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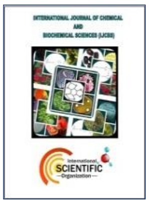

Characterization of Okra Genotypes at the Reproductive Stage under High Temperature Stress

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Abstract

Protein, fat, fiber-filled carbohydrates, iron, and vitamins A, B, and C are all abundant in okra. Its pods include glycosides as well as minute levels of K, P, Ca, and Mg. The mucilaginous extract of the fruit contains a blood level expander or plasma replacement. The three main factors that affect it are Water, Temperature, as well as Dampness, although in this work, we emphasized on the adverse effects of high temperature stress on the okra plant. In the suggested research, we evaluated the numerous morphological, biochemical, and physiological modifications in okra under high-temperature stress. Ten okra genotypes were exposed to three different temperature settings during the reproductive development stage: 23°C, 40°C, and 45°C. The categorization of the okra genotypes into groups that can survive and react to heat is the major purpose of this study. Several morphological, physiological, and biochemical indicators of high-temperature tolerance were used to group the organisms into different groups. Pen beauty, Rama Krishna, MF.03, and Shahzadi were heat-sensitive cultivars, whereas Green Wonder thrived in hotter climates.

Keywords: Vegetable, Reproductive stage, Okra, Stress, Genotypes,

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1. Introduction

Several species in the Malvaceae genus Abelmoschus are important as vegetable crops locally or globally. Okra (A. esculentus (L) Moench) it's a form of allopolyploid with an ambiguous origin and fluctuating chromosomal number. Okra was thought to have an Asian origin, despite suggestions that it came from Africa. As there is no known wild A. Esculentus, it was presumed that okra is a cultivable plant because it has been grown in Egypt and Arabia since 1200 B.C. Three other Abelmoschus vegetable crop species, "A. Caillei (A. Chev.) Stevels, A. MoschatusMedik, and A. Manihot (L.)" Medik can hybridize with A. esculentus. A. moschatus's leaves and immature pods are used as vegetables, while the roasted seeds, which have a flavor akin to sesame, are used to season food and drinks. In West Africa, A. caillei is grown for its delicious pods. [1]. Okra is a hot-term vegetable crop that does best in cold summers, where the maximum and minimum temperatures by 27°C as well as 44°C, respectively. In India, it is grown during the summer and the wet season. Its immature green fruits are the main reason it is widely planted. Okra seeds are a good source of both protein and high-quality edible oil. Okra's dried seeds have a protein content of 21–25% and an edible oil content of 14–23%. The term "integrated nutrient management" (INM) refers to a comprehensive strategy that takes into account all farm resources that can be used as plant nutrients [2]. The effective establishment of seedlings and subsequent growth depend on the seed germination stage of a plant's life cycle. As a result, seed germination, a delicate phase, impacts how well seedlings grow. Salts, water, light, and temperature are examples of abiotic variables that have an impact on the soil-seed interface and regulate seed germination. These stressors cause damage to plants, and in severe circumstances, they can even cause death. The main element among these that inhibited seed germination, seedling establishment, subsequent growth, and ultimately plant yield was salt. The majority of seed germination takes place in non-saline settings, and it gets worse as salinity levels rise. Salinity affects seed germination either by the toxicity of certain ions, such as Na+ and Cl, on growing seeds. The maintenance of osmotic potential within the seeds, which prevents or limits water intake, or the detrimental effects of certain ions, such as Na+ and Cl, on seedlings are two ways that salinity influences seed germination [3]. Moreover, Burkina Faso's culture is impacted by water scarcity throughout the 8 to the 9-month-long dry season. Water is a crucial element of agriculture and one of the prerequisites for seed germination since it enables the rehydration of tissues that have become dehydrated, which results in germination. Moreover, it promotes cell elongation and multiplication, supporting the growth of the seed embryo. In light of this, vegetables are grown throughout the dry season utilizing a variety of water sources, including conventional wells that are also used for drinking water. Finding alternate sources is thus required to enable okra farming throughout the dry season [4]. Only a few investigations on vegetables were done in the cowpea intercropping research, which was mostly focused on cereals. As a result, little research has been done on intercropping vegetables and legumes. The ideal timing to introduce the intercrop has not been thoroughly examined in the few research that has looked at vegetable-legume intercrop. By altering the timing of introducing cowpea into the okra and evaluating their agro-economic performance, this study investigated intercropping [5].

