_2O_5$) was added during soil preparation. Ammonium nitrate (33.5% N), a nitrogen fertilizer, was added in two equal amounts at a rate of 120 kg N/fed, half after thinning (before to the first irrigation) and the other half prior to the second irrigation. At the initial nitrogen fertilizer dosage, 50 kg/fed of potassium sulphate (48 % $K_2O$) was applied.

On the aforementioned sowing dates in the 2023 and 2024 seasons, maize grains were manually seeded in hills 30 cm apart at a rate of 2-3 grains/hill using the dry sowing method (Afeer) on one side of the ridge. Prior to the initial irrigation, each hill's plant population was reduced to one plant. With the exception of the parameters under investigation, agricultural activities were maintained as they are typically carried out in maize fields in accordance with the Ministry of Agriculture and Land Reclamation's instructions.

Number of days from sowing to 50 % tasseling and silking were recorded on plot basis as the number of days from sowing to 50 % tasseling and silking.

After 100 days from sowing, random samples of five guarded plants were taken from the outer ridges of each experimental plot to determine the following growth characters *i.e.* plant height (cm), first ear height (cm) and stem diameter (cm).

As stated by A.O.A.C. (2000), the Soxhelt apparatus and petroleum hexane as an organic solvent were used to measure the oil percentage (%) in a dried grains sample (50 g) obtained from each plot, cleaned, and ground into a very fine powder using a grinder.

As described by Gomez and Gomez (1984), the statistical analysis was carried out using the analysis of variance approach (ANOVA) for the strip-plot design using the "MSTAT-C" computer software program for each experiment (sowing dates). A combined analysis was then conducted between sowing dates. To determine whether error variances were homogeneous, Bartlett's test was used. The Snedecor and Cochran (1980) least significant differences test (LSD) at the 0.05 level of probability was used to assess differences between treatment means.

## RESULTS AND DISCUSSION

### 1. Effect of sowing dates:

The results of this study demonstrate that the dates of sowing maize—16 May for early sowing, 1 June for intermediate sowing, and 15 June for late sowing—had a significant impact on the grains quality (oil percentage) and flowering and growth characteristics (number of days from sowing to 50% tasseling and silking, plant height, first ear height, and stem diameter) in each season (Tables 3 and 4).

When compared to the intermediate sowing date (1 June) or the late sowing date (15 June) in each season, the early sowing date of maize (16 May) greatly recorded the most significant increases and produced the highest number of days from sowing to 50% tasseling and silking, plant height, first ear height, stem diameter, and oil percentage (Tables 3 and 4). In terms of its impact on the grain quality in each season as well as the investigated flowering and growth characteristics, the second-best sowing date was June 1. However, the late planting date (15 June) in each season produced the lowest number of days from sowing to 50% tasseling and silking, plant height, first ear height, stem diameter, and oil percentage. In general, each season's variations in the planting dates under study were noteworthy.

The delaying flowering and desirable effect on growth and grain quality characters of sowing maize as a result on early sowing date on 16th May may be attributed to the ideal environmental conditions, which are expressed as meteorological data, such as the maximum and minimum monthly temperature (°C) and relative humidity (%) that are displayed in Table 2. During this time, due to global and Egyptian climate change, both maximum seed germination and rapid growth and formation of a good canopy capable of making efficient photosynthesis both of which are essential for activating plant establishment and development and, consequently, increasing maize flowering and growth characteristics occurred. These results are incompatible with those stated by Ahmed and Saikia (2020), Abaza *et al.* (2023), An *et al.* (2024) and Simon *et al.* (2024).

**2. Yellow maize hybrids performance:**

The three yellow maize hybrids under study—single cross Gold-21 (SC Gold-21), single cross 168 (SC 168), and single cross Kahraman (SC Kahraman)—were found to differ significantly in terms of flowering and growth characteristics (number of days from sowing to 50% tasseling and silking, plant height, first ear height, and stem diameter) as well as grain quality (oil percentage) in each season, according to statistical analysis of the data collected (Tables 3 and 4).

