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Research Article

Evaluation of Polyethylene Glycol (PEG) induced Water Stress on Germination and Seedling Growth in *Vigna radiata* L.

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Abstract

Mung bean is a rich source of many nutrients with potential health benefits. It is a commonly used food in India. Water stress was induced by different PEG concentrations (2%, 4% and 6%) in *Vigna radiata* (Mung bean). The effect of PEG induced water stress on germination and early seedling growth stages was studied. The experiment was carried out in three replicates under complete randomised design. Results showed that water stress treatments significantly affected the germination percentage and other parameters. There was reduction in all parameters with increasing PEG concentrations. Based on these results Vigna radiata was found as sensitive to PEG induced water stress.

Keywords: PEG; Water Stress; Vigna Radiata; Germination; Seed Vigour Index.

Introduction

Several abiotic factors like drought, cold, flood, heat, elevated CO_2 level and light affect the plant growth. According to the available literature, climate change has a negative impact on agriculture production. 90% of global rural land area is affected by abiotic stress factors [7]. Abiotic stress is the primary cause of crop loss worldwide, reducing average yields for most major crop plants by more than 50% [6]. Drought stress is one of the most important environmental factors that reduce growth, development and production of plants. It is one of the most devastating environmental stresses [36].

Water stress affects almost every developmental stage of the plant such as germination, seedling shoot length, root length and flowering [17, 25]. It also increases mean germination time [35]. Mostafavi et al., 2011 and Khodarahmpour, 2011, [18, 22] also reported the effect of water storage on germination and seedling growth in different crops. In general plants sense changes in climate and adjust their metabolism and growth according to their capacity. Generally plants tolerant to particular abiotic stress establish a metabolic homeostasis and carry on their growth without suffering stress induced injuries. On the other hand sensitive plants unable to establish tolerant mechanism, that results in their reduction in growth, ultimately leading to death [5, 14].

The polyethylene glycol (PEG), induced inhibition of germination has been attributed to osmotic stress [8, 30]. PEG is a polymer and considered as better chemical than others to induce water stress artificially [15, 21]. PEG has been used often as abiotic stress inducer in many studies to screen drought tolerant germplasm (Almaghrabi 2012, Ahmad et al, 2013, Jatoi et al, 2014 and Basha et al., 2015) [2, 3, 5, 13] and it also induces osmotic stress which is in inductee to decrease water potential of the cell [11]. The increasing concentration of PEG caused a decrease in germination percentage, seedling vigor in certain crop plants [18].

Pulses are an important and essential source of dietary protein particularly in the predominantly vegetarian population of Indian subcontinent and constitute a significant part of diet. *Vigna radiata* L. (Mung bean) is an important pulse crop having high nutritive value. Seeds, sprouts and young pods are consumed as sources of proteins, vitamins and minerals, whereas plant parts are used as fodder and green manure [27]. Since it has nitrogen fixing properties that helps us to restore soil fertility. As compared to other legumes, proteins and carbohydrates derived from mung bean are easily digested and create less flatulence [26]. Vigna seeds have high amount of protein (24.3%), carbohydrate (60.4%) and fats (1.3%) [9]. Due to its palatable taste and nutritional quality, it has been used as iron rich whole source for baby food [24]. It is cultivated in India, China, Pakistan, Thailand, Indonesia, Burma, Philippines, Bangladesh, Vietnam, Laos, Cambodia, and in hot and dry areas of Southern Europe and United States [33]. In India, it is produced in Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Orissa, Rajasthan, Uttar Pradesh, Gujarat, Madhya Pradesh, West Bengal and Punjab constituting 11.8% of all pulses [37]. Therefore, the present investigation was carried out to evaluate germination characters and seedling growth of *Vigna radiata* against different concentrations of PEG.

Materials and Methods

All the experiments were conducted at Botany Laboratory, Kanoria PG Mahila Mahavidyalaya, Jaipur, Rajasthan, India, during October 2018-december 2018. Seeds of Vigna radiata were purchased from local market of Jaipur. Seeds were surface sterilized with 0.1% mercuric chloride for 2 minutes. They were washed several times with distilled water to remove excess of mercuric chloride. 30 seeds were placed for germination in the petridishes with corresponding PEG concentrations (2%, 4% and 6%) and kept in an incubator at 25°C. The petridishes were irrigated daily with required amount of respective solution. Each treatment was replicated thrice. Seedlings were allowed to grow up to 7 days after germination. Number of seeds germinated and the seed germination characters were recorded manually.

