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RESEARCH ARTICLE

Studies on the adaptive morphological seedling traits of Benisuif-5 durum wheat genotype in response to drought and salinity stresses

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Abstract

The present study was conducted to assess performance of Benisuif-5 durum wheat genotype to drought and NaCl stresses. Two factors with four regimes of each one had been applied, the first factor was drought regime with control and the second factor was NaCl regime. Seedling length, root numbers, seedling fresh weight, seedling dry weight, tissue water content (TWC), tolerance index and its reduction percentages were investigated under each factor. Benisuif-5 durum wheat responded well with mean values of studied traits were significantly decreased, which confirms by heatmap double dendogram cluster analysis. Hence, outcome of the research can be used in breeding programs because of depicting preliminary selection for the drought and salinity effects.

Keywords: Wheat, drought, NaCl, traits, performance

Introduction

Durum wheat (*Triticum durum*) is widely cultivated cereal crop in semi-arid areas (Ayed *et al.,* 2017 and Leal *et al.,* 2018). Its production facing several abiotic stresses such as, drought and salinity stresses that influenced plant growth by reducing cell elongation of plant cell (Sarto *et al.,* 2017; Duvnjak *et al*., 2023) During stem elongation drought and salinity stresses reduces elongation of cell expansion, that is related to changes in metabolism of some hormones (Litvin *et al.,* 2016). Tolerant plants induced dramatic morphological, biochemical, physiological, and molecular changes such as soluble sugars, proline and chlorophyll contents (Sallam *et al.,* 2019; Nardini, 2022) which are linked to complex genetic basis through plant development (Izanloo *et al.,* 2008) to regulate osmotic functions at tissue level (Shahinnia *et al.,* 2016; Jiang and Asami, 2018). Additionally, seedling shoot and root lengths and seedling fresh and dry weight are morphological traits that have been revealed adaptive response of plant toward abiotic stresses, and thus considered as potentially useful way for breeding purposes (Marti *et al.,* 2007). Thus, size, quantity, distribution, metabolism, and variation in activity of root system directly influence growth and development of above-ground tissues and eventually grain yield (Figueroa *et al.,* 2020). Hence, selection for drought and salinity at seedling stage displays quick, cheap and reliable pathways for resistance (Mohammadi, 2018). Therefore, the study was done to assess response of Benisuif-5 durum wheat genotype as tolerant genotype toward abiotic stresses at seedling stage, to identify adaptive seedling traits that have relationships to drought and salinity resistance.

Materials and methods

Grains of Benisuif-5 durum wheat genotype were surface sterilized by 5% aqueous sodium hypochlorite solution. Then rinsed with distilled water three times and placed in petri dishes with water soaked filter paper for three days in dark room. Three days after, germinated seedlings were transplanted to 500 gm pot contains 1:1:2 (loam: peat moss: sand) nursery soil. At three leaf stage and for one month duration, application of drought regime were done according to field capacity (FC) as (100% (control), 75% (moderate stress), 25% (moderate stress) and 25% (severe stress)), and application of salinity regime were done as (0mM (control), 50mM (moderate stress), 100mM (moderate stress) and 200mM (severe stress)) in randomized complete design (CRD) with three biological replications to minimize environmental effects in greenhouse at Faculty of Agriculture Sohag University, Sohag, Egypt. After one month, morphological seedling traits were measured. Seedling length, measured in centimeter with ruler at the time of experiment termination. Root numbers, measured in counting roots of each seedling. Seedling fresh weighted, weighted in grams (g) at the end of the experiment. Seedling dry weight, weighted in grams (g) after dried cultivated seedling in 72 hours in hot air oven at 65 °C. Seedling length reduction percentage, root number reduction percentage, seedling fresh weight reduction percentage and seedling dry weight reduction percentage equal (value under stress level - value at 0 level) Farshadfar *et al.,* (2015). Tissue water content percentage, TWC (%) = (seedling fresh weight - seedling dry weight/ seedling fresh weight) x100) Muscolo *et al.,* (2013). Tolerance index was calculated by dividing dry weight of the stressed seedlings by dry weight of control seedlings (Maiti *et al.,* 1994). Heatmap correlation analysis were calculated on mean data between studied morphological seedlings traits using Excel software package 2013 and NCSS software package 2023.

