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Study the effect of using selenium resources and amounts on stress susceptibility indexes to wheat cultivars in Maragheh rainfed region conditions

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Abstract

Randomised complete block design with the three-factor factorial test was executed with three replications in the garden 10 km away from Maragheh-Hashtrud road in the 2017-2018 agricultural year to study the effect of various resources and amounts of selenium, yield components, and stress susceptibility indexes to wheat cultivars. The experimental treatments include factor (a) of various selenium resources (sodium selenate and selenite index), factor (b) of various selenium amounts (0, 18, and 36 g/ha), and factor (c) of three wheat cultivars (Azar 2, Pishtaz, and Sardari). The characteristics of yield, yield components, stress susceptibility index (SSI), tolerance index (TOL), mean productivity (MP), geometrical mean productivity (GMP), yield index (YI), and yield stability index (YSI) were examined. The yield of wheat cultivars in drought stress conditions (not using selenium) (Ys) and in normal conditions (using selenium) (Yp) was used to estimate the tolerance index and drought susceptibility index. The mean factor a level from various selenium resources (sodium selenate and selenite) showed that using selenite is prior than selenate in all three characteristics of grain weight, yield in spike, and weight of thousand grains. The selenite treatment was selected as the prior treatment, and then it was examined based on the mentioned characteristics and estimation of SSI and TOI. The results from variance analysis showed a significant difference between the yield and yield components of cultivars in the normal conditions (18 and 36 g/ha of sodium selenite) and water stress (non-usage of selenium). The grain means yield and weight in the spike of the studied genotypes in the normal condition (18 and 36 g/ha selenite) were 1752.83 kg/ha 0.591 g and 1790.82 kg/ha and 0.59 g, respectively. Pishtaz and Sardari genotypes in normal conditions (18 and 36 g/ha sodium selenite) and water stress (non-usage of selenium) had the maximum and minimum yield. The grain yield of Pishtaz is significantly higher than Azar 2 and Sardari cultivars in the normal conditions (18 and 36 g/ha sodium selenite), while it was indicated by imposing the water stress (non-usage of selenium) that water stress has a weaker effect on grain yield of Azar 2 and Sardari cultivars but it significantly reduced the grain yield of Pishtaz cultivar as grain yield of Pishtaz cultivar was more than Azar 2 and Sardari cultivars in water stress condition (non-usage of selenium). In this research, the Pishtaz cultivar had the maximum stress tolerance in both conditions of 18 and 36 g/ha sodium selenite with a mean of 1.05 and 1.02, respectively whereas the Sardari cultivar showed the minimum stress tolerance with a mean of 0.94 and 0.92, respectively.

Keywords: wheat, sodium selenate, sodium selenite, yield and yield components, SSI
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1 Introduction

