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Mitigation of Salinity Stress Effects on Wheat Growth Using dry Yeast

Seham M. Alzweek and Radia O. Salem

Department of Crop Science, Faculty of Agriculture, University of Tripoli, Tripoli, Libya.

[1]E-mail: se.moh.zw.2019@gmail.com

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ABSTRACT

Salinity stress is a major constraint to wheat (Triticum aestivum L.) production, adversely affecting crop growth and development. Reducing the negative impacts of salinity is essential to improving crop stability and yield in a sustainable and economically viable. To investigate the influence of dry baker's yeast on the germination % and early seedling growth of soft wheat (cv. Bohouth-210) under salinity stress levels, a lab experiment was conducted at the Seed technology laboratory, Department of Crop Sciences, University of Tripoli, Libya, during the cropping season of 2023/2024. A factorial experiment with two factors designed in a completely randomized design (CRD) was used with three replicates for each treatment. The first factor was the dry yeast concentrations were at the rates (0, 4, 6, 8, and 10 g/L) and the second factor was the salinity levels (0, 5000, 10000, 15000 and 20000 ppm) of sodium chloride solution (NaCl). The results showed that increasing salinity levels reduced germination percentage (%), seedling length, fresh weight, and seedling vigor compared to the control treatment (zero). Whereas Yeast decreased the negative effect of sodium chloride levels, increasing the ability of wheat grains to tolerate salt stress at the seedling stage up to a concentration of 10 g/L. The interaction between salt and yeast concentrations had a significant effect on most of the studied traits. Moreover, soaking wheat grain in a dry yeast concentration of 10 g/l achieved the highest values for all the studied characteristics under high salinity levels.

INTRODUCTION

Triticum aestivum L., or wheat, is a member of the Poaceae family and it is the main food supply for many countries worldwide, especially emerging nations like Libya. It is among the world's and Libya's most important and widely grown cereal crops. Wheat therefore supplies around 20% of the calories consumed worldwide. Even so, livestock may be fed with wheat. The entire area under wheat cultivation in Libya was around 168770 hectares, and the total yield exceeded 130000 tonnes (FAO, 2021). To reduce the gap between production and consumption, the focus should be on increasing and improving wheat production. To expand the wheat planting area, it is necessary to relocate to new reclaimed soils.

Salinity refers to the quantity of salts contained in the soil as opposed to the quantity of salts dissolved in water. Salinization-causing salts include ions such as Na^+, K^+, $Ca2^+$, $Mg2^+$, and Cl^-; however, sodium predominates among all cations that cause salinity or sodicity (Rath *et al*., 2019). Sodium (Na) is the most well-known of the several toxins that produce certain ions. It inhibits root growth, which has a negative impact on seedling development following germination (Hussain *et al*., 2021). Additionally, by altering the

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potassium (K) content, excessive Na absorption causes an ionic imbalance in the plants. The turgidity of stomata is adversely affected by this Na and K imbalance, which disrupts the plants' gas exchange characteristics (Ahmad *et al*., 2018; Zhang *et al*., 2010). A significant increase in the soil salinity decreases the potential of water and ultimately minimizes its optimum uptake into the plants (Huang *et al*., 2010). The ability of seeds to germinate is a crucial component that determines whether a crop establishment succeeds or fails. It also prevents crops from absorbing nutrients and water (Gong *et al*., 2018). Early seedling survival under salt stress raises the likelihood that the plant population will survive to maturity (Hassan *et al.*, 2021). Because it disrupts the physiological and metabolic balance and drastically lowers the rate of seed germination, high salt concentration restricts the growth of roots (Munns *et al.*, 2006). In addition, salinity causes ionic imbalance, leading to reduced metabolic activity and cell division and expansion. Salt stress impacts on seed germination and seedling growth, which are known to be more sensitive stages for most crops, and seed priming may reduce this negative effect in addition to genotypes (Mustafa *et al*., 2020). Coleoptile and root length, fresh and dry weights, and the percentages of initial and final germinations were all considerably reduced at salinity levels of 0.5, 1.0, and 1.5%. However, a salt level of 2% inhibited germination. Coleoptile and root lengths, fresh and dry weights, and the first germination count all showed a significant improvement in plant efficiency to salt tolerance due to yeast. All assessed characteristics were markedly enhanced by the high level of yeast (8 g/l), except for coleoptile length, which was enhanced by the maximum level (12 g/l). It seems that the most interactions were important. The capacity of the yeast to raise the indicator of germination values of wheat seedlings under 1.5% NaCl salinity or without salinity is what we can infer (Abraheem *et al*., 2016). In the same trend, Öner and Kırlı (2018) reported that coleoptile and radicle weights and lengths decreased with increasing salt concentrations. It was concluded that salinity negatively influenced germination times and seedling growth of wheat.