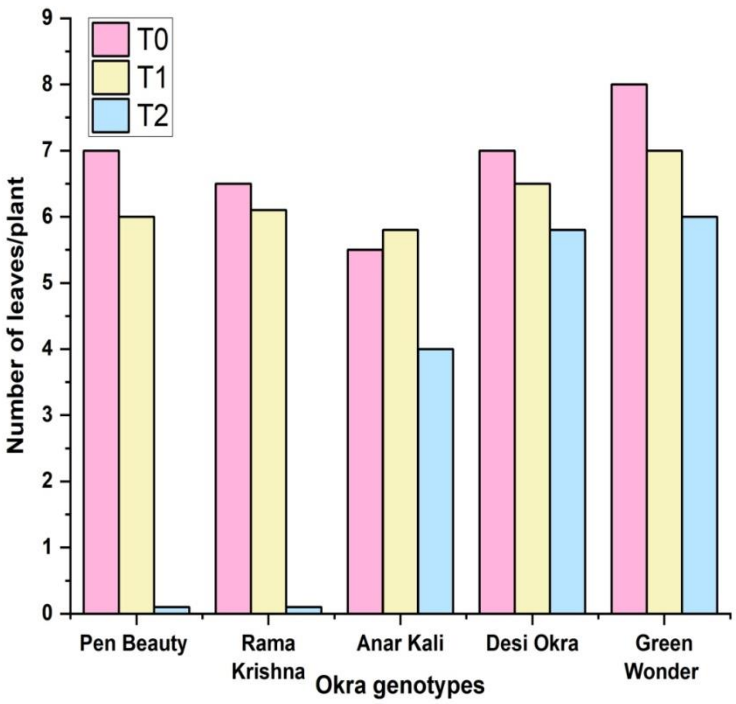
The research [6] produced more nutrient-dense and stress-resistant varieties, and traits from the biodiversity of okra were preserved and gathered from gene bank collections. A middle group of 200 okra accession, including A. Esculentus, A. Moschatus, A. Caillei, and A. Maniho, was developed from the germplasm collection of the World Vegetable Center based on a diversity study utilizing 20 microsatellite markers. The research [7] is to use complementary phenotypic indicators and simple sequence repeat (SSR) to identify the hereditary variation that may exist amongst okra accessions. The finest genetically different parental accessions were also sought for pre-breeding. It also sought to identify the best parental accessions for pre-breeding that were genetically dissimilar. The paper [8] determined potential candidate genotypes for drought resistance breeding by analyzing how various okra genotypes respond to drought stress using yield plus yield-related factors. The paper [9] looked at how different okra genotypes responded to heat stress in terms of their growth, morphology, physiology, and enzyme activity. The study [10] demonstrated the genetic diversity among genotypes for seed production, fruit production, and nutrient content, suggesting the possibility of developing okra variations with high fruit yields and high nutrient contents. The article [11] offered a history of the advancements in the study of phenotypic and genotypic divergence, breeding for drought resistance, and preservation of okra. For important agronomic, horticultural, and physiological qualities to enhance drought tolerance, gene introgression, and ideotype breeding, the review focused on the diversity of okra. Tamil Nadu has a very limited amount of agricultural and production land. The current study [12] combines the use of genetic variance and fundamental measurements of variability to construct novel sorts. The study [13] examined the development and crop production of 20 pre-commercial okra accessions to ascertain the association between genetic markers and physical features. With the help of five qualitative and fourteen quantitative descriptors, 19 morphological traits were measured. For breeding projects, the wild okra relatives are a great source of variety, especially for traits related to biotic and abiotic stressors and fruit quality. Yet there are still no wild species used for okra breeding. Breeders will benefit from the knowledge gained from the study on the connection between crossability, phenotypic characterization, and heterosis in interspecific hybrids [14]. The study [15] evaluated the variety of the twenty-four genotypes of okra germplasm for morphological, yield, and quality-related variables. Only the internodal length, fruit girth, and days to fruit maturity, in addition to vitamin C did not show any discernible variation.