One of the important objectives of sustainable development in a state is promoting the society's health level and realizing the motto that an ounce of prevention is worth a pound of cure. Attention to enriching foodstuff (supplying the essential minerals for human body cells) and controlling pollutant concentrations in agricultural products are some ways to realize this matter [20]. Wheat is the most important crop with the maximum agricultural land and the highest production among various agricultural plants in the world [26]. Wheat is the first and the most important agricultural plant that supplies human food needs. Increasing the world population has increased the need for wheat as a strategic product and doubled the importance of this product. Therefore, all countries seek policies to be needless of importing this product and reach self-sufficiency in its optimum production [5]. Wheat and the obtained bread are considered as the most important food resources and provide a significant part of the needed calories and protein of the country [20]. The cultivated area of wheat is 6061248 ha (39% irrigated and 61% rainfed) [1]. Today, water scarcity is one of the most important limiting factors for crop growth in arid and semi-arid regions [22]. One of the first reactions of plants in the drought stress condition is the accumulation of active oxygen species [2]. Membranes and proteins can reduce irrigation and damage the increase of active oxygen species at the cellular level [3]. Plants protect the cell against the toxic effect of active oxygen species using the enzyme and non-enzyme oxidants [14]. Studies have shown that selenium protects plants through the effect of enzymes and other dependent proteins against the resulting cell damage by free radicals [8]. Selenium is one of the low-consumed essential elements for humans and animals [34]. However, it hasn't been classified as an essential element for plants [7]. Although, its useful effect for plants with high selenium accumulation has been proved [32], there are pieces of evidence based on the protective role of exogenous selenium on drought stress in the plant. Selenium may increase the plants' tolerance against various non-organic stresses [17]. Adsorption and accumulation of selenium depend on the chemical shape, concentration, soil factors like acidity, salinity, amount of calcium carbonate, the concentration of rival ions, plant ability to absorb, and selenium metabolism [16]. Selenium adsorption in the plant is different based on the type of soil and plant. The most important factor is the shape and concentration of selenium in the soil. The dominant mineral shape of selenium in aerobic soils is selenate and selenite. Selenate is adsorbed by pant easier and more amounts are accumulated in the aerial parts than root [35]. Various studies have proved the useful effect of selenium in plants because it increases the antioxidant activity in plants and so better yield. Moreover, the biological enrichment of agricultural products with the application of selenium with fertilizer is a useful technique to increase selenium consumption by plants and animals [7]. It was reported that selenium consumption in drought stress conditions incurred the activity of catalase and peroxidase enzymes significantly in wheat plantlets. Nonetheless, this increase was effective on fat peroxidation [36]. In limited irrigation conditions, consuming 3 mg/l selenium from sodium selenate resource reduces potassium, leaf water, transpiration, and stomatal conductance in the Melilotus officinalis plantlets and limits soluble water flow rate in the vascular system. Selenium improves plant tolerance to water shortage by reducing transpiration and osmosis potential [19]. Studies have shown that the protective effect of selenium against oxidative stress in organic plants is tied to the increase of glutathione peroxidase activity and reducing lipid peroxidation [10]. Compounds like selenium can remove the free radicals and prevent membrane fat peroxidation in plantlets [9]. According to the importance of wheat as a strategic product in low-water and developing countries like Iran and the selenium's role in improving the plant's tolerance to drought stress, this research examined the selenium role on the yield, yield element, and their improvement, stress tolerance index to use for yield estimation in stress and non-stress conditions in order to introduce the most proper index or stress tolerance index and finally prior genotype in the rainfed condition of Maragheh.

2 Materials and method

Randomized complete block design with the three-factor factorial test was executed with three replications in the garden 10 km away from Maragheh-Hashtrud road in the 2017-2018 agricultural year to study the reaction of agricultural characteristics to spraying with various resources and amounts of selenium. After taking the sample from a 30 cm depth of soil and transfer to the soil science laboratory, it was indicated that the test soil had a clay loam texture, its absorbable potassium and phosphor were medium, and is considered a weak soil type-based on nitrogen amount. Some other physical and chemical characteristics of the mentioned soil in 0-30 cm depth are as follows in table 1:

The experimental treatments include factor (a) of various selenium resources (sodium selenate and selenite), factor (b) of various selenium amounts (0, 18, and 36 g/ha), and factor (c) of three wheat cultivars (Azar 2, Pishtaz, and Sardari). The amounts of sodium selenate salt for the mentioned values and sodium selenite salt were calculated at 0, 43.07, and 86.14 g/ha and 0, 59.94, and 119.88 g/ha, respectively. 1120 kg/ha triple superphosphate fertilizer was added to the land before cultivation and mixed with soil during cultivation. The cultivation was carried out

Soil depth (cm)	Texture	Sand%	Clay%	Silt%	PH of soil	Soil EC (mmhos/cm)
0-30	Sand-loam	38	24	38	7.99	1.95
Total N%	Organic C%	Absorbable phosphor P(ava)	Absorbable potassium K(ava)			
0.08	0.95	14 (mg/kg)	255 (mg/kg)			

Table 1: Other physical and chemical characteristics of the soil

manually. Three wheat cultivars with a density of 300 bushes per m2 were cultivated in line in each plot. There were 12 cultivation lines in each plot and each 4 of them were related to Pishtaz, Azar 2, and Sardari cultivars equally. There was a 50 cm heap between two cultivars. The cultivation line gap was 15 cm from each other with a length of 6 m. Urea top-dress fertilizer was carried out in stem lengthening step for all treatments similarly in the amount of 2.5 kg per plot. The first step of sodium selenate and selenite spraying was conducted by a 20l sprayer in the first step of the fifth node arrival in the stem when the plant had a proper canopy cover to increase the efficiency of solution absorption. The second step of sodium selenite and selenate spraying was in 75% of inflorescence spikelet arrival step [11, 37]. In this research, yield, yield components, stress susceptibility index (SSI), tolerance index (TOL), mean productivity, (MP), geometric mean productivity (GMP), yield index (YI), and yield stability index (YSI) were evaluated. The mean 15 bushes were calculated in the complete examination of agricultural characteristics. 1 m2 area was taken to calculate the grain yield. Harvest was ground cutting with three margin lines removal and half half-meter gap from two ends of the plot. Wheat cultivars yield in conditions with non-usage of selenium (YS) and in the condition of usage of selenium (Yp) was used as follows:

Equations (2.1) and (2.2) of SI and SSI was calculated based on Fischer and Maurer [13] method.

$$\mathrm{SI} = 1 - (Y_s/Y_p) \tag{2.1}$$

and

$$\mathrm{SSI} = \frac{Y_s/Y_p}{1-\bar{Y}_s\bar{Y}_p} \tag{2.2}$$

Equations (2.3) and (2.4) of tolerance index and mean productivity was calculated based on Rosielle and Hamblin [27] method.

$$\mathrm{TOL} = Y_p - Y_s \tag{2.3}$$

and

$$\mathrm{MP} = (Y_p + Y_s)/2 \tag{2.4}$$

Equations (2.5) and (2.6) of GMP and STI were calculated based on Fernandez [12] method.

$$\mathrm{GMP} = \sqrt{Y_s \times Y_p} \tag{2.5}$$

and

$$\mathrm{STI} = (Y_p \times Y_s)/\left(\tilde{Y}_p\right)^2. \tag{2.6}$$

Equation (2.7) of YI was calculated based on Gavuzzi et al [15] method.

$$YI = Y_s/\hat{Y}_s. \tag{2.7}$$

Equation (2.8) of yield stability index (YSI) was calculated based on Bouslama and Schapaugh [6] method.

$$YSI = (Y_s/Y_p) \tag{2.8}$$

Y_p= the potential yield of each cultivar in condition without drought stress (usage of selenium) Y_s= the potential yield of each cultivar in condition with drought stress (non-usage of selenium) $\tilde{Y}_s$= the mean yield of all cultivars in condition with drought stress (non-usage of selenium) $\tilde{Y}_p$= the mean yield of all cultivars in condition without drought stress (usage of selenium)

The correlation coefficient (r) is defined as follows: The factorial design model is as follows:

$$r = \frac{\int_{\mathrm{i}=1}^{\mathrm{n}} (\mathrm{X_i} - \bar{\mathrm{X}})(\mathrm{Y_i} - \bar{\mathrm{Y}})}{\sqrt{[\int_{\mathrm{i}=1}^{\mathrm{n}} (\mathrm{X_i} - \mathrm{X})^2] + [\int_{\mathrm{i}=1}^{\mathrm{n}} (\mathrm{Y_i} - \mathrm{Y})^2]}}. \tag{2.9}$$

How to estimate degrees of freedom, sum and average of squares and F in the above experiment: Model of a randomized block design:

$$y_{ijkl} = \mu + \theta_1 + \tau_j + \omega_k + \varphi_i + \varepsilon_{ijkl} \tag{2.10}$$

where, $i = 1, 2 \ldots p, j = 1, 2 \ldots p, k = 1, 2 \ldots p, l = 1, 2 \ldots p$. Statistic F_0 for hypothesis testing:

$$H_0 = \tau_1 = \tau_2 = \tau_i = 0 \tag{2.11}$$

$$H_1 = \text{Contrary to the null hypothesis} \tag{2.12}$$

is used and in addition:

$$\text{SStotal} = \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{c}(y_{ijk} - y)^2 \tag{2.13}$$

$$\text{SS}a = b + \sum_{i=1}^{a}(y_i - y)\,2 \tag{2.14}$$

$$\text{SS}b = a + \sum_{j=1}^{b}(y_j - y)^2 \tag{2.15}$$

$$\text{SS}c = c + \sum_{l=1}^{c}(y_k - y)^2 \tag{2.16}$$

$$\text{SSerror} = \text{SStotal} - \text{SS}a - \text{SS}b - \text{SS}c \tag{2.17}$$

After testing the normality of data, data variance analysis was conducted as randomized complete block design with three-factor factorial test in three replications then data mean was compared by LSD method in 5% level by SAS, SPSS-24 [33] and MSTATC [24] software. Finally, figures were plotted by EXCEl computer software.

