УДК **633:11:547.979.7**
DOI

EVALUATION OF LODGING RESISTANCE AMONG THE DIFFERENT WHEAT SPECIES (*TRITICUM* SPP.) IN THE CONDITIONS OF ABSHERON

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Abstract. *The article presents the results of field research on the comparative study of lodging resistance among the different wheat species (Triticum spp.) in relation with the associated morphological traits in 2018-2021.*

Key words: *wheat species, resistance to the lodging, morphological traits, correlation of the traits*

Introduction. Lodging is one of the constraints that limit wheat yields (up to 80%) and grain quality due to the unexpected bending or breaking stems on wheat (*Triticum aestivum* L.) production worldwide. Lodging is the state of permanent displacement of the stems from their vertical, upright position, which is could be induced by various causes: anatomical and chemical characteristics of stems and roots, as well as the associated traits (plant height, stem strength, culm wall thickness, pith diameter, stem diameter, root plate spread and depth, and etc.); legion, disease attack, overdose application of nitrogenous fertilizers, over plant population, soil density, natural disasters such as storm damage, sowing date, seed type and etc. Two types of lodging exist. Root lodging occurs when the anchorage of the root/soil system fails. Stem lodging occurs when the stem base buckles. Lodging resistance is considered as a polygenic trait with major effects of a few single genes.

In many cereal plants, including rice (*Oryza sativa* L.) and barley (*Hordeum* L.), among for other favorable traits, the use of wild species as a donor to increase resistance to lodging is currently recommended [3, 4], in wheat, this trait has been studied mainly in collections of different cultivars or in separate lines. However, the wide use of various wild and cultivated species of wheat as donors in improving agricultural performance requires their comprehensive, complex study as initial material, including their lodging resistance. The aim of our study was the assessment of lodging resistance and some associated morphological traits in the set of plant accessions belonging to the various wild and cultivated wheat species.

Material and Methods. Plant material used in our study were obtained from National Genebank of Genetic Resources Institute of Azerbaijan National Academy of Sciences (GRI of ANAS). It consited a set of 26 accessions from the 11 wheat species plants with the three ploidy levels (di-, tetra- and hexaploid): *T. boeoticum* Boiss. ($2n=2x=14$, A^bA^b), *T. urartu* Thum. ex Gand. ($2n=2x=14$, A^uA^u), *T. dicoccum* (Schrank) Schuebl. ($2n=4x=28$, AABB), *T. dicoccoides* Schweinf. ($2n=4x=28$, AABB), *T. persicum* Vav. ($2n=4x=28$, AABB), *T. polonicum* L. ($2n=4x=28$, AABB), *T. jakubzinerii* Udachin & Shakhm. ($2n=4x=28$, AABB), *T. macha* Dekapr. & Menabde ($2n=6x=42$, AABBDD), *T. spelta* L. ($2n=6x=42$, AABBDD), *T. compactum* Host. ($2n=6x=42$, AABBDD) and *T. vavilovii* Jakubz. ($2n=6x=42$, AABBDD). Plant sampling were carried out by measuring of 5 parameters associated with lodging resistance: plant height (PH), spike length (SL), spike weight (SW), peduncle weight cm $^{-1}$ (PDW) (calculated from dried peduncle weight and length), and vertical bending (or lodging) of the stem (VBS). The latter parameter was evaluated on a 5-point scale with minor modifications [1]:

1 - strongest lodging (bending of the stem at an angle of about 61-90 ° with respect to the vertical position);

2 - strong lodging (bending of the stem at an angle of about 46 - 60 ° to the vertical position);

3 - medium displacement (bending of the stem at an angle of about 31-45 ° with respect to the vertical position);

4 - weak displacement (bending of the stem at an angle of about 5-30 ° with respect to the vertical position);

5 – totally upright (the stem is in a vertical position or bends less than about 5 ° relative to the vertical position).

Mean values were used for phenotypic correlation to determine the relationships between morphological traits and lodging resistance. Statistical analysis carried out by using the computer program IBM SPSS Statistics 25.

