**Screening of groundnut (*Arachis hypogaea* L.) varieties for drought tolerance using polyethylene glycol**

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**Abstract**

Identifying groundnut varieties that are tolerant to drought will be of great importance to the improvement of the crop.Drought has been a major environmental factor contributing to reduce crop productivity. This study aimed to screen groundnut varieties for drought tolerance using polyethylene glycol (PEG 6000) and treatments comprise of 28 groundnut varieties, including cultivars and advanced breeding lines. and different concentration of PEG 6000 (0, 5, 10,15, 20 %). The treatments were laid out in a Completely Randomized Design with three replications, where 15% PEG concentration was identified as the LD50 value for TMV 1.Data were collected on germination percentage, germination velocity index, and root length in both control and simulated drought using polyethylene glycol. The drought tolerance of each variety was determined by calculating the percent reduction over control for each trait. A significant (P<0.05) reduction was observed in all the treatments as the concentration of PEG increases. The results indicated that VRI5 recorded the lowest reduction over control in germination percentage, CO7 the lowest reduction in germination velocity index, and CO2 the lowest reduction in root length, identifying them as the drought-tolerant varieties. Conversely, VRI 3 showed the highest percent reduction across all three traits, suggesting high drought susceptibility. The results indicated that PEG (6000) can be used for simulating water stress under in vitro condition. This study will serve as a baseline for future in vitro screening for drought tolerance in groundnut.

**Key words:** Groundnut, PEG, Drought screening,Oilseeds

**Introduction**

Groundnut (*Arachis hypogea* L.) stands as a crucial oilseed crop that contains 47-53% oil and 25-36% protein (Prasad et al., 2010). China ranks first in total annual production (18.3 million tons) and area of (4.4 million ha) whereas India stands first in area (5.7 million ha) and ranks second in production (10.1 million tons) other significant countries in the order of production are Nigeria, United States of America, Sudan and Myanmar. This could be attributed to the effect of drought on crop productivity (Benga, 2020 and Sen et al., 2012) and the crucial role of rainfall in Groundnut production in many countries (Boote and Ketrind, 1990). Although the global area and production of groundnut have seen growth, productivity levels have largely remained unchanged.

Groundnut is grown in rainfed conditions within the semi-arid tropics and is exposed to many abiotic stresses among which drought stress is the major yield-limiting factor. Yield decline caused by insufficient soil moisture has been documented on a global scale (Vorosoot et al., 2003 andSongsri, 2009).The identification and selection of drought-tolerant genotypes are crucial for sustainable agricultural production under water-deficit conditions.Screening techniques using osmotic agents like polyethylene glycol (PEG) provide a controlled environment to simulate drought stress, enabling the evaluation of genotypic responses to water deficit (Michel, 1973).

Polyethylene glycol (PEG) has emerged as an effective tool for simulating drought stress in a controlled manner. PEG, which exists in various forms from viscous liquids to waxy solids, is widely used in plant research to create osmotic stress by lowering cell water potential (Govindaraj et al., 2010). Increasing concentrations of PEG, particularly PEG-6000, have been shown to adversely affect critical growth parameters such as germination rate, root and shoot length, and seed vigor in many crop species(Khodarhmpour, 2011). This makes PEG an essential medium for evaluating drought tolerance and studying plant responses under water-limiting conditions. PEG-induced drought stress screening has been widely used in crop research due to its ability to create consistent and reproducible osmotic conditions without causing toxicity to plants (Hohl and Schopfer, 1991).

In this study atotal of 28 groundnut genotypes, including cultivars and advanced breeding lines, were screened for drought tolerance. Key physiological traits such as germination percentage, germination velocity index, and root length were measured, and their percent reduction over control conditions was calculated to identify drought-tolerant and drought-susceptible genotypes. The results provide critical insights into the drought adaptation potential in groundnut, contributing to the development of resilient varieties for drought-prone regions.

**Materials and Methods**

***Experimental material***

The study was conducted using 28 groundnut genotypes, including both cultivars and advanced breeding lines. TMV 1, a drought-tolerant variety, was used to determine the lethal dose 50 (LD50) concentration of polyethylene glycol (PEG) for subsequent screening.

**PEG Screening for LD50 determination**

PEG-6000 was prepared at concentrations of 5%, 10%, 15%, and 20% (w/v) to simulate varying levels of drought stress. Seeds of TMV 1 were surface-sterilized and subjected to these PEG solutions under laboratory conditions. Germination percentage were monitored to determine the LD50, which was identified as 15% PEG-6000.

**Screening of genotypes**

Following LD50 determination, the 15% PEG-6000 concentration was used to evaluate drought tolerance in the 28 groundnut genotypes. Seeds of each genotype were surface sterilized and placed in a petri plate containing blotter paper imbibed in the 15% PEG solution. At the same time, all the accessions were germinated in distilled water were maintained as the control group. The study was conducted in a completely randomized design (CRD) with three replications per genotype. Each replication consisted of ten seeds per treatment (PEG and control). Germination Percentage(GP), Germination Velocity Index (GVI),and Root Length (RL) were observed in both control and treatment. The percent reduction over the control was calculated for each trait.

