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Research Article
Effect of Gibberellic Acid on Germination of Six Wheat Cultivars under Salinity Stress Levels

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Abstract

Background and Objective: There is an urgent need to pre-soaking in hormonal substance (GA_3) and choosing the most tolerance cultivars to minimize the decreases of wheat germination characters and seedling parameters due to the high levels of salinity in either soil or water irrigation. Therefore, this experiment aimed to study the performance of some wheat cultivars under seed soaking in GA_3, salinity stress levels and their interaction. **Materials and Methods:** A laboratory experiment was applied at Research Institute of Nyiregyhaza using Factorial Experimental based on Randomized Complete Block Design (RCBD) with four replications. Factors under study were six of wheat cultivars containing three Algerian cultivars i.e., Semito, Geta and Cirta and three Hungarian wheat cultivars i.e., Mikebudai, Komlo and Elet in relations of seed germination characters and seedling growth parameters were tested under seed soaking in gibberellic acid (GA_3) at two levels of GA_3 0 and 150 ppm and at six salinity stress levels 0, 3.5, 7.0, 10.5, 14.0 and 17.5 dS m^{-1}. **Results:** Seed soaking before sown at 150 ppm of GA_3 significantly affected germination characters and seedling properties and produced the highest values of germination characters as compared with non-soaking. Mikebudai cultivar exceeded all studied cultivars in all studied traits and recorded the highest values of tolerance index (TI) and the lowest values of seedling height reduction (SHR). Increasing salinity levels from 0, 3.5, 7, 10.5, 14 and 17.5 dS m^{-1} significantly affected all studied characters. **Conclusion:** Mikebudai, Cirta and Komoli cultivars clearly showed best cultivars with under seed soaking at 150 ppm of GA_3 and the highest levels of salinity stress as compared with other six wheat cultivars under study.

Key words: Wheat cultivars, seed soaking, hormonal substance GA_3, salinity stress, germination, seedling parameters

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Wheat (*Triticum* spp. L.) is classify as a main of cereal crop in several parts of the world; it is the 1st widely plant play an important role in the development of civilization, it has the most regularly traded crop of all edible commodities due to it is easy to stores and transport. Moreover, wheat is consider the essential source of carbohydrates and numerous essential nutrients and nutritive fiber[1]. According to FAO[2] the total cultivated area of wheat in the world reached about 220.10 million ha in 2016 and the total production exceeded about 749.46 million t. However, the total cultivated in Hungary reached about 1.05 million ha and the total production reached about 4.78 million t. While, the total cultivated area in Algeria reached about 1.44 million ha with total production reached about 2.44 million t.

Per-sowing seed treatments in hormonal substances such as Gibberellic acid (GA_3) significantly have been shown to increase and encourage the process of seed germination characters and seedling parameters, cell division, hypocotyls growth as well as stand establishment[3], Gibberellic Acid (GA_3) is consider the most important growth regulator, which play a vital role in breaks seed dormancy, encourages germination, intermodal length, hypocotyls growth and cell division and increases the size of leaves. Moreover, GA_3 stimulates hydrolytic enzymes that are needed for the degradation of the cells surrounding the radical and thus speeds germination by promoting seedling elongation growth of cereal seeds[4]. Seed soaking can do different methods such as osmopriming, hydropriming, potassium salts, hormones polietylinghlycon, nutritional imbalance, osmotic effects, maximizing nutrient reserves through increased physiological activities, root proliferation and rapid seedling appearance that can product strong plants[5,6]. Seed soaking with GA_3 i.e., 5 mg L^{-1} or 150 ppm caused significantly increased in shoot length, root length, dry weight and fresh weight[7-11].

Choosing the high tolerance cultivars is consider one of national strategies to rise wheat germination; growth and yield production under the areas suffer from salinity. Usually, traditional farmers planted varied assemblages of wheat genotypes i.e., landraces varieties to lower the risk of failure and raise food security because they had low capacity to control the spatially heterogeneous and temporally unpredictable environment. This practice led to the development of landrace meta-populations of wheat and the emergence of farmer's seed systems through which they accessed and exchanged diverse genetic material. Wheat cultivars were differed in germination characters and seedling parameters[11-14].

