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A Modern Equation for Determining the Dry-spell Resistance of Crops to Identify Suitable Seeds for the Breeding Program Using Modified Stress Tolerance Index (MSTI)

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ABSTRACT

Today's world is facing various challenges that impose remarkable stress on the very environment and species that man relies on for his existence. Drought, for instance, is one of the main sources of environmental stress. To tackle the environmental difficulties caused by drought, investigating types of plants with drought-resistant properties is both useful and, arguably, essential. The selection procedure of plant materials includes many formulas, such as SSI, STI, TOL, GMP, YI, YSI, and MP. Under drought stress and non-stress conditions, these formulas rely on seeds' weight. Low viability of seeds can mislead research with inauthentic data for the selection of an optimal species of plants. Thus, this study suggested the inclusion of 'seed viability' in these formulas. Based on the results of other research projects, the Stress Tolerance Index (STI) is the most useful selection criterion. Since breeders have to meet the needs of both research laboratories and the breeding program, selecting a set of seed with high viability is vital, hence the final formula: MSTI= ((Ypi xYsi)/Yp2)×SV Ysi= yield of the cultivar in stress condition, Ypi= yield of the cultivar in normal condition, Yp2= SV= seed viability. *Note: SV is for the selected condition that we want to use seeds in It should be noted that the provided formula here is only for the breeding program and laboratory experiments.

KEY WORDS: MSTI, DROUGHT STRESS TOLERANCE, NEW FORMULA, BREEDING PROGRAM.

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INTRODUCTION

The drought-induced stress is of the main factors that limit the production of crops, including wheat on the national and international levels. The limiting role of drought becomes more prominent when it comes to dry and semi-arid regions (Kirigwi & Van Ginkel et al., 2004). The severity of this issue becomes clearer when statistics indicate about 1/4 of Earth's land is dry, and an estimated 1/3 of the world's arable land suffers mild to severe water shortage (Gholamin and Khayatnezhad 2020). Drought tolerance is defined as the ability of crops to grow and produce under conditions of water shortage. If the drought persists over the long term, the stress that it causes can negatively impact plants' metabolic reactions, physiological properties, unsettle the stages of growth, and damage soil's water storage capacity.

Crops indicate different drought tolerance in comparison with wild species. In reaction to a condition where access to water is severely limited, crops go through serious deficit-related trauma, perish, or significantly lose yield, whereas, in the wilderness, plants may fight the deficit and remarkably survive without yield decline. Nevertheless, breeders in dry areas, where land suffers a shortage of water, have always considered the drought-resistant properties of their crops a determining breeding factor, seeking ways to maximize production while keeping water consumption to the minimum, (Talebi, Fayaz et al., 2009).

While attempts at enhancing grain yield in areas with favorable environmental conditions have proven much successful, genetic modification of crops to maximize the yield in harsh environments remains a challenge to date (Richards, Rebetzke et al., 2002). Hall defines drought resistance as a genotype's relative yield compared with other genotypes' yield when subjected to the same level of drought stress (Hall 1993). Research studies often measure genotypes' drought susceptibility as a function of yield reduction under drought-induced stress (Blum 1988) whilst the values are confounded with genotypes' differential yield potential (Ramirez-Vallejo & Kelly, 1998) defined 'stress tolerance' as the different levels of yield under stress (Ys) and non-stress (Yp) conditions.

They also defined mean productivity (MP) as the average yield of Ys and Yp. Fischer and Maurer proposed a new index that could help distinguish the more susceptible plants from others in an experiment: It was called the 'stress susceptibility index' or SSI (Fischer & Maurer, 1978). A new advanced index, the Stress Tolerance Index, which is used for the identification of an optimal genotype with the highest production under stress and non-stress conditions, was introduced by '90s (Fernandez, 1992). The list of criteria used in determining drought resistance is not limited to STI, though, as other research studies use geometric mean (GM), mean productivity (MP), and tolerance (TOL) (Gholamin and Khayatnezhad 2020). Not all breeders use the geometric mean as only those interested in improving the relative performance tend to employ it. The reason for this tendency lies within the unstable nature of the stress caused by drought or harsh conditions as it can change in severity in the long run (Ramirez-Vallejo and Kelly 1998, Sallam et al 2019).