Result and Discussion

PEG had an inhibitory effect on germination percentage. There was a continuous decrease in the percentage germination with the increase of PEG concentration. In control there was 100% germination. At 2% and 4%, it was decreased by 15%, while at 6%, the % germination was 80% (Table 1, Figure 1). All decreases were significant in relation to control. PEG produced deleterious effects on seedling growth. A steady decline in the seedling growth was observed with the increase in PEG concentration. Water stress due to drought is one of the most significant abiotic factors that limit the seed germination, seedling growth, plant growth and yield [12, 32]. PEG molecules are inert, non-ionic, virtually impermeable chains and have been used frequently to induce water stress in crop plants [20, 25, 31]. The results were in agreement with the reports of Khayatnezhad et al., 2010, Khodarahmpour 2011 and Mostafavi et al., 2011, Basha et al., 2015 and Partheeban et al., 2017 [5, 17, 18, 22, 23]. Ayaz et al., 2001, [4] reported the decrease in seed germination under stress conditions. It is due to some metabolic disorders. Increasing drought stress level caused delay in seedling emergence as a result of reduced cell division and plant growth metabolism. Water stress affects almost every developmental stage of the plant. However, the adverse effect of PEG stress was more noted on various growth stages such as germination, seedling shoot length, root length and flowering [17, 25]. Shoot length was decreased at all concentrations. At 6% concentration, there was no shoot development was recorded (Table 1, Figure 2). A significant sharp decrease was observed in roots at 6% as compared to control (Table 1, Figure 2). The root length was found to be higher at control (2.2cms, Table 1). Roots are the primarily affected plant part under water stress conditions than any other parts [10]. Root traits of all varieties provided useful information against different levels of PEG and this is very important attribute to study the drought stress. The germplasm which has better growth under stressed environment may have drought tolerance mechanism [28].

A strong negative correlation between root-shoot length and PEG concentrations had been observed. All the concentrations showed common trend i.e. reduction rate in root-shoot length with increasing concentrations of PEG. The decline in shoot length traits in response to induced osmotic stress is a commonly observed phenomenon which depends on the tolerance capacity of the plant. Waseem et al., (2006), Kulkarni and Deshpande, (2007), Aazami et al., (2010) and Basha et al., (2015), [1, 5, 19, 34] reported decrease in growth rate with increasing osmotic stress. Different

Table 1. Effect of various concentrations of PEG on different growth parameters.

S.No	Parameters	Control	2%	4%	6%
1	Germination (%)	100	85	85	80
2	Mean root length (cms)	2.2	1.5	1.3	1.1
3	Mean shoot length (cms)	0.6	0.25	0.1	0
4	Mean seedling length (cms)	3.1	2.1	1.6	1.5
5	Seedling vigour index	2.79	1.78	1.36	1.20
6	Mean seedling fresh weight (gms)	2.37	1.75	1.58	1.46
7	Mean seedling dry weight (gms)	1.25	0.68	0.65	0.61

Figure 1. Effect of various concentrations of PEG on germination percentage.

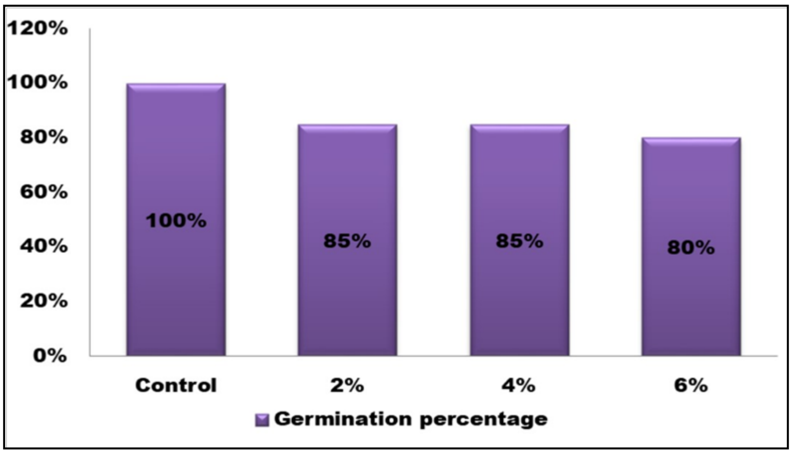


Figure 2. Effect of different concentrations of PEG on mean root, shoot and seedling length.

