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Response of different Upland Cotton Genotypes under Salt Stress Conditions

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Abstract : Two year field experiment was conducted between 2021-2022 and 2022-2023 aimed to assess the effects of salt stress on seed cotton yield and boll weight in selected cotton genotypes. The results demonstrate a significant decrease in seed cotton yield and boll weight under salt stress conditions. Our observations indicate consistent seed cotton yield across most genotypes, while boll weight declines in cotton genotypes subjected to salt stress. Particularly noteworthy is the performance of genotype H 1529, which shows promise for seed cotton yield, while genotypes H 1491 and H 1529 exhibit potential for maintaining average boll weight under these conditions.

Key words: Salt stress, sodium, potassium, upland cotton, seed cotton yield.

The increasing global population and shrinking cultivable land present a significant threat to global agriculture (Shahbaz and Ashraf, 2013). Abiotic stresses contribute substantially to a 50 per cent decline in overall productivity. Salinity stress, a primary factor in reducing agricultural productivity and quality, occurs mainly due to the continuous natural build up of salts over time (including chlorine, sodium, calcium, magnesium, and sometimes sulfate and carbonate) in soil or surface water (Shahbaz and Ashraf, 2013). Conversely, human activities lead to secondary soil salinity by disrupting the soil's hydrological balance, impacting the equilibrium between water input (through irrigation or rainfall) and water uptake by crops (via transpiration) (Munns, 2005; Hasanuzzaman *et al.*, 2011). Salt stress exerts a significant effect on plant antioxidant-mediated metabolism and reactive oxygen species (ROS) levels (Choudhury *et al.*, 2013; Anjum *et al.*, 2015; Sehar *et al.*, 2019; Jahan *et al.*, 2020). ROS, such as Hydrogen peroxide, Singlet oxygen, and Hydroxyl radical, can induce cellular metabolic arrest by damaging lipids, proteins, and other macromolecules. Furthermore, salt stress can variably modify key constituents of the antioxidant defense system (Sehar *et al.*, 2019; Jahan *et al.*, 2020). The upsurge in ROS degrading enzymes and/or metabolites may potentially assist salt stressed plants in effectively scavenging various ROS and mitigating the adverse effects caused by their accumulation (Rasheed *et al.*, 2020). Additionally, increased soil salinity can influence the absorption and processing of various essential nutrients by plants, including calcium, potassium, nitrogen, phosphorus, and sulfur (Nazar *et al.*, 2011; Syeed *et al.*, 2011; Astolfi and Zuchi, 2013; Khan *et al.*, 2015).

MATERIALS AND METHODS

The study was conducted on 17 upland cotton genotypes at the cotton research area, CCS Haryana Agricultural University, Hisar. Sowing was done on May 10th, 2021 and May 5th, 2022 by manually dibbling method on the well-prepared saline with soil ECe ranged from 7-8.0 dSm-1 and pH 7.20-7.91plots with row to row spacing of 67.5 cm and plant to plant spacing of 30 cm. in a split plot design along with three replications.

All the recommended practices were

followed to raise a healthy crop. Data of yield attributing characters was recorded from each plot's five tagged plants, and each plot's seed cotton yield was recorded and converted into kilogram per hectare. Sodium and potassium were recorded using a flame photometer from leaves of cotton plant collected at the time of final picking.

The Sodium to Potassium ratio is calculated from the following formula:

$$\text{(Na/K) Ratio (mg/kg)} = \frac{\text{Concentration of Sodium (Na) in plant leaves}}{\text{Concentration of Potassium (K) in plant leaves}}$$

RESULTS AND DISCUSSION

The seed cotton yield varied significantly among the genotypes under conditions of salt stress. In 2022, the genotype H 1529 exhibited the highest seed cotton yield, succeeded by H 1531, H 1530, and H 1521. Meanwhile, in 2023, the genotype H 1530 showed the highest seed cotton yield, followed by H 1539, H 1547, H 1529, and H 1553 (Fig. 1). In 2022, genotype H1491 displayed the highest boll weight, while genotype H 1529 achieved the highest boll weight in 2023 represented in Fig. 2. In 2022, the genotype H 1529 exhibited the highest potassium-to-sodium ratio, followed by H 1531, H 1530, H 1521, and H 1098i. Similarly, in 2023, shown in Fig 3, genotype H 1529 maintained the highest potassium-to-sodium ratio, followed by H 1564, H 1491, H 1553, and H 1547.