2. Materials and methods

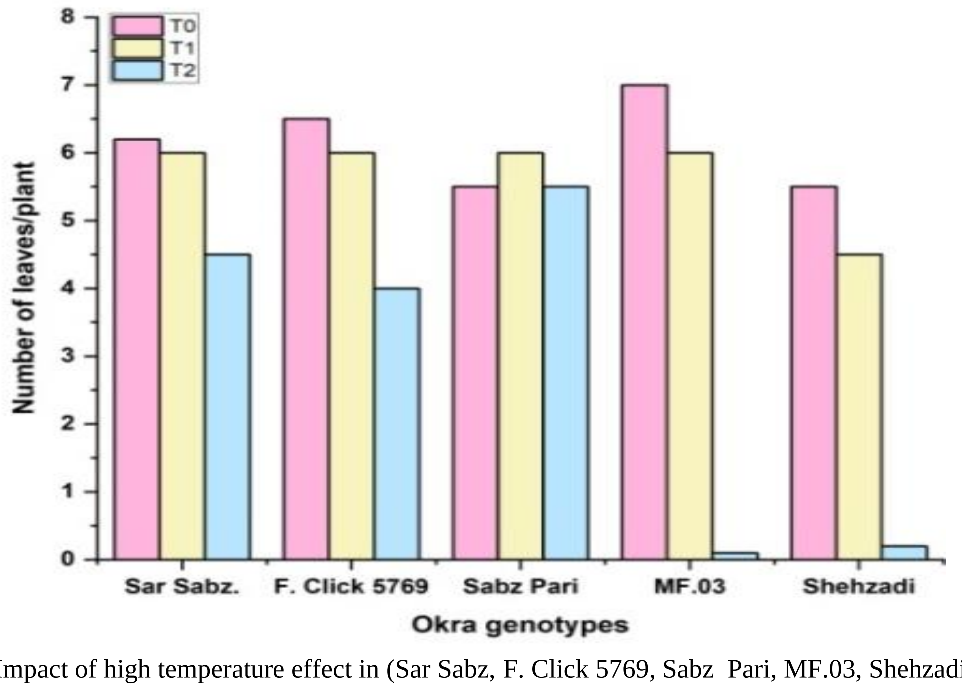
The study was conducted at the Department of Horticulture's growth chamber at the University (A) Agriculture. An experiment was developed and executed to confirm the findings of the Identification of okra genotypes throughout the phase of reproduction under temperature stress. The Agricultural Research Center (A), distributed seeds for ten distinct types of okra. Sodium hypochlorite in a 5% solution was used to clean the seeds. The seedlings were placed in nine-inch plastic containers after being surface cleaned. Vermiculite was used as the rooting medium, and peat was used to fill the pots. Five seeds were sown in a pot. Behind plants had developed, they were thinned out by eliminating the weaker and less resilient saplings. From seed to fruit production, the crops were permitted to develop in a regulated setting at 23°C. Plants experienced their first temperature stress at the beginning of the floral bud, and data were collected ten days later. A week after the initial data collection, the plants were subjected to a different temperature range, and data were again gathered after 10 days. The plants were exposed to various temperatures after the appearance of flowers one week after the start of the heat stress, and information on a wide range of morphological and physiological aspects was gathered. The 8.1 statists program was used to gather and evaluate data about numerous morphological l, physiological, and dietary aspects.