The genotypes were classified as drought-tolerant or drought-susceptible based on the mean value of percent reduction for each trait over control. Genotypes with the lowest mean performance for the percent reduction over control were considered as drought tolerant, while those with the highest reductions were considered as drought susceptible.

**Results and Discussion**

Poly Ethelene Glycol (PEG) is the most commonly used osmotic agent for simulating drought in different crops. The evaluation of 28 groundnut genotypes under simulated drought conditions using 15% PEG 6000 revealed significant variations in germination percentage (GP), germination velocity index (GVI), and root length (RL) reductions compared to control conditions as presented in table 1. These differences highlight the genotypes variability in drought responses aligns with previous findings, which demonstrate the effectiveness of PEG 6000 in simulating drought stress by lowering cell water potential (Govindaraj et al., 2010).

**Germination Percentage (GP)**

Traits such as GP serve as critical indicators of early-stage drought tolerance, with lower reductions reflecting enhanced physiological and biochemical adaptations to water scarcity (Khodarhmpour, 2011). The percent reduction in germination percentage ranged from 10.00% in VRI 5 to 100.00% in VRI 3. VRI 5, along with CO 7 (12.50%) and ALR 1 (14.29%), displayed minimal reductions, indicating their potential to maintain seed viability under water deficit conditions. Conversely, VRI 3 exhibited complete failure in germination, making it the most drought-susceptible genotype.

**Germination Velocity Index (GVI)**

The percent reduction in germination velocity index varied between 19.34% in CO 7 and 100.00% in VRI 3. CO 7 showed the least reduction, reflecting its ability to sustain seedling vigor. Moderate reductions were observed in genotypes like VRI 5 (56.07%) and BSR 2 (59.31%). In contrast, VRI 3 (100.00%) and TMV 7 (97.38%) recorded the highest reductions, emphasizing their vulnerability to drought stress.

**Root Length (RL)**

Root traits, in particular, play a pivotal role in accessing deeper water reserves, contributing to better drought resilience (Biswasbet al., 2002).Maximum rootlength wasobserved in the control treatment (medium devoid of PEG).Root length reduction ranged from 4.00% inCO 2 to 100.00% in VRI 3. Genotypes such as CO2 (4.00%), CO7 (13.91%) VRI 4 (25.00%) exhibited better root growth under simulated drought conditions, suggesting their ability to adapt by promoting root elongation. CO 2 recorded the lowest reductionin root length as represented in Fig.1, emphasizing its superior drought tolerance in maintaining root development. Meanwhile,COG17007 (95.77%) suffered significant reductions as presented in fig. 2, underscoring their susceptibility. Similar results were observed in groundnut genotypes (Abdulmalik et al., 2018).

**Table 1. Percent reduction of physiological traits over control under simulated drought conditions in groundnut**

|  |  |
| --- | --- |
| **Genotypes** | **Percent reduction over control** |
| **GP (%)** | **GVI (%)** | **RL (%)** |
| **VRI7** | 77.78 | 95.33 | 80.06 |
| **CO 1** | 60.00 | 79.52 | 34.52 |
| **TMV 7**  | 90.00 | 97.38 | 33.87 |
| **CO7** | 12.50 | 19.34 | 13.91 |
| **VRI5** | 10.00 | 56.07 | 27.22 |
| **CO4** | 66.67 | 89.15 | 65.52 |
| **TMV 13** | 60.00 | 79.22 | 67.31 |
| **COG18-37** | 50.00 | 87.41 | 72.48 |
| **VRI6**  | 60.00 | 89.93 | 60.13 |
| **ALR 1**  | 14.29 | 73.70 | 82.80 |
| **COG17006** | 60.00 | 86.19 | 66.00 |
| **VRI 8** | 88.89 | 96.76 | 75.76 |
| **BSR 2**  | 50.00 | 59.31 | 64.85 |
| **CO 2** | 66.67 | 65.14 | 4.00 |
| **COG0539** | 25.00 | 74.94 | 76.40 |
| **TMV 1** | 60.00 | 87.56 | 45.21 |
| **ALR 2** | 55.56 | 64.63 | 28.41 |
| **VRI 4** | 60.00 | 88.73 | 25.00 |
| **VRI 9** | 80.00 | 92.62 | 68.18 |
| **VRI 3** | 100.00 | 100.00 | 100.00 |
| **ALR 3** | 70.00 | 90.98 | 74.13 |
| **COG 0549** | 33.33 | 63.26 | 74.57 |
| **COG17007** | 40.00 | 81.95 | 95.77 |
| **TMV 14** | 57.14 | 82.41 | 40.61 |
| **VRI 10**  | 80.00 | 94.75 | 87.90 |
| **TMV 10**  | 50.00 | 83.13 | 54.77 |
| **CO 6** | 30.00 | 71.98 | 84.45 |
| **COG0537** | 70.00 | 89.05 | 61.41 |

