Emirates Journal of Food and Agriculture. 2023. 35(5): 436-441
doi: 10.9755/ejfa.2023.v35.i5.3099
http://www.ejfa.me/

RESEARCH ARTICLE

Evaluation of wheat (*Triticum aestivum L.*) lines for drought tolerance in Kyrgyzstan

Isaeva Venera Karabekovna*

Department of Agriculture, Kyrgyz-Turkish Manas University, Manas, Bishkek, Kyrgyz Republic

ABSTRACT

The study was carried out to explore drought stress indices in F4 hybrid generations of *Triticum aestivum* L. to select drought stress tolerant lines for rainfed areas of Kyrgyzstan. Wheat is the main food crop in Kyrgyzstan. There are about 0.3 million ha allotted for wheat, more than half of these sown areas (0.2 million ha) are in rainfed farming zones, where the amount of precipitation rarely exceeds 300-400 mm per year. The study was conducted in 2019 at the experimental field of Agricultural Faculty of Kyrgyz-Turkish Manas University. Eighteen hybrid lines of spring wheat and two released varieties (standard) were evaluated under irrigated and non-irrigated conditions. The results of the study show that the mean grain yield of evaluated lines under stress condition as compared to non-stressed condition was decreased by 51.72%. The analysis of correlation coefficient indicated that the productivity of lines under both conditions highly depends from their stress tolerance indexes (STI) (0.769 to 0.928). Tolerance index (TOL) and stress susceptibility index (STI) were negatively correlated (-0.411 to -0.813) with yield of genotypes under stress condition (YS). The correlation between yield stability index (YSI) and yield of genotypes under stress condition (YS) was strongly and highly positive (1.000). Based on provided analysis, Line-1, Line-3, Line-5, Line-12, Line-13, Line-14 and Line-15 were selected as potential genotypes to cultivate in drought areas of Kyrgyzstan and can be used as drought tolerance genetic resources in crop improvement programs.

Keywords: Correlation; Drought tolerance; Hybrid lines; Stress tolerance indices; *Triticum aestivum* L.

INTRODUCTION

Drought stress is one of the leading constraints to wheat (*Triticum aestivum* L.) production globally. Breeding for drought tolerance using novel genetic resources is an important mitigation strategy (Mwadzingeri, 2016). Selection of different lines under abiotic stress conditions helps plant breeder to exploit genetic variation to improve stress tolerant cultivar (Khan and Kabir, 2014). In the plant-environment system, special attention should be paid to the potential of the plant (Rybas, 2016). The results of many researches (Hooshmandi, 2019; Modaressi et al., 2010; Pakul and Plisko, 2018 and others) concluded that the effect of the duration and intensity of stress conditions on the growth and development of wheat depends on the genotype.

Hybridization is a complex process of new forms formation, based on the development of the genotype in constantly changing environmental conditions (Aseeva and Zenkina, 2018). One of the major achievements of biological, agronomic science and practice is the production and wide distribution of hybrid forms of economically important plants, characterized by a pronounced heterotic effect (Orlovskaya, 2012). Success in the implementation of the tasks set is determined by the features of the created source material (Samofalova et al., 2015). The assessment of the obtained hybrids is expressed not only by the absolute level of resistance to adverse environmental factors, but also by the value of the realization of potential productivity under these conditions, which is the result of the interaction of quantitative traits with a polygenic genetic basis (Koleda, 2016). Variability and potential productivity of varieties is closely related to the climatic conditions of the region. In conditions of soil and air drought, productivity indicators are significantly reduced (Isaeva, 2013). About 80% of the world's cultivated area is located in rainfed areas (Rockstrom, 2007). 237 million ha, i.e., more than half of the world's wheat crops are periodically subject to drought (Rajaram, 2001). The reduction in wheat yield due to drought can be as much as 55% (Rashidi et al, 2011). Bread wheat requires a minimum of 450-650 mm of rainfall in

***Corresponding author:**
Isaeva Venera Karabekovna, Department of Agriculture, Kyrgyz-Turkish Manas University, Manas, Bishkek, Kyrgyz Republic,
E-mail: isakarabek@yahoo.com

Received: 20 March 2022; **Accepted:** 16 December 2022

the growing season (Mehraban et al., 2018). In Kyrgyzstan, crops are grown on both irrigated and rainfed lands, located at an altitude of 500 to 2000 m, where the total amount of precipitation is 200-800 mm per year. The areas of arid lands in the republic make up 40% of the total arable land, that is 0.5 million ha (477800 ha) from 1.2 ha (http://www.stat.kg/ru/news) are located in mountainous area.