3. Results and Discussions

Data on leaf count per plant showed that when the temperature rose, the number of leaves per plant reduced in comparison to the control (T0). Treatment T0 had the most leaves per plant (6.53), followed by Treatments T1 (5.73), and Treatment T2 (3.00), whereas Treatment T2 had the fewest leaves per plant (2.00). (3.00). All varieties of okra demonstrated a noticeable difference in plant growth as a result of temperature stress. Green Wonder, however, outperformed "Anar Kali, Desi Okra, Sar Sabz, F.Click 5769, and Sbaz Pari" by having the most leaves (7.00), according to data based on the average number of leaves per plant. The cultivar Shahzadi has the fewest leaves under higher temperatures (3.22 per plant). Variations are also shown through the interaction of treatments and variety. The number of leaves per plant declined the least in all temperature ranges for Green Wonder, but as temperature increased, the number of leaves reduced in all other okra cultivars (Figure 1).

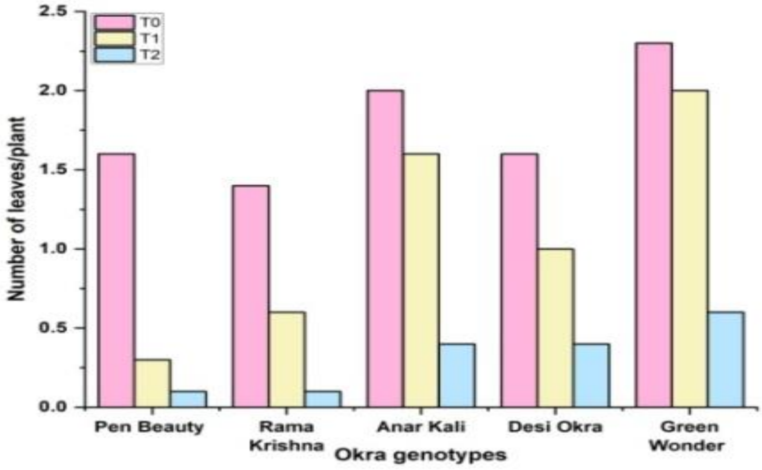


(a) Impact of high temperature effect in (Pen Beauty, Rama Krishna, Anar Kali, Desi Okra, Green Wonder)

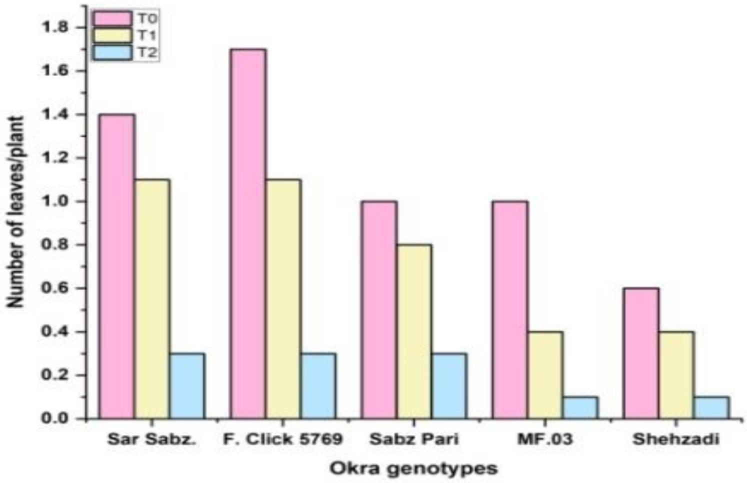


(b) Impact of high temperature effect in (Sar Sabz, F. Click 5769, Sabz Pari, MF.03, Shehzadi)

Figure 1. Several okra genotypes were subjected to high-temperature stress, which had an effect on the average number of leaves per plant (T0: 23 °C, T1: 40 °C, T2: 45 °C).

