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Productivity of corn (*Zea mays*) under varying drought duration and nitrogen application at La, Trinidad, Benguet

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ABSTRACT

This study investigates the impact of varying durations of drought and different nitrogen application strategies on corn. The study employed a Split Plot Design with three replications. Main plots (levels and timing of nitrogen) included NO FERT (no fertilizer), RR+OA (recommended rate at one-time application), RR+SA (split application), RR+50N+OA (50% nitrogen), and RR+50N+SA. Subplots tested drought durations of 10, 15, and 20 days (DD). Data were analyzed using two-way ANOVA, and treatment mean differences were assessed using LSD at the 5% significance level. Significant ($P < 0.05$) effects of fertilizer were observed on leaf area (LA), total number of kernel rows per ear (TNE), and chlorophyll content (CC). Drought significantly affected plant height (PH), LA, root weight (RW), ear length (EL), ear weight (EW), total number of kernels per row (TKR), TNE, total weight of corn ears (TWE), CC, drought score (DS), and recovery rate (RR). No significant differences were found in the interaction of drought and fertilizer, except for root weight. Subjecting plants to longer drought durations showed more negative effects on productivity. The recommended rate plus 50% of nitrogen at one-time application, along with the recommended rate and split application, are the best levels and timing of application when exposed to drought during the vegetative stage.

Contribution/Originality: The study uniquely evaluates the effects of drought duration and nitrogen application on the productivity of corn under greenhouse conditions. The methodology employs a Split Plot Design with three replications for comprehensive analysis.

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1. INTRODUCTION

Corn (Zea mays L.) is a vital crop for food security in the Philippines (Sierra & Cantos, 2007). It is a major source of income for one-third of Filipino farmers (Gerpacio, Labios, Labios, & Diangkinay, 2004). It is also considered a staple food for Filipinos, especially in the Southern Philippines. However, productivity is influenced by various abiotic and biotic factors. Among these, drought stress and nitrogen deficiency are significant constraints that adversely affect growth and yield. In relation to the study by Modhej, the application of nitrogen rates at 100, 150, and 200 kilograms per hectare influenced the physiological responses of maize to water stress. An increasing level of nitrogen application led to an increase in the plant's ability to hold relative water content under drought stress conditions. Even though the maize yield showed the highest response to nitrogen fertilizer in optimal irrigation treatment, an early application of nitrogen, particularly during drought stress at the vegetative stage, somewhat decreased the negative effects of drought stress on grain yield in corn (Modhej, Davoodi, & Behdarvandi, 2017).

In 2023, Presse reported through the Philippine Star that about 77% of the country's provinces experienced severe drought, with 292,000 hectares of rice and corn areas completely damaged. Drought is one of the major constraints limiting crop production worldwide (Farooq, Hussain, Wahid, & Siddique, 2012). Under drought stress, reduced nutrient availability is one of the most important factors limiting plant growth. Drought stress reduces nutrient uptake by the roots because the decline in soil moisture results in a decreased rate of diffusion of nutrients from the soil matrix to the absorbing root surface (Studer, Hu, & Schmidhalter, 2017). Drought accelerates leaf senescence, leading to a decrease in canopy size, loss of photosynthesis, and reduced yields (Rivero et al., 2007).

Aside from drought, constraints related to soil fertility seriously affect maize production (Gerpacio et al., 2004). One reason for the decrease in grain yield in corn is the mismanagement of plant nutrition, such as the rate and timing of nitrogen application (Sharifi & Namvar, 2016). Thus, water stress indices are useful tools for evaluating crop water status; however, consideration of other factors, such as nutrient status, must be taken into account for predicting crop growth and yield, as reduced nutrient availability is one of the major factors limiting plant growth under drought (Caroll, 2015; Studer et al., 2017).

Drought has a negative effect on plant growth and yield, especially during the vegetative stages leading to the flowering stage in sweet corn (Zhang, Lei, Lai, Zhao, & Song, 2018). The detrimental effect of drought can be mitigated by the application of nutrients, which may enhance a plant's ability to tolerate drought stress by increasing biomass for early growth vigor and establishment (Aslam et al., 2012; Studer et al., 2017).

Purple sweet corn, a variety valued for its nutritional and antioxidant properties, has not been extensively studied in the context of water stressors. It is therefore important to study the effects of varying drought durations, nitrogen levels, and timing of application on the growth and yield of purple sweet corn. The primary objective of this study is to determine the effect of nitrogen application and varying drought durations on the growth and yield of purple sweet corn to help farmers and future researchers optimize irrigation practices and nitrogen application timing, ultimately enhancing corn production.