Tables 3 and 4 show that the single cross Gold-21 (SC Gold-21) produced the maximum number of days from sowing to 50% tasseling and silking, plant height, first ear height, stem diameter, and oil percentage in each season, outperforming the two other yellow maize hybrids (SC 168 and SC Kahraman). In contrast, the single cross Kahraman (SC Kahraman) was the second-best hybrid of yellow maize based on other blooming and growth characteristics as well as grain quality in each season. Single cross 168 (SC 168), on the other hand, produced the lowest plant height, initial ear height, stem diameter, oil percentage, and number of days from sowing to 50% tasseling and silking in each season.

**Table 3. During the 2023 and 2024 seasons, the average number of days from sowing to 50% tasseling and silking of maize as influenced by the dates of sowing, yellow maize hybrids, and the application of anti-stress chemicals, as well as their relationships.**

| Characters Treatments | Number of days from sowing to 50% tasseling | | Number of days from sowing to 50% silking | |
|---|---|---|---|---|
| | 2023 | 2024 | 2023 | 2024 |
| A. Sowing dates: | | | | |
| 16th May | 49.46 | 49.80 | 59.13 | 57.80 |
| 1st June | 47.65 | 47.96 | 57.00 | 55.72 |
| 15th June | 46.05 | 46.35 | 55.08 | 53.85 |
| LSD at 5 % | 0.06 | 0.07 | 0.05 | 0.10 |
| B. Yellow maize hybrids: | | | | |
| SC Gold-21 | 49.33 | 50.30 | 59.00 | 58.04 |
| SC 168 | 45.47 | 44.48 | 54.17 | 51.28 |
| SC Kahraman | 48.36 | 49.33 | 58.04 | 58.04 |
| LSD at 5 % | 0.05 | 0.06 | 0.06 | 0.08 |
| C. Spraying treatments with anti-stress substances: | | | | |
| Without | 47.72 | 48.04 | 57.07 | 55.79 |
| Irrigation water | 47.72 | 48.04 | 57.07 | 55.79 |
| Salicylic acid | 47.72 | 48.04 | 57.07 | 55.79 |
| Potassium silicate | 47.72 | 48.04 | 57.07 | 55.79 |
| Proline acid | 47.72 | 48.04 | 57.07 | 55.79 |
| LSD at 5 % | NS | NS | NS | NS |
| D. Interactions (F. test): | | | | |
| A × B | * | * | * | * |
| A × C | NS | NS | NS | NS |
| B × C | NS | NS | NS | NS |
| A × B × C | NS | NS | NS | NS |

**Table 4. The 2023 and 2024 seasons' averages for plant height, initial ear height, stem diameter, and oil % in maize grains as influenced by the dates of sowing, hybrids of yellow maize, and the application of anti-stress sprays.**

