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Effect of different salt concentrations on the germination and early seedling growth of sorghum in laboratory conditions

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Abstract

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Salinity in soil is a major abiotic stress affecting crop productivity, especially in arid and semi-arid regions like Uzbekistan. This study investigates the salinity tolerance of two sorghum varieties, Toshkent oq donlisi and Massino, under controlled salinity gradients (0, 50, 100, 150, 200, and 250 mM NaCl). Morpho-physiological traits including plant height, leaf number, fresh and dry biomass, and chlorophyll content were recorded. Various stress tolerance indices were calculated to assess the resilience of both varieties. Results showed that Massino exhibited higher overall salinity tolerance, while Toshkent oq donlisi demonstrated moderate resilience at 100 mM salinity. These findings suggest varietal differences in salinity adaptation and provide valuable insights for crop selection in salt-affected areas.

Keywords: sorghum; soil salinity; salinity tolerance indices; biomass; Uzbekistan

Introduction

Soil salinization is among the most pressing environmental challenges facing agricultural sustainability, particularly in arid and semi-arid regions such as Uzbekistan. In this region, soil salinity has emerged as one of the principal limiting factors for crop yield and overall productivity. High concentrations of soluble salts in the soil interfere with water uptake by plants, disrupt nutrient availability, and ultimately impair physiological and metabolic processes essential for plant growth and survival. These adverse effects manifest in various forms, including poor germination, stunted growth, leaf chlorosis, and in severe cases, plant mortality.

In Uzbekistan, elevated salinity levels are commonly observed in irrigated lands, where improper water management, inadequate drainage, and the rising water table contribute to salt accumulation near the root zone. This phenomenon is exacerbated by the natural geomorphology of the region and increasingly erratic climatic patterns. The influx of saline groundwater to the upper soil layers causes salts to concentrate at the surface, thereby creating toxic growing conditions for many staple crops. The depletion in both quantity and quality of irrigation water further amplifies this problem, threatening the viability of agriculture on dry lands (Khasanov and Sayidjakhon, 2023).

According to the Food and Agriculture Organization (2015), Central Asia accounts for approximately 20% of the world's saline agricultural land, representing around 211.7 million hectares of the global 1060.1 million hectares. Uzbekistan, along with Kazakhstan and Turkmenistan, is among the most severely affected countries. In many areas, poor drainage infrastructure, flat topography, and inefficient irrigation techniques have accelerated the pace of salinization. Under such circumstances, developing and identifying crop varieties that can tolerate or thrive under saline conditions is vital for ensuring food security and maintaining agricultural productivity.

Salinity adversely affects plant growth by disturbing osmotic balance and ion homeostasis (Parida and Das, 2005). High concentrations of NaCl can inhibit seed germination and restrict water absorption, thereby affecting turgor

pressure and photosynthetic capacity (Acosta-Motos et al., 2017). Furthermore, prolonged salt stress leads to ion toxicity, oxidative stress, and metabolic dysfunction (Flowers and Colmer, 2008). One of the most visible signs of salinity impact is the reduction in leaf area expansion and total biomass, making these reliable indicators in assessing salt tolerance.

Sorghum (*Sorghum bicolor* L. Moench) has garnered increasing interest as a resilient cereal crop due to its inherent tolerance to abiotic stresses, including drought and salinity (Abuslima et al., 2022). However, not all sorghum genotypes respond equally to salinity, and understanding varietal differences is critical for breeding and agricultural application. In a previous study conducted by Djumaniyazova and Latipova (2020), the germination and early seedling development of various sorghum species – *S. vulgare*, *S. durra*, *S. sudanense*, and *S. saccharatum*, were evaluated under different salinity levels. The results revealed that increasing salinity significantly reduced seed emergence rates and root and shoot growth. Similarly, Djumaniyazova et al. (2022) reported that winter wheat varieties such as Chillaki, Tanya, and Yaksart showed variable tolerance to salinity stress during germination and early vegetative stages.

Given this context, the present study aims to evaluate and compare the salinity tolerance of two sorghum varieties Toshkent oq donlisi and Massino under controlled salt stress conditions. The focus is on analyzing their morpho-physiological responses during the seedling stage, including parameters such as leaf number, leaf area, blade length, biomass (fresh and dry), and chlorophyll content. The study also includes the calculation of salt tolerance indices to quantify and compare their adaptive capacity.

Preliminary observations from past studies have indicated that *S. bicolor* exhibits a more pronounced reduction in leaf number, leaf area, and biomass under salinity stress compared to *S. halepense*, largely due to higher accumulation of NaCl in its tissues. These physiological markers serve as vital criteria in evaluating varietal responses to salinity, particularly at the seedling stage when plants are most vulnerable (Amombo et al., 2022).