Results and discussion

Plant breeders aim to select high yielding genotypes by either direct or indirect selection of traits that are in relationship with abiotic stresses. The results displayed considerable variations among the studied seedling traits, which are useful as indirect selection traits to improve adaptation to drought and salinity stresses (Ceccarelli *et al.,* 2004; Adel *et al.,* 2020, Pandey *et al.,* 2021). Reduction magnitude was viewed for almost considered drought and NaCl regimes for all studied traits Fig. (1-2) due to did not absorbed grains water and induced solutions due to toxic effects on germination embryos. Regarding seedling length, regimes differ significantly from one another of drought and NaCl treatments comparing to distilled waters (100% and 0mM, respectively), which result favourable responding to stressors, as mentioned by its lower values. Meanwhile, in the context of root numbers trait, the results showed increased in root numbers with respect of drought regimes. While, root numbers decreased with increase of NaCl regimes, as demonstrated by its high values, respectively. In spite of, seedling fresh weight was significantly decreased with raising amounts of drought and NaCl levels. Whereas, seedling dry weight were significantly increased with high levels of drought effects and decrease with high levels of NaCl effects. On the other hand, all reaction magnitude of studied traits were observed under drought and NaCl, respectively. Additionally, values regarding tissue water content (TWC) responded differently to observations, as showed its values were significantly dcreased under drought levels and lightly decreased under NaCl levels.

Conversely, tolerance index values were significantly increased under drought effects and significantly decreased under NaCl effects. From the heatmap correlation analysis, the results showed all morphohological studied traits are influenced to drought levels 50% and 25% other than 100% and 75% , which confirms the previous studied traits and as the same in salinity levels, as mentioned in Fig. (3). By comparing averages of control with studied various drought and NaCl treatments, it can be noted that high levels of drought and NaCl regimes significantly reduced average values of traits, which can be used for a preliminary selection for breeding drought and salinity resistance.

Fig. 1: Effect of different levels of drought effects on seedling length, root numbers, seedling fresh weight, seedling dry weigh, TWC, tolerance index and its reduction percentages for Benisuif-5 durum wheat genotype (Means ± S.E)