2. MATERIALS AND METHODS

2.1. Location of the Study

The experiment took place in May 2018 at Benguet State University's Department of Agronomy Experimental Station greenhouse, located in La Trinidad, Benguet, Philippines. La Trinidad is a hilly area situated at 16.4544° N latitude and 120.5903° E longitude. The average temperature in May at La Trinidad ranged from approximately 15°C (59°F) to 24°C (75°F). This location offers a distinctive environment for agricultural research due to its altitude and milder climate, which markedly contrasts with the lowland regions of the Philippines.

2.2. Pot Preparation

Before initiating the experiment, thorough preparations were conducted in the greenhouse to create an ideal environment for the study. The area was cleaned to ensure a contamination-free setting. A total of 450 perforated plastic pots, each measuring 8 x 8 x 14 inches, were carefully filled with exactly 15 kg of soil. These pots were arranged into three replicates, with each replication containing 150 pots, ensuring consistency and precision in the experimental setup. The study focused on the Morado purple sweet corn variety, a high-yielding, early-maturing crop ready for harvest within 60 to 62 days after planting (DAP). This variety reduces the risk of lodging, has resistance to northern corn leaf blight, and possesses exceptional qualities, including larger ears and kernels that are sweet, smooth, and sticky. This setup provided an optimal framework for examining the growth and development of purple sweet corn under controlled environmental conditions.

2.3. Treatments and Experimental Design

The experiment employed a split-plot design with main plot factors focusing on nitrogen application levels and timing. Main plots included the levels and timing of nitrogen: NO FERT (no fertilizer), RR+OA (recommended rate at one-time application), RR+SA (recommended rate, split application), RR+50N+OA (recommended rate with 50% nitrogen in one-time application), and RR+50N+SA (recommended rate with 50% nitrogen in split application). Subplots were based on varying durations of drought stress during the sensitive stage of corn growth: D1 (10-day drought or 10 DD at 24-34 days after emergence), D2 (15-day drought at 24-39 days after emergence), and D3 (20-day drought at 24-44 days after emergence). After each drought period, the plants were re-watered, and subsequent observations and measurements were conducted to assess the impact of nitrogen application strategies and drought durations on corn growth and development.

2.4. Observation and Collection of Data

The data collected on growth parameters includes Plant Height (PH), where the initial height was measured from the base of the plant at ground level to the tip of the youngest shoot using a meter stick from ten sample plants one week after emergence. Final height was taken by measuring the height of ten sample plants two weeks before harvesting, from the base of the plant at ground level to the tassel tip using a meter stick. Leaf Area (LA) was determined for fully expanded and healthy sample leaves using the replica weight method, where the formula is: Leaf Area = Area of ordinary paper (cm^2) x Weight of replica (g) / Weight of ordinary paper (g). The total number of leaves per plant (TLP) was gathered after the flowering stage of ten sample plants per plot. Root Length (RL) was determined by measuring the length of the taproot after harvest using a meter stick. Root Weight (RW) was measured after subjection to drought. Moreover, the Percentage of Emergence (PE) was obtained by dividing the number of plants that emerged by the total number of seeds sown, then multiplied by 100. Days from sowing to emergence (DSE) was calculated by counting the number of days from sowing to the time when at least 50% of plants emerged per pot.

On the other hand, other parameters gathered are the yield and yield components, such as Ear Length (EL), measured from the point of attachment to the tip of the husked ear using ten randomly selected sample ears per treatment. Ear Weight (EW) was obtained by weighing all dehusked ear cobs from each treatment. Ear Diameter (ED) was measured using a Vernier caliper on ten sample ears. The total number of kernels per row (TKR) was determined by counting the kernels per row on the ear. The total number of kernel rows per ear (TNE) was gathered by counting the entire row of kernels per ear from ten samples per treatment at harvest time. The total weight of corn ears harvested per plant (TWE) was recorded. Chlorophyll content (CC) was measured at the base, middle, and tip of the 6th leaf of each plant before and after drought stress using a chlorophyll meter (SPAD meter). Drought scores (DS) were taken on the last day of drought duration per treatment. Visual scores were based on leaf wilting and the visual condition of the canopy, using a scoring system based on the CIP rating scale, as shown in Table 1. Recovery ratings (RR) were assessed after watering, and the recovery rating was presented in Table 2.

Table 1. The drought score and recovery rating of corn plants.