Thus, the overarching goal of this research is to identify which of the two sorghum varieties demonstrates superior adaptability to saline environments, thereby contributing valuable insights for salinity management and varietal improvement in regions facing increasing soil degradation.

Materials and Methods

This study was conducted to assess the salinity tolerance of two sorghum (Sorghum bicolor) varieties: Toshkent oq donlisi and Massino. Seeds of both varieties were collected from experimental fields located in the Khorezm region of Uzbekistan. Toshkent oq donlisi is a cultivar developed by the Research Institute of Animal Husbandry of Uzbekistan (UzChITI), while Massino originates from the Corn Selection and Seed Breeding Experimental Station. The seeds were subjected to a thorough pre-treatment process: 300 seeds of each variety were hand-counted and verified using an electronic seed counter. Prior to planting, seeds were washed three times with tap water and soaked in distilled water for 24 hours to initiate germination.

After pre-treatment, the seeds were germinated under ambient laboratory conditions. The most vigorous 144 seeds of each variety (288 in total) were selected based on visual inspection of radicle and plumule emergence. These seeds were then planted on June 9 in a completely randomized design using 36 plastic pots (18 for each variety), each containing four seedlings. The experimental setup consisted of six salinity treatments: 0 mM (control), 50 mM, 100 mM, 150 mM, 200 mM, and 250 mM NaCl. Each treatment was replicated three times for each variety, resulting in 18 pots per genotype.

Each pot was filled with 1 500 grams of dry sand-loam soil, previously sterilized and homogenized to ensure uniform texture and nutrient content. Pots were placed outdoors under natural environmental conditions and arranged on benches to avoid waterlogging. A shading cloth was installed to prevent direct solar radiation and minimize heat stress while allowing sufficient light for photosynthesis. To ensure accurate monitoring, each seedling was planted in a specific quadrant of the pot, and its position was recorded to facilitate daily measurements.

The salinity gradient consisted of 0 mM (control), 50 mM, 100 mM, 150 mM, 200 mM, and 250 mM NaCl (Table 1). Three replications under the same salt concentration were grouped together.

Table 1. Salt gradient setting and number of plants

Salinity solutions	Number of pots	Plant per pot
0 mM (Control)	3	4
50 mM	3	4
100 mM	3	4
150 mM	3	4
200 mM	3	4
250 mM	3	4

Source: Authors' own elaboration

Plant maintenance and salinity treatment

The seedlings were irrigated daily with 150 ml of distilled water during the initial establishment phase, lasting for ten days post-sowing. Around 5 days after sowing (DAS), the seedlings began to show visible signs of growth. At 10 DAS, a balanced nutrient solution containing nitrogen (N),

phosphorus (P), and potassium (K) in a 15:15:15 ratio (15 g per 3.8 L of water) was applied to all pots to support uniform development.

Chlorophyll content was measured at 17 DAS using a SPAD-502 chlorophyll meter (Minolta, Japan). Measurements were taken from the middle portion of the uppermost fully expanded leaf from four randomly selected plants per pot. These SPAD values were used as a proxy for leaf nitrogen status and photosynthetic potential.

Salinity stress was introduced at 18 DAS. Saline solutions were prepared using analytical-grade sodium chloride (NaCl) and applied gradually to the soil to reach final concentrations of 50, 100, 150, 200, and 250 mM NaCl, while the control group continued receiving distilled water. Each treatment continued for ten days. During the treatment period, soil moisture was maintained by adjusting irrigation volume and frequency to ensure consistency.

Growth and morphological measurements

At 27 DAS, several morphological and physiological parameters were recorded for each plant. These included:

- **Plant height (Lp)**: measured from the soil surface to the tip of the highest leaf;
- **Root length (Lr)**: measured after carefully removing the plant from soil;
- **Leaf blade length (Lb)**: average length of the three uppermost leaves;
- **Number of leaves per plant (Nl)**: leaves were counted for each plant**;**
- **Fresh and dry weight of leaves and shoots (AGB)**: leaves and stems were separated, weighed immediately for fresh mass, then oven-dried at 70°C for 72 hours before being reweighed to determine dry mass;
- **SPAD meter measurement** top fully expanded leaves middle part measured with chlorophyll meter SPAD to determine leaf chlorophyll content.

Salinity Tolerance Indices

Salinity Tolerance Indices (STIs) are critical numerical tools used to evaluate the ability of plant genotypes to withstand saline conditions, which are a growing concern in agricultural systems globally. Salinity refers to the accumulation of soluble salts in soil or water, and it can drastically hinder plant growth, reduce yield, and even cause plant death. High salt concentrations disrupt the osmotic balance within plant cells, impair nutrient uptake, and induce physiological stress, all of which compromise crop productivity.