Salinity is consider one of the most critical of abiotic stresses affecting seed germination characters and seedling parameters. The total world's land suffered from salinity stress reached[15,16] about 7%. In addition, salinity stress prompts water stress by reducing the osmotic potential of the soil solutes and thus making it very difficult for the roots to absorb the water from the media of cultivation. In addition, the response of salinity stress by plant is depending on the growth stage of plant, time of salinity and the type of salt. Salinity induced oxidative stress that decrease germination characters and seedling parameters[17,18]. Seed germination characters and water and nutrient uptake of wheat plants significantly affecting due to salinity stress conditions under arid and semiarid regions[19,20]. Moreover, the dangerous significances of salinity stress for germination characters and early seedling growth parameters of crops arise probably due to, disrupting cellular homeostasis and uncoupling major physiological and biochemical processes, osmotic stress that prevents specific ion toxicity or water absorption[21,22]. Generally many researchers noticed that salinity stress adversely affected and caused gradual reduction in seed germination characters and seedling parameters of wheat plants i.e.[7,13,14,23-26].

Regarding to the interaction effects of factors under study, there are significant improvement in germination characters and seedling growth parameters of wheat cultivars due to soaking treatment in GA_3[9,27,28]. Also, wheat cultivars showed a great differences in germination characters due to salinity effects[13,23,25,29]. Moreover, the role of GA_3 in confident development of the inhibitory effect of salinity stress levels of wheat cultivars may be due to its vital and essential roles in changes in ionic balance in seedlings and minimized the levels of sodium accumulation and increase the levels of potassium content in the seedlings[8,14].

Consequently, the main purposes of the current investigation was to increasing seed germination and seedling parameters of wheat cultivars under salinity stress by seed soaking in GA_3 under the laboratory experiment of Research Institute of Nyíregyháza, Hungary.

MATERIALS AND METHODS

Description of study area: A laboratory experiment under controlled condition was conducted at Research Institute of Nyíregyháza, Hungary during the period of December, 2017 to January, 2018 to study the performance of some Algerian and Hungarian wheat cultivars to germination under seed priming in gibberellic acid (GA_3) and salinity stress, to be able to select and chose the best cultivars for salinity tolerance among six wheat cultivars.

Treatments and experimental design: The treatments were distributed in the design of Factorial experiment based on Randomized Complete Block Design (RCBD) with four replicates. Factor A: contained two treatments the first treatment was without soaking in GA3 and the second treatment was seed soaking in GA_3 at concentration of 150 ppm, the hormone solutions of the used concentration was prepared by using 250 g of seeds from each cultivar were soaked in 500 mL of each solutions and retired near to original weight with forced air under shade[30]. Factor B: included six of wheat cultivars containing three Algerian cultivars i.e., Cirta, Gita, Semito and three Hungarian wheat landraces i.e., Elet, Komloi, Mikebudai. The Algerian wheat cultivars were obtained from Field Crop Research Institute, Agriculture Research Center, Guelma, Algeria. While, Hungarian Wheat landraces were obtained from Hungarian Center for plant diversity, Tapioszele. These Hungarian wheat landrace's are defining as a variety developed over many years by one or more farmers using simple selection methods for local adaptation and a wide variety of quality traits. Factor C: included six salinity stress levels i.e., control without 0, 3.5, 7.0, 10.5, 14.0 and 17.5 dS m^{-1} as shown in Table 1. Thus, the total experiment unit contained 288 clear plastic boxes.

All seed were sterilized with 2% sodium hypochloride for about 10 min after that washed with distilled water and air-dried before sowing[31]. Then, 25 of healthy seeds of each treatment for each cultivar were allowed to germinate on a filter paper in sterile clear plastic boxes. Each filter paper was moistened with 10 mL distilled water (control) and a water solution at different salinity stress levels. The clear plastic boxes were labeled and incubated in a germinator (Phytotron) at 20$\pm$1°C and relative humidity of 70% for 18/6 h day/night illumination for germination. Radicle protrusion of 5 mm was recorded as germination. After 4 and 8 days the first and final account of seed germinated were recorded, according to The International Rules of Seed Testing Association (ISTA)[32].

Studied traits

Germination characters

Germination percentage (GP %): It was calculated after 14 days from sowing date and expressed as percentage according to the following equation as described by Ellis and Roberts[33] and Ruan *et al.*[34]:

$$GP = \frac{\text{Number of germinated seed}}{\text{Total number of tested seed}} \times 100$$

Germination rate (GR): It was calculated according to the following equation as described by Ellis and Roberts[35]:

Table 1: Weight of salts and salinity levels in dS m^{-1}

Salinity stress (dS m^{-1})	Weight of NaCl
0 (distilled water as the control)	-
3.5	2.24 g L^{-1} (distilled water)
7.0	4.48 g L^{-1} (distilled water)
10.5	6.72 g L^{-1} (distilled water)
14.0	8.96 g L^{-1} (distilled water)
17.5	11.20 g L^{-1} (distilled water)

$$GR = \frac{\text{Number of germinated seed}}{\text{Number of days of germination}}$$