Score	DS description	RR description
1	No stress	No recovery
3	30% of the leaves wilted	30% of the leaves will be able to recover
5	50% of the leaves wilted	50% of the leaves will be able to recover
7	80% of the leaves wilted	80% of the leaves will be able to recover
9	Complete wilting and death of the plants	Complete recovery of the plants

Note: The drought score (DS) for plants was based on leaf wilting and the visual condition of the canopy. The scoring system utilized the CIP rating scale. The recovery rating (RR) was assessed after the plants were watered and left for 24 hours, using the specified scale Tad-Awan and Jose (2008).

Table 2. The growth performance of sweet corn in terms of plant height, leaf area, total number of leaves per plant, root length, root weight, days from sowing, tasseling, and maturity under varying drought durations and nitrogen applications.

Factors	PH (cm) 8DAE	PH (cm) 81 DAE	LA before (cm2/Plant)	LA after (cm2/Plant)	TLP	RL (cm)	RW (g)
Fertilizer (F)							
NO FERT	17.13 ± 4.14	150.30 ± 13.92	63.91±6.88^{b}	217.11±60.68^{c}	12.28±0.04	33.72±1.06	46.86±1.39
RR+OA	17.61 ± 4.25	145.42 ± 13.47	76.39±5.60^{a}	267.86±9.93^{bc}	12.03±0.29	34.08±0.70	45.71±2.54
RR+SA	16.39 ± 3.90	157.96 ± 14.63	76.30 ±5.51^{a}	296.48±18.69^{ab}	12.5±0.18	34.55±0.23	50.86±2.61
RR+50N+OA	16.08 ± 3.88	153.91 ± 14.23	71.32± 0.53^{ab}	342.45± 64.66^{a}	12.58±0.26	34.9±0.12	52.15±3.90
RR+50N+SA	16.54 ± 3.99	154.47 ± 14.27	66.05± 4.74^{ab}	265.06± 12.73^{bc}	12.23±0.09	36.67±1.89	45.68±2.57
Drought (D)							
10 DD	16.97 ± 3.95	171.97 ± 9.19^{a}	68.95±1.84	287.90 ±10.11^{a}	12.39±0.06	33.25±1.53	55.40±7.15^{a}
15 DD	16.52 ± 3.84	152.96 ± 8.18^{b}	73.45±2.66	283.37± 5.58^{a}	12.42±0.09	34.09±0.69	48.22±0.03^{b}
20 DD	16.76 ± 3.89	132.30 ± 7.08^{c}	69.98±0.81	262.10 ±15.69^{b}	12.17±0.16	37.01±2.23	41.14± 7.11^{c}

Note: No fertilizer (NO FERT), Recommended rate (RR), Split application (SA), 50% of N (50N), One-time application (OA), Day drought (DD), Days after emergence (DAE), Plant height (PH), Leaf area (LA), Total number of leaves per plant (TLP), Root length (RL), and Root weight (RW). The different factors are presented along with their respective standard deviations (SD) using the mean ± standard deviation, followed by different subscript letters (e.g., a, b, c, d) used to denote significant differences at a 5% probability level by LSD.

2.5. Data Analysis of the Study

In this study, quantitative data were rigorously analyzed using the Analysis of Variance (ANOVA) to compare means among all the factors and to determine if there are any statistically significant differences between the treatment means. The results were presented as mean values with their corresponding standard deviations (mean ± SD), providing a measure of data dispersion around the mean. To assess the significance of differences among the various treatment means, the Least Significant Difference (LSD) test was applied, with a significance threshold set at $p \leq 0.05$. This approach ensured a thorough examination of the data, allowing for the identification of statistically significant differences between treatments.

3. RESULTS AND DISCUSSION

3.1. Plant Height (PH)

The table illustrates the effects of varying drought durations (DD) and fertilizer applications on the PH of purple sweet corn at two different growth stages: 8 days after emergence (DAE) and 81 DAE. Generally, across different nitrogen applications such as no fertilizer (NO FERT), recommended rate + one-time application (RR+OA), recommended rate + split application (RR+SA), recommended rate + 50% nitrogen + one-time application (RR+50N+OA), and recommended rate + 50% nitrogen + split application (RR+50N+SA), there is a noticeable consistency in plant height at 8 DAE, ranging approximately between 16.08 ± 3.88 cm to 17.61 ± 4.25 cm. However, as the DD increases from 10 DD to 20 DD, significant variations in PH at 81 DAE emerge. Specifically, PH declines notably with prolonged drought, with values decreasing from 171.97 ± 9.19 cm (10 DD) to 132.30 ± 7.08 cm (20 DD). This indicates a clear negative impact of increasing DD on the final PH of purple sweet corn, highlighting the importance of water availability in sustaining optimal growth despite different nitrogen applications. The findings are in line with previous research, indicating that water deficit at the vegetative stage significantly reduces plant height, leaf size, stem extension, and root proliferation, disrupts plant water relations, and diminishes water-use efficiency (Farooq, Wahid, Kobayashi, Fujita, & Basra, 2009; Sah & Zamora, 2005). Reduced water potential in cells due to drought also hampers cell division and size, ultimately stunting plant growth (Nonami, 1998). These results emphasize the need for effective water management strategies to mitigate the adverse effects of drought on purple sweet corn, ensuring sustainable agricultural practices.