(GP- Germination percentage, GVI- Germination velocity index, RL- Root length)

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| **Figure 1. Variations observed in the root length of the groundnut variety CO2** | **Figure 2. Variations observed in the root length of the groundnut COG17007** |
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In combination of all the parameters, VRI 5, CO 7 and CO 2 were identified as the most drought-tolerant genotypes, showing the least reduction in germination percentage, germination velocity index, and root length, respectively. Suggestingthese varieties to be more drought tolerant as they had better rooting, which could have superior their capability to absorb water even under PEG induced water stress. Water deficit influenced mostly the numberof lateral roots and the variety with a greater increase of its lateral root numbers could be considered a drought tolerant variety (Badiane et al., 2004).Genotypic variation under PEGsimulated drought has also been reported in tomato, sunflower and cactus cultures (Mengesha et al., 2016). This serves the deployment of this current procedure for drought particularly with the groundnut genotypes used in this study.

**Conclusion**

This study demonstrated that PEG (6000) at a concentration of 15% effectively simulateswater stress in groundnut, allowing for the identification of drought-tolerant genotypes.Among the 28 evaluated varieties, VRI 5, CO 7, and CO 2 exhibited the lowest reduction ingermination percentage, germination velocity index, and root length respectively, makingthem the most drought-tolerant varieties. Their ability to sustain seedling vigor and maintainroot growth under water stress conditions suggests their potential for cultivation in drought-prone environments. The findings confirm that PEG-induced screening is a reliable approachfor assessing drought tolerance in groundnut and can serve as a baseline for future droughttolerance studies. Further validation of these results under field conditions will enhancebreeding strategies aimed at improving drought resilience in groundnut.

**References**

Prasad PV., Kakani VG, Upadhyaya HD. 2010. Growth and production of groundnut. UNESCO *Encyclopedia*.1-26.

Begna T. 2020. Effects of drought stress on crop production and productivity. *Intl J Res Stud Agric Sci.***6**:34-43.

Sen B, Topcu S, Türkeș M, Sen B, Warner JF. 2012. Projecting climate change, drought conditions and crop productivity in Turkey. *Climate Research*. **52**:175-91.

Peña-Gallardo M, Vicente-Serrano SM, Domínguez-Castro F, Beguería S. 2019. The impact of drought on the productivity of two rainfed crops in Spain. *Natural Hazards and Earth System Sciences*.**19**(6):1215-1234.

Boote K and Ketring D. 1990. Peanut. *Agronomy*. **30**:675-717.

Rao RN, Singh S, Sivakumar M, Srivastava K, Williams J. 1985. Effect of Water Deficit at Different Growth Phases of Peanut. *Agronomy Journal*. **77**(5):782-786.

Vorasoot N, Songsri P, Akkasaeng C, Jogloy S, Patanothai A. 2003. Effect of water stress on yield and agronomic characters of peanut (*Arachis hypogaea* L.). *Songklanakarin J Sci Technol*. **25**(3):283-288.

Songsri P, Jogloy S, Holbrook C, Kesmala T, Vorasoot N, Akkasaeng C, 2009. Association of root, specific leaf area and SPAD chlorophyll meter reading to water use efficiency of peanut under different available soil water. Agricultural water management. **96**(5):790-8.

Michel BE, Kaufmann MR. 1973. The osmotic potential of polyethylene glycol 6000. *Plant physiology.***51**(5):914-6.

Govindaraj M, Shanmugasundaram P, Sumathi P, Muthiah A. 2010. Simple, rapid and cost effective screening method for drought resistant breeding in pearl millet. *Electronic J of plant breeding.***1**(4):590-599.

Khodarahmpour Z. 2011. Effect of drought stress induced by polyethylene glycol (PEG) on germination indices in corn (*Zea mays* L.) hybrids. *African J of Biotechnology*. **10**(79):182-227.

Hohl, M and Schopfer, P. 1991. Water relations of growing maize coleoptiles: comparison between mannitol and polyethylene glycol 6000 as external osmotica for adjusting turgor pressure. *Plant Physiology*. **95**(3):716-722.

Biswas J, Chowdhury B, Bhattacharya A, Mandal A. 2002. *In vitro* screening for increased drought tolerance in rice. *In Vitro Cellular & Developmental Biology-Plant*. **38**:525-530.

Abdulmalik, M.M., Usman, I.S., Usman,A, Mohammed,M.S. and Sani, L.A. 2018. In vitro Screening of groundnut (*Arachis hypogaea* L.) Varieties for drought Tolerance using polyethylene glycol (PEG 6000). *FUDMA Journal of Sciences* (FJS). **2** (2): 59-71.