The STI serves as a quantitative measure to determine the resilience of a plant variety to salt stress. Typically, STI is expressed as either a percentage or a numerical score, with higher values indicating superior salt tolerance. This index is calculated using several physiological and morphological parameters, such as seedling dry weight, growth rate, chlorophyll content, above-ground biomass (AGB), and overall plant survival under both normal and saline environments (Ashraf et al., 2008).

The formula to compute STI is:

$$STI = (Y_p \times Y_s)/(\bar{Y}_p)^2,$$

where Y_p is the average seedling dry weight of a given genotype under non-stress conditions.
Y_s is the average seedling dry weight of the same genotype under saline conditions.
$\bar{Y}_p$ is the mean seedling dry weight of all genotypes under non-stress conditions.

In addition to the Stress Tolerance Index (STI), several stress tolerance indices adapted from the methodology of Kausar et al. (2012) were used to evaluate the response of sorghum seedlings to salinity stress. The original physiological indices proposed by Kausar et al. (2012) were modified to correspond with the growth parameters measured in the present study, including plant height, above-ground biomass, blade length, leaf number and fresh leaf weight. The equations used are presented below.

$$Plant\ Height\ Stress\ Tolerance\ Index\ (PHSI) = \frac{Plant\ height\ of\ stressed\ plants}{Plant\ height\ of\ control\ plant} \times 100$$

$$AGB\ Fresh\ weight\ stress\ tolerance\ index\ (AGBFSI) = \frac{AGB\ fresh\ weigtht\ os\ stressed\ plants}{AGB\ fresh\ weitht\ of\ control\ plants} \times 100$$

$$AGB\ dry\ weight\ stress\ tolerance\ index(AGBDSI) = \frac{AGB\ dry\ weight\ of\ stressed\ plants}{AGB\ dry\ weight\ of\ control\ plants} \times 100$$

$$Blade\ Length\ Stress\ Tolerance\ Index\ (BLSI) = \frac{Blade\ length\ of\ stressed\ plants}{Blade\ length\ of\ control\ plants} \times 100$$

$$Number\ of\ Leaves\ Stress\ Tolerance\ Index\ (NLSI) = \frac{Number\ of\ leaves\ of\ stressed\ plants}{Number\ of\ leaves\ of\ control\ plants} \times 100$$

$$Fresh\ Leaf\ Weight\ Stress\ Tolerance\ Index\ (FLSI) = \frac{Fresh\ leaf\ weight\ of\ stressed\ plants}{Fresh\ leaf\ weight\ of\ control\ plants} \times 100$$

Statistical analysis

All data were subjected to two-way analysis of variance (ANOVA) using GraphPad Prism version 5.0 to determine the significance of treatment effects and interactions. Post hoc comparisons were conducted where appropriate using Tukey's HSD test at a significance level of $p < 0.05$.

Results and Discussion

The present study investigated the response of two sorghum varieties, Toshkent oq donlisi and Massino, to different levels of salt stress. The plants were evaluated under control, 150 mM, and 250 mM NaCl conditions over a four-week period. The analysis focused on several morphological and physiological traits, including plant height, number of leaves, blade length, final biomass, dry leaf weight, and SPAD values.

Figures 1 and 2 present the daily measurements of plant height (in cm) for two sorghum varieties, Toshkent oq donlisi and Massino, under three salinity conditions: control (0 mM NaCl), 150 mM, and 250 mM NaCl, across 4 weeks (from 5 to 25 DAS (days after sowing)).

For the Toshkent oq donlisi variety (Fig. 1), a clear variation in plant height was observed in response to increasing salinity. Under control conditions, the plant height gradually increased, reaching a maximum of approximately 15.8 cm by 24 DAS. In contrast, at 150 mM NaCl, the growth curve showed a moderate upward trend, with the height peaking just under 12 cm by 24 DAS. The most significant reduction in plant height was observed under 250 mM NaCl salinity, where the plants showed limited vertical growth and achieved only around 9 cm in height. The differences between the control and salt-treated plants became especially noticeable after 10 DAS, where the control plants consistently outperformed the salt-stressed ones. This suggests that Toshkent oq donlisi is particularly sensitive to salt stress, especially at higher concentrations.