3.2. Leaf Area (LA) before and after Drought

Significant variations in leaf area (LA) were observed among sweet corn plants treated with different fertilizer application regimes and subjected to varying drought stress, as detailed in Table 2. The widest LA was observed in RR+OA with an amount of 76.39 ± 5.60 cm^2, followed by RR+SA with 76.30 ± 5.51 cm^2, while the lowest mean was revealed in NO FERT with 63.91 ± 6.88 cm^2. Right after the drought, LA surprisingly increased in RR+50N+OA with an LA of 342.45 ± 64.66 cm^2, which is significantly different from RR+OA, NO FERT, and RR+50N+SA, with results of 267.86 ± 9.93 cm^2, 217.11 ± 60.68 cm^2, and 265.06 ± 12.73 cm^2, respectively.

Notably, before subjecting the plants to drought duration (DD), the leaf area (LA) measurements showed that the plants in 15 DD had the highest mean LA of 73.45 ± 2.66 cm^2, while those subjected to 10 DD had the lowest mean LA of 68.95 ± 1.84 cm^2. However, ANOVA revealed that the differences were not statistically significant, suggesting that the initial LA was relatively uniform across the different DD treatments. After the DD, it was observed that there was a positive impact on LA. Corn subjected to 10 DD achieved the highest mean LA of 287.90 ± 10.11 cm^2, followed by those subjected to 15 DD with a mean LA of 283.37 ± 5.58 cm^2. In contrast, plants exposed to 20 DD showed the lowest mean LA at 262.10 ± 15.69 cm^2. These results highlight the significant effect of prolonged DD on leaf development in corn, demonstrating a clear decline in LA as the DD increased. Even though there is a detrimental effect of drought stress on leaf size, corn exhibits adaptive mechanisms such as reduced leaf expansion and succulent leaf traits to mitigate water loss, as observed in previous studies Farooq et al. (2009). The variations in LA observed across the treatments highlight the complex interplay between drought stress and plant physiology. Surprisingly, plants under moderate drought conditions (10 and 15 DD) showed higher LA compared to those under severe drought (20 DD), suggesting that corn can adapt to moderate drought stress. However, the reduced LA in plants subjected to 20 DD reflects the detrimental impact of extended drought on photosynthesis and overall productivity. These findings emphasize the resilience of corn under moderate drought conditions and its potential for improving water-use efficiency. By carefully managing drought durations, farmers could optimize growth and yield, enhancing stress tolerance and promoting sustainable agricultural practices, especially in regions with variable water availability.

3.3. Total Number of Leaves Per Plant (TLP)

The data presented in Table 2 reveal notable insights into the effects of different fertilizer applications and drought conditions on the total leaf production (TLP) of sweet corn. Among the fertilizer treatments, RR+50N+OA exhibited the highest mean TLP with 12.58 ± 0.26 leaves per plant, closely followed by RR+SA at 12.50 ± 0.18 leaves. In contrast, RR+OA showed the lowest mean TLP of 12.03 ± 0.29 leaves, suggesting that the combination of RR and 50N+OA may be particularly effective in promoting leaf production. However, the differences in TLP among the fertilizer treatments were relatively modest, indicating that while certain combinations might provide slight advantages, the overall leaf count remains relatively stable across the different fertilization strategies. Regarding drought conditions, the highest mean TLP was observed under 15 DD with 12.42 ± 0.09 leaves, while the lowest was at 20 DD with 12.17 ± 0.16 leaves. These findings suggest that although drought stress does influence leaf count, the effect is not drastic. The consistency in TLP across different drought conditions aligns with previous research by Zhang et al. (2018), which also noted a relatively stable leaf count under drought conditions compared to well-watered environments. This stability in TLP might be indicative of a certain level of resilience in sweet corn plants, which are able to maintain leaf production even under varying levels of drought stress. Overall, the results suggest that both nitrogen application and drought conditions have a limited impact on TLP after flowering in this study. While slight variations were observed in leaf production based on fertilizer type and drought duration, the lack of significant differences, as revealed by the ANOVA results, indicates that the total leaf count remains relatively stable. This stability could be beneficial in maintaining plant productivity under diverse environmental conditions.