Germination Index (GI): It was calculated by using the following equation as described by Karim *et al.*[36]:

$$GR = \frac{\text{Germination (\%) each treatment}}{\text{Germination (\%) in control treatment}} \times 100$$

Seedling parameters: Ten seedlings were randomly chosen and the following characters were measured: shoot length and root length (cm), root length (cm), shoot and root fresh weight (g), shoot and root dry weight, seedling vigor index (SVI): It was calculated according to the following equation:

$$SVI = \text{Shoot length} + \text{Root length} \times GP\ (\%), \text{ Tolerance index (TI)}$$

It was calculated by using the following equation as described by Maiti *et al.*[37]:

$$TI = \frac{\text{Dry weight of seedlings under salinity stress}}{\text{Dry weight of control seedlings}} \times 100$$

Seedling height reduction (SHR): It was calculated by using the following equation:

$$SHR = \frac{\text{Seedling height under control} - \text{Seedling height under saline condition}}{\text{Seedling height under saline condition}} \times 100$$

Data analysis: All obtained data of this experimental were statistically analyzed by using Factorial Randomized Complete Block Design as described by Gomez and Gomez[38]. The differences between treatment means at 5% probability were calculated by using the Least Significant Difference (LSD) method as described by Snedecor and Cochran[39].

RESULTS

Seed soaking in GA_3 effect: Data showed in Table 2 and 3 significantly cleared that seed soaking in GA_3 increased wheat

Table 2: Means of germination percentage (GP%), germination speed (GS), shoot length (cm) and root length (cm) seedling vigor index (SVI) as affected by seed soaking in GA3, wheat cultivars, salinity stress and their interaction

Characters treatments	Germination (%)	Germination rate (GR)	Germination index (GI)	Shoot length (cm)	Root length (cm)	Seedling vigor index (SVI)
Seed soaking in GA_3 (ppm) effect						
Non soaking	72.48	2.26	80.64	13.19	6.66	1559.40
Soaking at 150 ppm	78.07	2.44	82.83	16.97	8.30	2122.29
F-test	*	*	*	*	*	*
Wheat cultivars performance						
Semito	71.33	2.22	79.11	12.94	5.67	1419.78
Geta	81.33	2.54	84.70	13.66	6.91	1742.78
Cirta	78.33	2.44	83.94	17.56	8.55	2139.58
Mikebudai	89.77	2.80	90.97	20.81	10.15	2859.11
Komloi	83.22	2.60	86.06	15.71	8.28	2075.35
Elet	47.66	1.49	65.62	9.78	5.30	808.46
LSD at 5%	1.36	0.04	1.61	0.40	0.29	50.30
Salinity stress (dS m^{-1}) effects						
Control	91.22	2.85	100.00	22.33	10.55	3053.0
3.5 dS m^{-1}	83.22	2.60	90.906	19.32	9.66	2487.4
7 dS m^{-1}	79.33	2.47	86.439	16.79	8.20	2054.44
10.5 dS m^{-1}	72.66	2.27	78.678	14.46	7.17	1646.94
14 dS m^{-1}	65.33	2.04	70.472	10.41	6.03	1132.75
17.5 dS m^{-1}	59.88	1.87	63.938	7.15	3.27	670.45
LSD at 5%	1.56	0.05	1.68	0.39	0.19	58.38
Interactions effect						
A×B (F-test)	*	*	*	*	*	*
A*C (F-test)	NS	NS	NS	*	*	*
B*C (F-test)	*	*	*	*	*	*
A*B *C (F-test)	NS	NS	NS	*	*	*

Table 3: Means of shoot fresh weight (g), shoot dry weight (g), root fresh weight (g), root dry weight (g), tolerance index (TI) and seedling height reduction (SHR) as affected by seed soaking in GA_3 wheat cultivars, salinity stress and their interaction

