The Effect of Salicylic Acid and Polyethylene Glycol on Wheat Germination

Marin SOARE, Paula IANCU*, Elena BONCIU, Ovidiu PĂNIȚĂ

Faculty of Agronomy, University of Craiova, Libertatii Street, no 19, 200583, Romania

*corresponding author; e-mail: paula.iancu76@gmail.com

Bulletin USAMV series Agriculture 75(1)/2018

Print ISSN 1843-5246; Electronic ISSN 1843-5386

DOI 10.15835/buasvmcn-agr: 002617

Abstract

The present paper analyses the effect of pre-treatment with salicylic acid (SA) on germination and the growth of winter wheat seedlings in water stress conditions induced by polyethylene glycol (PEG). A two-factor experiment was conducted in a completely randomized projection. The first factor (A) included three levels: a1- distilled water - control; a2 - 0.25 mM SA; a3 - 0.75 mM SA and the second factor (B) included three levels: b1- distilled water; b2 - 15% PEG and b3 - 25% PEG. Biological material was represented by a DH winter wheat line. It were made observations on germination percentage (GP), root length (RL), cotyledons length (CL), seedling fresh weight (SFW) and vigor index (VI). After the analysis of the obtained results it can appreciate that the 25% PEG concentration played the main role for the significant decrease of the germination percentage (GP) and vigor index (VI). Also, seeds pre-treatment with 0.75 mM SA could be a way to improve germination characteristics in drought conditions.

Keywords: *salicylic acid, PEG solution, germination, drought stress*

Introduction

Environmental factors present the highest impact on morphology and phenology of culture species and these allows their growing in different areas. Drought is one of the major abiotic stresses which limit the crop production, but some species can respond and adapt to water stress by altering their cellular metabolism and invoking various defense mechanism (Boudsocq et al., 2005; Zhu, 2002). The genotypes that possess *Rht* type genes have greater sensitivity to adverse conditions, but have a higher production potential under normal precipitation conditions (Păniță et al., 2010).

Significant advances have been made in crop improvement, but today's agriculture is facing with some unprecedented challenges such as: to keep pace with the growing human demand in an environmentally and socially sustainable manner and in a context of climate change (Paux, 2017). An objective of NARDI Fundulea is to create varieties with wide adaptability to the contrasting environmental

conditions. These can reduce the risks in the production decline during the unfavorable years (Mustătea et al., 2008).

Water stress decreases percentage and rate of germination and also seedling growth. Polyethylene glycol (PEG) solution is an agent often used to simulate osmotic stress in laboratory conditions. Salicylic acid is a hormone of phenolic nature that has diverse effects on tolerance to abiotic stresses and become a common technique for increasing the speed and uniformity of germination (Ashraf et al., 2005). It has been reported that SA provides protection against salinity stress in wheat case (Barakat, 2011). The capacity to adjust osmotically is an inherited trait, which in wheat is controlled by alternative alleles at one locus on chromosome 7A (Bănică et al., 2008).

The present study was made to evaluate the effect of polyethylene glycol (PEG) induced-water stress on germination characteristics of a DH wheat productive line in order to recommend this as drought tolerant genotype to hydric stress.

Figure 1. Working parameter of germination Chamber and Petri dishes with experimental variants (R1)

Material and method

The present paper analyses the effect of pre-treatment with salicylic acid on germination and growth of winter wheat seedlings in water stress conditions. A two-factor experiment was conducted in a completely randomized projection in the laboratory of Genetics from Faculty of Agronomy of University of Craiova. The first factor (A) included 2 levels of salicylic acid: 0 - distilled water; 0.25 mM; 0.75 mM and the second factor (B) included 2 levels of PEG: 0 - distilled water; 15% and 25%. Biological material was represented by a productive winter wheat DH line. It were made observations on germination percentage (GP), root length (RL), cotyledons length (CL) and fresh weight (CFW) and vigour index (VI).

For that, first the method of testing was: 30 grains of each treatment were separated and after sterilization with hypochlorite for two minutes were let to dry at room temperature. Then, grains were soaked in the mentioned concentrations of SA for 24 hours. After that, grains were placed in Petri dishes on paper and applied PEG solution. These Petri dishes were put in the germination chamber (temperature of 24°C, relative humidity 80%, two days in dark conditions and 5 days in light conditions). Starting with the second day of experiment, the number of germinated seeds was counted every day (Standard germination is when the root tip was approximately 2 mm).

Percentage of germination was determined using formula given by Nicols (1968): $S/T \times 100$ (S = number of germinated seed; T = total number of seed). Root and cotyledons length was measured. Seedling fresh weight was determined using a precision balance and vigor index was calculated: the length of seedling x the number of germinated seeds in the last day of counting (Agrawal, 2003).

