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Peg Induced Drought Stress in Pea (*Pisum sativum* L.)

Sandeep Bagri, Harmeet Singh Janeja

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ABSTRACT

Drought is a natural process that is now become the major limiting factor for production of all type of crops including pea. Drought limits the growth pattern of plant by effecting the morphological and physiological metabolism, which causes subsequent yield loss from past few years. Progress has made to develop drought tolerant genotypes by use of *in vitro* screening approach. PEG (Polyethylene glycol) 6000 is an osmotic agent commonly used to induce drought conditions without toxic effect. This approach of selection under *in vitro* condition helps in finding the drought tolerant genotypes and thereby, minimizing the loss due to drought stress by further utilizing selected drought tolerant cultivars in breeding programs.

Keywords Drought, Metabolism, Genotypes, PEG, Breeding.

Sandeep Bagri, Harmeet Singh Janeja*
Department of Genetics and Plant Breeding, School of Agriculture, Lovely Professional University, Phagwara 144411, Punjab, India
Email:harmeet.12964@lpu.co.in
*Corresponding author

INTRODUCTION

Pea (*Pisum sativum* L.) is second most important leguminous crop grown widely in the world for its protein quality along with the ability of nitrogen fixation that improves the fertilizing capacity of soil (Kumari *et al*. 2013). In India, pea is grown as winter crop for its tender and seeds that are utilized as vegetable. Its seeds contain the good proportion of protein, carbohydrates, anti-oxidants, dietary fibers and vitamins (Aysh *et al.* 2014).Like all other pulse crops, pea has the ability to adapt in varied climatic conditions and by practicing proper crop management to achieve considerable yields. However in context with current scenario, there is a lot of fluctuation witnessed in the precipitation with respect to time intervals and proportion of rains (Bernstein *et al.* 2007, Dai 2013) affecting the final produce and protein content of the crop. From past several decades, groundwater level is reaching down along with reduction in the overall rainfall leading to drought conditions in several parts of world (Ceccarelli *et al.* 2010). Drought is now the main limiting factor for the crop production (Ali *et al*. 2017). Decreased content of water in plant parts, reduction in turgidity, lack of cell and tissue development are the characters noticed in plants during drought stress (Jaleel *et al*. 2009). This suppress the overall yield of legumes by 35% to 50% (Siddique *et al*. 2001, Sabaghpour 2003).

Breeding techniques has evolved various improvements in pea with respect to achieve drought tolerant varieties. However, the most common method used is screening of plants after inducing the stress

via treating plants with different agents. PEG (Polyethylene glycol)-6000 is an osmotic agent with a molecular weight of 6000 that induce drought stress in plants (Jiang *et al*. 1995) without its absorption in cell (Tarkow *et al.* 1996) followed by osmotic stress that effect the physiological processes like photosynthesis and morphological changes like shoot and root development, elongation in their length. Since, PEG cannot penetrate the cell wall (Rubinstein and Turner 1982) so it commonly used for determination of induced stress and analysis of related data in plants (Turkan *et al.* 2005, Landjeva *et al.* 2008). In this review, use of PEG-6000 is discussed for inducing drought in different genotypes of pea without any toxicity to plants (Emmerich and Hardegree 1990). The objective of the review is to discuss and analyse the effect of PEG on germination, shoot and root growth, seedling vigour index of pea genotypes under *in vitro* conditions for selection of drought tolerant cultivars.

MATERIALS AND METHODS

Material for this review collected from various sources of information. Relevant articles, books, reports and research papers consist of evidences on effect of PEG induced drought stress are taken in consideration to summarize the findings on plant response due to stress.

Germination percentage –Normally seeds which when observed for one day to a week for calculation of germination percentage by using mean values of replication in the formula (Salma *et al*. 2016):

$$\text{Percent germination} = \frac{\text{No. of seeds germined}}{\text{total seed sets}} \times 100$$

Seedling vigour index (SVI)–The formula given by Abdul - Baki and Anderson (1973).

SVI = Seedling length (cm) × germination percentage
Where, Seedling length = root length + shoot length.

Chlorophyll estimation –Arnon (1949) formulated method for the extraction and estimation of chlorophyll content. Following formulae are used for calculation of chlorophyll A and B, total chlorophyll content (mg/g) –

Chlorophyll 'a' = (12.7X A663 – 2.69X A645) V/W
Chlorophyll 'b' = (22.9X A645 – 4.68X A663) V/W
Total Chlorophyll = (20.2 X A645 – 8.02 X A663) V/W

Where,

A = Absorbance at specific wavelengths
V = final volume of chlorophyll extract in 80% Acetone
W= fresh weight of tissue extracted 12.7, 2.69, 22.9, 4.68, 20.2 and 8.02 are the constants.

Discussion and findings

Drought is one of the abiotic stress affecting the morphological and physiological processes in plant. It limits the seed germination, seedling development, root and shoot length and their elongation (Lonbani and Arzani 2011).

Effect on germination percentage

Germination is primary factor to study for screening drought tolerance in plant genotypes (Richards 1978). Water is necessary for the seeds to germinate. Under dry conditions, water imbition does not occur in seed. This result in poor or no germination of seeds (Harris *et al.* 2002). Plant cells losses turgidity under water stress (Jaleel *et al.* 2009).

Evidence has shown that PEG induce drought stress in pea and significantly affect germination. It decreases the germination rate to 70 to 80%. Since the PEG is non-toxic, seeds that are not germinated show 100% germination rate (Okçu *et al.* 2005).

Effect on shoot, root elongation and seedling vigour index

Seedling development has drastically affected by drought stress conditions. Root and stem development is comparatively decreased in with increase in concentration of PEG. This result in decreased seedling vigour index. Shoot elongation is more affected than root elongation. Evidences show that cultivars are not able to develop seedlings even under at low PEG concentration @ 5% (Okçu *et al*. 2005).

Effect on photosynthesis

Photosynthesis is an important physiological process for plant metabolism and structural development including leaf, stem, root, fruits. In plants (Chl) chlorophyll pigments are present in leaves that are responsible for photosynthesis. Chlorophyll content decreased under long progressive water stress conditions and this affect the plant photosynthetic system (PS1, PS2). The cause of decreased content of chlorophyll is due to peroxidation of lipids by reactive oxygen molecules like O_2 and H_2O_2 (Guo *et al*. 2013).

Evidences show that PEG 6000 significantly influence the photosynthetic process and chlorophyll pigment activity. Hsu and Kao (2003) reported the effect of PEG in rice reducing the chlorophyll content and observed more sensitivity of Chl A over Chl B pigment. Similar result on variable range of sensitivity of chlorophyll pigments reported in sesame (Hassanzadeh *et al.*2009) and in black gram (Pratap and Sharma 2010).

CONCLUSION

This review offers evidences for the effect of PEG induced drought stress in association with various characters like germination percentage, shoot length, root length, seedling vigour index and chlorophyll content in pea. Drought is a natural process but has been accelerated by recent climatic change. With the use of PEG, screening of drought tolerant cultivars has been sorted. However, limited progresses have been developed with the *in vitro* screening approach. Furthermore, advancement in the breeding program and integration of molecular approach will help to improve the drought tolerance in the crop.

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