Characters treatments	Shoot fresh weight (g)	Shoot dry weight (g)	Root fresh weight (g)	Root dry weight (g)	Tolerance index (TI)	Seedling height reduction (SHR)
Seed soaking in GA_3 (ppm) effect						
Non soaking	0.22	0.04	0.15	0.02	74.23	84.65
Soaking at 150 ppm	0.32	0.06	0.18	0.04	67.60	68.30
F-test	*	*	*	*	*	*
Wheat cultivars performance						
Semito	0.20	0.03	0.14	0.02	67.67	92.84
Geta	0.23	0.04	0.15	0.03	71.07	74.60
Cirta	0.35	0.07	0.20	0.04	74.21	74.86
Mikebudai	0.39	0.08	0.22	0.04	77.52	63.46
Komloi	0.28	0.05	0.16	0.04	67.88	62.74
Elet	0.19	0.03	0.11	0.02	67.15	90.36
LSD at 5%	0.03	0.01	0.02	0.01	3.01	8.56
Salinity stress (dS m^{-1}) effects						
Control	0.35	0.07	0.21	0.05	100.00	0.00
3.5 dS m^{-1}	0.32	0.06	0.19	0.04	87.31	17.44
7 dS m^{-1}	0.29	0.05	0.17	0.03	72.86	35.33
10.5 dS m^{-1}	0.25	0.05	0.15	0.03	64.69	59.73
14 dS m^{-1}	0.25	0.04	0.12	0.02	54.42	119.11
17.5 dS m^{-1}	0.19	0.03	0.13	0.02	46.22	227.25
LSD at 5%	0.04	0.02	0.03	0.03	3.06	7.89
Interactions effect						
A×B (F-test)	NS	NS	*	NS	*	*
A*C (F-test)	NS	*	NS	NS	*	*
B*C (F-test)	*	*	**	NS	*	*
A*B *C (F-test)	NS	*	NS	NS	*	*

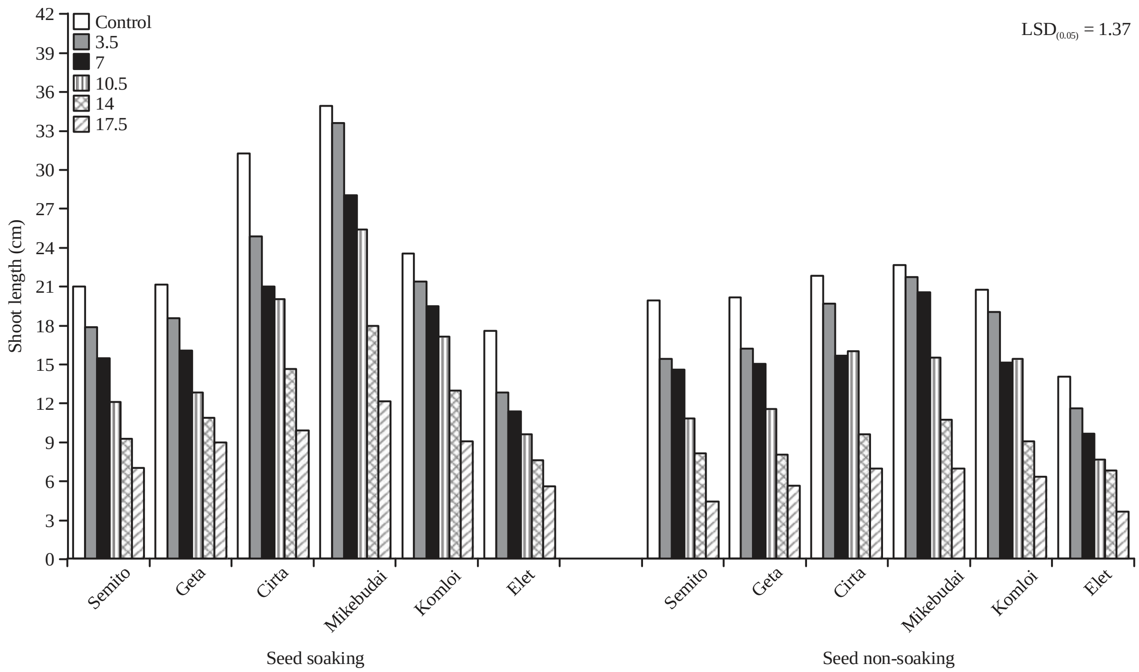

Fig. 1: Averages of shoot length (cm) as affected by the interaction between seed soaking, wheat cultivars and salinity stress (dS m^{-1})

germination characters and seedling properties as compared with the control treatment. Highest percentages of germination (78.07%), germination rate (2.44), germination index (82.83%), shoot length (16.97 cm), root length (8.30 cm), seedling vigor index (2122.29), shoot fresh weight (0.32 g), shoot dry weight (0.06 g), root fresh weight (0.18 g), root dry weight (0.04 g) were obtained from seed soaking in GA_3 at the levels of 150 ppm. Whereas, the lowest values of all studied characters were recorded with control treatment.