3.4. Root Length (RL) and Root Weight (RW)

Table 2 shows that there were no significant differences (as ANOVA revealed) in RL and RW among the other treatments, with mean RL ranging from 33.72 ± 1.06 cm to 36.67 ± 1.89 cm and mean RW ranging from 45.68 ± 2.57 g to 52.15 ± 3.90 g. Despite the lack of statistical significance in RL and RW across treatments, the interaction effects presented in Figure 1 reveal noteworthy variations in RW. Moreover, the highest RW was observed in corn treated with RR+50N+SA under 10 DD, revealing a mean of 63.06 ± 14.81 g, followed by RR+OA – 10 DD (60.11 ± 11.86 g), RR+SA – 15 DD (58.60 ± 10.35 g), and RR+50N+OA – 10 DD (56.35 ± 8.10 g). Although these treatments did not exhibit significant differences from each other, they were significantly different from the RR+OA – 15 DD treatment, which had a much lower mean RW of 37.42 ± 10.83 g. The data suggest that specific combinations of fertilizer and DD can mitigate some of the adverse effects of drought on RW. For instance, the higher RW observed in plants treated with RR+50N+SA under 10 DD indicates that this combination is particularly effective in supporting root growth even under drought conditions. This is consistent with findings from Studer et al. (2017), which demonstrated that plants often enhance root biomass or increase root absorptive surface in response to drought stress. Enhanced root growth observed in this study may enable plants to better explore and absorb available water and nutrients from the soil, potentially improving their overall resilience and performance under drought conditions. These results are important for optimizing both fertilizer application and drought management practices to support root development and plant health. By strategically applying fertilizers and managing drought stress, it may be possible to enhance root growth and improve plant stability and productivity in challenging environmental conditions. Furthermore, while RL and RW showed no significant differences among treatments, the observed variations in RW, particularly the superior performance of certain treatments under drought conditions, provide valuable insights into how nutrient management and DD can influence root development.

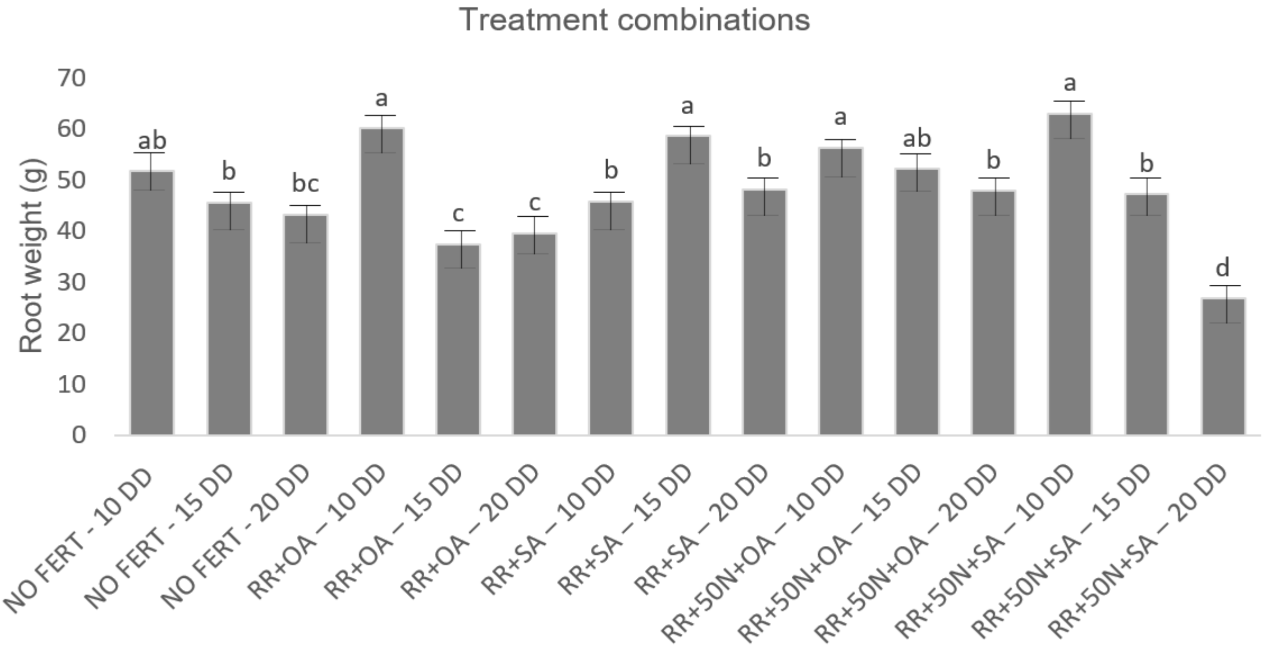

Figure 1. Analyze the interaction effect of the duration of drought, the amount, and the timing of fertilizer application on the growth of corn in terms of root weight (RW) in purple sweet corn.