| Characters Treatments | Plant height (cm) | | First ear height (cm) | | Stem diameter (cm) | | Oil (%) | |
|---|---|---|---|---|---|---|---|---|
| | 2023 | 2024 | 2023 | 2024 | 2023 | 2024 | 2023 | 2024 |
| A. Sowing dates: | | | | | | | | |
| 16th May | 211.9 | 211.5 | 114.0 | 108.9 | 2.56 | 2.84 | 3.86 | 5.33 |
| 1st June | 211.1 | 208.2 | 111.7 | 107.8 | 2.46 | 2.64 | 3.79 | 5.15 |
| 15th June | 210.2 | 206.8 | 107.8 | 106.6 | 2.42 | 2.47 | 3.67 | 4.53 |
| LSD at 5 % | 1.2 | 1.0 | 1.0 | 0.08 | 0.08 | 0.05 | 0.03 | 0.02 |
| B. Yellow maize hybrids: | | | | | | | | |
| SC Gold-21 | 221.2 | 215.2 | 114.0 | 112.0 | 2.78 | 2.84 | 4.19 | 5.26 |
| SC 168 | 196.6 | 204.1 | 107.7 | 104.1 | 2.25 | 2.46 | 3.07 | 4.70 |
| SC Kahraman | 215.5 | 207.2 | 111.7 | 107.1 | 2.41 | 2.65 | 4.06 | 5.05 |
| LSD at 5 % | 1.0 | 0.9 | 0.9 | 0.07 | 0.07 | 0.04 | 0.02 | 0.02 |
| C. Spraying treatments with anti-stress substances: | | | | | | | | |
| Without | 204.3 | 202.7 | 102.4 | 100.8 | 2.21 | 2.48 | 3.19 | 3.82 |
| Irrigation water | 206.9 | 203.2 | 110.9 | 104.1 | 2.37 | 2.56 | 3.52 | 4.74 |
| Salicylic acid | 216.9 | 215.7 | 116.2 | 114.0 | 2.73 | 2.81 | 4.26 | 5.83 |
| Potassium silicate | 214.8 | 214.4 | 113.8 | 110.7 | 2.60 | 2.74 | 4.06 | 5.51 |
| Proline acid | 212.5 | 208.2 | 112.4 | 109.1 | 2.50 | 2.65 | 3.85 | 5.11 |
| LSD at 5 % | 0.9 | 0.7 | 0.8 | 0.06 | 0.03 | 0.03 | | |
| D. Interactions (F. test): | | | | | | | | |
| A × B | * | * | NS | NS | * | * | * | * |
| A × C | * | * | * | * | * | * | * | * |
| B × C | * | * | * | * | * | * | * | * |
| A × B × C | * | * | * | * | * | * | * | * |

The genetic differences amongst the new yellow maize hybrids may be the cause of their differences in blooming, growth, and grain quality traits. Similar outcomes were attained by Abd *et al.* (2021), Alogaidi *et al.* (2021), Gomaa *et al.* (2021), Attia *et al.* (2022), Asefa *et al.* (2024) and Hasan *et al.* (2025).

**3. Effect of foliar spraying treatments with anti-stress substances:**

When it comes to the effects of foliar spraying treatments with anti-stress substances, such as control treatment (no foliar spraying), spraying with irrigation water, salicylic acid at 5 g/L, potassium silicate at 5 $cm^3$/L, and proline acid at 2.5 g/L in each spraying, on flowering and growth characters (plant height, first ear height, and stem diameter), as well as on grain quality (oil percentage), the results obtained indicate that these traits were significantly impacted by the studied foliar spraying treatments with anti-stress substances, while the number of days from sowing to 50% tasseling and silking was insignificantly affected by foliar spraying treatments with anti-stress substances in each season (Tables 3 and 4).

When maize plants were sprayed with 5 g/L of salicylic acid every season, the highest values of plant height, first ear height, stem diameter, and oil % were noted (Tables 3 and 4). In terms of its impact on flowering and growth characteristics as well as grain quality in each season, the second-best foliar spraying treatment with anti-stress substances was applying potassium silicate at a rate of 5 cm3/L per spraying, followed by proline acid at a rate of 2.5 g/L per spraying, and finally irrigation water. In contrast, each season's control treatment yielded the lowest values for plant height, first ear height, stem diameter, and oil %.

When anti-stress chemicals (salicylic acid, potassium silicate, and proline acid) are sprayed on maize, the growth and grain quality characteristics increase. This could be because salicylic acid regulates several physiological processes in plants, including stomata closure, ion uptake and transport, inhibition of ethylene biosynthesis, nitrate metabolism, a transpiration, membrane permeability, photosynthesis, flowering and growth, and abiotic stress tolerance (Ashraf *et al.* 2010). Moreover, potassium silicate is used in agriculture as a source of silicon (Si) and potassium (K) amendments. The primary macronutrient that plants absorb in quite considerable amounts is potassium. Additionally, silicon helps plants withstand a variety of stressors. According to Khan *et al.* (2025), proline supplementation also improves osmoprotection, lowers oxidative stress, improves growth, and efficiently increases maize productivity under abiotic stress. This is because it promotes the development of metabolic products, improves early growth, and increases dry matter accumulation, all of which increase the growth characteristics of maize. These findings are consistent and in good agreement with those documented by Gomaa *et al.* (2021), Wasaya *et al.* (2021), El-Nwehy *et al.* (2022), Mohamad *et al.* (2023), Asl *et al.* (2024) and Tiwar (2024).