The assesment of the lodging resistance on plant accessions was conducted in 2018-2021 under irrigation and open field conditions at the Absheron Experimental Base of GRİ. The place where the Absheron Experimental Base located - Absheron Peninsula extends 60 km eastward into the Caspian Sea, and reaches a maximum width of 30 km. The peninsula is the most arid part of Azerbaijan (precipitation here is around or less than 200 mm a year) and, therefore, the local agriculture requires irrigation. The average annual amplitude of air temperature inside the peninsula is 22-23ºC. According to long-term indicators, the average January temperature in Absheron is 3.8 ° C, and the average July temperature is 23-28 ° C. During the years of the study, no significant deviations from the temperature indicators were observed.Winds are a key element of the Absheron climate and may cause both type – stem and root lodgings in wheat plants under irrigation conditions, especially starting from the early milk stage to the end of the wax-ripe stage of seeds.

Results and discussion. The data from the measurements of the 4 traits associated with the stem bending and obtained on the 26 wheat accessions belonging to the different wheat species showed in the **Table 1**. The amount of variation for the plant height trait (PH) was 61–149 cm [minimum for *T. persicum* (№ 18), maximum - for *T. dicoccum* (№ 15), for the spike length (SL) trait - 6.5–26.0 cm (minimum for *T. urartu* (№ 10), maximum – for *T. dicoccoides* (№ 16), for the spike weight (SW) -

0.3–4.0 g (minimum – for both accessions of *T. urartu* (№ 10 and № 11), maximum - for *T. dicoccoides* (№ 16)), and for the peduncle weight (PDV) - 0.3E-2–2.2E-2 mg (minimum for *T. dicoccum* (№ 15), maximum for *T. compactum* (№ 25)].

Table 1. Morphological traits and lodging score measurements for the 26 accessions of different wheat species