Yeast is a microbial organism, a single cell, eukaryotic, multiplying by simple division or sprouting and producing oxycene, gerbillin, and cytokine that are important to germination, growth, and differentiation of plant tissues and their responsiveness to environmental conditions (El-Tohamy *et al*., 2008). Bread dry yeast also produces many enzymes, contains vitamins and minerals such as P, K, Ca, Fe, Mn, and Zn, and other compounds, as well as amino acids such as lysine and methionine (Sacakli *et al*., 2013). Additionally, Fedotov *et al*., (2017) studied the role of soil yeasts in seed germination and found that microorganisms multiply on the surface of seeds that are soaked in solution; also, the endophytic microorganisms inside the seed and the seeds themselves begin to develop when treated using a semi-dry method. Soil yeasts accelerated the seeds development of wheat and barley. In the same trend, Abraheem *et al*. (2016) demonstrated that soaking wheat seeds in yeast extract (8 g l-1) significantly enhanced germination rates, radicle length, and seedling dry weight, both under salt stress and with up to 1.5% NaCl. In addition, Abdelaal *et al*. (2017) showed that the application of yeast extract (6 g/L) improved the physiological characteristics and yields of salt-stressed plants as compared with untreated stressed plants. They showed the important role of yeast extracts in enhancing sweet pepper growth and tolerance to salinity stress via modulation of the physiological parameters and antioxidants machinery.

However, its development and production are negatively impacted by salt stress (Trnka *et al*., 2014).

The goal of this study is to examine how varied concentrations of dry yeasts under varying salinity rates affect the growth of the present bread wheat cultivars and how these changes interact under the study conditions.

MATERIALS AND METHODS

Experiment Site:

A laboratory experiment was conducted in the Seed Testing Laboratory of the Agronomy Department, Faculty of Agriculture, University of Tripoli, 5 km east of Tripoli, in the growing season of fall 2023, to study the effect of five concentrations of dry yeasts on the soft wheat cultivar Bohouth-210 under the five concentrations of NaCl and their interaction.

Experiment layout:

A factorial experiment with two factors was implemented using a complete randomized design (CRD) with three replications. The two factors are as follows:

a. **Factor 1:** Dry yeast at five different concentrations (control = 0, 4, 6, 8, and 10 g per liter).
b. **Factor 2:** Salinity levels of NaCl (control = 0, 5000, 10000, 15000, and 20000 ppm).

Application of Treatments:

1. **Preparation of Yeast Extract Solutions:**
   a. To prepare the yeast extract solutions, dissolve 0.5 g of sucrose in 1 liter of warm distilled water. Stir the mixture thoroughly to ensure complete dissolution of sucrose.
   b. Add commercial dry yeast (Pakmaya) in varying amounts to achieve the following concentrations: 0 g (control), 4 g, 6 g, 8 g, and 10 g per liter.
   c. Incubate the prepared solutions in an incubator at 30°C for 5 hours.
   d. Filter the incubated solutions using filter paper to obtain the yeast extract filtrates, which will be used for soaking the wheat grains.
2. **Soaking and Germination of Wheat Grains:**
   a. Wheat grains were sterilized by soaking them in a 10% sodium hypochlorite (NaOCl) solution for 10 minutes to eliminate fungal or insect infections on the grain surface.
   b. The grains were washed with distilled water three times to remove any residual sterilizing agent.
   c. The sterilized grains were soaked in the prepared yeast extract solutions for 24 hours at room temperature, with each concentration applied separately, including the control.
   d. After soaking, the grains were air-dried at room temperature.
3. **Planting the Grains:**
   a. The dried grains were planted in previously sterilized glass Petri dishes (9 cm in diameter) containing filter paper. A rate of 10 grains per dish was used.
   b. Saline solutions were prepared and added to the dishes according to the respective treatment groups (including the control treatment).
   c. The filter papers in the Petri dishes were replaced every two days throughout the experiment to maintain moisture and prevent contamination.
4. **Final Irrigation with Saline Solutions:**

   The wheat grains were irrigated with saline solutions prepared from sodium chloride (NaCl) at the required concentrations (0, 5000, 10000, 15000, and 20000 ppm). A volume of 10 mL of saline solution was added per dish for the duration of the experiment.