Note: No fertilizer (NO FERT), Recommended rate (RR), Split application (SA), 50% of N (50N), One-time application (OA), Day drought (DD), Plant height (PH), Leaf area (LA), Total number of leaves per plant (TLP), Root length (RL), Root weight (RW), and "at" (-) are the different factors presented along with their respective standard deviations (SD) using the mean ± standard deviation. Different subscript letters (e.g., a, b, c, d) are used to denote significant differences at a 5% probability level by LSD.

3.5. Corn Ear Length (EL), Ear Weight (EW) and Ear Diameter (ED)

The table 3 showed the length, weight, and diameter of the ears of purple sweet corn under varying drought durations and nitrogen applications. The study revealed no significant differences in ear length (EL), ear weight (EW), and ear diameter (ED) among sweet corn plants treated with various fertilizer application strategies. In terms of ear length, plants receiving RR+SA exhibited the longest ears at 20.50 ± 1.20 cm, followed closely by those treated with RR+50N+OA (19.93 cm) and RR+50N+SA (19.64 ± 1.15 cm). Conversely, plants with no fertilizer had the lowest mean at 17.79 ± 0.52 cm. In terms of drought stress effects, significant differences were observed in ear length and root weight. Sweet corn plants subjected to 15 DD and 10 DD periods exhibited the longest ears, measuring 20.37 ± 0.03

cm and 19.56 ± 0.03 cm, respectively; however, there were no significant differences between these two different drought durations, but there was a significant difference compared to 20 DD, which had a mean of 18.01 ± 0.03 cm, representing the shortest ears.

Table 3. Length, weight, and diameter of the ear of purple sweet potato under varying drought durations and nitrogen applications.

Factors	EL (cm)	EW (g)	ED (cm)	TKR	TNE	TWE (g)
Fertilizer (F)						
NO FERT	17.79 ± 0.52	68.33± 6.39	3.55 ± 0.09	15.25 ± 2.74	2.56 ± 1.02^{b}	202.67 ± 87.17
RR+OA	17.81± 1.10	69.67 ± 13.09	3.60 ± 0.21	19.81 ± 3.56	3.22 ± 0.36^{b}	256.44 ± 33.04
RR+SA	20.50 ± 1.20	88.16 ± 16.57	3.90 ± 0.23	18.18 ± 3.26	4.56 ± 0.98^{a}	394.11 ± 104.27
RR+50N+OA	19.93 ± 1.23	71.03 ± 13.37	3.84 ± 0.23	16.44 ± 2.95	4.33 ± 0.75^{a}	314 ± 24.16
RR+50N+SA	19.64 ± 1.15	86.73± 16.29	3.87 ± 0.23	17.56 ± 3.15	3.22 ± 0.36^{b}	282 ± 7.84
Drought (D)						
10 DD	19.56 ± 0.03^{a}	77.62 ± 0.75^{ab}	3.80 ± 0.00	18.82 ± 3.36^{a}	4.33 ± 0.75^{a}	335.53 ± 45.69^{a}
15 DD	20.37 ± 0.03^{a}	84.84 ± 0.82^{a}	3.89 ± 0.00	18.10 ± 3.22^{a}	4.27 ± 0.69^{a}	367.53 ± 77.69^{a}
20 DD	18.01 ± 0.03^{b}	67.89 ± 0.66^{b}	3.56 ± 0.00	15.42 ± 2.75^{b}	2.13 ± 1.45^{b}	166.47 ± 123.37^{b}

Note: No fertilizer (NO FERT), Recommended rate (RR), Split application (SA), 50% of N (50N), One-time application (OA), Day drought (DD), Ear length (EL), Ear weight (EW), Ear diameter (ED), Total number of kernels per row (TKR), Total number of kernel rows per ear (TNE), and Total weight of corn ears harvested per plant (TWE). The different factors are presented along with their respective standard deviations (SD) using the mean ± standard deviation, followed by different subscript letters (e.g., a, b, c, d) used to denote significant differences at a 5% probability level by LSD.

