

RESEARCH ARTICLE

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 the reduction of crop productivity. This study aimed to screen groundnut varieties for drought tolerance using polyethylene glycol (PEG 6000), with treatments comprising 28 groundnut varieties, including cultivars and advanced breeding lines. Different concentrations of PEG 6000 such as 5, 10, 15, 20% were used for this study. 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 the control for each trait. A significant ($P < 0.05$) reduction was observed in all the treatments as the concentration of PEG increased. 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 conditions. This study will serve as a baseline for future in vitro screening for drought tolerance in groundnut.

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INTRODUCTION

Groundnut (*Arachis hypogaea* 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 (4.4 million ha). In contrast, 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, the 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 groundnuts have seen

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growth, productivity levels have remained mainly unchanged. Groundnut is grown in rainfed conditions within the semi-arid tropics. It is exposed to many abiotic stresses, with drought stress being the major yield-limiting factor. Yield decline caused by insufficient soil moisture has been documented on a global scale (Vorosoet *et al.*, 2003 and Songsri, 2009). The identification and selection of drought-tolerant genotypes are crucial for sustainable agricultural production under water-deficient 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 (Khodahrmpour, 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, a total of 28 groundnut genotypes, including cultivars and advanced breeding lines, were screened for drought tolerance. Key physiological traits, including 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 was 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 that 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 the 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 percentage reduction for each trait over the 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 Ethylene 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, aligning with previous findings, which demonstrate the effectiveness of PEG 6000 in simulating drought stress by lowering cell water potential (Govindaraj *et al.*, 2010).

Maheswari et al. (2019) studied the morpho-physiological characters of different groundnut genotypes viz., CO 7, COGn 4, TMV 7 and TMVGn 13 to water stress at different flowering phases viz., Pre Flowering Drought (PFD) between 15-30 DAS, Flowering Drought (FD) between 35-50 DAS and Post Flowering Drought (PoFD) between 75-90 DAS by withholding irrigation and a control was also maintained with irrigation to field capacity for comparison.

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 (Khodahrmpour, 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

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)

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



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 (Biswas et al., 2002). Maximum root length was observed in the control treatment (medium devoid of PEG). Root length reduction ranged from 4.00% in CO 2 to 100.00% in VRI 3. Genotypes such as CO2 (4.00%), CO7 (13.91%), and 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 reduction in 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 its susceptibility. Similar results were observed in groundnut genotypes (Abdulmalik et al., 2018).

In combination with 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. Suggesting these varieties to

be more drought tolerant as they had better rooting, which could have improved their capability to absorb water even under PEG-induced water stress. Water deficit primarily influenced the number of lateral roots, and the variety with a greater increase in lateral root numbers could be considered drought-tolerant (Badiane et al., 2004). Genotypic variation under PEG-simulated drought has also been reported in tomato, sunflower, and cactus cultures (Mengesha et al, 2016). This supports the deployment of the current procedure for drought management, particularly with the groundnut genotypes used in this study.

CONCLUSION

This study demonstrated that PEG (6000) at a concentration of 15% effectively simulates water 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 in germination percentage, germination velocity index, and root length, respectively, making them the most drought-tolerant varieties. Their ability to sustain seedling vigor and maintain root growth under water stress conditions suggests their potential for cultivation in drought-prone environments. The findings confirm that PEG-induced screening is a reliable approach for assessing drought tolerance in groundnut and can serve as a baseline for future drought tolerance studies. Further validation of these results under field conditions will enhance breeding strategies aimed at improving drought resilience in groundnut.

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