Research Paper

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Optimization of Osmotic Stress Induced by Different Concentrations of Polyethylene Glycol-6000 for Drought Tolerance Screening in Eggplant (Solanum Melongena L.,)

Botany

KEYWORDS : Eggplant, Drought, Polyethylene glycol and Root/Shoot ratio

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ABSTRACT

An attempt was made to optimize the degree of osmotic stress induced by different concentrations of PEG-6000 for drought tolerance screening in eggplant cv. Green Round. Six different concentrations of PEG-6000 (2.5, 5, 7.5, 10, 12.5 and 15 percent) along with a control (Distilled water) were used. Significant differences were observed for germination per cent, lengths of root, shoot and seedlings, seed vigour and root/shoot ratio at different concentrations of PEG-6000 ($p < 0.01$). The PEG-6000 concentration above 12.5% has drastically reduced per cent germination, seed vigor and there was a significant increase in root/shoot ratio at 12.5% PEG-6000. Hence, 12.5% PEG-6000 appears to be an ideal concentration for drought tolerance screening of eggplant in vitro.

INTRODUCTION

Eggplant (*Solanum melongena* L.) is a popular vegetable grown in tropical and subtropical regions of the world and is native to India. India is the second largest producer of eggplant in the world where it is cultivated on an area of 0.72 m.ha with a production of 13.44 m. tonnes and the productivity stands at 18.6 t/ha (Anon, 2013). The productivity of eggplant in India is only half of that realized in China and is only 69% of the global average productivity which is due to adoption of local varieties in larger area by the farmers. Further, a total of 1.4 million small, marginal and resource-poor farmers grow eggplant in 7.22 lakh hectares annually throughout India. Added to this, a substantial proportion of yield is lost due to biotic and, abiotic stresses including drought (Srivastava, 2012).

In the era of unpredictable climatic change, droughts are becoming increasingly common in many parts of the world. In the past decade, Brazil, Argentina, Uruguay, Australia, United States, Canada, India, China, and many Southeast Asian countries are ravaged by drought (Gathara, Gringof, Mersha, Sinha Ray & Spasov, 2006). In Karnataka, 28 of 30 districts and 125 of 176 taluks have been declared as drought-hit areas in 2014 (Naheed, 2014).

Though eggplant in general, is considered to be the drought susceptible crop (Chen *et al*., 2002). The identification of drought tolerant or moisture stress tolerant cultivars in eggplant is very important to realize sustainable production and save the irrigation water for other crops. There are very scanty reports on the screening methodologies for drought tolerance in eggplant. Screening for drought tolerance by inducing artificial osmotic stress under *in vitro* conditions using polyethylene glycol (PEG) was proved to be a reliable method in many crops (Versules, Ober & Sharp 1998; Gobu, Harish Babu, Thimmanna, Gangaprasad, & Dushyantha Kumar, 2014; Yohannes, Mebeaselassie & Abuhay, 2014). Hence, an attempt was made to optimize the concentration of PEG-6000 for drought tolerance screening in eggplant.

MATERIALS AND METHODS

The optimum concentration of polyethylene glycol-6000 (PEG-6000) for drought tolerance screening of eggplant under *in vitro* conditions was standardized using a popular cultivated genotype of the region *viz*., Green Round variety obtained from a commercial seed vendor. The seeds of the eggplant were subjected to osmotic stress at germination stage induced by PEG-6000 at different concentrations *viz*., 2.5, 5, 7.5, 10, 12.5, and 15 per cent in 4 replications. For control, sterile distilled water was applied instead of PEG-6000 solution.

For each of the concentrations of PEG-6000 solution, 50 seeds per replication were surface sterilized with 70 % ethanol for 1 minute followed by washing with sterile distilled water three times. Later, the eggplant seeds were kept in 200 mm diameter petri-plates having a moisturized germination paper. Seeds were moisturized with 2.5, 5, 7.5, 10, 12.5, and 15% PEG-6000 solution for treatment plates and with sterile distilled water for control plates and kept for incubation for 10 days. Using a sterile pipette, a small quantity of PEG-6000 solution/sterile distilled water was added to petri-plates regularly to maintain the uniform level of osmotic stress as induced by different concentrations of PEG-6000 throughout the incubation period. Germination was recorded on daily basis. The observations on germination per cent, root length (cm), shoot length (cm), seedling length (cm) were recorded 10 days after incubation. Further, the seed vigour and root: shoot ratios were computed (Manoj and Deshpande, 2005; Gobu *et al*., 2014). The seed vigor was calculated by the following formula: Seed vigour = Seedling length (cm) × Germination percentage.

RESULTS AND DISCUSSION

The success of a drought tolerance screening method depends on identifying a critical level of stress induced by a particular concentration of an agent capable of inducing moisture stress (Manoj and Deshpande, 2007; Yohannes et al., 2014). In the present study, we have used various concentrations of polyethylene glycol-6000 (PEG-6000) for inducing variable degrees of osmotic stress to identify a critical concentration of PEG-6000 capable of identifying moisture stress tolerance in eggplant genotypes so that which can be used in screening a large germplasm for moisture stress tolerance under *in vitro* conditions.

