**Indexing of physiological traits for subtropical improved maize with Seedling, growth under drought conditions**

**Abstract**

The present study was carried out in the Laboratory and Field Experimentation Centre of Faculty of Sciences, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during Rabi season 2021-22 and 2022-23 entitled “Indexing of physiological traits for subtropical improved maize with Seedling, growth under drought conditions”, this experiment was conducted by randomized block design (RBD) design with six screening variety (V1-GP-170, V2-MGC-240, V3-MGC-222, V4-GP-87, V5-VL-191073 and V6-Check) and four treatment including control viz., T0-Control, T1PEG-11.8g\100ml water, T2PEG-19.7g\100ml water, T3PEG-25.4g\100ml water and T4 PEG-40.1g\100ml. It was found that significant difference between variety and treatment on Germination %, Germination rate, Seminal root number, Root length (cm), Shoot length (cm), Fresh weight (g), Dry weight (g) and Seed Vigour index, based on the research findings, it can be concluded that the six maize genotypes V5-VL-191073 and V3-MGC-222 performed better under drought conditions and thus can be declared drought tolerant, whereas the maize genotypes V1-GP-170 and V2-MGC-240 were regarded as drought sensitive when compared with other variety with To-control treatments.

Keywords: Seedling, growth, maize, genotypes and Drought stress,( PEG-6000)Polyethyleneglycol.

**INTRODUCTION**

Drought stress is a major abiotic stress affecting plants worldwide due to global climate change. It occurs when evapotranspiration demand exceeds soil water availability, affecting plants' genetic potential. Climate, soil type, soil water (storage & precipitation), and plant genotype influence the occurrence, intensity, and duration of drought **(Goswami *et al*., 2019)**. Agriculture is the most affected sector, with varying levels of intensity, duration, and spatial extent impacting production.

Water stress acts by decreasing the percentage and rate of germination and seedling growth **(Delachiave and De pinho, 2003).** Drought not only affects seed germination but also increases mean time germination time in maize crop **(Willanborb *et al*., 2004).** The adverse effect of water shortage on germination and seedling growth has been well reported in different crops such as corn

 **( Mohammadkhani and Heidari, 2008; Farsiani and Ghobadi,2009; Khayatnezhad *et al*., 2010).Mostafavi *et al*., 2011, Khodarahmpour, 2011).**

Drought can cause severe yield loss in crop plants, with India prone to drought or excess moisture stress, affecting up to 53-64% of maize yield **(Rufino *et al*., 2018).** Reproductive and grain filling stages are more critical, as they determine the final seed set or yield. Exposure to drought stress can reduce up to 90% of maize yield. **(Awosanmi *et al*., 2016; Daryanto *et al*., 2016)**

Maize is an important cereal crop grown all over the world **(Farhad *et al*., 2009).**

Also it is a stable food and commercial crop (**Tri-da *et al*., 2006).** Which is sensitive to drought **(Khan *et al*., 2004).**

staple cereal for humans and animals, is gaining importance for bio-energy production and industrial uses globally. India's third most important grain crop, Zea mays, is widely cultivated worldwide due to its high genetic yield potential and adaptability to tropical, subtropical, and temperate climatic zones. Maize is the second most valuable crop in terms of acreage globally, covering an area of 19.90 million hectares with a production of 1077.98 million metric tonnes and a productivity of 5.62 metric tonnes per hectare.

India Agristat reports that Karnataka stands first in maize cultivation in India, covering 9.38 million hectares with a production of 28.75 million metric tonnes and a productivity of 3.06 metric tonnes per hectare. Maize is rich in mineral nutrients, dietary fibers, proteins, and phytochemicals, making it a vital food source for the growing population. However, maize production and productivity are impeded by various biotic and abiotic stresses, including drought and heat stress **(Deryng et al., 2014).** Climate change-induced abiotic factors, such as temperature extremes, drought, salt, and metal toxicity, have significantly lowered crop productivity by 50% **(Francini and Sebastiani, 2019).** Plants have distinct physiological responses to abiotic stressors due to their sessile nature, which can reduce crop yield **(Debnath et al., 2021).**

**Materials and Methods**

The present research work was carried out at the Department of Faculty of Sciences, Sam Higginbottom University of Agriculture, Technology and Sciences. Six maize genotypes (V1-GP-170, V2-MGC-240, V3-MGC-222, V4-GP-87, V5-VL-191073 and V6-Check) were used to study the effect of drought stress by using PEG-6000 on germination and early seedling growth characters. The study was performed in petriplates having filter paper. The seeds were selected for size homogeneity, surface sterilized for 5 min in 1% (v/v) sodium hypochlorite and then rinsed twice in distilled water. Ten seeds of each genotype was placed in the petridishes with corresponding PEG concentration (T0-Control, T1PEG-11.8g\100ml water, T2PEG-19.7g\100ml water, T3PEG-25.4g\100ml water and T4 PEG-40.1g\100ml) and kept in an incubator (40% relative humidity) at 25°C. Respective PEG solution was applied to every petriplate on daily basis after draining out the previously applied solution. Number of seeds germinated was manually counted on each day up to7 days and the seed germination characters was considered based on the emergence of radicle and plumule (2mm). After seven days, emergence percentage and seedling vigour index was measured by following the protocol of International Seed Testing Association (**ISTA, 1996**). The Promptness Index (PI) and Germination Stress Tolerance Index (GSI) were calculated using the following formulae given by **Ashraf et al., (1990).**

The data collected were subjected to analysis of variance technique (**Steel et al., 1997**) using excel statistical software and numerical taxonomic techniques following the procedure of principal component analysis (**Sneath and Sokal, 1973**).