Studied Characteristics*:*

1. Germination percentage (%).
2. Germination speed of one seed per 2 days. The germination speed was measured after days of planting at a rate of every two days. A reading was taken.
3. Coleoptile length (cm): The length of the coleoptile (the first shoot of the seedling) measured in centimeters

4. Radical length (cm): Measure the length of the radical (the embryonic root) of the seedling in centimeters.
5. Seedlings length (cm): Measure the total length of the seedling from the tip of the coleoptile to the tip of the radical in centimeters.
6. Fresh weight (g). After seedlings are removed, the seedling fresh weight was recorded in grams using a sensitive balance.
7. Seeding vigor index and seeding vigor Index Svi; It is calculated as follows: Germination vigor index = Final germination rate % multiplied by seed length (cm), according to a formula obtained by Murti *et al*. (2004).

According to the Method:

The first count of seeds was carried out after 3 days of planting to calculate the germination rate, which was calculated according to the following formula:

Germination rate (seed/day) = (Second count in seed vegetation number)/(Second count until planting days number) + (First count in seed vegetation number)/(First count until planting days number) + (Last count in seed vegetation number)/(Last count until planting days number) according to (ISTA 2019).

After 10 days, the germination rate was calculated according to the following equation:

Germination rate (%) = 100 × (Natural seedlings number)/ (Total seeds number) according to the method described by Saied (1984).

Statistical Analysis*:*

All the collected data during the lab experiment were subjected to a statistical software package (CoStat 2005), using CRD analysis to get a two-way ANOVA table. Also, using the Least significant differences test (L.S.D.) at 0.05 probability level to test significances among mean values of each treatment (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Analysis of variance of some growth attributes of soft wheat c.v. Bohouth-210, including germination percentage, germination speed, coleoptile length, radical length (cm), seedling length (cm), seeding vigour index, and fresh weight (g), as influenced by dry yeast concentration, NaCl rates, and their interaction, is presented in Table 1. During the 2023 season, there were significant differences between these treatments.

Table 1. Analysis of variance of some growth characteristics of wheat as affected by dry yeast, NaCl concentrations in 2023 season.

Factors	df	Germination %	Germination speed	Coleoptile length	radical length (cm)	Seedling length (cm)	Seeding vigor index	Fresh weight (g).
Main effect								
A) Yeast conc.	4	1858.00**	9.30**	14.85**	3.98**	22.82**	44710.4.13**	1.32**
B) NaCl conc.	4	14634.67**	195.46**	433.96**	659.57**	2095.20**	20601447**	17.03**
Interaction								
A x B	16	212.17**	1.53**	2.12**	4.34**	7.67**	33250.40**	0.12*
Error	50	58.67	0.43	0.36	0.48	1.09	20612.17	0.17
Total	74							

*, and **: significant and highly significant differences at 0.05 and 0.01 levels of probability, respectively.

The findings presented in Table (2) clearly illustrate the significant main effects of the two factors under investigation, which are yeast and salinity levels. Additionally, the table highlights the interaction between these two factors and its influence on all the studied characteristics of wheat. This analysis provides valuable insights into how varying levels of yeast and salinity can affect the traits of wheat, underscoring the importance of examining these variables in agricultural research.

Regarding the impact of dry yeast application on the traits, Table 2 showed that, in comparison to the other treatments, particularly the control treatment (untreated), increasing the application of dry yeast up to 10 g/l produced the highest germination percentage, germination speed, coleoptile length, radical length (cm), seedling length (cm), seeding vigour index, and fresh weight (g). These findings are in consistent with those of Abraheem et al. (2019).

Furthermore, Table 2, demonstrated the significant impact of NaCl concentration on these characteristics. The highest values of the control treatments (no NaCl addition) were compared to the other treatments using 5000 ppm and 10000 ppm, respectively, while the lowest values were obtained using 15000 and 20000 ppm of NaCl, which reduced the wheat characteristics under study, including germination percentage, germination speed, coleoptile length, radical length (cm), seedling length (cm), seeding vigour index, and fresh weight (g). In this trend, Tabassum *et al.* (2017) confirmed that longer germination times with higher salt doses result from osmotic and ionic stress, reducing seed water uptake. Sourour *et al.* (2014) found that salts adversely affect the dry matter transported from seeds via coleoptile and radical. High soil or irrigation salt concentrations harm plant metabolism, disrupt cellular balance, and negatively affect physiological and biochemical processes (AL-Razak and AL-Saady, 2015).