In Kyrgyzstan, the main food crop is wheat until the 2010s occupied a third of the entire arable land - 1.3 million ha, accounting for about 0.4 million ha of area, of which 0.1 million ha were located on rainfed lands. At present total area under wheat is estimated about 0.3 million ha (250623 ha). More than half of these areas (177799 ha) are located in the rainfed zone of agriculture, where the amount of precipitation rarely exceeds 300-400 mm per year. In the summer months, moisture is practically absent in a meter-long layer of soil. In this regard, for rainfed areas of agriculture in Kyrgyzstan, early maturing, heat- and drought-resistant varieties are needed, with intensive growth in spring and rapid grain filling, moving away from air and soil drought. In wheat breeding for drought tolerance several selection indices have been suggested on the basis of mathematical relationship between non-stressed and stress conditions (Sayyah et al., 2012). The indices GMP, MP, STI, TOL and YI are more suitable criteria to select for drought tolerance (Ballesta et al., 2019; Mohammadijoo et al., 2015; Puri et al., 2015). The GMP is often used by breeders interested in relative performance to identify tolerance of genotypes for vary of drought stress (Fernandez, 1992). High value of TOL indicates that the genotype is susceptible to drought. The genotypes with high amounts of MP, GMP, STI indexes (Fard and Sedaghat, 2013) and low amount of SSI (Hooshmandi, 2019) are tolerant to drought. The positive and significant correlation of yield under drought stress and non-stress conditions identifies high potential genotypes (Semaheng et al., 2020). Thus, the objective of the present study was to explore drought stress indices in F_4 hybrid generations of Triticum aestivum L. to select drought stress tolerant lines for rainfed areas of Kyrgyzstan.

MATERIALS AND METHODS

The field experiment was conducted at Agriculture Faculty experimental field of the Kyrgyz-Turkish Manas University, located on the southern foothill zone of Bishkek city (825 m above sea level; 42.8746° N, 74.5698° E) (Fig. 1), where the average air temperature in summer reaches to 23-26 °C and the average relative humidity during grain filling is 40%. The soil of the experimental plot is northern light gray soil. The northern gray soils in the arable horizon are precariously lumpy. Water penetrability and water holding capacity are low (Mamytov et al., 1966). Groundwater in the rainfed agricultural zone of Kyrgyzstan is located at a depth of more than 20 m. At the end of June and in the beginning of July, there is practically no moisture in the meter layer of soil (Ohrimenko and Kuznethsov,1986), so the only source of soil moisture is precipitation. The study of eighteen lines were conducted in randomize complete blocks design with three replications in drought stress and non-stress conditions. The studied lines were sown on April 15. The sowing of the studied lines was carried out manually (Fig. 2). The lines were planted in 1.5 m^2 (2 m x 0.75 m) plots and the space between rows were 22-25 cm. The varieties Intensivnaya and ISRNT-16 were sown as the standard.

The experiment field, before sowing, was watered at the rate of 2500 m^3/ha. In non-stress condition studied lines were irrigated two times. The first irrigation was done after stem elongation in amount of 800 m^3/ha and second was carried out at heading stage in amount of 1200 m^3/ha. The irrigation of lines under drought-stress condition was not carried out. In the year of the study, the average daily air

Fig 1. The experimental field of the Kyrgyz-Turkish Manas University

Fig 2. Sowing of lines

temperature during the period of "heading-filling of grain" (May-26 June of 2019) averaged 18.1-23.2 ˚C. In growing season, the total amount of precipitation amounted to 239.8 mm, which is 46.2 mm lower than long-term data (Table 1). According to Konyushenko and Tarova (2008) 239.8 mm precipitation amount is equal to 2398 m^3/ha. This is obtained by multiplying the layer of water 1 mm per area of 1 ha, expressed in m^2 (0.239 x 10000 = 2398 m^3).