In a study by El-Beltagi *et al.* (2017), the effects of potassium citrate (PC) and salicylic acid (SA) on cotton plants under salt stress were examined. The experimental design included watering plants with varying concentrations of seawater (12000, 8000, and 4000 ppm), subsequently alternating with normal water. The control treatment received only tap water irrigation. Results indicated a significant influence of salt concentration on yield-related traits, such as the number of flowers and bolls, weight of the boll, index of the seed, and cotton seed yield. Particularly at 12000 ppm, a decrease in yield characteristics was noted with increasing salt concentrations. In contrast, our study conducted over two years revealed that seed cotton yield remained relatively stable. This suggests that the salinity levels did not reach a critical threshold capable of significantly decreasing the cotton crop yield. The observed reduction in yield could be attributed to salinity's known ability to hinder the rate of photosynthetic CO2 assimilation. Salts accumulated within plant tissues raise osmotic potential, leading to a decrease in water potential caused by reduced stomatal conductance (Munns *et al.*, 2006). The decline in seed cotton yield could be associated with decreases in its constituents, such as the number of open bolls per plant, boll weight, and seed index (Namich *et al.*, 2007). The boll, or fruit, holds paramount importance in cotton production. Cotton bolls can vary in weight, ranging from under 3 grams to over 6 grams each. Approximately 60 per cent of this weight constitutes seeds, while the remaining portion is lint. This translates to 100,000-200,000 bolls/bale, or 200-400 bolls needed to produce 1 pound of lint. Approximately 60% of this weight constitutes seeds, while the remaining portion is lint. This translates to 100,000-200,000 bolls/bale, or 200-400 bolls needed to produce 1 pound of lint. The yield and quality of a cotton field can be indefinitely influenced by genetic, environmental, and cultural factors. Each cotton variety possesses a unique set of molecular templates that govern the initiation and duration of physiological processes crucial for boll growth and development. Elevated salt concentrations can disrupt the balance of potassium (K^+) and sodium (Na^+) ions within the cytoplasm, lowering the cytosolic K^+/Na^+ ratio (Guo *et al.*, 2020 Zhu, 2003). Excessive amounts of Na^+ and Cl^- can further exacerbate this imbalance, potentially causing a deficiency of Kz due to the