Results and discussions

Obtained results show that experimented DH line responded differently to the induced water stress. As concern percent of germination as it can be seen in figure 1, there are few significant differences between the levels of priming with distilled water and salicylic acid (SA) and the potential drought stress levels caused by polyethylene glycol (PEG) and the treatment effect. Treatment with SA influenced positively the energy and germination faculty of DH wheat grains and could be considered as a regulatory substance of growth and his application can lead to answers of plants favorable to stress factors.

Control variant (priming with distilled water) realized maximum GP; same value of GP was also realized in variants a1b2 (priming with distilled water + PEG 15%), a3b1 (priming with SA 0.75 mM + distilled water) and a3b2 (priming with SA 0.75 mM + PEG 15%). The lowest percentage of germination is occurred in a2b3 (priming with SA 0.25 mM + PEG 25%) and a2b2 (priming with SA 0.25 mM + PEG 15%).

Laboratory conditions offered to wheat seeds in PEG solutions affected negatively the germination properties. It is thank that the reason for the decreased germination percentage can be explained by the toxic effect of these concentrations on germination embryos, which caused the decreased germination percentage. Similar effects were observed with the treatment with KCl on wheat seeds and reported by Giri and Schillinger (2003) and Yari *et al.* (2011).

A decisive indicator of drought simulation is root length (cm). The results of this laboratory experiment showed that the SA treatment increased root length, but only in the variants a3b2 (priming with SA 0.75 mM + PEG 15%) and a3b1 (priming with SA 0.75 mM + distilled water).

Figure 2. Percent of germination

Figure 3. Root length (cm)

Figure 3. Cotyledons length (cm)

These values of 11.45 cm, respectively 10.98 cm are higher than those registered in control variants. Increasing the stress level up to 25% root length decreased considerably (4.85 cm). Decastro *et al.* (2000) reported that IAA, IBA and NAA seed treatments enhanced root formation and development.

By comparing the averages obtained in control variants with the ones obtained in the different level of priming and treatment (figure

3) it can be observed that in the low doses of SA 0.25 mM + PEG 15% and PEG 25%, registered low cotyledons length (0.98 cm, respectively 1.1 cm). Lowest value was recorded in a3b3 variant (priming with SA 0.75 mM + PEG 25%) while the highest value was realized by the variant a3b1 (priming with SA 0.75 mM + distilled water).

Soare *et al.*, (2015) sustain that chickpea seedlings can tolerate salt stress in the tested doses and salicylic acid concentrations of 0.75

Figure 5. Differences of growth between control and PEG solution

Figure 6. Cotyledons and root growth (25%, 15%, Ct. - R2)

Figure 7. PEG 25% effect upon cotyledon growth (R3)

Figure 8. Vigor index

mM alleviate the impact of the stressor as concern antioxidant enzyme activity.

Also, in a study made by Băbeanu Cristina *and al.*, (2012) in order to evaluate the effect of polyethylene glycol (PEG) induced-water stress on lipid peroxidation and on scavenger enzymes in wheat leaves at seedling stages, they concluded that when seedlings were subjected to PEG - induced water stress, antioxidant enzyme activities and malondialdehyde (MDA – a consequence of protective mechanism of scavenging capacity)

content increased for all studied genotypes in comparison with control.

Seed priming with SA improved some germination characteristics under the two stress levels with PEG (root length), but reduced others (cotyledons length) having inhibitory effects.

Vigor index (also called power of seed or seed viability) is the power and ability of seed emergence in difficult conditions (stress).

Maximum seed vigor was obtained in high level of SA priming and control variants. By increasing osmotic potential due to PEG, seed

Figure 9. Root and cotyledons fresh weight (mg)

vigor is decreased. Interaction effect between seed priming with SA and PEG solution (fig. 4) shows that the highest seed vigor is associated with a3b1 treatment (priming with SA 0.75 mM + distilled water), followed by a1b1 (priming in distilled water + distilled water - control), a2b1 (priming with SA 0.25 mM + distilled water) and a3b2 (priming with SA 0.75 mM + PEG 15%). Minimum seed vigor was registered in a3b3 variant (priming with SA 0.75 mM + PEG 25%). These data are in accordance with the ones listed by Sharafizad *et al.*, (2013).

Control variants presented the highest values of measured characteristics while in medium to high concentration of PEG decreased significantly because the grains could not absorb this solution.

Treatments performed with PEG significantly reduced the average of fresh weight of root cotyledons. The utilized doses of PEG solution induced very well drought because wheat seeds produced shorter roots with weight of 0.0035 mg (priming with SA 0.25 mM + PEG 25%) until 0.035 mg (priming with SA 0.75 mM + distilled water). It can see that in the variants priming with SA 0.25mM and the two concentrations of PEG, it were obtained the reduced values.

Based on these results, it can be concluded that the concentrations of SA can have positive effects on wheat germination. It is necessary to make further investigation to determine the right concentration.

These laboratory results obtained by the field productive DH line (5312.5 Kg/ha obtained in agricultural year 2015-2016) and reported by Iancu Paula *et al.*, 2016, can be considered a test which can be used for preliminary characterization

and selection as genotype used in breeding for drought resistance.