Analysis of variance revealed significant differences for different traits in eggplant at various concentrations of PEG-6000. Significant differences were observed at one per cent level of probability for all characters studied except for shoot length which differed significantly at 5 per cent level of probability (Table 1). The mean performance of eggplant for various traits at different concentrations of PEG-6000 is presented in the Table 2.

The per cent germination in eggplant varied from 40.75 to 99.50 at various concentrations of PEG-6000 and it was 100 per cent in case of control (Distilled water or 0% PEG-6000). Maximum reduction in per cent germination (59.3 %) was recorded at 15% PEG-6000 concentration when compared to control and least reduction (0.5%) was observed at 2.5% PEG-6000 as polyethylene glycol-6000 is known to induce osmotic stress which affects per cent germination in many crop plants at varying concentrations (Khodarahmpour, 2011). Further, the PEG-6000 is also known

to affect root and shoot elongation at various concentrations. The root length in eggplant varied from 1.26 to 2.4 cm at different concentrations of PEG-6000. The root elongation was minimum (1.26 cm) at 10% PEG-6000 and it was maximum at 2.5% PEG-6000. However, the root elongation was 3 cm under control where distilled water was used instead of polyethylene glycol-6000. The shoot length in eggplant was in the range of 0.41 to 2.90 cm at variable concentrations of PEG-6000. Maximum shoot length of 2.90 cm was observed at 2.5% PEG-6000 while it was minimum (0.41 cm) at 12.5% PEG-6000. However, the shoot length at control was 3.34 cm. The total seedling length varied from 1.79 to 5.30 cm at different concentrations of PEG-6000 and it was 6.34 cm in case of control. Among different concentration regimes of PEG-6000, maximum seedling length was recorded at 2.5% while it was minimum at 10%.

The seed vigor exhibited a wide range of variation from 89.93 to 526.89 at variable concentrations of PEG-6000 and it was 630.57 in case of control (distilled water). The highest value of seed vigor *i.e.,* 526.89 was recorded at 2.5% PEG-6000 while it was least (89.93) at 15% PEG-6000. Since seed vigor is the product of total seedling length and per cent germination, it is influenced by parameters like root length, shoot length and germination per cent. Further, the root/shoot ratio, an important parameter to judge the drought tolerance ability of a crop or genotype was computed and it also showed a considerable variation ranging from 0.63 to 5.67 at different concentration levels of PEG-6000. However, the root/shoot ratio in case of control was 0.90. Generally, under moisture stress conditions, plants tend to elongate their roots much faster than their shoots in search of moisture for their survival which invariably results in higher values for root/shoot ratio as evident in many crops (Khodarahmpour, 2011; Gobu *et al*., 2014; Yohannes et al., 2014). In the present investigation on eggplant, the root/shoot ratio was maximum at 12.5% PEG-6000 wherein the eggplant has put in a maximum elongation of roots compared to shoots indicative of a critical value of osmotic stress in eggplant. However, at 15% PEG-6000, the root/shoot ratio declined indicating that the osmotic stress at this level is injurious to eggplant as the root and shoot elongation were severely affected. From the foregoing results of this investigation, it can be summarized that, the optimum concentration of PEG-6000 at 12.5% appears to be ideal for screening eggplant genotypes for moisture stress tolerance under *in vitro* conditions since the seed vigor and root/shoot ratio were drastically reduced beyond this concentration. Similar findings were reported in tomato and eggplant (Manoj and Deshpande, 2005; Gobu *et al*., 2014). Based on the findings of present investigation, we recommend that the polyethylene glycol-6000 at 12.5% concentration can be used for screening a large number of germplasm collections of eggplant in a short time under *in vitro* conditions.

Table 1: Analysis of variance for different traits in eggplant at various concentrations of polyethylene glycol-6000

Source	Degrees of freedom	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seed vigor	Root/Shoot ratio
Treatments	6	2350.86**	1.41**	6.43*	11.58**	179044.41**	12.47**
Replications	3	8.03	0.05	0.04	0.15	847.80	0.33
Error	18	9.31	0.02	0.03	0.04	494.61	0.17

*Significance at 5% **Significance at 1%

Table 2: Mean performance of eggplant for various traits at different concentrations of polyethylene glycol-6000 under *in vitro*

Sl. No.	Concentration of polyethylene glycol-6000	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seed vigor	Root/Shoot ratio
1	2.5%	99.50	2.40	2.90	5.30	526.89	0.83
2	5%	99.50	1.69	2.70	4.39	437.02	0.63
3	7.5%	92.00	1.84	1.16	3.00	276.05	1.61
4	10%	82.50	1.26	0.53	1.79	147.73	2.49
5	12.5%	53.50	2.28	0.41	2.69	143.66	5.67
6	15%	40.75	1.60	0.61	2.21	89.93	2.70
7	0% [Distilled Water]-Control	100.00	3.00	3.34	6.34	630.57	0.90
	Mean	81.04	2.01	1.66	3.67	321.69	2.12
	Range	40.75-99.50	1.26-3.00	0.41-3.34	1.79-6.34	89.93-630.57	0.63-5.67
	CV	3.77	7.13	8.14	5.71	6.91	19.21
	CD (5%)	4.53	0.21	0.24	0.31	33.04	0.60
	CD (1%)	6.21	0.29	0.33	0.43	45.26	0.83

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