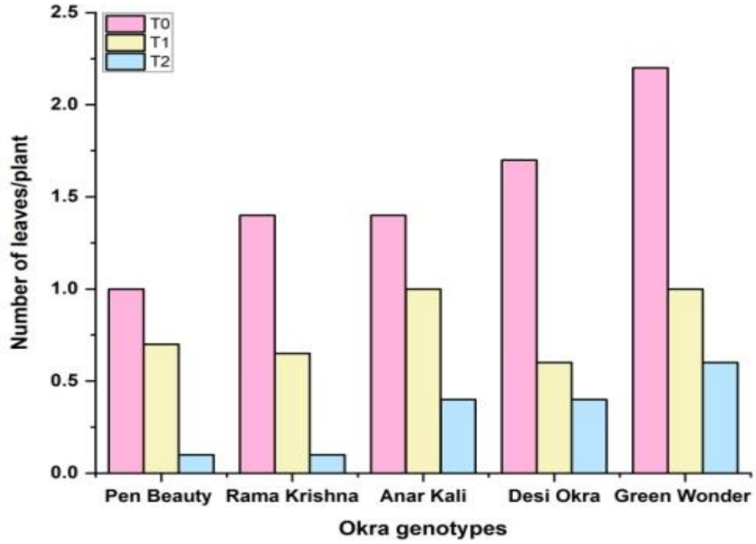


(a) Impact of high temperature effect in (Pen Beauty, Rama Krishna, Anar Kali, Desi Okra, Green Wonder).

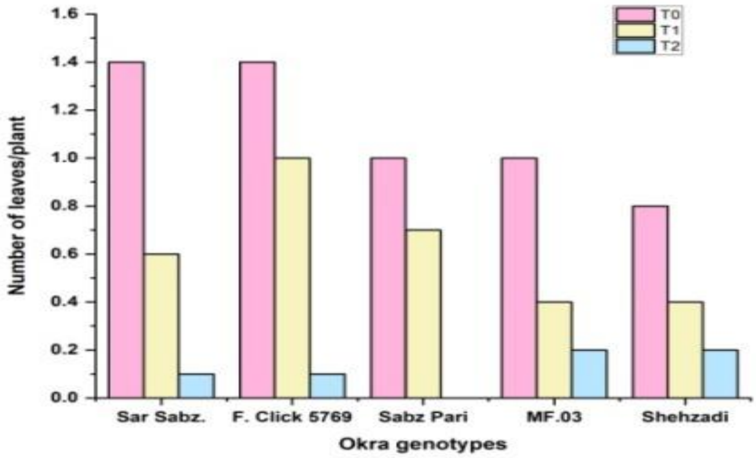


(b) Impact of high temperature effect in (Sar Sabz, F. Click 5769, Sabz Pari, MF.03, Shehzadi)

Figure 2. Several okra genotypes were subjected to high-temperature stress, which had an effect on the average number of leaves per plant (T0: 23 °C, T1: 40 °C, T2: 45

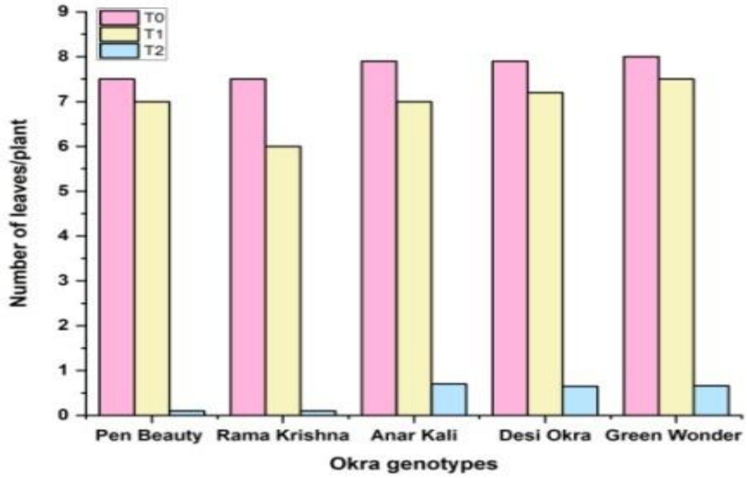


(a) Impact of high temperature effect in (Pen Beauty, Rama Krishna, Anar Kali, Desi Okra, Green Wonder)