Seedling test can be very useful for a better understanding of differential responses of genotypes to water stress and for preliminary selection in breeding programs (David, 2013).

Conclusions

After the analysis of the values obtained for some germination characteristics in this experiment it can be considered that using salicylic acid could increase plant tolerance to drought stress, but further study is needed to determine the right dose.

Seed priming with SA improved some germination characteristics under the two stress levels with PEG, but reduced others having inhibitory effects.

The 25% PEG concentration played the main role for the significant decrease of both the germination percentage (GP) and vigour index (VI). Also, seeds pre-treatment with 0.75 mM SA could be a way to improve germination characteristics in drought conditions and it can be recommended to farmers in the study area.

This DH line showed good tolerance to water stress as concern root and cotyledons length, but once with the increase of PEG dose, these characteristics value decreased, but by addition of SA, it appears that the tolerance is higher. It is necessary to make further investigation to determine the right concentration.

Acknowledgements: This work was supported by the research project ADER 1.1.6/2015 - "The use of biotechnological methods for increasing genetic variability of material to improve and accelerate genetic progress and stability in the level of yields

for the main crops in the context of climate change" (2015-2018).

References

1. Agrawal R (2003). Seed Technology. Newdehli India: Pub. co. Ltd.
2. Ashraf M, Foolad MR (2005). Pre-sowing seed treatment a shotgun approach to improve germination, plant growth, and crop yield under saline and non-saline conditions. *Advances in Agronomy*, 88: 223-265.
3. Barakat-Nasser AM (2011). Oxidative stress markers and antioxidant potential of wheat treated with phytohormones under salinity stress. *Journal of Stress Physiology & Biochemistry*, vol. 4/issue 7: 251-268.
4. Băbeanu C, Păunescu A (2012). Antioxidant enzyme activities and lipid peroxidation in wheat seedlings under PEG - induced water stress. *Annals of University of Craiova. Chemistry Series*.
5. Bănică C, Petcu E, Giura A, Săulescu NN, Nicolae N (2008). Relationship between genetic differences in the capacity of osmotic adjustment and other physiological measures of drought resistance in winter wheat (*Triticum aestivum* L.). *Romanian Agricultural Research*, 25: 7-11.
6. Boudsocq M, Lauriere C (2005). *Plant Physiol*: 138, 1185.
7. David Monica (2013). Seedling response to water stress induced by gradual drying of the substrate - a simple method to approximate drought resistance in wheat. *Romanian Agricultural Research*, 30: 31-36.
8. De Castro RD, van Lammeren AA Groot SP, Bino RJ, Hilhorst HW (2000). Cell division and subsequent radicle protrusion in tomato seeds are inhibited by osmotic stress but DNA synthesis and formation of microtubular cytoskeleton are not. *Plant Physiol* 122:327-336.
9. Giri GS, Schillinger WF (2003). Seed priming winter wheat for germination, emergence and yield. *Crop Sci.* 43:2135-2141.
10. Iancu P, Soare M, Bonea D, Păniță O (2016). Preliminary results concerning the genetic variability of some mutant lines of wheat experimented to ARDS Caracal. *Analele Universității din Craiova, seria Agricultură - Montanologie - Cadastru (Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series)*, XLVI: 159-164.
11. Mustățea P, Săulescu NN, Ittu G, Păunescu G, Voinea L, Stere I, Marlogeanu S, Constantinescu E, Năstase D (2008). Comportarea unor soiuri de grâu în condiții contrastante de mediu (The reaction of some wheat varieties in contrasting environmental conditions). *Anale INCDA Fundulea, București*, LXXVI: 7-15.
12. Nicols MA, Heydecker W (1968). Two approaches to the study of germination date. *Proc. In to seed test. Asso.*, 33, 561-540.
13. Paux, E (2017). How can genome organization impact wheat breeding (and vice versa)? *Proceedings 13th International Wheat Genetics Symposium*.
14. Păniță O, Soare M, Soare R (2010). The yield potential evaluation of some autumn wheat izogene varieties based on drought sensibility index (DSI) in the conditions of Oltenia South Central area. *Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series*, 40(2): 241-245.
15. Soare M, Soare R, Babaeanu C, Bonea D (2015). The effects of salicylic acid pretreatment on the antioxidant enzymatic system of chickpea seedlings under salt stress. *Journal of Biotechnology*, 208: S115.
16. Sharafizad M, Ahmad N, Seyed A, Tayeb S, Shahram L (2013). Effect of Salicylic Acid Pretreatment on Germination of Wheat under Drought Stress. *Journal of Agricultural Science*, 5(3): 178-199.
17. Yari L, Khazaei F, Sadegh, H, Sheidaei S (2011). Effect of seed priming on grain yield and yield components of bread wheat (*Triticum aestivum* L.). *J. Agr. Biol. Sci.* 6:1-5.
18. Zhu JK (2002). *Annu. Rev. Plant Biol* 53, 247.