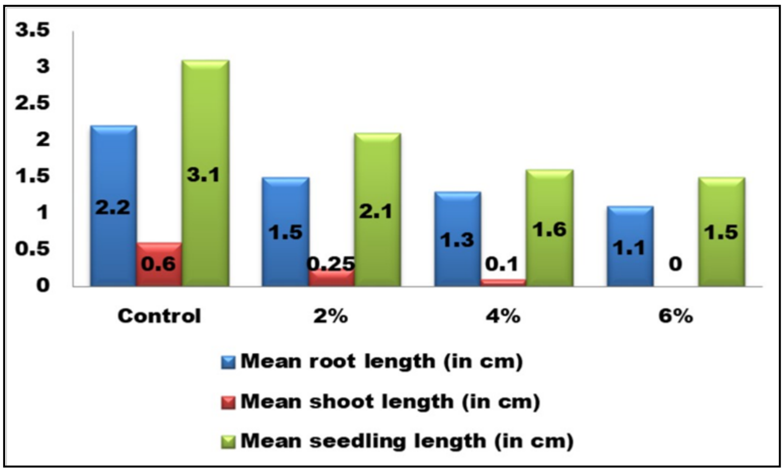


Figure 3. Effect of different concentrations of PEG on seedling vigor index.

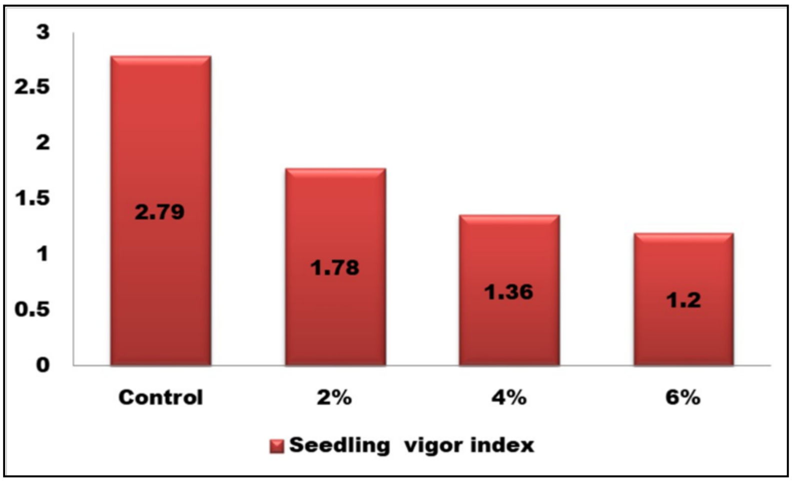
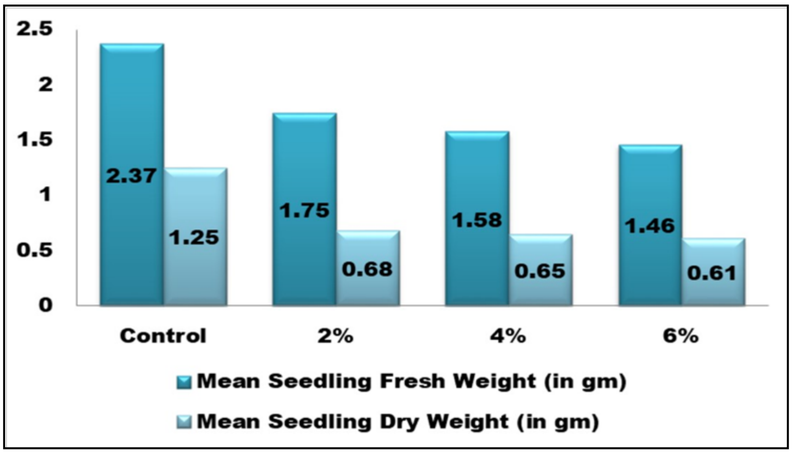


Figure 4. Effect of different concentrations of PEG on mean fresh and dry weight.



levels of PEG significantly influenced seedling vigor index. Vigor index was found higher at control and lowest at 6% concentration. The results of seedling vigor index showed that the speed of germination was reduced with the increase in PEG concentrations (Figure 3). Shaban (2013)[29], investigated that, as water is one of the primary requirements in seed germination and due to water stress (developed by PEG), there is great reduction in germination ability of seeds.