In comparison, the Massino variety (Fig. 2) displayed more resilience under salinity stress. The plants grown under control conditions reached a height of approximately 21.5 cm, exhibiting a robust and consistent upward growth trend. At 150 mM salinity, Massino still managed to maintain moderate growth, peaking at around 15 cm. Even at the highest salinity treatment (250 mM), Massino demonstrated a better performance than Toshkent oq donlisi, with final plant height nearing 13 cm. Notably, plant height in Massino began to diverge clearly between salinity treatments around 8 DAS,

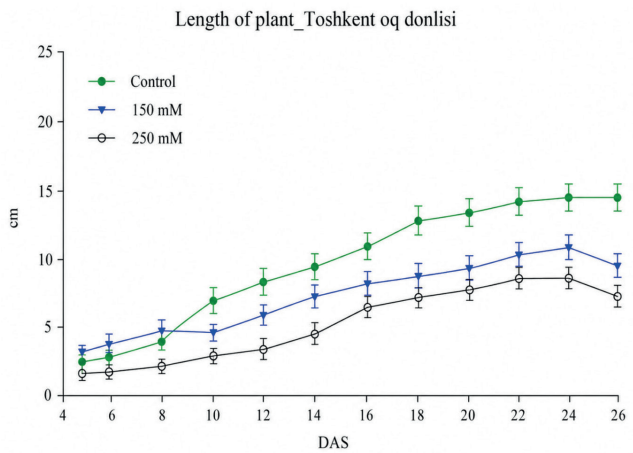


Fig. 1. Length of the plant measurement daily basis for Toshkent oq donlisi variety

Source: Authors' own elaboration

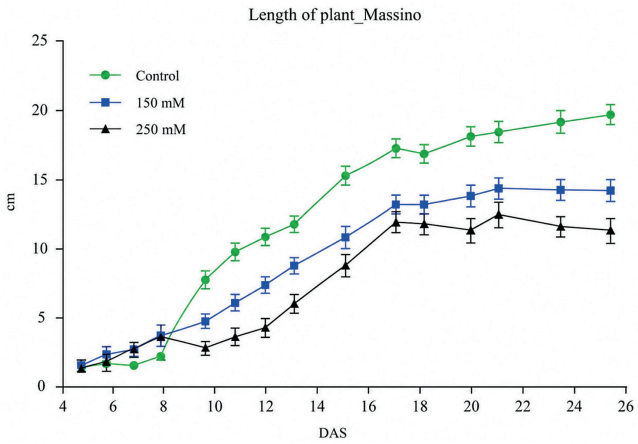


Fig. 2. Length of the plant measurement daily basis for Massino variety

Source: Authors' own elaboration

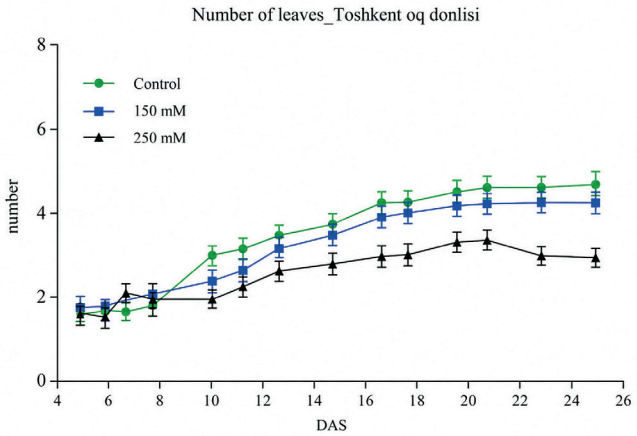


Fig. 3. The number of the leaves on a daily basis for Toshkent oq donlisi variety

Source: Authors' own elaboration

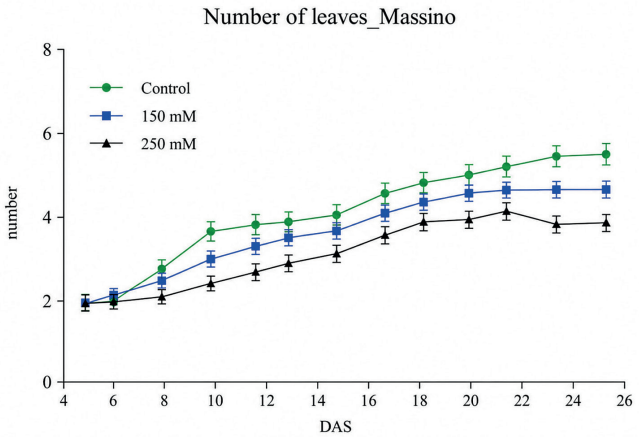


Fig. 4. The number of the leaves on a daily basis for Massino variety

Source: Authors' own elaboration

indicating that the salt stress effect manifested early but did not entirely inhibit growth.