3 Discussion and results

The results of variance analysis for the randomized complete block design with the three-factor factorial test in three replications under the effect of selenium showed the table 2 significant difference in 1% p-value based on 1000 grains weight and grain weight in spike between factor (b) and (c). However, no significant difference was observed based on the bilateral and trilateral effects. In addition, a significant difference was observed in 5 and 1% levels based on grain yield of factor (a) for various selenium resources (sodium selenate and selenite), factor (b) for various selenium amounts (0, 18 and 36 g/ha), factor (c) for three wheat cultivars (Azar 2, Pishtaz, and Sardari), and reciprocal effect of $b \times c$. Sajedi et al [30] sprayed solutions with various selenium resources to examine the agricultural characteristics of wheat and barley and reported that the simple effect of selenium amounts, the reciprocal effect of resources in selenium amounts, and resources on the species were significant in 5% p-value and species effect on grain weight in a spike in 1% p-value.

Comparing the mean levels of a factor (a) of various selenium resources (sodium selenate and selenite) had a significant priority in all the evaluated characteristics of using sodium selenate rather than sodium selenate 3. According to this point and a more complete examination of yield, yield components, SSI, and STI, sodium selenite will be used. Their results showed that the maximum grain weight in the spike was obtained by solution spraying of sodium selenite which increased 6.4% of grain weight than spraying sodium selenate but this increased 5.3% in wheat.

After selecting sodium selenate treatments as the prior one and more effectiveness on the yield and yield components, it is more examined on the mentioned characteristics and estimation of SSI and TOL whose statistical results summary are shown in 4 about the yield variance and yield components in the normal conditions (18 and 36 g/ha of sodium selenate) and water stress (non-usage of selenium). The obtained results from variance analysis showed that the significant difference between the yield and yield components of cultivars in the normal condition (18 and 36 g/ha of sodium selenite) and water stress (non-usage of selenium) that are shown in Table 3 indicate the genetic varieties of the studied cultivars between the examined characteristics. The results of this research were consistent with the findings of Sajedi and Madani [29]. Foliar application by 18 g/ha of selenium increased the grain yield from 1776.31 kg.ha-1 in control to 1889.92 kg.ha-1, while grain yield was decreased (about 1539.62 kg.ha-1) as compared to control when 36 g.ha-1 of selenium was used. It could be concluded that foliar application of 18 g.ha-1 selenium as sodium

R.O.V	**df**	**Mean square**		
		Grain weight in spike	**1000 grains weight**	**Grain yield**
Rep	2	0.00007	5.565**	1091.341
Factor a (selenium resources)	1	0.00004	1.664	24155.001**
Factor b (selenium amounts)	2	0.005**	18.879**	17723.115**
b×a	2	0.00035	1.395	1220.489
Factor c (cultivars)	2	0.003**	746.076**	44290.61**
c×a	2	0.0004	0.16	497.995
c×b	4	0.0005	0.915	2704.617*
c×b×a	4	0.0005	0.469	495.569
Error	34	0.00017	1.039	999.115
Coefficient of variation (%)		12.29	14.33	10.82

Table 2: Randomized complete block design with three-factor factorial test of yield an d yield components of wheat cultivars under the effect of selenium, where * and ** are sig. level in 5 and 1% p-value

Main effects		Evaluated characteristics		
		Grain weight in spike	Weight of 1000 grains	Grain yield (Kg/ha)
Various resources of selenium	Selenate	0.578a	43.66a	1718.08b
	Selenite	0.581a	44.01a	1760.38a

Table 3: Mean factor levels of different sources of selenium (sodium selenate and selenium)

selenite or sodium selenite in wheat and barley during stem elongation and the emergence of spike increases grain yield in dryland conditions.