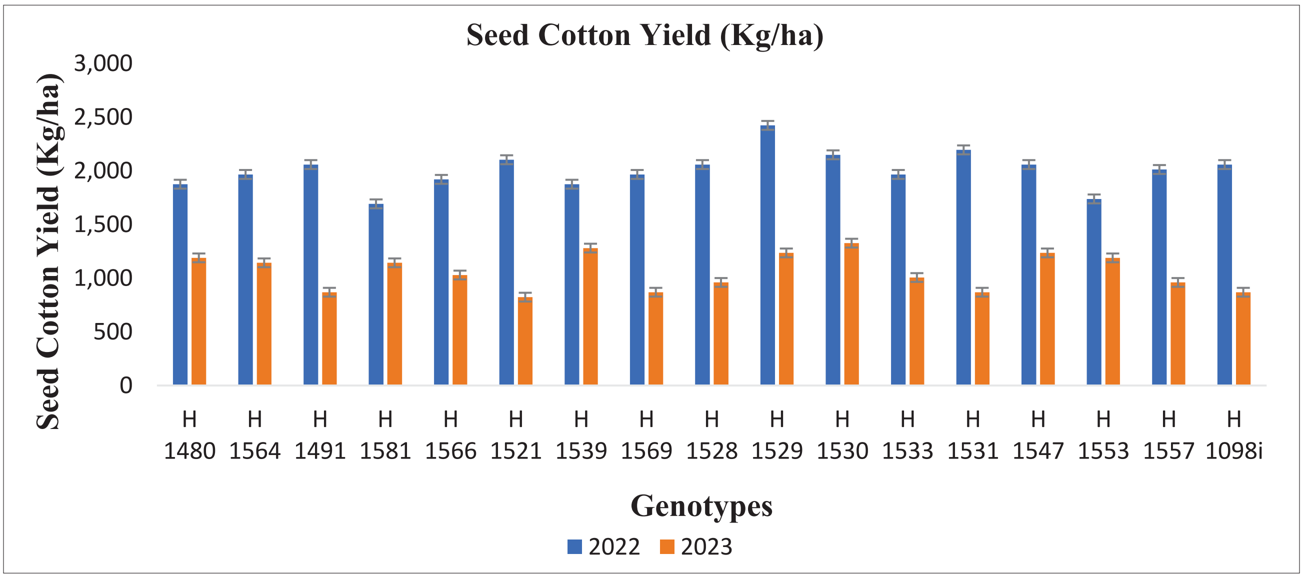

Fig. 1. Effect of drought stress on seed cotton yield of upland cotton

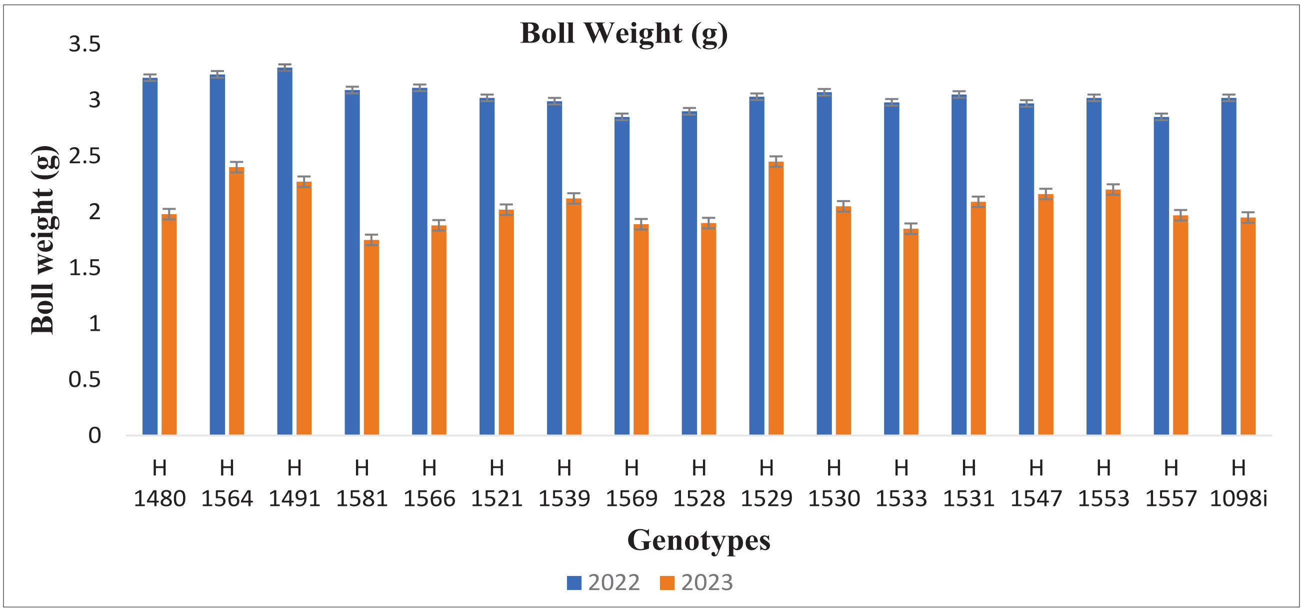

Fig. 2. Effect of drought stress on boll weight in upland cotton

compromised selectivity of root membranes. This disruption in ion balance can result in nutrient starvation, inhibition of enzyme activities, and the onset of ionic toxicity and oxidative stress. Ali *et al.* (2008) observed a higher K: Na ratio in the younger leaves of cultivar MNH-786 at 10 and 20 days after transplanting. This elevated K: Na ratio in younger leaves was interpreted as an indication of potassium re-absorption and translocation from the xylem. Addressing salinity is a critical factor in ensuring global food security, impacting over half of the nation's worldwide.