Regarding the number of leaves, a similar trend was observed. As indicated in Figure 3, Toshkent oq donlisi showed a decrease in leaf number with increasing salinity, particularly at 250 mM, where leaf development stagnated. Meanwhile, Massino maintained a more consistent increase in leaf number even under stress conditions, although a slight decline was noted at 250 mM (Figure 4).

The visual response of the Toshkent oq donlisi variety to increasing salt concentrations is presented in Figure 5. Progressive reductions in plant vigor, leaf expansion, and root development were observed as salinity increased from 50 to 250 mM.

Figure 6 shows the morphological response of the Massino variety under different salt concentrations. Although plant growth gradually decreased with increasing salinity, the seedlings maintained relatively better growth than those exposed to the highest salt treatment.

At 50 mM salt concentration, the plants exhibited minor wilting of the lower leaves, whereas at 250 mM, severe wilting and leaf necrosis were observed.

Blade length is a sensitive indicator of salt stress. As shown in Figure 7, both varieties showed a declining trend in blade length with increasing salt concentration. In Massino,

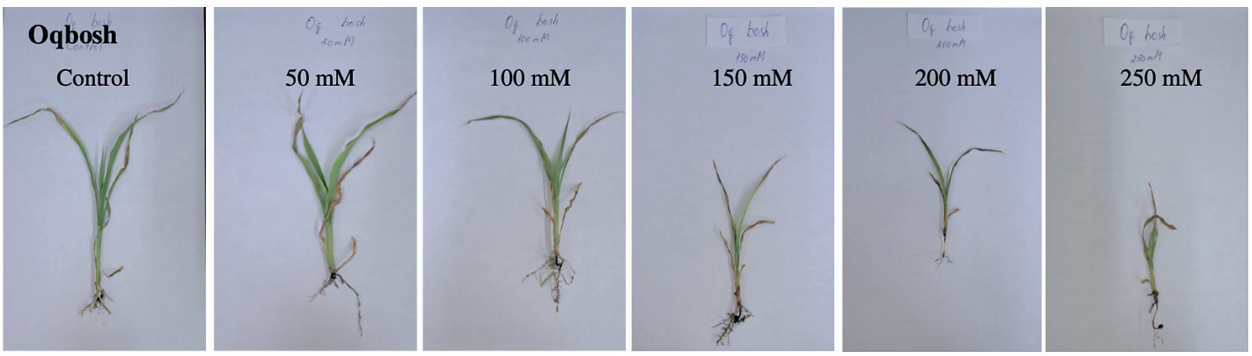


Fig. 5. Plant status of the Toshkent oq donlisi variety in different salt concentrations (control, 50 mM, 100 mM, 150 mM, 200 mM, 250 mM)

Source: Authors' own elaboration

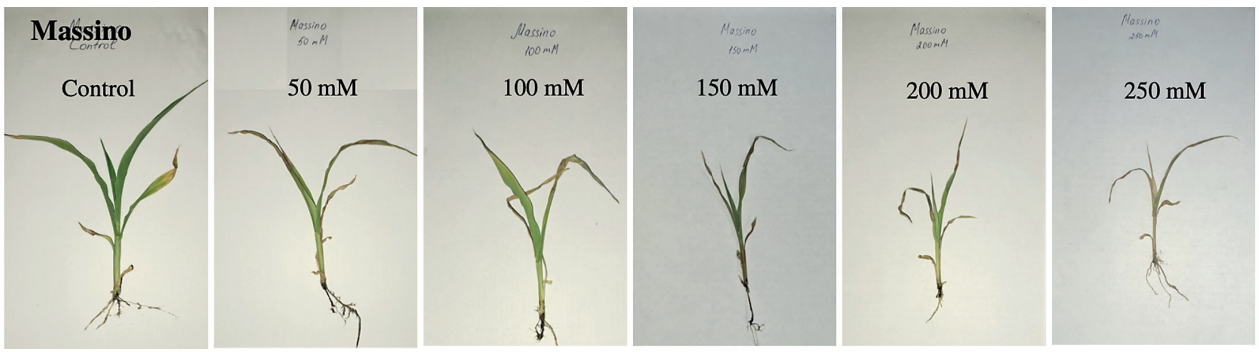


Fig. 6. Plant status of the Massino variety in different salt concentrations (0 mM (control), 50 mM, 100 mM, 150 mM, 200 mM, 250 mM)