The grain yield data were recorded by harvesting crop from each plot (1 m^2). The grain yield from obtained samples was measured in gram per meter square. The indicators of productivity and drought tolerance indices were calculated by the following relationships:

1. Mean productivity (MP): MP = (Ys + Yp)/2MP = (YP +YS)/2 (*Hossain* et al.*,1990*), where YP is a yield of lines in non-stress condition and YS is a yield of lines in drought stress condition
2. Geometric mean productivity (GMP): GMP= $(Yp \times Ys)^{0.5}$ *(Fernandez, 1992)*
3. Tolerance index (TOL): TOL = (Yp – Ys) *(Hossain* et al.,*1990)*
4. Stress tolerance index (STI): STI = (Yp * Ys)/$(\hat{Y}p)2$ *(Fernandez, 1992)*, where is an average productivity of lines in non-stress condition
5. Stress susceptibility index (SSI): SSI = [1-(Ys/Yp)]/[1] (*Fisher and Maurer, 1978*), is an average productivity of lines in stress condition
6. Yield stability index (YSI): Ys/Yp (*Gavuzi* et al, *1997; Lin* et al, *1986*)
7. Yield index (YI): YI = Ys/(*Lin* et al, *1986*)

The statistical analysis of collected and calculated data was conducted using the SPSS version 22 to obtain a more exact evaluation regarding the tolerated wheat cultivars to drought.

RESULTS AND DISCUSSION

Drought tolerance of wheat is determined by different mechanisms operating at different levels of plant organization (Amunova, 2017). Drought exerts negative effects on growth and development of wheat genotypes thus ultimately reducing the grain yield (Mujtaba et al., 2018). The reasons of yield reducing can be high variability of the quantitative traits (Kaya and Akcura, 2014) such as productive tiller number, kernel weight per plant and per spike under stress conditions (Isaeva, 2006). Yield reduction caused by drought stress for each cultivar of wheat is an important index to evaluate the amount of yield changes of one cultivar of wheat in stress condition than its yield in non-stress condition (Hooshmandi, 2019), since drought resistance is the hereditary ability of plants to survive periodic water scarcity without significant consequences for growth, development and productivity (Dorofeev et al., 1985).

Drought indices such as GMP, MP, STI and YI are the best for identifying superior genotypes across various water availability conditions (Mohammadi et al., 2010; Ayalew et al., 2016) by having positive and significant associations with grain yield under both drought stress and non-stress conditions (Ballesta et al., 2019). The calculated indicators of productivity and drought tolerance indices were shown in Table 2. Yields under non-stress condition were about two times higher than yield under drought stress (Poudel et al., 2021), amounting total mean of YP 704.7 than YS 364.5. High amount of MP causes distinction between genotypes which have high mean yield in both stress and non-stress conditions than other genotypes (Mehraban et al., 2018), accordingly Line-1 (617.2), Line-12 (608.7) and Line-13 (611.7) distinguished with high value of this index. Line-2 (467.4) and Line-18 (448.2) showed the greater value of TOL. The minimum value of TOL belongs to Line-14 (210). The lower value of TOL is favorable for selection of high yielding genotypes under stress condition (Nouri et al., 2011). Selection based on SSI helps to determine high yielding genotypes under both conditions (Karmani et al., 2017). Line-2 (1.2), Line-6 (1.16), Line-9 (1.16) and Line-10 (1.16) showed higher value of SSI and consequently their YS were reduced more than two times. Genotypes with lower SSI values were considered as stress tolerant, because such genotypes showed a lower reduction in grain yield under stress environment compare to non-stress environment. SSI has been widely used by researchers to identify sensitive and resistant genotypes (Winter et al.,1998; Sayyah et al., 2012). Line-1 (617.2; 584.2 and 0.69), Line-12 (608.7; 586.5 and 0.69) and Line-13 (611.7; 590.5 and 0,70) showed more higher value of MP, GMP and STI. Sayyah et al. (2012), Karmani et al. (2017) and Poudel et al. (2021) reported the similar results and suggested selection based

Table 1: Monthly mean temperature and rainfall in 2019 at the experimental station during growing season