Seedling fresh weight and dry weight were also significantly affected by the different concentrations of PEG. Both fresh weight and dry weight of the seedling, demonstrated the continuous reduction in all concentrations as compared to the control (Figure 4).

Conclusion

The aim of this investigation was to determine the potential of PEG on Vigna radiata L. growth. The results revealed that PEG retards the germination of stressed seeds, seedling length, root-shoot length and seedling vigor index. All characters were decreased with an increase in PEG concentrations. At 6% PEG stress, the shoot did not emerged. Based on these results *Vigna radiat*a L. was found as sensitive to PEG induced drought stress.

References

[1]. Aazami MA, Torabi M, Jalili E. In vitro response of promising tomato genotypes for tolerance to osmotic stress. Afr. J. Biotechnol. 2010;9(26):4014-7.

[2]. Ahmad M, Shabbir G, Minhas NM, Shah MK. Identification of drought tolerant wheat genotypes based on seedling traits. Sarhad J. Agric. 2013;29(1):21-7.

[3]. Almaghrabi OA. Impact of drought stress on germination and seedling growth parameters of some wheat cultivars. Life sci. J. 2012;9(1):590-8.

[4]. Ayaz FA, Kadioglu A, Turgut R. Water stress effects on the content of low molecular weight carbohydrates and phenolic acids in Ctenanthe setosa (Rosc.) Eichler. Can. J. Plant Sci. 2000 Apr 1;80(2):373-8.

[5]. Basha PO, Sudarsanam G, Reddy MM, Sankar S. Effect of PEG induced water stress on germination and seedling development of tomato germplasm. Inter J. Recent Sci. Res. 2015 May;6(5):4044-9.

[6]. Boyer JS. Plant productivity and environment. Sci. 1982 Oct 29;218(4571):443-8.

[7]. Cramer GR, Urano K, Delrot S, Pezzotti M, Shinozaki K. Effects of abiotic stress on plants: a systems biology perspective. BMC plant biology. 2011 Dec;11(1):163.

[8]. Dodd GL, Donovan LA. Water potential and ionic effects on germination and seedling growth of two cold desert shrubs. Am J Bot. 1999 Aug;86(8):1146-53. PMID: 10449394.

[9]. El-Karamany MF, Zeidan MS, Gobarh ME. A comparative study on productivity of some mung bean varieties grown in sandy soil. Egypt. J. Agron. 2003;25:59-67.

[10]. Ghafoor A. Unveiling the mess of red pottage through gel electrophoresis: a robust and reliable method to identify Vicia sativa and Lens culinaris from a mixed lot of split "red dal". Pak. J. Bot. 2013 May 1;45(3):915-9.

[11]. Govindaraj M, Shanmugasundaram P, Sumathi P, Muthiah AR. Simple, rapid and cost effective screening method for drought resistant breeding in pearl millet. Electron. J. Plant Breed. 2010;1(4):590-9.

[12]. Hartmann, M., College, P. and Lumsden. Responses of different varieties of Loliumperenne to salinity. Annual Conference of the Society for Experimental Biology; 2005. Lancashire.

[13]. Jatoi SA, Latif MM, Arif M, Ahson MU, Khan AS, Siddiqui SU. Comparative assessment of wheat landraces against polyethylene glycol simulated drought stress. Sci. Tech. and Dev. 2014 Jan 15;33:1-6.

[14]. Jogaiah S, Govind SR, Tran LS. Systems biology-based approaches toward understanding drought tolerance in food crops. Crit Rev Biotechnol. 2013 Mar;33(1):23-39. PMID: 22364373.

[15]. Kaur S, Gupta AK, Kaur N. Gibberellic acid and kinetin partially reverse the effect of water stress on germination and seedling growth in chickpea. Plant Growth Regul. 1998 Jun 1;25(1):29-33.

[16]. Khayatnezhad M, Gholamin R, Jamaati-e-Somarin S, Zabihi-e-Mahmoodabad R. Study of water stress effect on wheat genotypes on germination indexes. Middle East J. Sci. Res. 2010;6(6):657-60.

[17]. Khayatnezhad M, Gholamin R, Jamaatie-Somarin SH, Zabihi-Mahmoodabad R. Effects of peg stress on corn cultivars (Zea mays L.) at germination stage. World Appl. Sci. J. 2010;11(5):504-506.

[18]. Khodarahmpour Z. Effect of drought stress induced by polyethylene glycol (PEG) on germination indices in corn (Zea mays L.) hybrids. Afr. J. Biotechnol. 2011;10(79):18222-7.