**4. Effect of interactions:**

Regarding the interactions, all three of the factors investigated in this study—sowing dates, yellow maize hybrids, and anti-stress substance spraying—had a significant impact on all flowering and growth characteristics and grain quality. The only exceptions were the interactions between sowing dates and anti-stress substance spraying, between yellow maize hybrids and anti-stress substance spraying, and between sowing dates, yellow maize hybrids, and anti-stress substance spraying on the number of days from sowing to 50% tasseling and silking in each season (Tables 3 and 4).

The interaction between the three factors under study (sowing dates, yellow maize hybrids, and anti-stress substance spraying) had a significant impact on the quality of the grains (oil percentage) and flowering and growth characteristics (plant height, first ear height, and stem diameter) in each season (Table 5).

**Table 5. Averages of plant height, first ear height, stem diameter, and oil % in maize grains over the 2023 and 2024 seasons as influenced by the combination of anti-stress spraying, yellow maize hybrids, and sowing dates.**

| Sowing dates | Hybrids | Spraying treatments | Plant height (cm) | | First ear height (cm) | | Stem diameter (cm) | | Oil (%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2023 | 2024 | 2023 | 2024 | 2023 | 2024 | 2023 | 2024 |
| 16th May | SC Gold-21 | Without | 214.3 | 215.5 | 113.3 | 105.2 | 2.56 | 3.00 | 3.95 | 5.01 |
| | | Water | 218.6 | 215.5 | 115.0 | 110.2 | 2.66 | 3.00 | 4.00 | 5.11 |
| | | Salicylic acid | 231.6 | 221.0 | 121.6 | 120.3 | 3.10 | 3.06 | 4.70 | 6.11 |
| | | Potassium silicate | 228.3 | 220.0 | 118.3 | 119.1 | 3.06 | 3.00 | 4.85 | 6.31 |
| | | Proline acid | 224.0 | 220.5 | 115.0 | 115.2 | 2.83 | 3.00 | 4.22 | 5.81 |
| | SC 168 | Without | 188.6 | 195.4 | 108.3 | 100.2 | 2.10 | 2.50 | 2.10 | 4.31 |
| | | Water | 191.6 | 195.4 | 110.0 | 100.2 | 2.23 | 2.50 | 3.04 | 4.61 |
| | | Salicylic acid | 204.3 | 220.5 | 115.0 | 110.2 | 2.60 | 3.00 | 3.24 | 5.31 |
| | | Potassium silicate | 200.3 | 215.5 | 110.0 | 110.2 | 2.46 | 2.76 | 3.19 | 5.31 |
| | | Proline acid | 199.6 | 200.4 | 110.0 | 105.2 | 2.36 | 2.63 | 3.18 | 4.91 |
| | SC Kahraman | Without | 212.3 | 205.5 | 111.6 | 100.2 | 2.06 | 2.66 | 3.67 | 3.70 |
| | | Water | 213.6 | 205.5 | 111.6 | 105.2 | 2.46 | 2.73 | 3.87 | 5.51 |
| | | Salicylic acid | 219.6 | 215.5 | 116.6 | 115.2 | 2.73 | 3.00 | 4.71 | 6.51 |
| | | Potassium silicate | 218.3 | 215.5 | 116.6 | 110.2 | 2.63 | 2.96 | 4.71 | 6.21 |