Wheat cultivars behaviors: Results presented in Table 2 and 3 clearly showed that the tested wheat cultivars significantly varied for germination characters and seedling parameters. It could be stated that Mikebudai cultivar recorded the highest averages of GP, GR and GI, followed by Komloi, Geta, Cirta, Semito and Elet cultivars (89.77, 2.80 and 90.97%), respectively. Also, Mikebudai cultivar recorded the highest averages of shoot length (20.18 cm), root length (10.15 cm), SVI (2589.11), shoot fresh weight (0.39 g), shoot dry weight (0.08 g), root fresh weight (0.22 g), root dry weight (0.04 g), TI (77.52%), followed by followed by Komloi, Cirta, Geta, Semito and Elet cultivars. On the other hand, Mikebudai cultivar recorded the minimum averages of SHR. Therefore, Mikebudai cultivar is consider one of most salinity tolerant cultivar between all studied cultivars followed by Komloi or Geta cultivars.

Salinity stress effect: As presented in Table 2 and 3 salinity levels significantly affected GP%, GR, GI, shoot length (cm), root length (cm), SVI, shoot fresh weight (g), shoot dry weight (g), root fresh weight (g), root dry weight (g), TI and SHR (%). increasing salinity levels from 0, 3.5, 7, 10.5, 14 and 17.5 dS m^{-1} reduced all germination and seedling parameters. Except, SHR were increased with increasing salinity stress levels.

Interactions effect: Regarding to interactions effect there were several significantly affected due to the three-way interaction among seed soaking, wheat cultivars and salinity stress levels as showed in Table 2 and 3. Thus, the significant three-way interactions only among studied factors were focused herein. As illustrated in Fig. 1-6, the highest values of shoot length (Fig. 1), root length (Fig. 2), seedling vigor index (Fig. 3) and shoot dry weight (Fig. 4) were obtained from sowing Mikebudai cultivar under seed soaking of in GA_3 at the levels of 150 ppm under control treatment, followed by Cirta, Komloi, Geta, Semito and Elet cultivars with combined with seed soaking in GA_3 at 150 ppm under the lowest levels of salinity stress. In addition, the highest values of tolerance index (Fig. 5) was recorded with in all studied cultivars under control treatment. While, the lowest averages of SHR (Fig. 6) was recorded with Geta cultivar under seed soaking with GA_3.

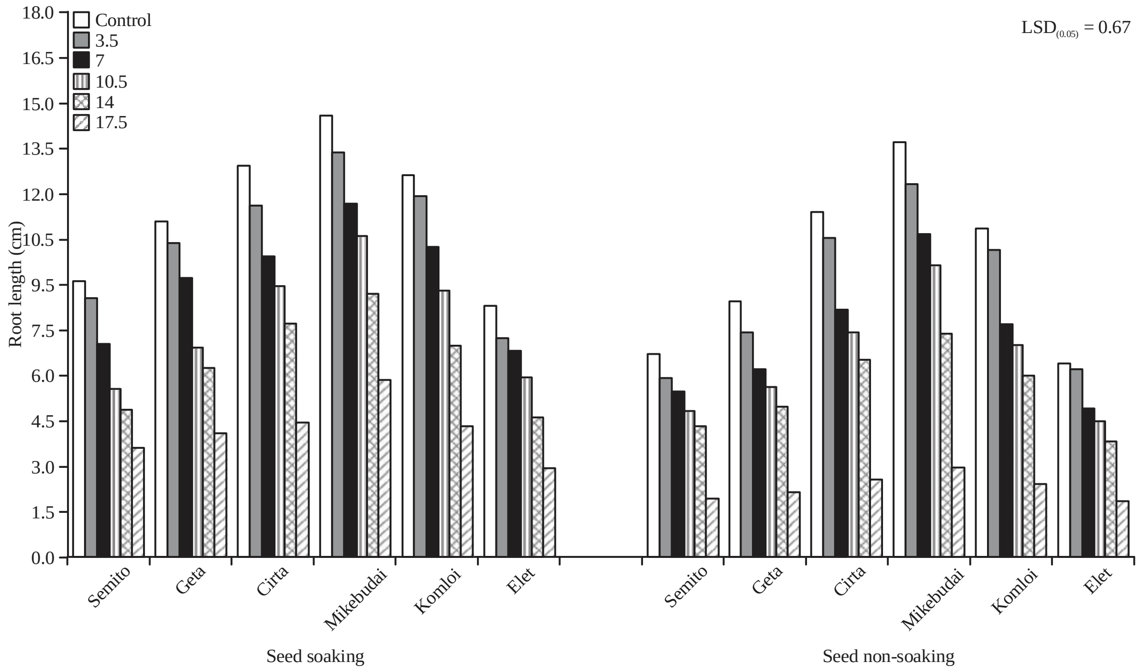

Fig. 2: Averages of root length (cm) as affected by the interaction between seed soaking, wheat cultivars and salinity stress (dS m^{-1})