Table 2. Effect of dry yeast, NaCl concentration and their interaction on some wheat characters characters in 2023 season.

Factors	Germination %	Germination speed	Coleoptile length	Radical length (cm)	Seedlings length (cm)	Seeding vigor index	Fresh weight (g).
A) Yeast concentration (g/l)							
10	78.67a	6.84a	9.46a	6.81a	16.26a	1462.08a	2.26a
8	70.00b	5.52b	7.54b	6.13bc	13.94b	1205.35b	1.63b
6	62.67c	5.49b	7.41bc	6.54ab	13.68bc	1155.91bc	1.60b
4	54.00d	4.94c	7.13bc	6.92a	13.66bc	1065.78cd	1.59b
Control = 0	52.00d	4.89c	7.02c	5.67c	13.08	1020.60d	1.57b
LSD @0.05	5.62	0.48	0.44	0.51	0.77	105.30	0.29
B) NaCl concentration (ppm)							
Control = 0	98.67a	9.59a	13.39a	16.04	29.43a	2904.40a	2.97a
5000	80.00b	7.75b	12.09b	10.06b	22.15b	1761.85b	2.41b
10000	69.33c	6.58c	8.55c	4.63c	13.18c	927.75c	1.96c
15000	53.33d	3.10d	3.70d	1.27d	4.96d	277.16d	0.93d
20000	16.00e	0.67e	0.82e	0.06e	0.88e	38.56e	0.37e
LSD @0.05	5.62	0.48	0.44	0.51	0.77	105.30	0.29
Interaction							
A x B	**	**	**	**	**	**	**

*, and **: significant and highly significant differences at 0.05 and 0.01 levels of probability, respectively.

On the other hand, Table (3), clearly illustrates the substantial interactive impact that the application of the two factors, specifically yeast and NaCl, has on the characteristics examined in this study. It is evident that the maximum level of NaCl, when paired with a high concentration of dry yeast, leads to an increase in these investigated traits. Notably, the highest values recorded for the previous parameters associated with wheat were achieved with an application of 10 g/l of yeast in the absence of any NaCl treatment (control). Conversely, at this concentration of yeast, there was a noticeable reduction in the effect of NaCl when applied at concentrations of 5000 or 1000 ppm. Furthermore, it is important to highlight that there was no significant effect attributable to yeast when dealing with the higher concentrations of NaCl. These results may suggest a critical role that yeast plays in mitigating the negative impacts of salinity on wheat grains, as supported by the findings of previous studies (Abraheem *et al*., 2016; Abdelaal *et al*., 2017). This implies that the interaction between yeast and NaCl is complex and may involve mechanisms that limit the detrimental effects of salt stress on wheat development.

Table 3. Interaction effect between dry yeast and NaCl concentration on some wheat characters characters in 2023 season**.**

A) Yeast concentration (g/l)	NaCl concentration (ppm)	Germination %	Germination speed	Coleoptile length	Radical length (cm)	Seedling length (cm)	Seeding vigor index	Fresh weight (g).
	Control = 0	100.00	10.41	14.80	17.61	32.41	3240.67	3.40
	5000	96.67	8.03	12.03	7.70	19.73	1907.27	2.73
10	10000	90.00	8.85	10.01	5.35	15.35	1390.20	2.80
	15000	60.00	4.77	6.75	3.05	9.80	588.00	1.37
	20000	46.67	2.16	3.67	0.32	3.99	184.27	1.25
	Control = 0	100.00	8.91	13.25	15.43	28.67	2867.33	2.77
	5000	86.67	8.33	13.05	9.13	22.17	1919.20	2.17
8	10000	73.33	6.47	8.23	4.93	13.15	966.27	1.57
	15000	66.67	2.97	2.75	1.19	3.95	265.40	1.13
	20000	23.33	0.91	0.45	0.00	0.45	8.53	0.20
	Control = 0	100.00	9.34	12.89	15.51	28.40	2840.00	2.90
	5000	76.67	7.93	11.39	12.12	23.51	1803.80	2.37
6	10000	73.33	6.53	8.12	4.24	12.36	905.80	1.83
	15000	56.67	3.63	3.21	0.83	4.03	229.93	0.73
	20000	6.67	0.00	0.00	0.00	0.00	0.00	0.17
	Control = 0	96.67	9.95	12.51	16.95	29.46	2841.27	3.07
	5000	70.00	7.73	11.37	12.39	23.76	1662.97	2.60
4	10000	50.00	4.63	7.74	4.63	12.37	618.67	1.83
	15000	50.00	2.14	3.50	0.62	4.12	206.00	0.60
	20000	3.33	0.26	0.00	0.00	0.00	0.00	0.07
	Control = 0	96.67	9.36	13.51	14.70	28.21	2732.73	2.73
	5000	70.00	6.70	12.63	8.96	21.59	1516.00	2.20
Control = 0	10000	60.00	6.42	8.64	4.03	12.67	757.80	1.77
	15000	33.33	1.97	2.28	0.63	2.91	96.47	0.83
	20000	0.00	0.00	0.00	0.00	0.00	0.00	0.43
LSD @0.05		12.56	1.07	0.98	1.14	1.71	235.45	0.67