Climatic parameters	MAR	APR	MAY	JUN	JUL	AUG	Mean
Mean temperature (˚C) of months	9.3	13.1	18.1	23.2	25.9	25.5	19.2
Average long- term temperature for 2015-2019	7.9	13.2	18.7	23.4	26.9	24.3	19.1
Rainfall (mm) of months	52	114.5	28.5	31.3	4.2	9.3	39.9
Average long- term rainfall for 2015-2019	57.8	87.6	65.6	36.8	28.6	9.6	47.7

on MP, GMP and STI would identify higher yielding and drought tolerant genotypes. The diversity in drought stress adaptability allowed identifying drought stress tolerant and drought stress susceptible genotypes (Gonzalez-Hernandez et al., 2021). Decreasing yield in low water levels indicates that water is a limiting factor in experiment (Soares et al., 2021). The productivity of Line-2 (812,6) and Line-18 (802,8) under non-stressed condition was high, however it reduced more than two times under stress conditions 345.2 and 354.6 appropriately. Line-6 (284), Line-7 (295.1), Line-8 (281) and Line-10 (289.2) showed lower value of yield at drought stress condition and identified as not stress tolerant ones. Line-1 (418.2), Line-3 (401.3), Line-5 (412.1), Line-12 (445.9), Line-13 (451.9), Line-14 (471.2), Line-15 (402.1) showed higher yields under stress conditions than others and were selected as drought stress tolerant lines.

Correlation coefficients between grain yield and stress tolerance indices were identified by Pearson's correlation test (Table 3). Correlation coefficient is helpful to find out the degree of overall association between two attributes (Nouri et al., 2011; Talebi et al., 2009). The analysis of correlation coefficient indicated that the productivity of lines under both conditions highly depends upon their stress tolerance indexes (STI) (0.769 to 0.928). Tolerance index (TOL) and stress susceptibility index (SSI) were negatively correlated (-0.411 to -0.813) with yield of genotypes under stress condition (YS). The correlation between yield stability index (YSI) and yield of genotypes under stress condition (YS) was strongly and highly positive

Table 2: Grain yield (g/m²) of evaluated wheat lines and stress tolerance indices

Genotypes	YP	YS	MP	GMP	SSI	STI	TOL	YSI	YI
Intensivnaya	739.4	416.8	578	555.1	0.89	0.62	322.6	0.56	1.14
ISRNT-16	618.7	369.4	494	478.1	0.84	0.46	249.3	0.59	1.01
Line-1	816.2	418.2	617.2	584.2	1,.1	0.69	398	0.51	1.15
Line-2	812.6	345.2	578.9	529.6	1.2	0.56	467.4	0.42	0.95
Line-3	776.2	401.3	588.7	558.1	0.98	0.63	374.9	0.52	1.1
Line-4	615	303.7	459.3	432.2	1.04	0.38	311.3	0.49	0.83
Line-5	696.3	412.1	554.2	535.7	0.83	0.58	284.2	0.59	1.13
Line-6	662.1	284	473	433.6	1.16	0.38	378.1	0.43	0.78
Line-7	672.5	295.1	483.8	445.5	1.14	0.4	377.4	0.44	0.81
Line-8	617.9	281	449.4	416.7	1.12	0.35	336.9	0.45	0.77
Line-9	712.3	310.2	511.2	470.1	1.16	0.44	402.1	0.43	0.85
Line-10	667.9	289.2	478.5	439.5	1.16	0.39	378.7	0.43	0.79
Line-11	639.6	385.2	512.4	496.4	0.81	0.49	254.4	0.6	1.06
Line-12	771.5	445.9	608.7	586.5	0.86	0.69	325.6	0.58	1.22
Line-13	771.6	451.9	611.7	590.5	0.86	0.70	319.7	0.58	1.24
Line-14	681.2	471.2	576.2	566.5	0.63	0.65	210	0.69	1.29
Line-15	695.6	402.1	548.8	482.4	0.86	0.56	293.5	0.58	1.1
Line-16	726.3	334.6	530.4	492.9	1.1	0.49	391.7	0.46	0.91
Line-17	598.2	312.9	455.5	432.6	0.98	0.38	285.3	0.52	0.86
Line-18	802.8	354.6	578.7	284.5	1.14	0.57	448.2	0.44	0.97
Total mean	704.7	364.5	534.6	490.5	0.99	0.52	340.5	0.51	0.99

YP=yield of genotypes under non-stress condition; YS=yield of genotypes under stress condition; MP=Mean productivity; GMP=Geometric mean productivity; TOL=Tolerance index; STI=Stress tolerance index; SSI=Stress susceptibility index; YSI=Yield stability index; YI=Yield index