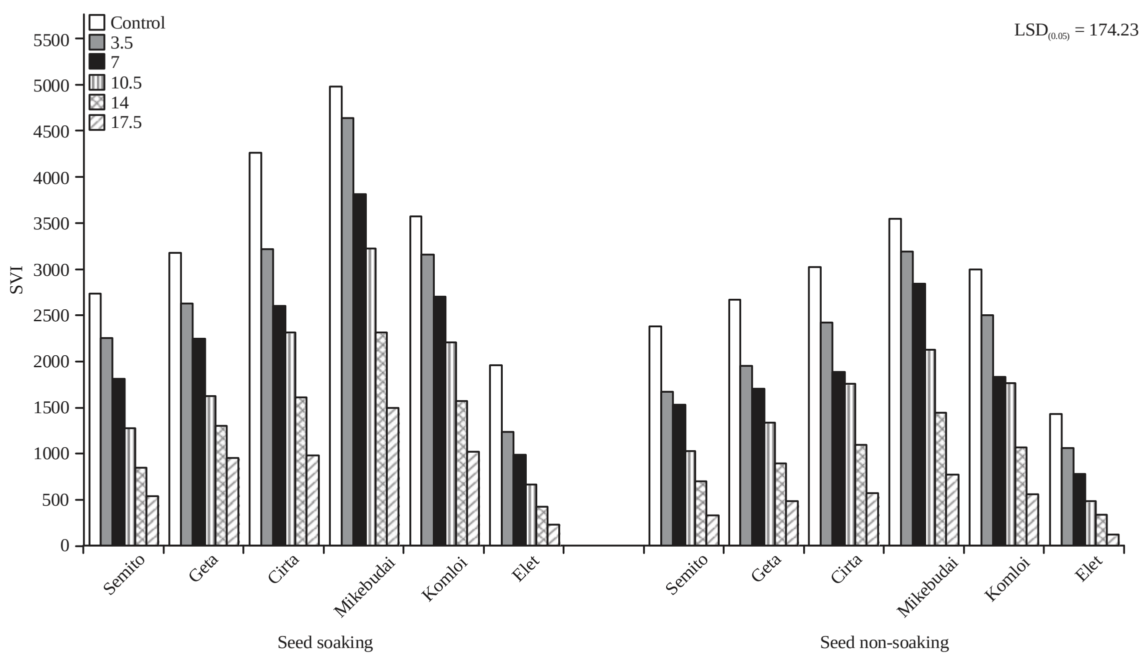

Fig. 3: Averages of seedling vigor index (SVI) as affected by the interaction between seed soaking, wheat cultivars and salinity stress (dS m^{-1})

DISCUSSION

Regarding seed soaking in GA_3 effect, seed soaking caused increasing in germination characters and seedling parameters. These results may be due to the vital and important role of GA_3 during the plant cycle start from germination stage, which improving germination processes, division of cell, hypocotyls growth and maximize and control