Similarly, the heaviest ear weight (EW) was recorded in RR+SA (88.16 ± 16.57 g), followed by RR+50N+SA (86.73 ± 16.29 g), while the lowest was in the NO FERT treatment (68.33 ± 6.39 g), as shown in Table 3. However, the ANOVA results showed that there were no significant differences. Moreover, in terms of drought duration (DD), the heaviest ears were recorded in plants subjected to 15 DD (84.84 ± 0.82 g), closely followed by those in 10 DD (77.62 ± 0.75 g), while the lightest ears (67.89 ± 0.66 g) occurred in plants enduring 20 DD. Surprisingly, ANOVA revealed that significant differences were found in EW across different drought durations.

Furthermore, in terms of ear diameter (ED), the highest mean among the various nitrogen applications was found in RR+SA (3.90 ± 0.23 cm), closely followed by RR+50N+SA (3.87 ± 0.23 cm) and RR+50N+OA (3.84 ± 0.23 cm), while the lowest mean was in the NO FERT treatment, with a mean of 3.55 ± 0.09 cm. When considering drought durations, the highest mean ED was found in the 15 DD treatment, with 3.89 ± 0.00 cm, and the lowest in the 20 DD treatment, with a mean of 3.56 ± 0.00 cm. However, ANOVA results indicated no significant differences among all these factors. This suggests that while certain nitrogen applications and DD may lead to variations in ED, these differences are not statistically significant, and the combined effects of nitrogen application and drought stress do not significantly impact ED in sweet corn.

Overall, while specific nitrogen application strategies and DD led to variations in ear characteristics, these differences were generally not significant for ear length (EL) and ED, though significant differences were noted for EW under drought conditions. These findings suggest that while fertilizer application may influence EL and EW, drought stress (DS) has a more pronounced effect on ear weight, particularly under severe drought conditions. The stability in ear length and diameter across treatments indicates that these attributes might be less sensitive to variations in fertilizer application and DS compared to EW.

3.6. Total Number of Kernels per Row (TKR) and Total Number of Kernel Rows per Ear (TNE)

In Table 3, the highest total kernel row (TKR) count in response to nitrogen application was observed in the RR+OA treatment, with a mean of 19.81 ± 3.56 counts, while the lowest was in the NO FERT treatment, with a mean of 15.25 ± 2.74 counts. However, ANOVA revealed no significant differences among the nitrogen treatments. In contrast, significant differences were observed in TKR in response to varying durations of drought stress. Plants subjected to 10 DD and 15 DD periods had the highest counts, with 18.82 ± 3.36 counts and 18.10 ± 3.22 counts, respectively, whereas those exposed to 20 DD had fewer kernels per row at 15.42 ± 2.75 counts.

For the total number of ears (TNE), based on the ANOVA, significant differences were found for both nitrogen application and drought durations. Among the nitrogen applications, RR+SA had the highest mean TNE of 4.56 ± 0.98 counts, followed closely by RR+50N+OA, also with 4.56 ± 0.98 counts, while the lowest was in the NO FERT treatment, with a mean of 2.56 ± 1.02 counts. Regarding drought durations, 10 DD resulted in the highest mean TNE of 4.33 ± 0.75 counts, while the lowest was 20 DD, with a mean of 2.13 ± 1.45 counts.

3.7. Total Weight of Corn Ears Harvested per Plant (TWE)

In Table 4, the fertilizer treatment RR+SA had the highest mean TWE (total weight estimate) at 394.11 ± 104.27 g, followed by RR+50N+OA with a mean of 314 ± 24.16 g. The lowest mean TWE was observed in the NO FERT treatment, with a mean of 202.67 ± 87.17 g. However, ANOVA revealed no significant differences among these treatments. Similarly, Tarighaleslami et al. (2012) reported that increased nitrogen levels significantly affected grain yield, with the highest yield at 180 kg/ha of nitrogen and the lowest at 80 kg/ha. In contrast, during the DD (drying duration) treatments, ANOVA revealed significant differences. The 10 DD and 15 DD treatments had significantly higher mean TWE values of 367.53 ± 77.69 g and 335.53 ± 45.69 g, respectively, compared to the 20 DD treatment, which had a mean TWE of 166.47 ± 123.37 g.

Table 4. The chlorophyll content, drought score, and recovery rating of purple sweet corn.