The obtained results from comparing means showed that the mean grain yield, grain weight in spike, and 1000 grains weight in the normal condition (18 and 36 g/ha of selenite) were more than the ones in water stress conditions (non-usage of selenium). The mean grain yield and grain weight in the spike of the examined genotypes in the normal condition (18 and 36 g/ha selenite) were 175.83 kg/ha, 0.591 g, 1790.82 kg/ha and 0.59 g, respectively. However, the mean of the mentioned characteristics in the water stress condition (non-usage of selenium) was 1737.47 kg/ha and 0.562 g. 1000 grains mean weight of the studied genotypes in the normal condition (18 and 36 g/ha) and water stress (non-usage of selenium) was 43.44, 45.31, and 43.28 g **??**table 5). The grain yield reduces through reducing the yield components (number of grains in spike, grain weight in spike, and 1000 grains weight). Furthermore, grain weight is reduced by reducing the grin growth speed or filling period. According to the results, Pishtaz and Sardari genotypes in normal conditions (18 and 36 g/ha sodium selenite) and water stress (non-usage of selenium) have the maximum and minimum grain yield. The grain yield of the Pishtaz cultivar was significantly higher than the grain yield of the Azar 2 cultivar in normal conditions (18 and 36 g/ha sodium selenite). At the same time, it was indicated by conducting water stress (non-usage of selenium) that water stress has less effect on Azar 2 and Sardari cultivars. Still, it significantly reduced the grain yield of the Pishtaz cultivar until the grain yield of the Pishtaz cultivar was higher than the grain yield of Sardari and Azar 2 cultivars in the water stress condition (non-usage of selenium) **??**table 5). The maximum grain weight in the spike in the normal condition (18 and 36 g/ha of sodium selenite) is for Pishtaz and Azar 2 cultivars, respectively. The minimum grain weight in the spike was for the Sardari cultivar. The significant point about the Sardari cultivar is that the maximum 1000-grain weight with a mean of 49.94 g was in the water stress condition (non-usage of selenium). Although the maximum 1000 grains weight in the normal condition is attributed to the genotype, it was in the third rank based on the grain yield and grain weight in the spike **??**table 5). Sajedi et al [30] stated that the maximum grain yield was obtained at 1757.45 kg/ha of 18 g spraying of sodium selenate which increased 9% than the grain yield of the control treatment. Sajedi and Madani [29] reported that with foliar application of wheat with 18 g.ha-1 sodium selenite increased the grains per spike by 9.4% as compared to control and foliar application of barley with 18 and 36 g.ha-1 of sodium selenite increased the grains per spike by 8 and 12%, as compared to control, respectively. Two times foliar applications of these two plants with sodium selenate and sodium selenite increased their relative water content.

S: water stress (non-usage of selenium) N1: normal (18 g/ha of selenite), and N2: normal (36 g/ha selenite)

S.O.V	df	Mean squares								
		water stress (no-usage selenium)			Normal (18 g/ha selenite)			Normal (36 g/ha selenite)		
		Grain weight	1000 grain weight	grain yield	Grain weight	1000 grain weight	grain yield	Grain weight	1000 grain weight	grain yield
Rep	2	0.0002^{ns}	22.12*	874.83	0.0003^{ns}	3.8*	1560.18*	0.0002^{ns}	1.458^{ns}	919.812^{ns}
Genotype	2	0.003**	102.812**	6691.39*	0.006**	134.877**	9231.48*	0.005**	129.191**	3822.16*
error	4	0.00022	1.386	755.406	0.00011	0.891	260.414	0.00022	0.664	483.338
C.V (%)		12.14	11.72	10.58	13.46	12.17	13.92	12.77	11.8	10.23

Table 4: Simple variance analysis of yield and yield components of wheat cultivars in the normal conditions (18 and 36 kg/ha of sodium selenite) and water stress (non-usage of selenium), where ns,*, and ** are non-significant, and significant in 5 and 1%

The examined genotypes	Mean characteristics								
	Grain weight per spike (g)			1000 grains weight (G)			grain yield (kg/ha)		
	S	N1	N2	S	N1	N2	S	N1	N2
Pishtaz	0.577b	0.62a	0.62a	38.98b	38.35b	40.68b	1786.7a	1813.8a	1822.9a
Azar 2	0.583a	0.613ab	0.617ab	40.9b	40.94b	40.42b	1733.2ab	1739.5ab	1797.2ab
Sardari	0.572ab	0.54b	0.543b	49.94a	50.04a	52.82a	1692.5b	1705.2b	1752.4b

Table 5: Comparing the yield mean and yield components of whet cultivars in the normal condition (18 and 36 g/ha of sodium selenite) and water stress (non-usage of selenium)