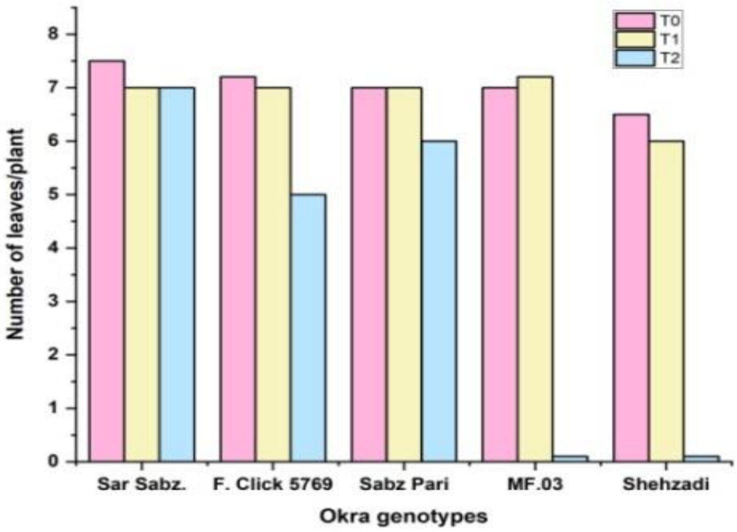


(b) Impact of high temperature effect in (Sar Sabz, F. Click 5769, Sabz Pari, MF.03, Shehzadi)

Figure 3. Number of flowers/plants of several okra genotypes as a result of high-temperature stress (T0: 23 °C, T1: 40 °C, T2: 45 °C)

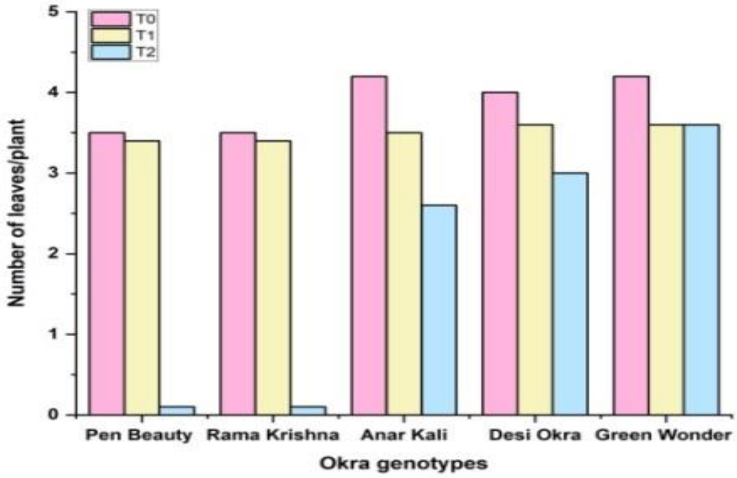


(a) Impact of high temperature effect in (Pen Beauty, Rama Krishna, Anar Kali, Desi Okra, Green Wonder)