Factors	CC (Before)	CC (After)	DS	RR
Fertilizer (F)				
NO FERT	45.31 ± 0.50^{ab}	44.17 ± 0.71^{b}	5.00 ± 0.14	7.00 ± 0.12
RR+OA	44.09 ± 0.72^{bc}	43.19 ± 1.69^{b}	5.00 ± 0.14	7.00 ± 0.12
RR+SA	45.40 ± 0.59^{ab}	47.31 ± 2.43^{a}	5.00 ± 0.14	7.00 ± 0.12
RR+50N+OA	45.57 ± 0.76^{a}	44.97 ± 0.09^{ab}	5.00 ± 0.14	7.00 ± 0.12
RR+50N+SA	43.67 ± 1.14^{c}	44.77 ± 0.11^{b}	5.00 ± 0.14	7.00 ± 0.12
Drought (D)				
10 DD	44.49±0.32	46.17 ± 1.29^{a}	3.00 ± 0.08^{c}	9.00 ± 0.16^{a}
15 DD	44.92±0.11	46.29 ± 1.41^{a}	4.87 ± 0.14^{b}	7.13 ± 0.13^{b}
20 DD	45.02 ± 0.21	42.18 ± 2.70^{b}	7.00 ± 0.12^{a}	5.00 ± 0.09^{c}

Note: NO FERT = No fertilizer, RR = Recommended rate, SA = Split application, 50N = 50% of N, OA = One-time application, DD = Day drought, CC = Chlorophyll Content, DS = Drought score, RR = Recovery rating. The different factors are presented along with their respective standard deviations (SD) using the mean ± standard deviation, followed by different subscript letters (e.g., a, b, c, d) used to denote significant differences at a 5% probability level by LSD.

3.8. Chlorophyll Content Before and After Drought Stress (CC)

In Table 4, ANOVA revealed that significant differences in chlorophyll content (CC) were observed before and after drought, influenced by the level and timing of nitrogen application. Before drought imposition, plants treated with RR+50N+OA had the highest CC at 45.57 ± 0.76, while those treated with RR+50N+SA during planting had the lowest CC at 43.67 ± 1.14. After drought imposition, plants treated with RR+SA and RR+50N+OA had comparable CC values of 47.31 ± 2.43 and 44.97 ± 0.09, respectively. Modhej et al. (2017) Reported that increased nitrogen application significantly boosts chlorophyll content. The highest reduction in chlorophyll content under drought conditions was observed in treatments with lower nitrogen (100 N kg ha^{-1}), while the lowest reduction was seen in treatments with 200 N per hectare. Table 4 also shows a significant reduction in chlorophyll content after drought imposition compared to before drought. However, sweet corn subjected to 10 DD and 15 DD maintained the highest chlorophyll content at 46.29 ± 1.41 and 46.17 ± 1.29, respectively. A significant reduction in chlorophyll content was observed in sweet corn subjected to 20 DD, with a mean of 42.18 ± 2.70.

3.9. Drought Score (DS) and Recovery Rating (RR)

Table 4 presents detailed observations on the drought stress (DS) and recovery rates (RR) of sweet corn plants subjected to various fertilizer treatments and drought durations. Plants treated with NO FERT, RR+OA, RR+SA, RR+50N+OA, and RR+50N+SA exhibited similar DS and RR, with a mean DS of 5.00 ± 0.14 (approximately 50% of leaves wilting) and a mean RR of 7.00 ± 0.12 (indicating that 80% of leaves recovered after 24 hours). These results suggest that varying levels and timing of nitrogen application did not significantly impact DS and RR. In contrast, plants subjected to a 20-day drought (20 DD) showed the highest number of wilted leaves, with a mean DS of 7.00 ± 0.12, affecting 80% of the plant population, and the lowest RR, with a mean of 3.00 ± 0.08, meaning that only 50% of the plant population could recover after 24 hours. Conversely, plants subjected to a 15-day drought (15 DD) had the fewest wilted leaves, with a mean DS of 4.87 ± 0.14, or about 30% of the plant population affected. The 10-day drought (10 DD) treatment exhibited the highest recovery rate, with a mean RR of 9.00 ± 0.16, indicating that 90% of the plant leaves recovered. ANOVA results confirmed that DS and RR were significantly different among the drought duration treatments, highlighting the substantial impact of drought duration on plant stress and recovery.

4. CONCLUSIONS

Plants treated with RR+50N+OA and RR+50N+SA represent the optimal level and timing of nitrogen application when corn plants are subjected to drought stress (DD) during the vegetative stage. Drought stress adversely affected various morphological and physiological attributes of corn plants. Prolonged exposure to DD resulted in more detrimental effects on the growth and yield of corn, including plant height, leaf area, chlorophyll content, root weight, the number and weight of corn ears harvested, and the number of kernels per row. A significant interaction effect between DD and nitrogen application was observed only on the corn root weight. Based on the results, it is recommended to apply the recommended rate of fertilizer along with an additional 50% in a single application, as well as the recommended rate with split applications of nitrogen when corn plants are exposed to drought during the vegetative stage. Additionally, it is advisable to provide supplemental irrigation during the 6th leaf stage of corn, as prolonged drought during this period significantly impacts most growth and yield parameters of sweet corn.

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