In a research study for evaluation of pattern variance of stress resistance in wheat genotypes, they found that SSI for genotypes and their ranking pattern varies every year (Clarke & DePauw et al., 1992). Studying spring wheat plants, Guttieri and his team found that an SSI value more than 1 meant an above-average susceptibility to the stress caused by drought (Guttieri & Stark et al., 2001). (Golabadi & Arzani et al., 2006), and (Sio-Se Mardeh & Ahmadi et al., 2006) proposed that high mean productivity (MP), geometric mean productivity (GMP), and the stress tolerance index (STI) can facilitate the selection of a drought-tolerant genotype under stressed and non-stressed conditions.

Breeders mainly seek new ways of selecting suitable genotypes with high resistance to drought-induced stress so that they can enrich their genotypes storage with new modified variations with improved performance under harsh conditions. (Clarke, DePauw et al., 1992). Other research studies in this field utilized different indexes for identifying the plant with optimal resistance to water deficit (Khayatnezhad and Gholamin 2010), however, but in breeding program and laboratory experiments we need alive seeds and seed viability is important than seed weight.

Thus, seed viability is included in the Stress Tolerance Index equation (Eq.1).

Eq. 1

$$MSTI= ((Ypi\ xYsi)/Yp2)\times SV/100$$

Ysi= yield of cultivar in stress condition, Ypi= yield of Ysi= yield of the cultivar in stress condition, Ypi= yield of the cultivar in normal condition, SV= seed viability in stress. *Note: SV is for the selected condition that we want to use seeds in. Depicted below, is the explanation of this new idea:

Based on the conventional methods, EXP 2 is more resistant than EXP1 (Table 1), so we can select this genotype for the food program because EXP 2 has more seeds, thus more useful. We measured the seed viability of both samples (Table 2).

The study conducted the measurement using the suggested formula:

$$MSTI= ((Ypi\ xYsi)/Yp2)\times SV/100$$

Table 1. Stress tolerance values for example

Genotype	Ys	Yp	SSI	STI	TOL	MP	GMP	YSI	YI
EXP1	60.55	82.3	2.69	0.53	21.75	112.57	70.59	0.74	0.69
EXP2	95.8	137.45	3.09	1.39	41.65	185.35	114.75	0.7	1.09

Ysi= yield of cultivar in stress condition, Ypi= yield of cultivar in normal condition, SV= seed viability in stress.
*Note: SV is for selected condition that we want to use seeds

Table 2. values of seed Viability in stress condition for examples

Genotype	SA
EXP1	91%
EXP2	65%

Table 3. Percentage of growth ability and Stress tolerance

Genotype	STI	MSTI	Percentage of growth ability and Stress tolerance
EXP1	0.53	0.482	90.56
EXP2	1.39	0.903	66.90

As depicted in Table.3, the impact of seed viability on STI's percentage of growth in EXP 1 and EXP 2 was respectively 90.56% and 66.90%. The results find EXP2 unsuitable for the breeding program seed. Also, the EXP2 genotype is only suitable for food, but EXP 1 is stronger than EXP 2. Therefore, this genotype had fewer 1000-seeds weight, which meant it wasn't a fitting candidate for food consumption, while it proved more suitable for the breeding program. Based on the findings of these studies below, it is proposed that these indexes are relatively limited in terms of selecting the optimal genotype: (Khayatnezhad & Hasanuzzaman et al., 2011), (Khayatnezhad, Khayatnezhad, & Gholamin 2012) (Khayatnezhad, Gholamin, & Khayatnezhad, 2010), (Gholamin et al., 2010), (Khayatnezhad & Zaeifizadeh et al., 2010), and (Khayatnezhad & Zaefizadeh et al., 2011).Since this study needs alive seeds for the breeding program and relevant experiments, it will select high-viable seeds. Hence, these two factors, drought-resistance, and seed viability can play a vital role in helping ensure successful experimental projects to maximize yields and minimize water consumption.

REFERENCES

Blum, A. (1988). Plant breeding for stress envirnments/ by Abraham Blum.