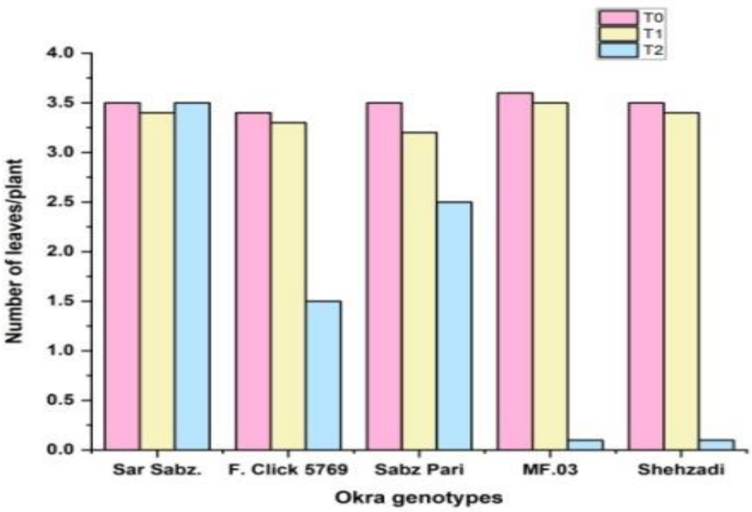


(b) Impact of high temperature effect in (Sar Sabz, F. Click 5769, Sabz Pari, MF.03, Shehzadi)

Figure 4. Different okra genotypes' rates of photosynthesis were affected by high-temperature stress (T0: 23 °C, T1: 40 °C, T2: 45 °C)



(a) Impact of high temperature effect in (Pen Beauty, Rama Krishna, Anar Kali, Desi Okra, Green Wonder)



(b) Impact of high temperature effect in (Sar Sabz, F. Click 5769, Sabz Pari, MF.03, Shehzadi)

Figure 5. Different okra genotypes' responses to high-temperature stress (T0: 23 °C, T1: 40 °C, and T2: 45 °C) on stomatal conductance

Statistics on flowering time per plant showed that, in comparison to the control, flowering time per plant reduced as temperature increased (T0). Treatment T0 had the most flowers per plant (8.83), followed by T1 (4.60), and T2 (0.93), correspondingly. Treatment T2 had the fewest flowers per plant (0.93). (0.93). All varieties of okra exhibit considerable differences in plant growth as a result of temperature stress. However, results based on the average number of flowers per plant revealed that Green Wonder had the most flowers (6.11), which distinguished it greatly as of "Anar Kali, Desi Okra, Sar Sabz, F.click 5769, and Sbaz Pari". When the temperature was greater, Shahzadi was the cultivar that produced the fewest flowers per plant (3.33). Variations are also shown through the interplay of treatments and diversity. At all temperatures, Green Wonder had the fewest flower reductions per plant, although as the temperature increased, all other okra cultivars also produced fewer blooms (Figure 2).
°C).

When temperatures increased, fewer fruits were produced per plant than in the control, according to data on the number of fruits produced by each plant. Most fruit allowed per Plant (1.30) be seen at treatment T0, followed through treatments T1 (0.69), and T2 (0.20), respectively. Treatment T2 showed the fewest fruits per plant (0.20). All varieties of okra exhibit considerable differences in plant growth as a result of temperature stress. However, according to the results of the mean value of fruit produced by each plant, Green Wonder produced the most fruit (1.33), which considerably differed from those produced by “Anar Kali, Desi Okra, Sar Sabz, F.Click 5769, and Sbaz Pari”. In warmer temperatures, the cultivar Shahzadi had fewer fruits (0.33) per plant. Variations are also shown through the interaction of treatments and variety. At all temperatures, Green Wonder demonstrated the smallest losses in fruit per plant, but the number of fruits declined in all other okra cultivars as temperature increased (Figure 3).

According to data on the rate of photosynthesis per plant, Figure 4 illustrates how the rate of photosynthesis per plant decreased when the temperature rose in contrast to the control. Treatment T0 showed the highest rate of photosynthesis per plant (7.35 mol CO2 m-2 s-1), followed by T1 (5.71 mol CO2 m-2 s-1), and T2 (3.88 mol CO2 m-2 s-1), whereas treatment T2 showed the lowest rate of photosynthesis per plant (4.77 mol CO2 m-2 s-1). All varieties of okra exhibit considerable differences in plant growth as a result of temperature stress. However, performance based on mean photosynthesis rates per plant revealed that Green Wonder had the highest rates of photosynthesis (7.20 mol CO2 m-2 s-1), which was much higher than those of “Anar Kali, Desi Okra, Sar Sabz, F.Click 5769, and Sbaz Pari”. At higher temperatures, cultivar Shahzadi showed the least amount of photosynthesis (3.90 mol CO2 m-2 s-1) (T3). This interaction of treatments and variety demonstrates variations as well. All other okra cultivars showed lower photosynthesis as temperature increased, while Green Wonder showed negligible losses in photosynthesis per plant at all temperatures.