[19]. Manoj K, Uday D. In vitro screening of tomato genotypes for drought resistance using polyethylene glycol. Afr. J. Biotechnol. 2007;6(6). 691-696.

[20]. Landjeva S, Neumann K, Lohwasser U, Börner A. Molecular mapping of genomic regions associated with wheat seedling growth under osmotic stress. Biol Plantarum. 2008 Jun 1;52(2):259-66.

[21]. Larher F, Leport L, Petrivalsky M, Chappart M. Effectors for the osmoinduced proline response in higher plants. Plant Physiol Biochem. 1993;31(6):911-22.

[22]. Mostafavi K, Geive HS, Dadresan M, Zarabi M. Effects of drought stress on germination indices of corn hybrids (Zea mays L.). Int J Agrisci. 2011;1(1):10-18.

[23]. Partheeban C, Chandrasekhar CN, Jeyakumar P, Ravikesavan R, Gnanam R. Effect of PEG induced drought stress on seed germination and seedling characters of maize (Zea mays L.) genotypes. Int J Curr Microbiol Appl Sci. 2017;6:1095-104.

[24]. Del Rosario RR, Flores DM, Maldo OM, Sabiniano NS. Development of Rice-Mungbean Based Baby Food. Phil. Journal of Food Science and Tech. 1987;2:95-109.

[25]. Rauf M, Munir M, ul Hassan M, Ahmad M, Afzal M. Performance of wheat genotypes under osmotic stress at germination and early seedling growth stage. African journal of biotechnology. 2007;6(8).

[26]. Fleming SE. A study of relationships between flatus potential and carbohydrate distribution in legume seeds. J. Food Sci. 1981 May;46(3):794-798.

[27]. Somta P, Srinives P. Genome research in mungbean (Vigna radiata (L.) Wilczek) and blackgram (V. mungo (L.) Hepper). Science Asia. 2007;33(Suppl 1):69-74.

[28]. Saxena NP, O Toole JC. Field screening for drought tolerance in crop plants with emphasis on rice: Proceedings of an International Workshop on FieldScreening for Drought Tolerance in Rice. 11-14 Dec 2000. ICRISAT; Patancheru, India. 2002.

[29]. Shaban M.. Effect of water and temperature on seed germination and emergence as a seed hydrothermal time model. International Journal of Advanced Biological and Biomedical Research, 2013;1(12):1686-169.

[30]. Sidari M, Mallamaci C, Muscolo A. Drought, salinity and heat differently affect seed germination of Pinuspinea. Journal of forest research. 2008 Oct 1;13(5):326-30.

[31]. Türkan I, Bor M, Özdemir F, Koca H. Differential responses of lipid peroxidation and antioxidants in the leaves of drought-tolerant P. acutifolius Gray and drought-sensitive P. vulgaris L. subjected to polyethylene glycol mediated water stress. Plant Sci. J. 2005 Jan 1;168(1):223-31.

[32]. Van den Berg L, Zeng YJ. Response of South African indigenous grass species to drought stress induced by polyethylene glycol (PEG) 6000. S Afr J Physiother. 2006 May 1;72(2):284-6.

[33]. Verma G, Kumawat N, Morya J. Nutrient management in mungbean [Vigna radiata (L.) Wilczek] for higher production and productivity under semi-arid tract of Central India. Int J Curr Microbiol Appl Sci. 2017;6(7):488-93.

[34]. Waseem M, Athar HR, Ashraf M. Effect of salicylic acid applied through rooting medium on drought tolerance of wheat. Pak. J. Bot. 2006;38:1127-1136.

[35]. Willenborg CJ, Gulden RH, Johnson EN, Shirtliffe SJ. Germination characteristics of polymer-coated canola (Brassica napus L.) seeds subjected to moisture stress at different temperatures. Agron. Res. 2004 May 1;96(3):786-791.

[36]. Xiong L, Wang RG, Mao G, Koczan JM. Identification of drought tolerance determinants by genetic analysis of root response to drought stress and abscisic acid. Plant Physiol. 2006 Nov 1;142(3):1065-74. PMID: 16963523.

[37]. Yadav DL, Pratik J, Pandey RN. Identification of sources of resistance in mungbean genotypes and influence of fungicidal application to powdery mildew epidemics. Int. J. Curr. Microbiol. App. Sci. 2014;3(2):513-519.