Dry matter and nitrogen accumulation of sweet corn (*Zea mays* var. *saccharatta* L.) under salt stress

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ABSTRACT

Sweet corn is popular among consumers due to its sweet taste, with 'Bonanza' being a variety widely cultivated by farmers in Madura. This research aimed to determine the dry matter and nitrogen accumulation in 'Bonanza' sweet corn under salt stress conditions. 'Bonanza' corn seedlings were grown in polybags containing a 1:1 mixture of soil and sand in a completely randomized design, with salt treatments of 0, 100, and 200 mM NaCl applied every two weeks. Each treatment was replicated eight times. Observed parameters included total plant weight, weight distribution of plant parts (roots, stems, leaves, tassels, ears, and seeds), percentage weight of plant parts, shoot/root ratio, and total nitrogen content in roots, stems, leaves, and seeds. Data were analyzed using one-way ANOVA followed by LSD post-hoc testing in SPSS 24. Results indicated that salt stress generally reduced total plant weight and the weights of individual plant parts. However, salt stress increased dry matter accumulation in leaves and stems, 2.5 and 8% respectively at a 100 mM increase in salt content, while decreasing it 11% in ear and 7.5% in seeds. Additionally, salt stress increased total nitrogen content in root, stems and leaves (average 2.6%) under but decreased in seeds (0.19%).

Keywords: accumulation, corn, dry, nitrogen, salt, dry, nitrogen,

INTRODUCTION

Salinity is an abiotic stress factor that greatly affects crop production in various areas, especially in arid and semi-arid areas. Soil salinity is the second factor causing soil degradation after erosion. Globally, daily salinity has caused a decrease in crop production in about 2000 cultivated fields, with a decline rate of 10-25% (Zaman and Heng, 2018). Indonesia is one of 100 countries that have problem of salinity (Pavulury, 2014). Madura is one of island in Indonesia that is affected by drought and salinity.

Corn is one of the cereal crops affected by salinity. Salinity decreased the ability of germination (Shtereva *et al.*, 2015), growth, and production (Dachlan *et al.*, 2013). The decreasing was related to physiological activities such as metabolism of nitrogen metabolism (Utama & Haryoko, 2020), sodium and potassium (Hoque *et al.*, 2015), proline, sugars and other antioxidant substances (Balkrishna & Shankarrao, 2013). Several genes have been known to be related to the mechanism of maize plant resistance to salinity e.g. SOS (Jiang *et al.*, 2018) and HKT (Bosnic *et al.*, 2018).

Sweet corn is widely preferred because of its sweet taste, short harvest time and more beneficial to farmers (Surtinah and Lidar, 2017; Surtinah, 2012). Bonanza, Golden Boy and Master sweet were known to be affected by salinity. Bonanza is more sensitive to salinity than other varieties (Sukma and Aini, 20023), although according to Nurdin *et al.*, (2023) it is more tolerant than sweet corn var. Golden Boy and var. Master Sweet. Salinity was decreased growth and production of those varieties, but its mechanism is not yet known. Understanding the mechanisms by its effect to dry matter accumulation could help to develop salinity tolerant varieties ad strategies to increase crop production. This research objectived was to determine the dry matter and nitrogen accumulation of Corn var. Bonanza under salt stress.

METHODS

Plant Material and Research Design

Corn seeds (var. 'Bonanza') were surface-sterilized in 2% (v/v) sodium hypochlorite (NaOCl) for 10 minutes, then rinsed thoroughly with distilled water before being germinated in distilled water. Seeds of similar size and weight were selected to ensure uniform germination rates. Five days after germination, 32 seedlings were transplanted into polybags filled with a 1:1 mixture of soil and sand. The experiment followed a completely randomized design with eight replications.

Plant Assays and Parameters

Seedlings were treated every two weeks with either distilled water (control, 0 mM NaCl) or salt solutions at concentrations of 100 mM and 200 mM NaCl. Measurements included total plant weight, as well as the weight of roots, stems, leaves, tassels, ears, and seeds. Additionally, total nitrogen content in the plants was analyzed using the Kjeldahl method.

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RESULT AND DISCUSSION

Dry Matter Accumulation

Salt stress reduced the dry weight of whole plant and all of the plant part (Table 1). It means that salt stress inhibit accumulation of plant biomass. The reducing was consistent with another research in another corn variety such as germination (Khayatnezhan and Gholamin, 2011), seedling (Hoque, 2011), production (Dahlan et al., 2015) and also callus stage in culture in-vitro (Sholihah and Saputro, 2016).

The reduction in dry weight, particularly in vegetatif (root, stem, leaf) and reproductive sructures (ear and seed) suggests that salt stress disrupts plant activity. When salt stress occurs, there is membrane instability and energy production, so metabolic processes such as photosynthesis and respiration are disrupted (Carillo et al., 2011). The plant's ability to absorb water from the soil is also reduced, leading to dehydration-like conditions, then reduce cell expansion and turgor pressure (Balasubramaniam et al. 2023). Salt stress also make accumulation of sodium (Na^+) and chloride (Cl^-) ions in plant tissues. Increasing of sodium content can decrease content of potassium, nitrogen, phosphorous, calcium, zinc and copper (Chakraborty et al., 2018). Those effects inhibit plant growth and survival (Carillo *et al.* 2011; Filippou *et al.* 2014; Abbasi *et al.* 2016).