Measurements on okra genotypes' stomatal conductance showed that, in comparison to the control, the okra plant's stomata density reduced as temperature increased. Treatment T0 had the highest stomata density (2.54 mmol m-2 s-1), followed by treatments T1 (4.17 mmol m-2 s-1), and T2, also along with others. Treatment T2 had the lowest stomata density (2.01 mmol m-2 s-1). All varieties of okra exhibit considerable differences in plant growth as a result of temperature stress. Green Wonder, however, displayed the highest stomata density (4.95 mmol m-2 s-1) and considerably differed from “Anar kali, Desi okra, Sar sabz, F.Click 5769, as well as Sbazpari” in terms of performance as measured by the mean value of stomata density. At higher temperatures, cultivar Shahzadi had the lowest stomata density (3.01 mmol m-2 s-1). Variations are also shown through the interaction of treatments and variety. When temperatures increased, all other okra cultivars' stomatal density dropped except for Green Wonder, which showed minimal declines at all temperatures (Figure 5).

The results of the current experiment show that when the temperature rose, the number of leaf shoots length, and root length all reduced. Even Nevertheless, the variety Green Wonder displayed the most leaves at higher temperatures and was unaffected by high temperatures when its sales were at their peak. These results support Amooaghaie and Moghym's hypothesis that heat shock stress reduced the length of the roots and shoots in soybean seedlings.The formation of pollen, fertilization, and the asynchrony of the development of the stamen and gynoecium all depend on the temperature during flowering. The fundamental rationale for the lower seed production in the legume could be the loss of pollination or stigma viability during high temperature stress. The results of the current investigation showed that flower set reduced as temperature was raised continually. Because it stopped the necessary protein degradation process, the cultivar Green Wonder showed the least decrease in chlorophyll content compared to other types, especially Shahzadi. Reduced fruit set at higher temperatures was primarily responsible for decreased pollen viability, lower pollen yield, and poor pollen tubes formation, all of which contribute to subpar flower fertilization. Decreased production of seeds and yields of seeds have also been linked to floral abortion in other crops, including the napus species Brapa and B. juncea. According to our research, the shahzadi kind of okra does not perform as well as the green wonder variety.

High temperatures have an impact on rubisco, which disrupts plant photosynthesis. Since high temperatures render the rubisco inactive, this is one of the factors contributing to the decline in photosynthesis. The consequences of the present experiment demonstrated that the photosynthetic rate reduced when the constant temperature was raised. Shahzadi, on the other hand, was unable to survive high temperatureshowever, the variety known as Green Wonder little felt the effects of the heat surge and kept the meaning of rubisco in hot weather.

High temperatures harm mesophyll cells, which worsens plant stomatal conductance. The high temperature leads to the formation of an incomplete vascular group and an unstable organelle structure. Our results were consistent with the earlier findings that stomatal conductance was significantly impacted by temperature increases and that this had a significant impact on plant growth. Yet, the Green Wonder cultivar did not suffer as much from heat exhaustion as the Shahzadi variety did, which failed to maintain good health under extreme heat.

4. Conclusions

People need to eat vegetables every day since they have a variety of nutritional advantages and are often either raw or cooked. People need vegetables in their everyday diets since they offer a variety of nutritional advantages and are often either raw or cooked. Okra (Abelmoschus esculentus L.) is a warm-season annual herbaceous vegetable crop which can be found in nearly every market in Africa. It is grown primarily for its young immature green fruits and fresh leaves used in salads, soups and stews. Okra genotypes called "green wonder" produced the best results in terms of morphological, physiological, and biochemical traits. Hence, under high-temperature stress circumstances, the top okra genotype is thought to be Green Wonder.

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