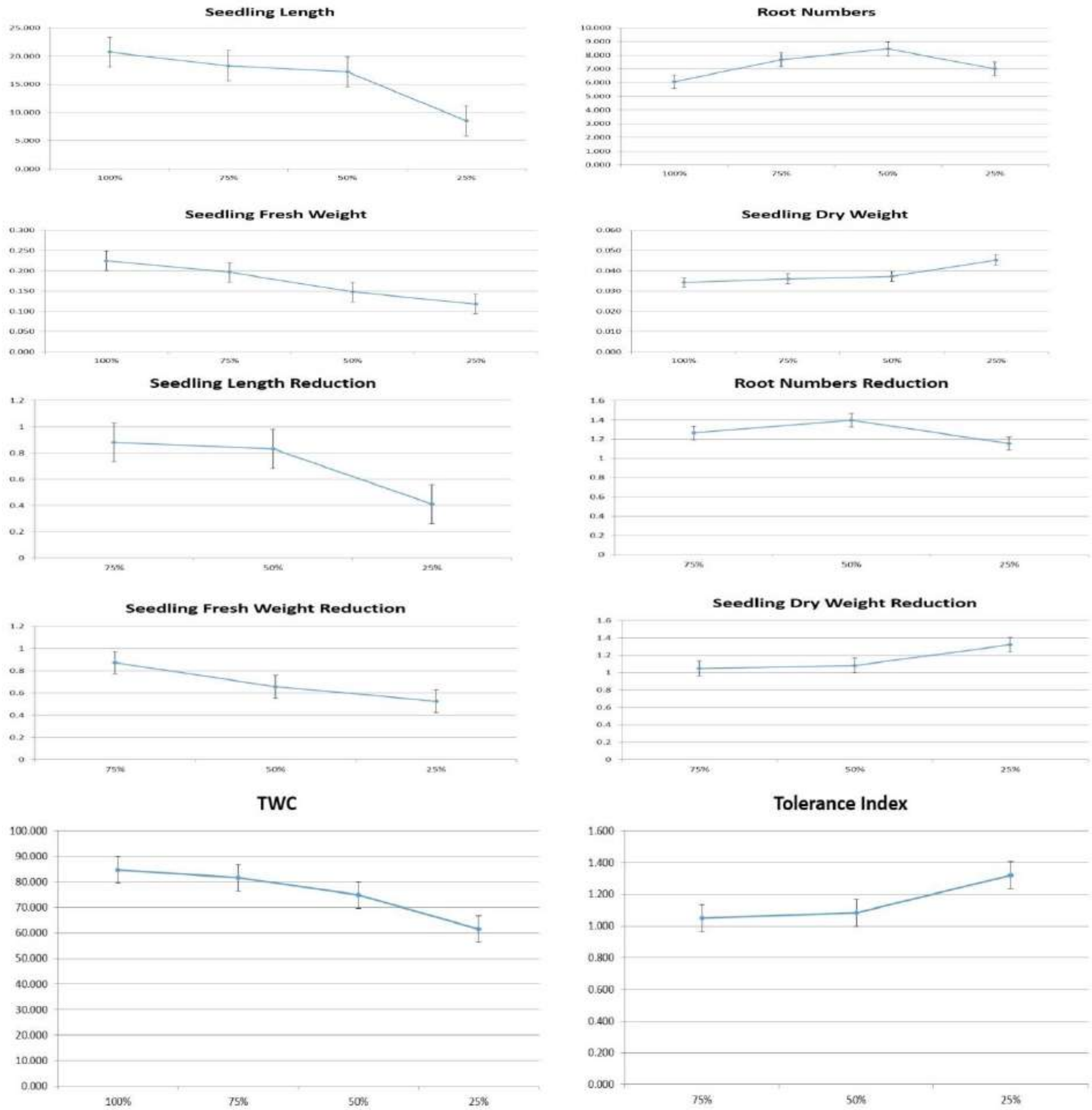

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Fig. 2: Effect of different levels of NaCl effects on seedling length, root numbers, seedling fresh weight, seedling dry weigh, TWC, tolerance index and its reduction percentages for Benisuif-5 durum wheat genotype (Means ± S.E)

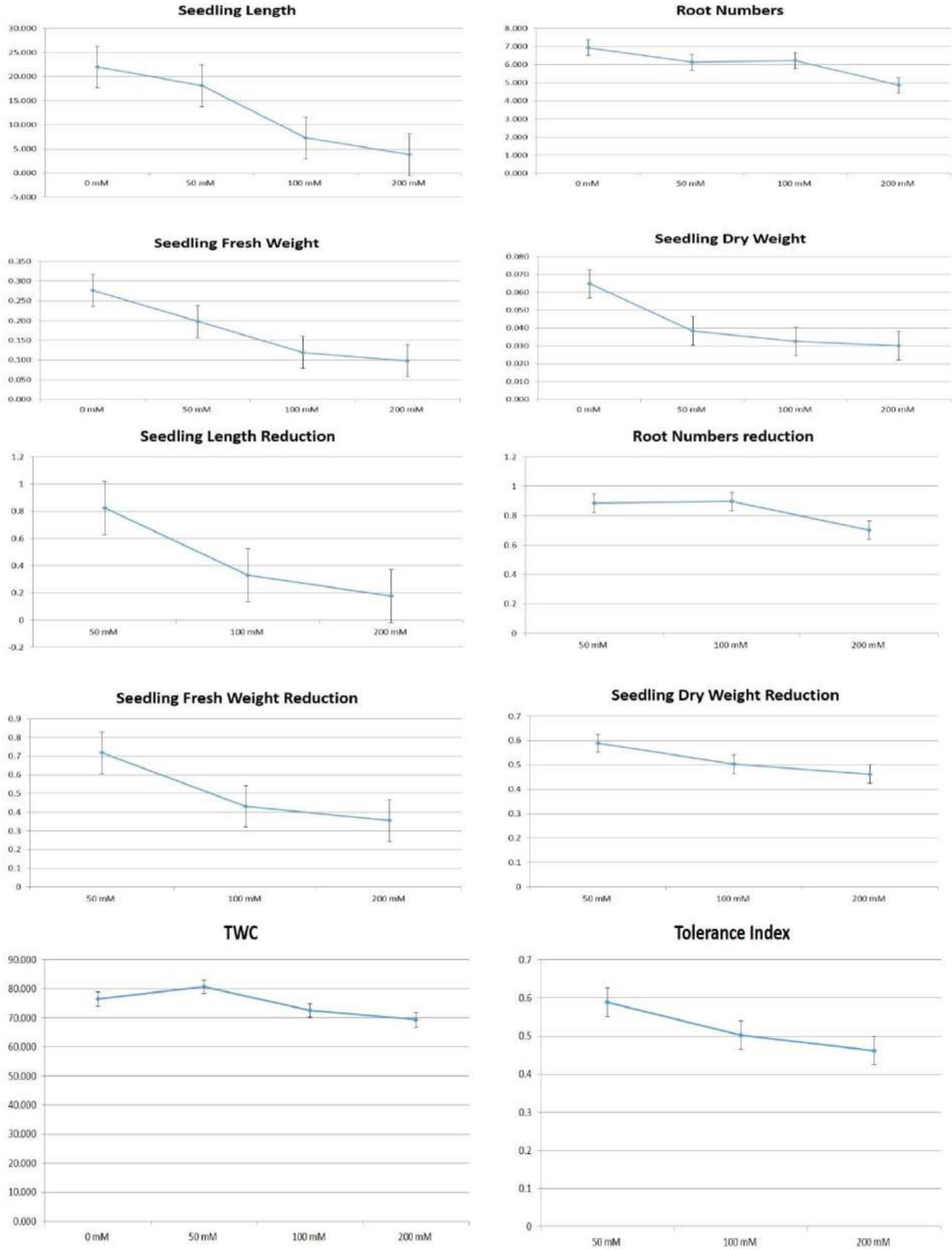
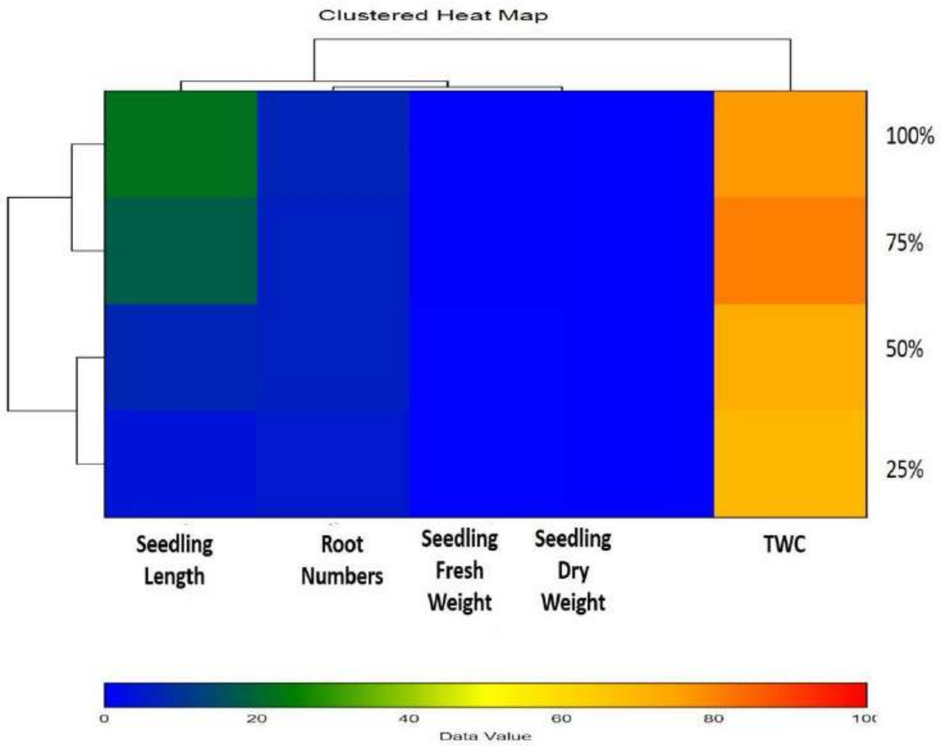