Although salt stress affected dry matter accumulation in almost part of maize plant, but based on Table 2. it not change root/shoot ratio significantly, similar with Neto et al. (2004) that the shoot/root dry mass ratio did not relate to salt tolerance. While change of shoot/root ratio may not be statistically significant, it indicates a trend of greater dry matter accumulation to roots under salt stress. Zang et al. (2024) mention increasing of root/shoot ratio (means reducing shoot/root ratio) of two apples variety (*Malus haliana* and *Malus bacata*) was caused by salt stress. The reducing shoot/root ratio may related with adaptive strategy to enhance water and nutrient uptake under stress conditions, rather than a complete lack of impact on dry matter translocation (Amzeri et al. 2024; Arif et al. 2020).

Table 2 also showed that the weight percentage of vegetative (root, stem, and leaf) parts increased in salt stress, but decreased in reproductive parts. Its indicated that salt stress reduced nutritional translocation to reproductive parts. The reduction in different plant parts in salt stress might be related to reduction in chlorophyll and photosynthetic efficiency (Mohammad et al., 2021), lower stomatal conductance and lower uptake of nutrients from soil (Mondal *et al.* 2013; dos Santos et al., 2022). This reduced allocation can be linked to salt-induced osmotic stress, ion toxicity, and a reduction in photosynthetic efficiency, which together inhibit the plant's ability to transport essential nutrients, particularly to high-energy demanding reproductive organs.. Salt stress could make imbalance in nutrient translocation, leading to survival mechanisms rather than reproductive success. Accumulation of biomass in vegetative parts (root, stem and leaves) tend to maintain nutrient absorption, structural integrity and photosynthesis. The maintaining affected reproductive structure, receiving fewer nutrients and energy, resulting in a decrease in dry weight accumulation (Alhossini et al., 2013; Geshlagi et al., 2015).

Total Nitrogen Accumulation

Nitrogen is one of the mobile substances in plants and a constituent of structural and functional proteins. Table 3 shows, that under salt stress, the nitrogen content in the roots increase almost 100% compared with the control. The nitrogen content in leaves and stems also increases, while in seeds it decreases. Nitrogen allocation for each part of the plant percentage relative to whole plant) also showed an increase in the vegetative part (roots, stems and leaves) and showed a decrease in the reproductive part (seeds). Previous research showed that salt stress altered nitrogen uptake and translocation in different maize tissues (Turan *et al.* 2010). High N concentration in plant tissue under salt stress may related to NO3- translocation and increased synthesis of amino-N compounds (Demiral *et al.* 2017; Nazir et al., 2023; Jia et al., 2023).

Salt stress make plants tend to allocate more nitrogen to leaves to maintain metabolic activities that support stress adaptation, especially in photosynthesis and osmotic balance. Increased nitrogen in leaves will increase the production of chlorophyll which is important for the photosynthesis process. Photosynthesis is needed to provide the energy needed for various defense mechanisms such as the synthesis of osmolytes like amino acid proline, which stabilize cell turgor and protect cellular structures against the osmotic pressures caused by salt stress (Aslam et al., 2023; Zhang et al., 2023).

Table 1. Dry weight of corn plant and its part under salt stress

[NaCl] treatment (mM)	Weight (g)						
	whole plant	root	stem	leaf	tasel	ear	seed
0	169.40 b	22.85 a	52.13 b	22.48 b	3.01 a	71.39 b	39.78 b
100	154.03 b	20.36 a	50.9 b	17.83 b	2.93 a	56.36 b	30.4 b
200	105.03 a	15.44 a	30.38 a	12.83 a	2.21 a	26.13 a	9.58 a

Note: number followed by same letter on column, not significantly different on LSD 5%.

Table 2. Shoot/root ratio and plant part weight percentage under salt stress

[NaCl] treatment (mM)	shoot/root ratio	weight percentage to whole plant (%)					
		root	stem	leaf	tasel	ear	seed
0	6.25 a	0.13 a	0.30 a	0.12 a	0.018 a	0.43 b	0.24 b
100	6.67 a	0.13 a	0.37 ab	0.14 ab	0.019 a	0.34 b	0.18 b
200	5.88 a	0.14 a	0.46 b	0.17 b	0.021 a	0.21 a	0.09 a

Note: number followed by same letter on column, not significantly different on LSD 5%.

Table 3. Nitrogen total content in corn plant part under salt stress

[NaCl] treatment (mM)	Percentage of 1g dry matter (%)			
	root	stem	leaf	seed
0	0,11 a	0,27 a	0,19 a	0,31 c
100	0,22 b	0,30 a	0,61 b	0,18 b
200	0,21 b	0,31 a	0,69 b	0,08 a
	Percentage to Whole Plant			
0	1.48 a	8.31 a	2.52 a	0.55 c
100	2.91 b	10.04 b	8.65 b	0.34 a
200	3.09 b	11.92 b	13.16 c	0.17 b

Note: number followed by same letter on column, not significantly different on LSD 5%.

Nitrogen allocation to leaves also supports production of superoxide dismutase and catalase, which prevent oxidative damage (caused by reactive oxygen species), protecting cellular integrity and enhancing plant resilience (Martins et al., 2023). The allocation nitrogen to vegetatives show that plants should maintain growth and metabolic function although may limit reprodutive output and reduce production. But it is hoped that the seeds produced will be able to grow and develop in better condition (Yousuf & Frukh, 2022).

CONCLUSION

Overall, salt stress reduced the total weight and various parts of the Bonanza corn variety. Salt stress increased dry weight accumulation in the leaves and stems, while it decreased in the cobs and seeds. Total nitrogen content in the stems and leaves also increased under salt stress, whereas it decreased in the seeds.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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