№	Origin	Accessions	PH, cm	SL, cm	SW, g	PDW, mg	VBS, score
1	Iran	BOE-1/1_(*T. boeoticum* var. *boeoticum)*	70.67±1.16 (70÷72)	12.25±0.25 (12÷12.5)	1.2±0.1 (1.1÷1.3)	1E-2±0.1E-2 (0,9E-2÷1E-2)	3
2	Iran	BOE-1/2_(*T. boeoticum* var. *albinigrum)*	88.33±1.53 (87÷90)	9.25±0.25 (9÷9.5)	0.95±0.05 (0.9÷1)	1.1E-2±0.1E-2 (1E-2÷1.2E-2)	4
3	Turkey	BOE-4/1_(*T. boeoticum* var. *helenae)*	123.33±3.51 (120÷127)	8.5±0.5 (8÷9)	0.9±0.2 (0.7÷1.1)	0.8E-2±0.1E-2 (0.7E-2÷0.9E-2)	4
4	Turkey	BOE-4/2_(*T. boeoticum* var. *boeoticum)*	100.67±9.29 (90÷107)	10.25±1.25 (9÷11.5)	0.95±0.15 (0.8÷1.1)	1E-2±0.1E-2 (0.9E-2÷1.1E-2)	3
5	Azerbaijan	BOE-3/1_(*T. boeoticum* var. *helenae)*	92±7.21 (86÷100)	10.5±0.5 (10÷11)	0.9±0.1 (0.8÷1)	0.8E-2±0.1E-2 (0.7E-2÷0.9E-2)	5
6	Azerbaijan	BOE-3/2_(*T. boeoticum* var. *albinigrum)*	87.67±4.04 (83÷90)	11±0.5 (10.5÷11.5)	0.55±0.05 (0.5÷0.6)	1E-2±0.1E-2 (0.9E-2÷1.1E-2)	5
7	Azerbaijan (Nachchivan)	BOE-9_(*T. boeoticum* var. *boeoticum)*	90±10 (80÷100)	9.75±0.25 (9.5÷10)	0.85±0.25 (0.6÷1.1)	0.7E-2±0.1E-2 (0.6E-2÷0.8E-2)	5
8	Azerbaijan (Nachchivan)	BOE-11_(*T. boeoticum)*	115±9.54 (104÷121)	10.5±0.5 (10÷11)	1.2±0.2 (1÷1.4)	1.3E-2±0.1E-2 (1.2E-2÷1.4E-2)	5
9	Azerbaijan (Nachchivan)	BOE-12_(*T. boeoticum)*	112±3.46 (110÷116)	9±0.5 (8.5÷9.5)	0.75±0.05 (0.7÷0.8)	0,7E-2±0,1E-2 (0.6E-2÷0.8E-2)	4
10	Syria	URA-3_(*T. urartu* var. *nigrum)*	122±1 (121÷123)	6.75±0.25 (6.5÷7)	0.4±0.1 (0.3÷0.5)	0.9E-2±0.1E-2 (0.8E-2÷1E-2)	4
11	Armenia	URA-1/1_(*T. urartu* var. *spontaneorubrum)*	107.67±15.7 (90÷120)	11.83±1.76 (10÷13.5)	0.4±0.1 (0.3÷0.5)	1.6E-2±0.1E-2 (1.5E-2÷1.7E-2)	4
12	Armenia	URA-1/3_(*T. urartu)*	130±5 (125÷135)	9±1.5 (7.5÷10.5)	0.55±0.05 (0.5÷0.6)	0.4E-2±0.1E-2 (0.3E-2÷0.5E-2)	3
13	Germany	URA-2_(*T. urartu* var. *spontaneoalbum)*	120±1 (119÷121)	7.75±0.25 (7.5÷8)	0.85±0.05 (0.8÷0.9)	1.1E-2±0.1E-2 (1E-2÷1.2E-2)	4
14	Iran	URA-4_(*T. urartu)*	110±4 (106÷114)	11.17±0.76 (10.5÷12)	0.5±0.1 (0.4÷0.6)	0.9E-2±0.1E-2 (0.8E-2÷1E-2)	3
15	Spain	DIC-1_(*T. dicoccum* var. *dicoccum)*	140.33±7.57 (135÷149)	21.5±0.5 (21÷22)	2.6±0.1 (2.5÷2.7)	0.4E-2±0.1E-2 (0.3E-2÷0.5E-2)	4
16	Israel	DICS-5_*T. dicoccoides* var. *spontaneum*	110.67±10.12 (99÷117)	22.5±1.5 (21÷24)	2.75±1.25 (1.5÷4)	1.7E-2±0.1E-2 (1.6E-2÷1.8E-2)	4
17	Iraq	DICS-9_(*T. dicoccoides* var. *hirtiglumis)*	87±2 (85÷89)	18±1 (17÷19)	1.1±0.2 (0.9÷1.3)	0.6E-2±0.1E-2 (0.5E-2÷0.7E-2)	4
18	Georgia	PER-3_(*T. persicum* var. *persicum)*	66±5.57 (61÷72)	18.75±0.25 (18.5÷19)	1.2±0.3 (0.9÷1.5)	1E-2±0.1E-2 (0.9E-2÷1.1E-2)	5
19	Georgia	PER-1_(*T. persicum* var. *stramincum)*	81±3.61 (78÷85)	17.5±0.5 (17÷18)	1.02±0.1 (0.9÷1.1)	1.4E-2±0.1E-2 (1.3E-2÷1.5E-2)	5
20	Russia	POL-1_(*T. polonicum* var. *polonicum)*	73.33±4.16 (70÷78)	18.5±0.5 (18÷19)	2.85±0.25 (2.6÷3.1)	0.9E-2±0.1E-2 (0.8E-2÷1E-2)	4
21	Uzbekistan	JAK-1_(*T. jakubzinerii)*	104.67±5.13 (99÷109)	14±1 (13÷15)	1.15±0.05 (1.1÷1.2)	2E-2±0.1E-2 (1.9E-2÷2.1E-2)	5
22	Georgia	MAC-1_(*T. macha* var. *palaeoimereticum)*	103±7 (98÷111)	10.75±0.75 (10÷11.5)	1.13±0.23 (1÷1.4)	0.8E-2±0.1E-2 (0.7E-2÷0.9E-2)	5
23	Germany	SPE-1_(*T. spelta* var. *arduini)*	79.67±11.93 (70÷93)	17±2 (15÷19)	1.43±0.21 (1.2÷1.6)	1.1E-2±0.1E-2 (1E-2÷1.2E-2)	5
24	Kazakhstan	COM-1/1_(*T. compactum* var. *fetissovii)*	116±4.36 (111÷119)	13±0.5 (12.5÷13.5)	1.55±0.15 (1.4÷1.7)	2.1E-2±0.1E-2 (2E-2÷2.2E-2)	5
25	Tajikistan	COM-2_*T. compactum* var. *fettissovii*	112.67±3.51 (109÷116)	12.25±0.25 (12÷12.5)	1.45±0.05 (1.4÷1.5)	1.7E-2±0.1E-2 (1.6E-2÷1.8E-2)	5
26	Armenia	VAV-1_(*T. vavilovii* var. *vavilovilutescens)*	89.33±1.53 (88÷91)	11.5±1.5 (10÷13)	2.2±0.6 (1.6÷2.8)	1.7E-2±0.1E-2 (1.6E-2÷1.8E-2)	5