3.1 Stress susceptibility and tolerance indexes

Genotypes can be classified based on the tolerance and susceptibility of SSI and STI. In other words, the susceptible and tolerable genotypes to their yield potential can be indicated using these indexes [25]. The lower the SSI is, the genotype stress tolerance is more [13]. Azizinia et al [4] reported that using SSI has more advantages in selecting the wheat desirable cultivars in stress and non-stress conditions. Mollasadeghi et al [23] reported that MP, GMP, STI and MSTI had the highest correlation with performance in both conditions, which were selected as the best indicators. In this test, using SSI showed that the maximum tolerance to the water stress is in Azar 2 with the minimum value of 0.004 in both 18 and 36 g/ha sodium selenite treatment among the examined cultivars in tables 5 and 6. The values of total yield and grain mean yield in the normal condition (18 and 36 g/ha sodium selenite treatments) and water stress (non-usage of selenium) were mentioned in tables 6 and 7.

Ypi: grain yield of a genotype in the non-stress condition (non-usage of selenium), Ysi: grain yield of a genotype in the stress condition (18 g/ha selenium) Yp: grain mean yield in the non-stress condition (non-usage of selenium) Ys: grain mean yield of all genotypes in the stress condition (18 g/ha selenium)

Ypi: grain yield of a genotype in the non-stress condition (non-usage of selenium), Ysi: grain yield of a genotype in the stress condition (36 g/ha selenium) Yp: grain mean yield in the non-stress condition (non-usage of selenium) Ys: grain mean yield of all genotypes in the stress condition (36 g/ha selenium)

This research, using TOL showed that the Azar 2 cultivar with the minimum value (6) and the Pishtaz cultivar with the maximum value (27) had the maximum and minimum tolerance against water stress among cultivars when using 18 g/ha sodium selenite, respectively, but Pishtaz cultivar with the value of 36 and Azar 2 cultivar with the value of 64 had the maximum tolerance against the water stress when 36 g/ha sodium selenite was used. In other words, 36 g/ha sodium selenite reduced the stress in the Pishtaz cultivar and this cultivar was prior to Azar 2 based on TOL index tables 8 and 9. The high value of TOL shows more variation of cultivars' yield in the stress and non-stress water conditions and shows cultivars' susceptibility to the water stress in evaluating cultivars using the TOL index. According to the TOL index, the relative tolerance is more belongs to the cultivar with the lower TOL thus selection to tolerate the stress is tied with the minimum difference between Ys and Yp. The higher the MP values, the greater

Cultivars	Ysi	Ypi	Ys	Yp
Pishtaz	1833.9	1786.7	1752.8	1737.5
Azar 2	1739.5	1733.2	1752.8	1737.5
Sardari	1705.2	1692.5	1752.8	1737.5

Table 6: Grain yield and grain mean yield on cultivars in the normal condition (18 g/ha sodium selenite) and water stress (non-usage of selenium)

Cultivars	Y_s	Y_p	Y_s	Y_p
Pishtaz	1822.9	1786.7	1790.8	1737.5
Azar 2	1797.2	1733.2	1790.8	1737.5
Sardari	1752.4	1692.5	1790.8	1737.5

Table 7: Grain yield and grain mean yield of cultivars in the normal condition (36 g/ha sodium selenite) and water stress (non-usage of selenium)

Cultivars	Y_s	Y_p	YSI	YI	STI	GMP	MP	TOL	SSI
Pishtaz	0.015	27	1800	1800	1.05	1.03	0.99	1813.8	1786.7
Azar 2	0.004	6	1736	1736	0.98	1	1	1739.5	1733.2
Sardari	0.008	13	1699	1699	0.94	0.97	0.99	1705.2	1692.5

Table 8: Various stress tolerance indexes of wheat cultivars in the normal condition (18 g/ha sodium selenite) and water stress (non-usage of selenium)

the tolerance of that genotype to the stress. This research showed the maximum mean productivity index in both conditions of 18 and 36 g/ha sodium selenite with means of 1800 and 1805 for the Pishtaz cultivar which showed higher tolerance against drought stress than other cultivars of Azar 2 and Sardari. In addition, this stress tolerance value for consumption of 36 g/ha is a little more than it is for 18 g/ha sodium selenite tables 8 and 9.

Y_s: Yield Stress; Y_p: Yield productivity; SSI: Stress susceptibility Index; TOL: Tolerance; MP: Mean productivity; GMP: Geometric Mean productivity; STI: Stress Tolerance Index; YI: Yield Index; YSI: Yield Stability Index.