Clarke, J. M., et al. (1992). "Evaluation of methods for quantification of drought tolerance in wheat." Crop Science 32(3): 723-728.

Fernandez, G. C. (1992). Effective selection criteria for assessing plant stress tolerance. Proceeding of the International Symposium on Adaptation of Vegetables and other Food Crops in Temperature and Water Stress, Aug. 13-16, Shanhua, Taiwan, 1992.

Golabadi, M., et al. (2006). "Assessment of drought tolerance in segregating populations in durum wheat." African Journal of Agricultural Research 1(5): 162-171.

Gholamin, R. and M. Khayatnezhad (2020). "Assessment of the Correlation between Chlorophyll Content and Drought Resistance in Corn Cultivars (Zea Mays)." Helix 10(05): 93-97.

Gholamin, R. and M. Khayatnezhad (2020). "Study of Bread Wheat Genotype Physiological and Biochemical Responses to Drought Stress." Helix 10(05): 87-92.

Guttieri, M. J., et al. (2001). "Relative sensitivity of spring wheat grain yield and quality parameters to moisture deficit." Crop Science 41(2): 327-335.

Hall, A. (1993). "Is dehydration tolerance relevant to genotypic difference in leaf senescence and crop adaption to dry environments?" Current topics in plant physiology (USA).

Khayatnezhad, M. and R. Gholamin (2020). "Study of Durum Wheat Genotypes' Response to Drought Stress Conditions." Helix 10(05): 98-103.

Khayatnezhad, M. (2012). "Evaluation of the reaction of durum wheat genotypes (Triticum durum Desf.) to drought conditions using various stress tolerance indices." African Journal of Microbiology Research 6(20): 4315-4323.

Khayatnezhad, M. and R. Gholamin (2010). "Study of drought tolerance of maize genotypes using the stress tolerance index." American-Eurasian Journal of Agricultural & Environmental Sciences 9(4): 359-363.

Khayatnezhad, M. and R. Gholamin (2012). "The effect of drought stress on leaf chlorophyll content and stress resistance in maize cultivars (Zea mays)." African Journal of Microbiology Research 6(12): 2844-2848.

Khayatnezhad, M., et al. (2010). "Investigation and selection drought indexes stress for corn genotypes." Amer. Euras. J. Agri. Environ. Sci 9: 22-26.

Khayatnezhad, M., et al. (2011). "Assessment of yield and yield components and drought tolerance at end-of season drought condition on corn hybrids (Zea mays L.)." Australian Journal of Crop Science 5(12): 1493.

Khayatnezhad, M., et al. (2011). "Selection of useful index for drought stress tolerance in durum wheat genotypes." Middle East Journal of Scientific Research 9(2): 189-194.

Khayatnezhad, M., et al. (2010). "Investigation and selection index for drought stress." Australian Journal of Basic and Applied Sciences 4(10): 4815-4822.

Kirigwi, F., et al. (2004). "Evaluation of selection strategies for wheat adaptation across water regimes." Euphytica 135(3): 361-371.

Mardeh, A. S.-S., et al. (2006). "Evaluation of drought resistance indices under various environmental conditions." Field Crops Research 98(2-3): 222-229.

Ramirez-Vallejo, P. and J. D. Kelly (1998). "Traits related to drought resistance in common bean." Euphytica 99(2): 127-136.

Richards, R., et al. (2002). "Breeding opportunities for increasing the efficiency of water use and crop yield in temperate cereals." Crop Science 42(1): 111-121.

Rosielle, A. and J. Hamblin (1981). "Theoretical aspects of selection for yield in stress and non-stress environment 1." Crop Science 21(6): 943-946.

Talebi, R., et al. (2009). "Effective selection criteria for assessing drought stress tolerance in durum wheat (Triticum durum Desf.)." General and applied plant physiology 35(1/2): 64-74.

Sallam A Ahmad M. Alqudah, Mona F. A. Dawood P. Stephen Baenziger and Andreas Börner (2019) Drought Stress Tolerance in Wheat and Barley: Advances in Physiology, Breeding and Genetics Research Int J Mol Sci. 2019 Jul; 20(13):