Table 3: Correlation coefficients between grain yield and stress tolerance indices of studied wheat lines

	YP	YS	MP	GMP	SSI	STI	TOL	YSI	YI
YP	1.000								
YS	0.482*	1.000							
MP	0.880**	0.840**	1.000						
GMP	0.364	0.725**	0.618	1.000					
SSI	0.115	-0.813**	-0.369	-0.553*	1.000				
STI	0.769**	0.928**	0.979**	0.691**	-0.538*	1.000			
TOL	0.601**	-0.411	0.149	-0.282	0.861**	-0.045	1.000		
YSI	-0.099	0.822**	0.384	0.566**	-0.999**	0.551*	-0.852**	1.000	
YI	0.483*	1.000**	0.841**	0.727**	-0.812**	0.928**	-0.409	0.821**	1.000

YP=yield of genotypes under non-stress condition; YS=yield of genotypes under stress condition; MP=Mean productivity; GMP=Geometric mean productivity; TOL=Tolerance index; STI=Stress 15 tolerance index; SI=Stress susceptibility index; YSI=Yield stability index; YI=Yield index * Significant at 0.05 level of probability; ** Significant at 0.01 level of probability

(0.822 -1.000). There was significant positive correlation of grain yield under non-stress (YP) and stress (YS) conditions with MP and STI. Puri et al. (2020) and Poudel et al. (2021) concluded that selection of genotype considering MP, GMP and STI would determine genotype with high yield potential under both conditions. Poudel et al. (2021) had reported that the TOL and SSI were negatively and significantly correlated with YS, while YSI had positive significant correlation with YS and suggested that selection based on higher value of YSI and lower value of TOL, and SSI helps to identify stress tolerant genotypes. Above mentioned indices can be introduced as the best evaluation indices of stress tolerance (Hooshmandi, 2019).

CONCLUSIONS

The study showed that limited watering reduces the grain yield of wheat genotypes by about two times. All explored drought stress indices were useful on selection of lines to drought tolerance. Line-11 showed not high productivity in non-stress condition (YP-639.6), but it's reducing under stress condition was not high (YS-385.2). SSI (0.81) and TOL (254.4) of this line were low, accordingly YI (1.06) was high. In this regard, Line-11 had interested as a genetic source, having a high adaptive ability to adverse environmental factors. Line-1, Line-3, Line-5, Line-12, Line-13, Line-14 and Line-15 had higher value of YS than other studied lines. Correlation coefficients between grain yield and stress tolerance indices of studied lines showed that the YS highly and positively correlated with MP (0.840), GMP (0.725), STI (0.928), YSI (0.822) and YI (1.000). Accordingly, these indices' values of these lines were high. On the results of provided analysis, Line-1, Line-3, Line-5, Line-12, Line-13, Line-14 and Line-15 were selected as potential genotypes to cultivate in drought areas of Kyrgyzstan and can be used as drought tolerance genetic resources in crop improvement programs.

ACKNOWLEDGMENTS

The author is grateful to the Department of Fruit and Field Crops of Agricultural Faculty of Kyrgyz-Turkish University «Manas» for providing the structural facilities (experimental field station, equipment, planting, irrigation, harvesting, measuring).

AUTHOR CONTRIBUTION

Venera Karabekovna Isaeva carried out the whole research work (experimental work design, data collection, statistical analysis, writing of the original manuscript). The technical staff of the Agronomy Faculty helped with sowing, watering, and harvesting.

REFERENCES

Amunova, O. S. 2017. Source Material for Bread Wheat Breeding to Resistance of Volga-Vyatsko Region's Unfavorable Edaphic Factors. (Doctoral Dissertation), Zonal Scientific Research Institute of Agriculture of the North-East by N.V. Rudnitsky, Kirov.

Aseeva, and K. V. Zenkina. 2018. Inheritance of the main economically valuable traits in F1 hybrids of spring triticale at the conditions of the Middle Amur Region. Far. East Agrarian Bull. 4: 7-12.

Ayalew, H., T. Dessaleng, H. Liu and G. Yan. 2016. Performance of Ethiopian bread wheat (*Triticum aestivum* L.) genotypes under contrasting water regimes: Potential source of variability for drought resistance breeding. Aust. J. Crop Sci., 10: 370-376.