Source: Authors' own elaboration

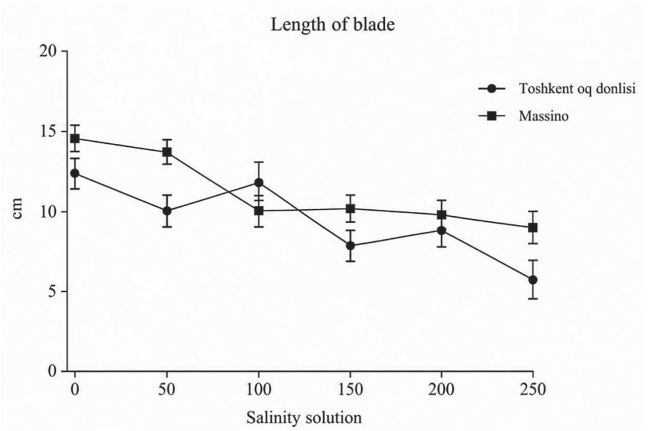


Fig. 7. The blade length of the two sorghum varieties
Source: Authors' own elaboration

blade length remained relatively stable at lower salt concentrations but declined steadily at 200 and 250 mM. In contrast, Toshkent oq donlisi displayed a more erratic response with a sharp decline at 250 mM. This suggests that leaf elongation is more sensitive in Toshkent oq donlisi and may serve as a useful visual marker for stress detection.

Final plant biomass (Figure 8) illustrates the total mass accumulation at 25 DAS. Control plants showed the highest biomass production for both varieties, with Massino producing nearly 0.26 g and Toshkent oq donlisi 0.12 g per plant. However, biomass dropped significantly with increased salinity, particularly at 150 mM and above. Notably, at 100 mM, Toshkent oq donlisi exhibited a slight biomass increase, which may indicate an adaptive physiological response at moderate stress.

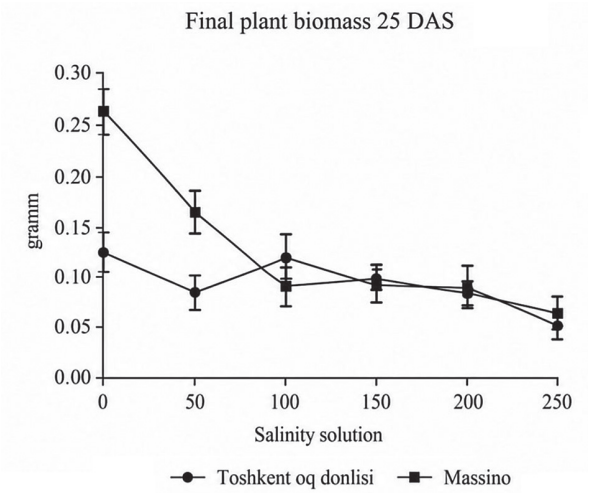


Fig. 8. Final plant biomass of the two sorghum varieties in different salt concentrations
Source: Authors' own elaboration

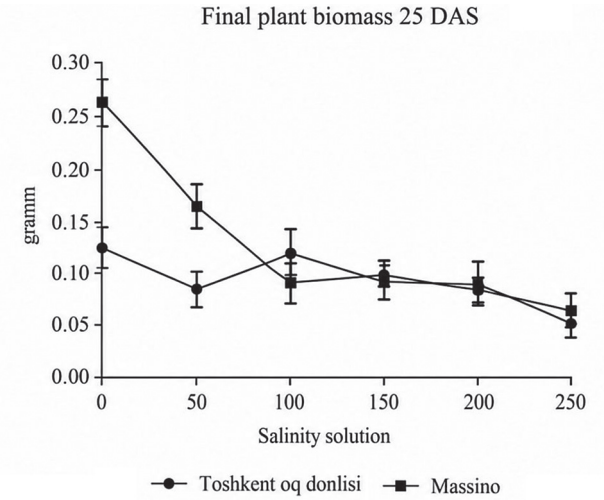


Fig. 9. The final weight of the dried leaves in two sorghum varieties
Source: Authors' own elaboration

The pattern in dry leaf weight (Figure 9) followed that of total biomass. Both varieties experienced a significant reduction in dry matter with higher salt concentrations. Massino showed a steady decline, whereas Toshkent oq donlisi demonstrated some fluctuation, especially at 100 mM, where dry weight briefly increased before decreasing again at higher concentrations. These observations reinforce the notion of variable salt response thresholds between the two varieties.