Fig. 3: Heatmap double dendogram cluters analysis of different levels of drought effects on on seedling length, root numbers, seedling fresh weight, seedling dry weigh and TWC for Benisuif-5 durum wheat genotype



In the present study at early seedling stage, most of physiological, biochemical and molecular changes take place. This stage is followed by intermediate stage which plants are preparing to acclimatize to environmental stresses to reach new homeostasis and acclimatization. Suggesting that, differentiation between drought and salinity stresses may be achieved by comparing its treatments. According to Botwright *et al.*, (2012) and Vincent *et al.*, (2014) long roots used to aid adaptation toward environmental constraints due to its role in absorption and metabolism inside plant tissue (Man *et al.*, 2016; Khadka *et al.*, 2020).

Similar finding was observed by Xu *et al.*, (2015), who found that root length was desirable trait for adaptation to drought and salinity stresses (Vadez, 2014). Hence, root architecture significantly influences agricultural plant growth and yield (Fenta *et al.*, 2014). Furthermore, there were significant differences in studied traits which indicate possibility of enhancing durum wheat performance due to reliable markers that are derived from root traits. Our findings were in harmony with Chachar *et al.*, (2014) who demonstrated significant decreased in seedling fresh and dry weight under drought and salinity stresses. In addition, Adel *et al.*, (2020) cleared that genotypes with fast germination and more root system are very desirable for seedling rapid establishment.

Hence, in conclusion our results demonstrated significant impact on status of Benisuif-5 durum wheat genotype with remarkable decrease in traits under drought and salinity effects, which will be valuable for future research in breeding programs, to improve resistance via studied traits expression as genetic background.

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