Ballesta, P., F. Mora and A. Del Pozo. 2020. Association mapping of drought tolerance indices in wheat: QTL-rich regions on chromosome 4A. Sci. Agric. 77: 1-7.

Dorofeev, V. F., N. N. Kozhushko and N. I. Kalinin. 1985. Summarizing results and prospects of investigations of the VIR on the problem of drought resistance. Bull. Appl. Bot. Genet. Plant Breed. 94: 3-10.

Fard, A. K. and S. Sedaghat. 2013. Evaluation of drought tolerance indices in bread wheat recombinant inbred lines. Eur. J. Exp. Biol. 3: 201-204.

Fernandez, G. C. J. 1992. Effective selection criteria for assessing stress tolerance. In: C. G. Kuo (Ed.), Proceedings of the International Symposium on Adaptation of Vegetables and Other Food Crops in Temperature and Water Stress. Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan.

Fisher, R. A. and R. Maurer. 1978. Drought resistance in spring wheat cultivars. Aust. J. Agric. Res. 29: 897-912.

Gavuzi, P., F. Rizza, M. Palumbo, R. G. Campaline, G. L. Ricciardi and B. Borghi. 1997. Evaluation of field and laboratory predictors of drought and heat tolerance in winter cereals. Can. J. Plant Sci. 77: 523-531.

Gonzalez-Hernandez, V. A, E. Lugo-Cruz, L. E. Mendoza-Onofre, A. Santacruz-Varela, M. A. Gutierrez-Espinoza and F. Zavala-Garcia. 2021. Maize (*Zea mays* L.) landraces classified by drought stress tolerance at the seedling stage. Emir. J. Food Agric. 33: 29-36.

Hooshmandi, B. 2019. Evaluation of tolerance to drought stress in wheat genotypes. Artículos de investigación. Res. Papers. 2: 37-43.

Hossain, A. B. S., A. G. Sears, T. S. Cox and G. M. Paulsen. 1990. Desiccation tolerance and its relationship to assimilate partitioning in winter wheat. Crop Sci. 30: 622-627.

Isaeva, V.K. and M.K. Junusova. 2006. Influence of ecological conditions on economical valuable parameters of the winter wheat examples. Sci. New Technol. 2: 114-117.

Isaeva, V. K. 2013. Productivity of winter wheat varieties at the conditions of provided rainfed lands. Sci. New Technol. Innov. Kyrgyzstan. 7: 163-167.

Kamrani, M., Y. Hoseini and A. Ebadollahi. 2017. Evaluation for heat stress tolerance in durum wheat genotypes using stress tolerance indices. Arch. Agron. Soil Sci. 64: 38-45.

Kaya, Y. and M. Akcura. 2014. Effects of genotype and environment on grain yield and quality traits in bread wheat (*T. Aestivum* L.). Food Sci. Technol. 34: 386-393.

Khan, A. A. and M. R. Kabir. 2014. Evaluation of spring wheat genotypes (*Triticum aestivum* L.) for heat stress tolerance using different stress tolerance indices. Cercet. Agron. Moldova. 47: 49-63.

Koleda, I. I. 2016. Inheritance of crop structure elements by soft winter wheat hybrids in the system of intraspecific crosses. Agric. Problems Prospects Agron. 32: 92-98.

Konyushenko, V. I. and Z. N. Tarova. 2008. Main values of Plant Water Regime and Their Use at Programming of Agricultural Crop's Productivity. Michurinsk. CT: Naukograd.

Lin, C. S., M. R. Binns and L. P. Lefkovitch. 1986. Stability analysis: Where do we stand? Crop Sci. 26: 894-900.

Mamytov, A. M., G. I. Roichenko, N. K. Bajenov, V. A. Makarenko and S. Ashirahmanov. 1966. Soils of Kyrgyzstana. Kyrgyzstan, CT: Frunze.

Mehraban, A., A. Tobe, A. Gholipouri, E. Amiri, A. Ghafari and M. Rostaii. 2018. Evaluation of drought tolerance indices and yield stability of wheat cultivars to drought stress in different growth stages. World J. Environ. Biosci. 7: 8-14.

Modaressi, M., V. Mohammadi, A. Zali and M. Mard. 2010. Response of wheat yield and yield related traits to high temperature. Cereal Res. Commun. 38: 23–31.