CONCLUSION

The yield and quality of a cotton field can be indefinitely influenced by genetic, environmental, and cultural factors. Each cotton variety possesses a unique set of molecular templates that govern the initiation and duration

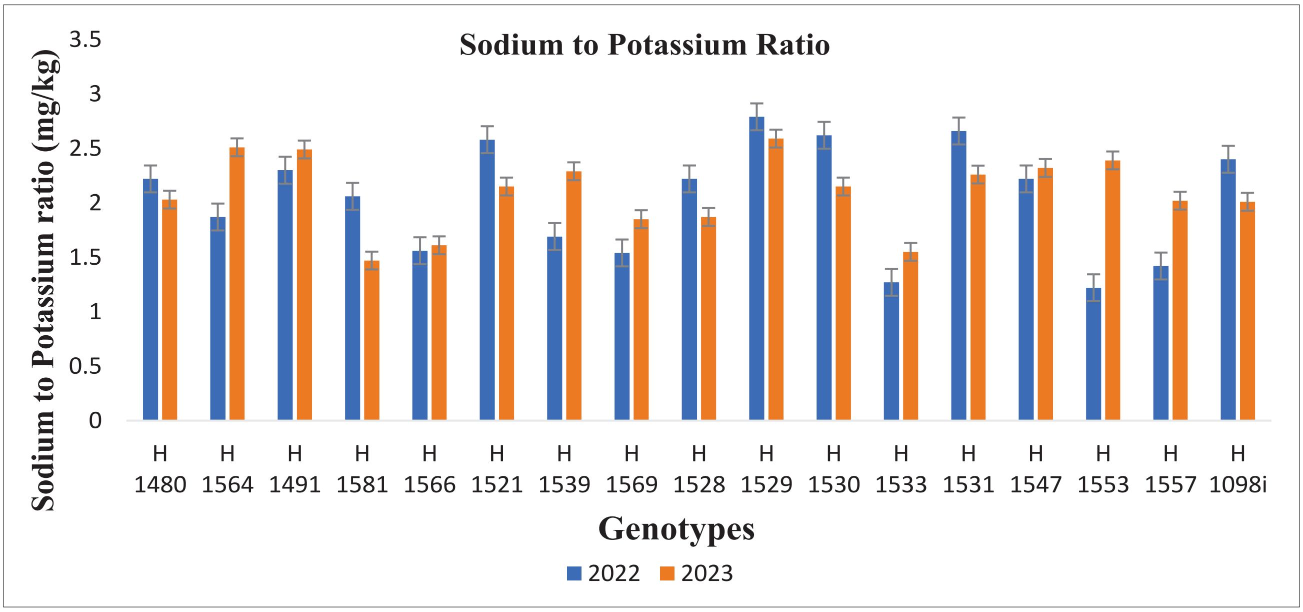

Fig. 3. Effect of drought stress on boll weight in upland cotton

of physiological processes crucial for boll growth and development. The boll, or fruit, holds paramount importance in cotton production. Cotton bolls can vary in weight, ranging from under 3 to over 6 grams each. A significant influence of salt concentration on yield related traits, such as the number of flowers and bolls, weight of the boll, index of the seed, and cotton seed yield has been observed. Elevated salt concentrations can disrupt the balance of potassium (K^+) and sodium (Na^+) ions within the cytoplasm, lowering the cytosolic K^+/Na^+ ratio. This disruption in ion balance can result in nutrient starvation, inhibition of enzyme activities, and the onset of ionic toxicity and oxidative stress. The detrimental effects of salt stress, including specific ion toxicity, induced water stress at the cellular level, and nutritional imbalances, adversely affect plant growth, development, and overall crop establishment. These effects extend to enzyme metabolism, nutrient absorption, and susceptibility to nutritional diseases, ultimately leading to reduced yields and compromised fiber quality in crops. To mitigate these challenges, the development of salt tolerant cotton cultivars emerges as a practical and strategic management approach for cotton cultivation under salt stress conditions. This effort aims to enhance the resilience of cotton plants, enabling them to thrive and maintain optimal productivity even in the presence of salinity-related challenges.

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