| | | Proline acid | 215.6 | 210.5 | 116.6 | 110.2 | 2.56 | 2.80 | 4.61 | 5.61 |
| 1st June | SC Gold-21 | Without | 214.3 | 210.5 | 111.6 | 104.2 | 2.43 | 2.60 | 3.38 | 3.96 |
| | | Water | 218.6 | 210.5 | 111.6 | 109.1 | 2.63 | 2.66 | 3.96 | 5.29 |
| | | Salicylic acid | 226.6 | 215.5 | 116.6 | 115.2 | 3.03 | 3.00 | 4.71 | 5.91 |
| | | Potassium silicate | 226.6 | 215.5 | 116.6 | 114.1 | 3.00 | 2.83 | 4.54 | 5.83 |
| | | Proline acid | 224.0 | 215.5 | 116.6 | 114.1 | 2.90 | 2.73 | 4.35 | 5.51 |
| | SC 168 | Without | 188.0 | 195.4 | 80.0 | 99.2 | 2.00 | 2.40 | 1.92 | 4.11 |
| | | Water | 189.0 | 195.4 | 115.0 | 99.2 | 2.03 | 2.46 | 2.47 | 4.41 |
| | | Salicylic acid | 203.0 | 220.5 | 121.6 | 109.1 | 2.36 | 2.70 | 4.25 | 5.81 |
| | | Potassium silicate | 200.0 | 215.5 | 118.3 | 109.1 | 2.26 | 2.60 | 3.55 | 5.11 |
| | | Proline acid | 199.0 | 200.4 | 115.0 | 104.2 | 2.16 | 2.56 | 2.83 | 5.01 |
| | SC Kahraman | Without | 211.6 | 200.4 | 108.3 | 99.2 | 2.16 | 2.50 | 3.74 | 4.21 |
| | | Water | 213.3 | 200.4 | 110.0 | 104.2 | 2.30 | 2.53 | 3.95 | 4.61 |
| | | Salicylic acid | 218.3 | 212.2 | 115.0 | 114.1 | 2.63 | 2.76 | 4.45 | 6.41 |
| | | Potassium silicate | 218.3 | 210.5 | 110.0 | 109.1 | 2.56 | 2.70 | 4.26 | 5.61 |
| | | Proline acid | 215.0 | 205.5 | 110.0 | 109.1 | 2.46 | 2.63 | 4.42 | 5.11 |
| 15th June | SC Gold-21 | Without | 210.0 | 210.5 | 109.0 | 103.0 | 2.40 | 2.50 | 3.74 | 3.41 |
| | | Water | 213.3 | 210.5 | 110.0 | 107.9 | 2.63 | 2.70 | 3.86 | 4.61 |
| | | Salicylic acid | 225.0 | 215.5 | 113.3 | 117.7 | 2.96 | 2.90 | 4.54 | 5.61 |
| | | Potassium silicate | 223.3 | 215.5 | 111.6 | 112.8 | 2.80 | 2.90 | 4.09 | 5.61 |
| | | Proline acid | 220.0 | 215.5 | 110.0 | 112.8 | 2.73 | 2.80 | 4.03 | 4.81 |
| | SC 168 | Without | 188.3 | 190.4 | 100.0 | 98.1 | 2.10 | 1.93 | 2.85 | 2.70 |
| | | Water | 191.0 | 195.4 | 100.0 | 98.1 | 2.10 | 2.10 | 3.08 | 4.01 |
| | | Salicylic acid | 203.6 | 210.5 | 105.0 | 107.9 | 2.63 | 2.30 | 3.72 | 5.41 |
| | | Potassium silicate | 201.3 | 210.5 | 105.0 | 107.9 | 2.23 | 2.30 | 3.50 | 5.11 |
| | | Proline acid | 201.0 | 200.4 | 103.3 | 103.0 | 2.16 | 2.23 | 3.20 | 4.41 |
| | SC Kahraman | Without | 211.6 | 200.4 | 80.0 | 98.1 | 2.06 | 2.30 | 3.39 | 3.01 |
| | | Water | 213.3 | 200.4 | 115.0 | 103.0 | 2.30 | 2.40 | 3.45 | 4.51 |
| | | Salicylic acid | 218.3 | 210.5 | 121.6 | 112.8 | 2.46 | 2.63 | 3.90 | 5.01 |
| | | Potassium silicate | 218.3 | 210.5 | 118.3 | 107.9 | 2.40 | 2.60 | 3.99 | 4.91 |
| | | Proline acid | 215.0 | 205.5 | 115.0 | 107.9 | 2.33 | 2.53 | 3.82 | 4.81 |
| LSD at 5 % | | | 2.0 | 1.7 | 0.30 | 0.20 | 0.10 | 0.08 | 0.03 | 0.03 |