**Results and Discussion**

The results of this study reveal that different concentrations along with the control had significant (P ≤ 0.05%) effect on the Germination %, Germination rate, Seminal root number, Root length (cm), Shoot length (cm), Fresh weight (g), Dry weight (g) and Seed Vigour index of maize genotypes. Analysis of variance and mean comparison showed that there were significant differences between variety levels and treatments ( Figure.1-8).

**Seedling growth parameters of maize genotypes**

The effect of variety and treatment on germination percentage is shown in ( Figure.1). Varieties (V1-GP-170, V2-MGC-240, V3-MGC-222, V4-GP-87, V5-VL-191073 and V6-Check) showed significantly maximum germination percentage (100.00%) in control and treatment T1, followed by (V5T2), while (V1T3) had the lowest, which was (37.50%). Similarly, ( Figure.2). on germination rate varieties (V1-GP-170, V5-VL-191073 and V6-Check) showed (100.00) with control, followed by (V3T1), while (V1T3) had the lowest, which was (30.00). ( Figure.3). Among the Seminal root number, V5T3 recorded highest (6.00), followed by (V3T3) and minimum was noticed between (V1control) with (3.00). However, ( Figure.4). on root length (cm), the maximum was noticed (21.98) between (V5T3), followed by (V6Control) and minimum in (V1T1) was (17.25) ( Figure.5). Significantly maximum shoot length (cm) was recorded in (V5 control) was (24.00), followed by (V2 control) and minimum was (16.00) between (V1T3). ( Figure.6). The highest Fresh weight (g) was (2.95) in (V5 control), followed (V5T1) while (V1T3) had the lowest which was (1.48). Similarly in ( Figure.7). dry weight (g) the maximum (1.35) shown between (V5 control), followed by (V2 control) and minimum was (0.61) in (V1T3). ( Figure.8). The highest seed vigour index (2400.00) between (V5 control), followed by (V2 control), while, minimum (600.00) in (V1T3). The results were in agreement with the reports of Khayatnezhad et al., (2010), Khodarahmpour (2011) and Mostafavi et al., (2011). Ahmad et al., (2009) also reported that drought stress has an inhibitory effect on sunflower seed germination. According to Ayaz et al., (2001), decrease in seed germination under stress conditions is due to some metabolic disorders. Increasing drought stress levels caused delay in seedling emergence as a result of reduced cell division and plant growth metabolism. These results were similar to those of Ahmad et al., (2009) who reported that PEG induced water stress at germination and seedling growth stages reduced the GSTI in six sunflower hybrids/breeding lines. The GSTI was used to interpret differences in the rate of germination due to osmotic stress (Bouslama and Schapaugh, 1984). Higher value of the GSI showed a high rate of germination which was inversely related to moisture stress. The root length provides an important clue to the response of plants to drought stress. A significant reduction in root and shoot length of all genotypes of maize was observed because of drought stress. The most severe level in reducing shoot length and root length was -6 bar of PEG. There are several reports in the literature for potential drought resistance traits like extensive viable root system that could explore deeper soil layers for water (Mirza, 1956; Bocev, 1963). Maize plants with more roots at seedling stage subsequently developed stronger root architecture system. Nejad (2011) reported that major parameters in drought conditions such as root length, number, decreased in mild water stress. Root length increased under conditions of severe water stress. The most severe level in reducing shoot length and root length was -6 bar of PEG. There are several reports in the literature for potential drought resistance traits like extensive viable root system that could explore deeper soil layers for water (Mirza, 1956; Bocev, 1963). Maize plants with more roots at seedling stage subsequently developed stronger root architecture system, produce more green matter and had higher values for most characters determining seed yield (Bocev, 1963).

**Fig 1:- :- Influence of PEG 6000 induced drought on Germination % of maize genotypes**

**Fig 2:- Influence of PEG 6000 induced drought on Germination rate of maize genotypes**

**Fig 3:- Influence of PEG 6000 induced drought on Seminal root number of maize genotypes**

**Fig 4:- Influence of PEG 6000 induced drought on Root length (cm) of maize genotypes**

**Fig 5:- Influence of PEG 6000 induced drought on Shoot length (cm) of maize genotypes**

**Fig 6:- Influence of PEG 6000 induced drought on Fresh weight (g) of maize genotypes**

**Fig 7:- Influence of PEG 6000 induced drought on Dry weight (g) of maize genotypes**

**Fig 8:- Influence of PEG 6000 induced drought on Seed Vigour index of maize genotypes**

**Conclusion**

Based on the research findings, it can be concluded that the maize genotypes V5-VL-191073 and V3-MGC-222 performed better under drought conditions and thus can be declared drought tolerant, whereas the maize genotypes V1-GP-170 and V2-MGC-240 were regarded as drought sensitive when compared to rest of the variety. Among all the varieties, the overall best performance was obtained by T0 control, which showed increase in seedling growth parameters with respect to treatments, including germination percentage, germination rate, root number, root length (cm), shoot length (cm), fresh weight (g), dry weight (g) and seed vigor index, which performed better under drought conditions and thus can be declared as drought tolerant.