Mohammadi-joo, S., A. Mirasi, R. Saeidi-Aboeshaghi and M. Amiri. 2015. Evaluation of bread wheat (*Triticum aestivum* L.) genotypes based on resistance indices under field conditions. Int. J. Biosci. 6: 331-337.

Mujtaba, S. M., S. Faisal, M. A. Khan, M. U. Shirazi and M. A. Khan. 2018. Evaluation of drought tolerant wheat genotypes using morpho physiological indices as screening tools. Pak. J. Bot. 50: 51-58.

Mwadzingeri, L., H. Shimelis, S. Tesfay and T. J. Tsilo. 2016. Screening of bread wheat genotypes for drought tolerance using phenotypic and proline analyses. Front. Plant Sci. 7: 1-12.

National Statistical Committee of the Kyrgyz Republic. 2021. In: 2021, There Was an Increase in the Sown Area of Agriculture. Kyrgyzstan; 2021. Available from: http://www.stat.kg/ru/news/v-2021-godu-otmechalos-uvelichenie-posevnyh-ploshadej-selskohozyajstvennyh-kultur

Nouri, A., A. Etminan, J. A. T. da Silvia and R. Mohammadi. 2011. Assessment of yield, yield-related traits and drought tolerance of durum wheat tolerance (*Triticum turgidum* var. durum Desf). Aust. J. Crop Sci. 5: 8-16.

Ohrimenko, N. P. and P. N. Kuznethov. 1986. The main ways of intensification of rainfed areas. Kyrgyzstan, CT: Frunze.

Orlovskaya, O. A. 2012. The genetic divergence degree influence of parents to the level of spring triticale F1 hybrids heterosis. Ecol. Genet. 3: 3-9.

Pakul, V. N. and L. G. Plisko. 2018. Drought tolerance of spring bread wheat varieties. Int. Res. J. 12: 49-52.

Poudel, P. B, M. R. Poudel and R. R. Puri. 2021. Evaluation of heat stress tolerance in spring wheat (*Triticum aestivum* L.) genotypes using stress tolerance indices in western region of Nepal. J. Agric. Food Res. 5: 100179.

Puri, R. R., N. R. Gautam and A. K. Joshi. 2015. Exploring stress tolerance indices to identify terminal heat tolerance in spring wheat in Nepal. J. Wheat Res. 7: 13-17.

Rajaram, S. 2001. Prospects and promise of wheat breeding in the 21th century. In: Wheat in a Global Environment. Dordrecht: Springer. p37-52.

Rashidi, V., S. Chalabiyani and A. Tarinejad. 2011. Evaluation of drought tolerance in promising lines and cultivars of bread wheat (*Triticum aestivum* L.). J. Food Agric. Environ. 9: 423-427.

Rockstrom, J. 2007. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. IWMI, Colombo.

Rybas, I. A. 2016. Improving of adaptability in the selection of grain crops. Agric. Biol. 5: 617-621.

Samofalova, N. E., M. A. Leshenko and N. P. Ilichkina. 2015. Comparative study of winter durum wheat first and second generations hybrids of different crosses types. Sci. J. KubSAU. 114: 1-13.

Sayyah, S., M. Ghobadi, S. Mansoorifar and A. R. Zebarjadi. 2012. Evaluation of drought tolerant in some wheat genotypes to post-anthesis drought stress. J. Agric. Sci. 11: 248-256.

Semaheng, Y., H. Shimelis, M. Laing and I. Mathew. 2020. Evaluation of bread wheat (*Triticum aestivum* L.) genoptypes for yield and related traits under drought stress conditions. Acta Agric. Scand. 70: 474-484.

Soares, G., W. Junior, L. Pereira, C. A. Lima, D. S. Soares, O. Muller and R. M. L. Ramos. Characterization of wheat genotypes for drought tolerance and water use efficiency. Sci. Agric. 5: 1-11.

Talebi, R., F. Fayaz and A. M. Naji. 2009. Effective selection criteria for assessing drought stress tolerance in durum wheat (*Triticum durum desf*). Gen. Appl. Plant Physiol. 35: 64-74.

Winter, S. R., J. T. Musick and K. B. Porter. 1998. Evaluation of screening techniques for breeding drought-resistance winter wheat. Crop Sci. 28: 512-516.