Conclusion

The results obtained from this study provided strong confirmation that the application of dry yeast resulted in a growth response in wheat that was significantly greater when the plants were exposed to levels of salinity. This suggests that dry yeast plays an important role in helping wheat plants thrive under less-than-ideal conditions. Likewise, it was observed that the treatment method involving soaking the seeds by dry yeasts prior to planting was also effective in promoting the growth of wheat. This was especially true when the wheat was subjected to various rates of salinity, indicating that soaking contributes positively to the growth process as well. Collectively, these findings underscore the noteworthy impact of both the application of dry yeast and the soaking treatment on enhancing the growth and development of wheat plants in conditions characterized by salinity. The implications of these results could be quite significant for agricultural practices aimed at improving crop yields in saline environments.

Declarations:

Ethical Approval: No plant, animal model(s) or human subjects were recruited directly for the current study. Consequently, no ethical considerations are necessary.

Conflict of interest: The authors declare no conflict of interest.

Authors Contributions: I hereby verify that all authors mentioned on the title page have made substantial contributions to the conception and design of the study, have thoroughly reviewed the manuscript, confirm the accuracy and authenticity of the data and its interpretation, and consent to its submission.

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ARABIC SUMMARY

ألتخفيف من آثار الإجهاد الملحي على نمو القمح باستخدام الخميرة الجافة

سهام محمد الزويك وراضية عمر محمد سالم
قسم علوم المحاصيل، كلية الزراعة، جامعة طرابلس، طرابلس، ليبيا.
[1]البريد الإلكتروني: se.moh.zw.2019@gmail.com

إن الإجهاد الناتج عن الملوحة يشكل عائقًا رئيسيًا أمام إنتاج القمح (*Triticum aestivum* L)، مما يؤثر سلبا على نمو المحصول وتطوره. ويعد تقليل التأثيرات السلبية للملوحة أمرا ضروريا لتحسين استقرار المحصول والعائد بطريقة مستدامة ومجدية اقتصاديا. لفحص تأثير خميرة الخبز الجافة على الإنبات والنمو المبكر لبادرات القمح الطري (صنف بحوث-210) للإجهاد الملحي، أجريت تجربة معملية في مختبر تكنولوجيا البذور، قسم علوم المحاصيل، جامعة طرابلس، خلال الموسم الزراعي 2024/2023. تم استخدام التصميم العشوائي الكامل (CRD) بثلاث مكررات لكل معاملة. كانت تركيزات الخميرة الجافة هي العامل الرئيسي بمعدلات (0، 4، 6، 8 و10 جم/لتر) وكان العامل الثانوي هو مستويات الملوحة (0، 5000، 10000، 15000 و20000 جزء في المليون) من محلول كلوريد الصوديوم. وأظهرت النتائج أن زيادة مستويات الملوحة أدت إلى انخفاض نسبة الإنبات وطول البادرات والوزن الطازج وقوة البادرات مقارنة بمعاملة الشاهد (صفر)، في حين قللت الخميرة من التأثير السلبي لمستويات ملح كلوريد الصوديوم مما أدى إلى زيادة قدرة بذور القمح على تحمل الإجهاد الملحي في طور البادرات حتى تركيز 10 جم/لتر، وكان للتفاعل بين تركيزات الملح وتركيزات الخميرة تأثير معنوي على معظم الصفات المدروسة، حيث حققت بذور القمح المنقوعة في تركيز 10 جم/لتر من الخميرة اعلي القيم لكل المتوسطات الحسابية.

الكلمات المفتاحية: القمح؛ الإنبات؛ النمو؛ الخميرة الجافة؛ كلوريد الصوديوم؛ الملوحة