None of the studied 26 accessions had a strongest or strong bending, and the 12 – were showed the totally upright stem position. Among of the wild diploid wheats (*T. boeoticum* and *T. urartu*) the stem lodging mainly were observed on the accessions from other countries, which can be explained by their low adaptability to local soil and climatic conditions compared to local plants. Among the tetraploid wheats, the stem lodging mainly were recorded in genotypes with high spike weight parameter. All evaluated accessions in our study belonged to the hexaploid wheat species were completely resistant to the lodging.

Of the 4 measured parameters the 2 traits that correlated best with the lodging resistance were the plant height (PH) and the peduncle weight cm $^{-1}$ (PDW) (**Table 2.**), that were in agreement with the numerous previous studies [2, 5].

Table 2. Phenotyping correlations beween 4 traits and the lodging score for 26 accessions belonged to the 11 wheat species

	PH	SL	SW	PDW	VBS
PH					
SL	- 0.153				
SW	- 0.014	0.731**			
PDW	- 0.044	0.130	0.201		
VBS	- 0.424**	0.096	0.084	0.365**	

** Correlation values are significant at the 0.01 probability level

Conclusion. In the semi-arid and irrigated conditions of Absheron Peninsula the 4 local accessions of wild diploid wheat species *T. boeoticum*, two accessions of tetraploid wheat species of different origins (*T. persicum* and *T. jakubzinerii*), and all four accessions of hexaploid wheat species (*T. vavilovii, T. spelta, T. macha* and *T. compactum*) were determined as the resistant to the lodging and can be used as the donors for this trait.

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ОЦЕНКА РАЗЛИЧНЫХ ВИДОВ ПШЕНИЦЫ (*TRITICUM* SPP.) НА УСТОЙЧИВОСТЬ К ПОЛЕГАНИЮ В УСЛОВИЯХ АПШЕРОНА

Г.Д. Мусаева, Р.Г. Рагимов

Аннотация: *В статье приведены результаты работ по сравнительной оценке различных видов пшеницы (Triticum spp.) на устойчивость к полеганию и связанных с данным явлением некоторых морфологических признаков. На основе проведенного исследования, было выявлено, что для гибридизации в качестве доноров на устойчивость к полеганию, могут привлекаться, в основном, местные генотипы диплоидной пшеницы T.boeoticum Boiss., два образца тетраплоидных пшениц различного происхождения – T. persicum Vav. и T. jakubzinerii Udacz. et Schahm., а также все образцы изученных нами гексаплоидных видов.*

Ключевые слова: *виды пшениц, устойчивость к полеганию, морфологические признаки, корреляция признаков/*