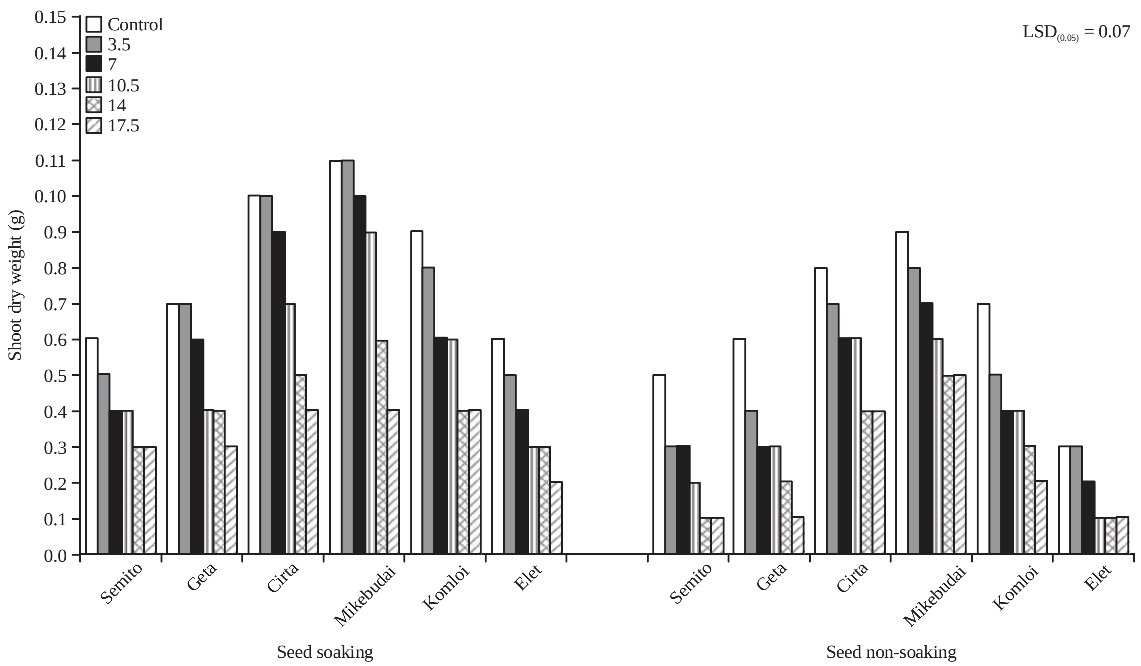

Fig. 4: Averages of shoot dry weight (g) as affected by the interaction between seed soaking, wheat cultivars and salinity stress (dS m^{-1})

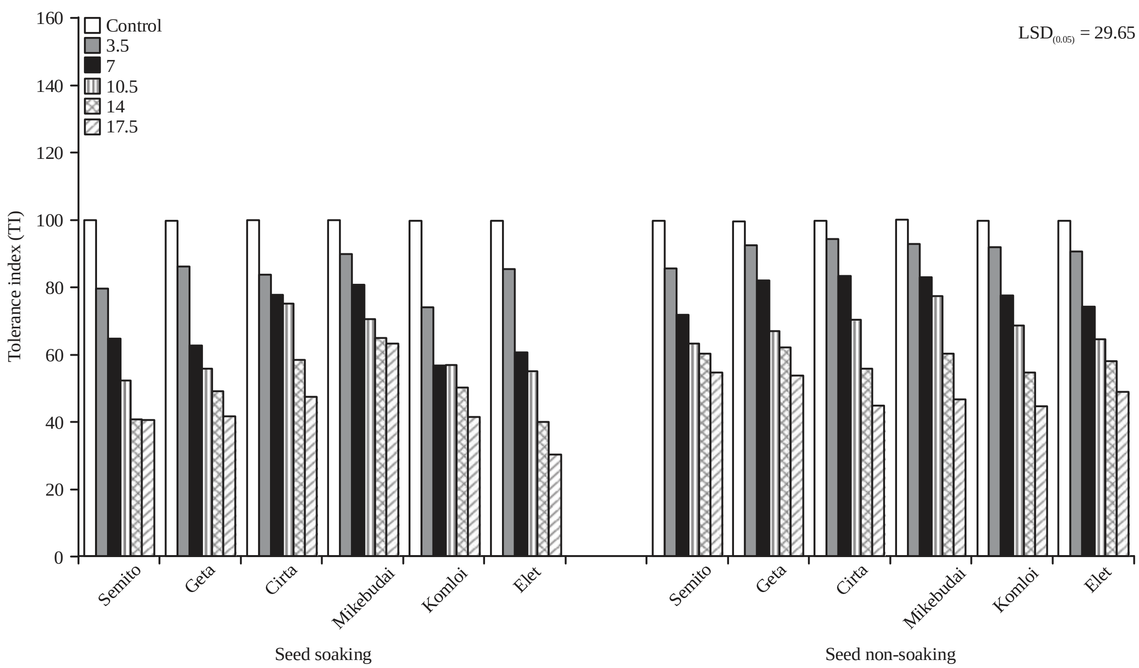

Fig. 5: Averages of tolerance index as affected by the interaction between seed soaking, wheat cultivars and salinity stress (dS m^{-1})

in the ions transport in plant tissues and declining the high decline of physiological and biochemical activities in roots and shoots. Moreover, GA_3 stimulates hydrolytic enzymes that are needed for the degradation of the cells surrounding the radical and thus speeds germination by promoting seedling elongation growth of cereal seeds[4]. These