Figure 10 shows the SPAD index measurements, which reflect chlorophyll content and photosynthetic capacity (Netondo et al., 2004). Under salt stress, SPAD values in

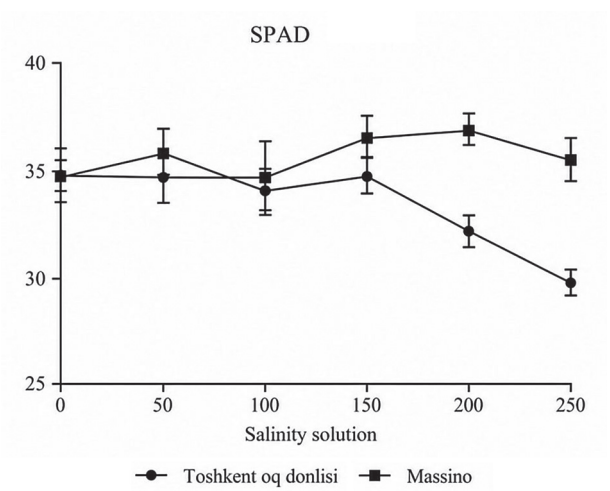


Fig. 10. The SPAD meter measurements of two sorghum varieties
Source: Authors' own elaboration

Toshkent oq donlisi declined significantly after 100 mM, indicating reduced chlorophyll synthesis and impaired photosynthetic machinery. In contrast, Massino maintained stable SPAD values up to 200 mM, after which a slight decline was observed. This implies better chlorophyll retention and possibly higher photosynthetic efficiency in Massino under stress.

As shown in Table 2, the Massino variety exhibited a significantly higher mean STI (0.783) compared to Toshkent oq donlisi (0.290). Across all salinity levels, Massino maintained higher STI values, indicating greater physiological resilience. Notably, Massino's STI at 50 mM was 1.142, while Toshkent oq donlisi dropped to 0.388. These findings highlight the better adaptation of Massino to saline environments, maintaining higher productivity potential.

According to Table 3, Toshkent oq donlisi slightly outperformed Massino with a higher mean PHSI (70.62 vs. 67.74), suggesting that this variety retained a relatively better plant height under salt stress. Both varieties showed a decline in PHSI with increasing salt concentration. At the 250 mM level, the values were nearly equal (Toshkent oq donlisi: 52.81; Massino: 52.08), indicating convergence of tolerance at higher salinity. The maximum difference was observed at 100 mM, where Toshkent oq donlisi showed a more robust height index.

Table 4 indicates that Toshkent oq donlisi again outperformed Massino with a higher average AGBFSI (48.49 vs. 43.83). At 50 mM NaCl, the AGBFSI for Toshkent oq donlisi was 74.96 compared to 63.95 for Massino, showing better retention of biomass under mild salt stress. However, both varieties demonstrated steep declines in fresh biomass with increasing salinity. At 250 mM, both dropped below 30%, reflecting severe stress on shoot biomass.

Table 5 illustrates that Toshkent oq donlisi maintained higher dry biomass under salinity conditions with a mean AGBDSI of 65.78, in contrast to 47.78 for Massino. This suggests that Toshkent oq donlisi has a better capacity to retain structural mass under stress, particularly from 50 to

Table 2. Salt tolerance index (STI) of two sorghum varieties in five salt levels

Sorghum varieties	Salt concentration (mmol dm^{-3})					Means	Ranking
	50	100	150	200	250		
Toshkent oq donlisi	0.388	0.318	0.283	0.247	0.212	0.290	2
Massino	1.142	0.854	0.710	0.692	0.517	0.783	1
Means	0.77	0.59	0.50	0.47	0.36		

Source: Authors' own elaboration

Table 3. Plant height stress tolerance index (PHSI) of 2 varieties of Sorghum

Sorghum varieties	Salt concentration (mmol dm^{-3})					Means	Ranking
	50	100	150	200	250		
Toshkent oq donlisi	90.32	85.62	63.78	60.56	52.81	70.62	1
Massino	88.89	72.10	66.26	59.37	52.08	67.74	2
Means	89.60	78.86	65.02	59.96	52.45		

Source: Authors' own elaboration

Table 4. AGB fresh weight stress tolerance index (AGBFSI) of 2 varieties of Sorghum

Sorghum varieties	Salt concentration (mmol dm^{-3})					Means	Ranking
	50	100	150	200	250		
Toshkent oq donlisi	74.96	58.06	40.67	42.33	26.46	48.49	1
Massino	63.95	47.79	39.76	38.73	28.94	43.83	2
Means	69.45	52.92	40.21	40.53	27.70		

Source: Authors' own elaboration

Table 5. AGB dry weight of stress tolerance index (AGBDWSI) of 2 varieties of Sorghum

Sorghum varieties	Salt concentration (mmol dm^{-3})					Means	Ranking
	50	100	150	200	250		
Toshkent oq donlisi	88.24	72.19	64.17	56.15	48.13	65.78	1
Massino	75.91	54.70	42.42	35.72	30.14	47.78	2
Means	82.07	63.45	53.29	45.94	39.13		