**References**

Ahmad, S., R. Ahmad, M.Y., Ashraf, M. Ashraf and Waraich, E.A. 2009. Sunflower (Helianthus annuus L.) response to drought stress at germination and growth stages. Pak. J. Bot., 41: 647-654.

Ashraf, M., and Mehmood, S. 1990. Response of four Brassica species to drought stress. Envir. Expt. Bot., 1: 93-100.

Awosanmi FE, Ajayi SA, Menkir A (2016) Impact of moisture stress on seed yield in tropical maize. Int J Agric Res 4:1033–1038.

Ayaz, F.A., A.Kadioglu and Urgut, R.T. 2001. Water stress effects on the content of low molecular weight carbohydrates and phenolic acids in Cienanthe setosa. Canadian J. Plant Sci., 80: 373-378.

Bocev, B.V. 1963. Maize selection at an initial phase of development. Kukuruzu, 1: 54.

Bouslama, M. and Schapaugh, W.T. 1984. Stress tolerance in soybean. Part 1: evaluation of three screening techniques for heat and drought tolerance. Crop Sci. J., 24: 933-937.

Daryanto S, Wang L, Jacinthe PA (2016) Global synthesis of drought effects on maize and wheat production. PloS One 11:e0156362.

Delachiave MEA, De Pinho SZ (2003). Germination of sennaoccidentalis linl:seed at different osmotic potential levels. Brazilian Arch. Tech.46:163-166.

Deryng D, Conway D, Ramankutty N, Price J, Warren R (2014) Global crop yield response to extreme heat stress under multiple climate change futures. Environ Res Lett 9(3):034011

Farhad W, Saleem MF, Cheema MA, Hammad HM (2009).Effect of poultry manure levels on productivity of spring maize(Zea mays L.) J.Anim.plant Sci.19:122-125.

Farsiani A, Ghobadi ME (2009).Effects of PEGand Nacl stress on two cultivars of corn (Zea mays L).at germination and early seedling stages. World Acad. Sci. Eng.Tech.57:382-385.

ISTA (International Seed Testing Association). 1996. International rules for seed testing rules. Seed Sci. Technol., 24, Supplement: 155-202.

Khan AA, Sajjad AR, McNeilly T(2004).Assessment of salinity tolerance based upon seedling root growth response functions in maize(Zea mays L.).Euphytica 131:81:-89.

Khayatnezhad, M., R, Gholamin, S.H., Jamaati – e – Somarin and Zabihi – Mahmoodabad, R. 2010. Effects of peg stress on corn cultivars (Zea mays L.) at germination stage. World Appl. Sci. J., 11(5): 504-506.

Khodarahmpour, Z. 2011. Effect of drought stress induced by polyethylene glycol on germination indices in corn (Zea mays L.) hybrids. Afr. J. Biotech., 10(79): 18222-18227.

Mirza, O.K. 1956. Relationship of radicle development to drought resistance of plants. Indian J. Agron., 1: 41-46.

Mohammadkhani N, Heidari R (2008). Water stress induced by polyethylene glycol 6000and sodium chloride in two corn cultivara.Pak. J. Biol.Sci.11(1):10-18.

Mostafavi, K.H., H. Sadeghi Geive, M. Dadresan and Zarabi, M. 2011. Effects of drought stress on germination indices of corn hybrids (Zea mays L.). Int. J. Agri. Sci., 1(2): 10-18.

Nejad, T.S., A. Bakhshande, S.B. Nasab and K. Payande, 2011. Effect of drought stress on corn root growth. Repor Opinion, 2: 47–52

Sneath, P.H.A., and Sokal, R.R. 1973. Numerical Taxonomy: The principles and practices of Numerical Classification. W.F. Freeman and Co., San Francisco, pp. 573. Sons, New York, USA.

Steel, R.G.D., J.H. Torrie and Dickey, D.A. 1997. Principles and procedures of statistics. A Biometric Approach. Mc Graw Hill Book Co. New York, USA.

Tri-da GE, Fang –Gong-SuinSOI, Ping BA, Yingyan LU, Guang-sheng ZH (2006).Effect of water stress on the protective enzymes and lipid per oxidation in radicals and leaves of summer corn Agric. Sci. China.5:228-291.

Willanborb CJ, Gulden RH, JhonsonEN, Shirtliffe SJ (2004). Germination characteristics of polymer –coated canola (Brassicanapus L.) seeds subjected to moisture stress at different temperatures .Agron.j.96:786-791.