The results showed that early sowing of yellow hybrid single cross Gold-21 (SC Gold-21) on May 16 and salicylic acid spraying at 5 g/L per spraying per season produced the highest values of plant height, first ear height, stem diameter, and oil percentage (Table 5). Considering the impact on blooming and growth characteristics as well as grain quality in each season, this interaction treatment was followed by early sowing of SC Gold-21 on May 16 and potassium silicate spraying at a rate of 5 cm3/L per spraying. On the other hand, delaying the sowing of yellow hybrid single cross 168 (SC 168) until June 15th without applying any anti-stress sprays during each season produced the lowest values of plant height, first ear height, stem diameter, and oil %.

## CONCLUSION

According to the study's findings and the global and Egyptian climate change, it is recommended that yellow hybrid single cross Gold-21 (SC Gold-21) be sown early on May 16 and sprayed twice with salicylic acid at a rate of 5 g/L each after 35 and 50 days from sowing in order to maximize growth and grain quality in the El-Sinbelaween district of the Dakahlia Governorate, Egypt.

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# استجابة نمو وجودة حبوب بعض هجن الذرة الشامية الصفراء للرش الورقى بمواد مضادة للإجهاد تحت مواعيد زراعة مختلفة لمواجهة التغيرات المناخية

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## الملخص

تم إجراء تجربتين حقليتين في حقل خاص بقرية الأورمان، مركز السنبلاوين، محافظة الدقهلية، خلال الموسمين الصيفيين المتتاليين ٢٠٢٣ و ٢٠٢٤ لدراسة استجابة صفات التزهير والنمو وجودة الحبوب لبعض هجن الذرة الشامية الصفراء الجديدة (هجين فردى أصفر جولد-٢١، هجين فردى أصفر جيزة ١٦٨ وهجين فردى أصفر كهرمان) للرش بمواد مضادة للإجهاد (بدون، رش ورقي بماء الري، حمض الساليسيليك بمعدل ٥ جم/لتر ، سيليكات البوتاسيوم بمعدل ٥ سم٣/لتر وحمض البرولين بمعدل ٢.٥ جم/لتر) تحت مواعيد زراعة مختلفة (الزراعة في ١٦ مايو، ١ يونيو و١٥ يونيو) لمواجهة التغيرات المناخية تحت الظروف البيئية لمركز السنبلاوين، محافظة الدقهلية، مصر. أُجريت كل تجربة موعد زراعة للذرة الشامية في تجربة منفصلة. نُفذت كل تجربة موعد زراعة في تصميم الشرائح المتعامدة فى بثلاثة مكررات. أنتجت الزراعة المبكرة للذرة الشامية في ١٦ مايو أعلى صفات النمو وجودة الحبوب. تفوق التهجين الفردي جولد-٢١ على هجيني الذرة الصفراء الآخرين وأسفر عن أعلى صفات النمو وجودة الحبوب. سُجِّلت أعلى صفات نمو وجودة حبوب عند رش نباتات الذرة بحمض الساليسيليك بمعدل ٥ جم/لتر في كل رشة في كلا الموسمين. بناءً على نتائج هذه الدراسة، وفي ضوء التغيرات المناخية التي يشهدها العالم أجمع، بما في ذلك مصر، من النتائج التي تم الحصول عليها من هذه وفي ضوء التغيرات المناخية التي يشهدها العالم أجمع ومصر على وجه الخصوص يمكن استنتاج أن الزراعة المبكرة للهجين الفردى الأصفر جولد-٢١(SC Gold-21) في ١٦ مايو والرش الورقى مرتين بعد ٣٥ و٥٠ يوم من الزراعة بحمض الساليسيليك بمعدل ٥ جم/لتر في كل رشة لتحقيق أقصى نمو خضرى وجودة الحبوب تحت الظروف البيئية لمنطقة السنبلاوين، محافظة الدقهلية، مصر.