Source: Authors' own elaboration

Table 6. Fresh leaves weight stress tolerance index (FLWSI) of 2 varieties of Sorghum

Sorghum varieties	Salt concentration (mmol dm^{-3})					Means	Ranking
	50	100	150	200	250		
Toshkent oq donlisi	85.57	74.16	59.90	42.93	31.38	58.79	2
Massino	80.61	75.24	64.49	59.11	37.62	63.41	1
Means	80.61	74.70	62.19	51.02	34.50		

Source: Authors' own elaboration

Table 7. Dry leaves weight stress tolerance index (DLWSI) of 2 varieties of Sorghum

Sorghum varieties	Salt concentration (mmol dm^{-3})					Means	Ranking
	50	100	150	200	250		
Toshkent oq donlisi	88.98	85.04	80.16	56.69	39.11	69.99	1
Massino	78.61	57.80	29.57	32.64	23.12	44.35	2
Means	83.79	71.42	54.86	44.67	31.11		

Source: Authors' own elaboration

150 mM, where its indices were consistently above 60%. This aligns with the hypothesis that tolerance mechanisms in some varieties are better reflected in dry matter retention than in fresh biomass.

Interestingly, Massino showed greater tolerance in terms of fresh leaf weight (mean FLWSI = 63.41) compared to Toshkent oq donlisi (58.79), as shown in Table 6. At 150 mM, Massino retained 64.49% of its fresh leaf weight, while Toshkent oq donlisi dropped to 59.90%. This indicates a slightly better osmotic adjustment or water retention capability in Massino's leaf tissues, particularly under moderate salt levels (100–200 mM).

Table 7 reveals significant divergence in dry leaf weight response. Toshkent oq donlisi had a notably higher mean DLWSI (69.99) compared to Massino (44.35), with the differences being especially prominent at 100 mM and 150 mM. This indicates that despite having lower STI and FLWSI, Toshkent oq donlisi preserves more of its structural leaf components under stress, which may be beneficial for maintaining photosynthetic area over time.

Our findings revealed significant varietal differences in the response of sorghum to salinity stress, particularly in parameters such as plant height, leaf number, blade length, biomass, and SPAD values. Massino consistently demonstrated greater tolerance to higher salt concentrations (100–250 mM NaCl), maintaining higher biomass and growth performance, which aligns with previous studies reporting genotype-dependent salt tolerance in sorghum (Kafi et al., 2003).

In particular, our results on leaf number and height under salinity stress are in agreement with the study by Blum (2004), which showed that leaf area reduction is a common physiological response of sorghum under salt-induced osmotic stress. Moreover, Massino's resilience in maintaining chlorophyll content under salinity stress is comparable to findings by Netondo et al. (2004), who reported that salt-tolerant sorghum cultivars retain higher SPAD values under NaCl stress due to better osmotic adjustment and ion compartmentalization.

This is consistent with the findings of Kausar et al. (2012), who demonstrated that physiological stress tolerance indices are reliable tools for screening sorghum genotypes under saline conditions, and who highlighted that STI is a reliable indicator for screening salinity tolerance in cereals. Furthermore, the decline in dry leaf and total biomass under severe salinity conditions parallels the results of Krishnamurthy et al. (2007), who observed significant biomass loss in susceptible sorghum cultivars grown under salt stress exceeding 150 mM.

While Toshkent oq donlisi showed reduced performance at higher salinity levels, its moderate resilience at 100 mM NaCl suggests that this variety might still be suitable for moderately saline soils. Similar genotype-specific tolerances have been reported by Ali et al. (2014), where certain sorghum accessions showed differential tolerance depending on the salt threshold.

Overall, the comparative analysis with other research confirms that sorghum demonstrates high genotypic variability in salt stress response (Ali et al., 2014). This underscores the need for further breeding programs focusing on the physiological and molecular mechanisms that confer salinity tolerance (Munns and Gilliham, 2015).

Conclusion

This study demonstrated clear varietal differences in salinity tolerance between two sorghum varieties. Massino consistently showed better performance across key traits, such as plant height, leaf number, chlorophyll content, and

biomass, especially under moderate to high salinity levels (100–250 mM NaCl). In contrast, Toshkent oq donlisi exhibited moderate tolerance at lower salinity (≤ 100 mM), particularly in dry biomass and leaf elongation.

The results suggest that Massino is more suitable for cultivation in salt-affected regions due to its higher resilience and physiological stability. Toshkent oq donlisi, while more sensitive, may still be useful in moderately saline soils (Roy et al., 2014). Further research under field conditions and at later growth stages is recommended to confirm these findings and support breeding programs for salt-tolerant sorghum.

Conflict of interest

The authors declare no conflict of interest.

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