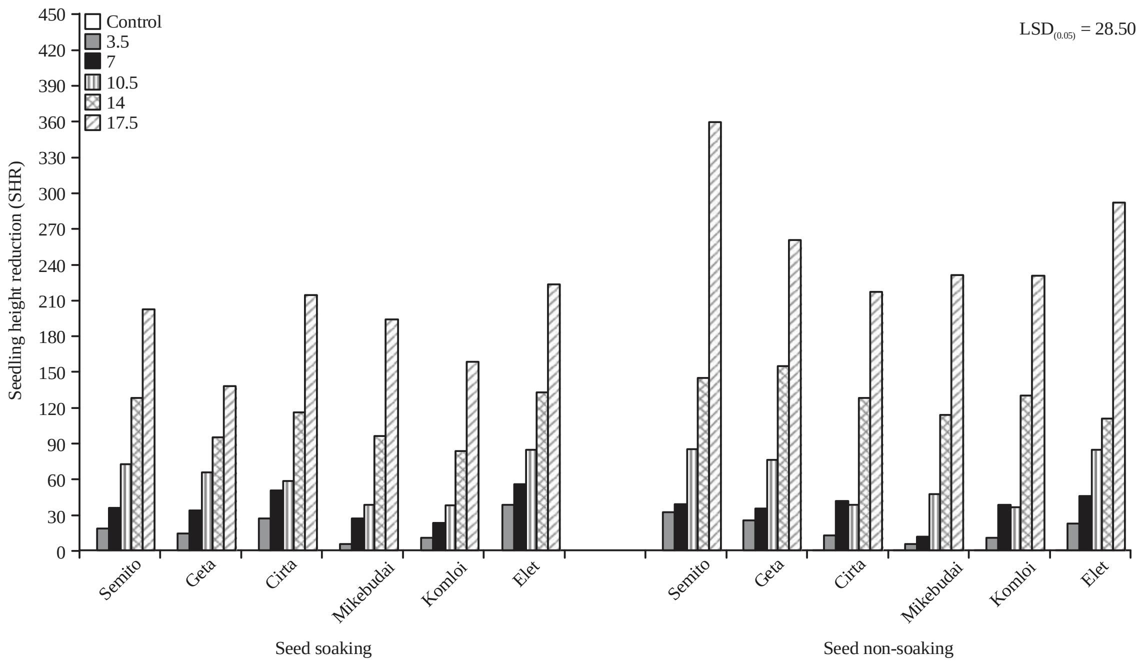

Fig. 6: Averages of seedling height reduction (SHR %) as affected by the interaction between seed soaking, wheat cultivars and salinity stress (dS m^{-1})

results are in a good harmony with those stated by Jamil and Rha[6], Ghobadi *et al.*[9], Kalpana *et al.*[10] and Abido and Laszlo[11].

Concerning to wheat cultivars behaviors, all cultivars under study were differed. These results might be due to the differences between wheat cultivars under study in their genetically structure and genetic factors makeup. These results in good accordance with those obtained by Abido and Laszlo[11], Asgari *et al.*[12], Hussain *et al.*[13] and Oproi and Madosa[14].

With respect salinity stress effect, data showed that increasing salinity levels from 0, 3.5, 7, 10.5, 14 and 17.5 dS m^{-1} reduced germination characters and seedling parameters. While, SHR were increased with increasing salinity stress levels. The decreases in germination characters and seedling parameters due to increasing salinity levels may be ascribed to the osmotic pressure on the tissue cells of plant that stops water absorption and reducing of water potential and make poisonous ions such as Na^+, Cl^-. Moreover, the dangerous significances of salinity stress for germination characters and early seedling growth parameters of crops arise probably due to osmotic stress that prevents specific ion toxicity or water absorption[17]. In addition, the increasing salinity in the irrigation water or soil led to shocking influence on the metabolism of plant, disrupting cellular homeostasis and uncoupling major physiological and biochemical processes[10]. These results are in conformity with those reported by Abido and Laszlo[11], Hussain *et al.*[13], Amor *et al.*[18] and Jovovic *et al.*[25].

Regarding to interactions effect there were several significantly affected due to the three-way interaction among seed soaking, wheat cultivars and salinity stress levels as presented in Table 2 and 3. These results might be due to the differences between wheat cultivars under study in their genetically structure and genetic factors makeup. In addition, seed soaking of wheat cultivars with suitable levels of GA_3 plays an important and essential role in the induction of tolerance to salinity stress and overcome limitations created by the environmental stress such as ion toxicity, nutritional imbalance and osmotic effects as well as maximizing nutrient reserves through increased physiological activities and root proliferation. These results are agreement with those noticed by Samad and Karmoker[8], Hussain *et al.*[13], Oproi and Madosa[14] and Jovovic *et al.*[25].

CONCLUSION

Seed soaking in GA_3 at 150 ppm caused increases in germination characters and seedling parameters. Salinity stress (NaCl) has a positive effect on all germination characters and seedling parameters of Hungarian and Algerian wheat cultivars. Among six wheat cultivars under studies, Mikebudai and Komoli cultivars were able to prompt better salinity tolerance under high levels of salinity.

SIGNIFICANCE STATEMENT

This study discover that, seed soaking in GA_3 and using Mikebudai and Komoli cultivars are beneficial for increasing wheat germination characters and seedling parameters under the arid suffer from salinity stress. This study will help the researcher to start breeding programs on promising wheat cultivars.

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