Y_s: Yield Stress; Y_p: Yield productivity; SSI: Stress susceptibility Index; TOL: Tolerance; MP: Mean productivity; GMP: Geometric Mean productivity; STI: Stress Tolerance Index; YI: Yield Index; YSI: Yield Stability Index.

Pishtaz cultivar among all the examined cultivars and evaluation conditions with means of 1800 and 1805 had the maximum GMP while the Sardari cultivar had the minimum GMP with means of 1699 and 1722, respectively in tables 7 and 8. According to the results of various researchers, the best index to select cultivars is STI because it can separate cultivars in both conditions of stress and non-stress with high performance (group A), from two cultivars groups with only non-stress condition (group B), or only in stress condition (group C) with relatively high yield [18, 28] In this research, Pishtaz cultivar among all the examined ones in conditions of 18 and 36 g/ha sodium selenite had the maximum STI with means of 1.05 and 1.02, respectively. Nonetheless, Sardari cultivar with means of 0.94 and 0.92 showed the minimum STl in tables 8 and 9. Shaffazadeh et al. [31] concluded while examining bread wheat genotypes that indexes of MP, GMP, and STI showed a better result in detecting the stress tolerance genotypes than two other indexes of TOL and SSI. A significant correlation was obtained between the grain yield in the normal condition (18 g/ha sodium selenite) and water stress (non-usage of sodium selenite) with indexes of GMP, MP, and STI. Of course, no significant correlation was obtained between the grain yield in the stress condition (non-usage of selenium) and SSI and TOL. On the contrary, a positive and significant correlation was observed in 5% sig. the level between SSI and TOL indexes in table 10. The related results to the correlation between grain yield in the normal condition (36 g/ha sodium selenite) and water stress (non-usage of selenium) were a little different from the normal condition (18 g/ha sodium selenite). In other words, only the water stress (non-usage of selenium) was correlated with indexes of GMP, MP, and STI in this condition in table 11. However, the very high correlation between STI and GMP in both normal conditions (18 and 36 g/ha sodium selenite) with MP index hides the MP index between the two indexes so selecting genotypes based on STI and GMP indexes mainly uses the high values of MP indexes [25]. Mollasadeghi et al. [21] reported that the highest correlation was between grain yield under drought stress conditions and indicators such as STI, MP and GMP. Using three indexes of GMP, MP, and STI to identify the desirable genotypes doesn't make a difference in the result based on the correlation among them.

Cultivars	Y_s	Y_p	YSI	YI	STI	GMP	MP	TOL	SSI
Pishtaz	0.02	36	1805	1805	1.02	1.03	0.97	1822.9	1786.7
Azar 2	0.037	64	1765	1765	0.97	1	0.96	1797.2	1733.2
Sardari	0.035	60	1722	1722	0.92	0.97	0.97	1754.2	1692.5

Table 9: Various stress tolerance indexes of wheat cultivars in the normal condition (36 g/ha sodium selenite) and water stress (non-usage of selenium)

	Ys	Yp	SSI	TOL	MP	GMP	STI
Ys	1						
Yp	0.991	1					
SSI	0.688	0.777	1				
TOL	0.712	0.798	0.999*	1			
MP	0.997*	0.998*	0.74	0.762	1		
GMP	0.997*	0.998*	0.74	0.76	0.99**	1	
STI	0.997*	0.998*	0.642	0.742	0.98**	0.99*	1

Table 10: Correlation among various STIs of wheat cultivars in the normal condition (18 g/ha sodium selenite) and water stress (non-usage of selenium), where * and ** are significant in 5 and 1%

	Ys	Yp	SSI	TOL	MP	GMP	STI
Ys	1						
Yp	0.973	1					
SSI	0.757	0.585	1				
TOL	0.712	0.53	0.998*	1			
MP	0.995*	0.953	0.804	0.762	1		
GMP	0.995*	0.95	0.803	0.76	0.99**	1	
STI	0.995*	0.952	0.805	0.764	0.98*	0.99*	1

Table 11: Correlation among various indexes of STI of wheat cultivars in the normal condition (36 g/ha sodium selenite) and water stress (non-usage of selenium), where * and ** are significant in 5 and 1%

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