Short communication

SORGHUM GERMINATION UNDER PEG-INDUCED DROUGHT STRESS

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SUMMARY

The aim of this study was to investigate the effects of the increasing polyethylene glycol – PEG concentrations (2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, and 30.0%) on germination and early seedling growth of grain sorghum genotypes NS A174 × Re37/07 and NS Gold. The trial included distilled water as control where no significant differences between genotypes were observed for any of the examined parameters. The drought treatments starting from 10.0% PEG decreased germination energy and percentage, and the most discriminative treatment was 17.5%. The shoot growth parameters provided better differentiating between the genotypes than those of root growth. The discriminative treatments were in the range of 7.5-15.0% PEG. NS A174 × Re37/07 was less affected by the PEG-imposed drought than NS Gold; however the comprehensive field study would be required to confirm the presumable drought tolerance of the hybrid.

KEYWORDS: drought, germination, polyethylene glycol, sorghum

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INTRODUCTION

Grain sorghum is among world's major crops; occupies 40 million ha roughly and yields about 1.4 t ha^{-1}. The largest areas are in Africa where it is also the center of origin of this plant. In Europe, there is about 0.3 million ha under sorghum, however with high average yield of 3.7 t ha^{-1} which is attributed to both advanced production technology and quality assortment. In Serbian environments, with intensive agro-technology, grain sorghum hybrids of local origin achieve yields of over 10 t ha^{-1} (Berenji & Sikora, 2004; Sikora & Berenji, 2005; FAO, 2020).

Sorghums are considered as tolerant to drought and high temperatures, as well as to have modest requirements towards soil conditions and nutrients, at least when compared to e.g. maize. Therefore growing sorghum in unfavorable environments may provide comparatively stable and sufficient yields of protein per unit area. Yet, there is an inheritable variability among sorghum cultivars and hybrids regarding the ability to cope with various environmental constraints including drought. Satisfactory tolerance to lower water supply is certainly a desirable trait in breeding programs and the possibility to test large number of plants at early stages of development would be of great practical importance (Assefa et al., 2010; Mutava et al., 2011; Sikora et al., 2019; Velazco et al., 2019). The most widely used method for simulating drought in laboratory conditions is by lowering osmotic potential of plant growth medium with polyethylene glycol, PEG (Ibrahim et al., 2001; Hellal et al., 2018).

The aim of this preliminary study was to test the effects of the series of increasing PEG concentrations on germination and early seedling growth of two sorghum genotypes with different maturity; and to establish the PEG concentrations that are the most discriminative.

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MATERIAL AND METHODS

Sorghum (*Sorghum bicolor* (L.) Moench) experimental early maturing hybrid NS A174 × Re37/07 and registered commercial late maturing hybrid NS Gold, bred at the Institute of Field and Vegetable Crops, National Institute of the Republic of Serbia, Novi Sad, were used in this study. The sorghum seeds were germinated on filter paper, in Petri dishes placed in dark chamber at 25°C. The paper was moistened with polyethylene glycol (PEG) 6000 solutions of 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5 and 30.0%, having the osmotic pressure of -0.19, -0.50, -0.93, -1.48, -2.16, -2.95, -3.87, -4.91, -6.07, -7.35, -8.75 and -10.27 bars, respectively (Michel & Kaufmann, 1973). The assay included distilled water as control. There were 100 seeds in every dish and each variant was replicated three times. The first reading was done on the fourth day after trial setting, when the germination energy, i.e. % of the germinated seeds, was determined. The readings continued on the daily basis until the tenth day. Germination percentage and time (number of days required to complete germination) were noted. Root length (cm), shoot height (cm), fresh root and shoot weight (mg) were measured on the seventh day and expressed as mean values of 20 seedlings.

Statistical data processing included analysis of variance and LSD test. Calculation and graphing was done using Statistica 12.0 (StatSoft, Dell Inc., USA; University of Novi Sad License) software.

RESULTS AND DISCUSSION

Germination parameters

When germinated on filter paper soaked with distilled water i.e. control, the studied grain sorghum genotypes did not differ in germination energy, percentage nor time (Figure 1.). Germination energies were 71.8 and 73.5%, for NS A174 × Re37/07 and NS Gold, respectively. The germination percentage values of 73.7 and 76.3% indicate that the seed meets the regulations established by the Ordinance on the quality of seeds of agricultural plants, which is at least 70.0% (Službeni list SRJ, 2002). The seeds completed germination in 7.0 and 7.3 days.

The lowest PEG concentration of 2.5% did not affect the sorghum seeds, while 5.0% increased germination energy and percentage in NS Gold and decreased the same paramerers in NS A174 × Re37/07. Haghighat et al. (2012) reported improvement in sorghum germination after priming with approx. 5.0% PEG. Possible positive effects of priming NS Gold seeds with low-concentrated PEG should be examined in more detailed studies. The PEG-imposed drought stress led to significant decrease in germination energy starting from the concentration of 10.0%, which applies to both genotypes. The value of germination energy was halved at 17.5% and this treatment provided the most conspicuous differentiation between the two genotypes; with NS Gold being more susceptible than NS A174 × Re37/07. At 22.5% treatment, soghum seeds had germination energy of 1.0-5.0%, while starting from 25.0% treatment seeds did not germinate at all.

Similar trends were observed for germination percentage, however the differences between the two genotypes were less pronounced. In addition, a small number of both genotypes' seeds (1.0-4.0%) germinated at 25.0% PEG.

Germination time remained statisticaly unchanged from control up to 15.0% treatment, where NS Gold required an extra day to complete germination. NS A174 × Re37/07 had a day longer germination time at 17.5% PEG treatment. At 25.0% treatment germination time was significantly reduced.

Parameters of early seedling growth

Due to severely reduced or completely inhibited germination at PEG treatments of 22.5% and upwards, the parameters of early seedling growth were analyzed only for treatments ranging 2.5-20.0%. The two sorghum genotypes did not differ significantly neither in root nor shoot growth when germinated at control (data not shown).

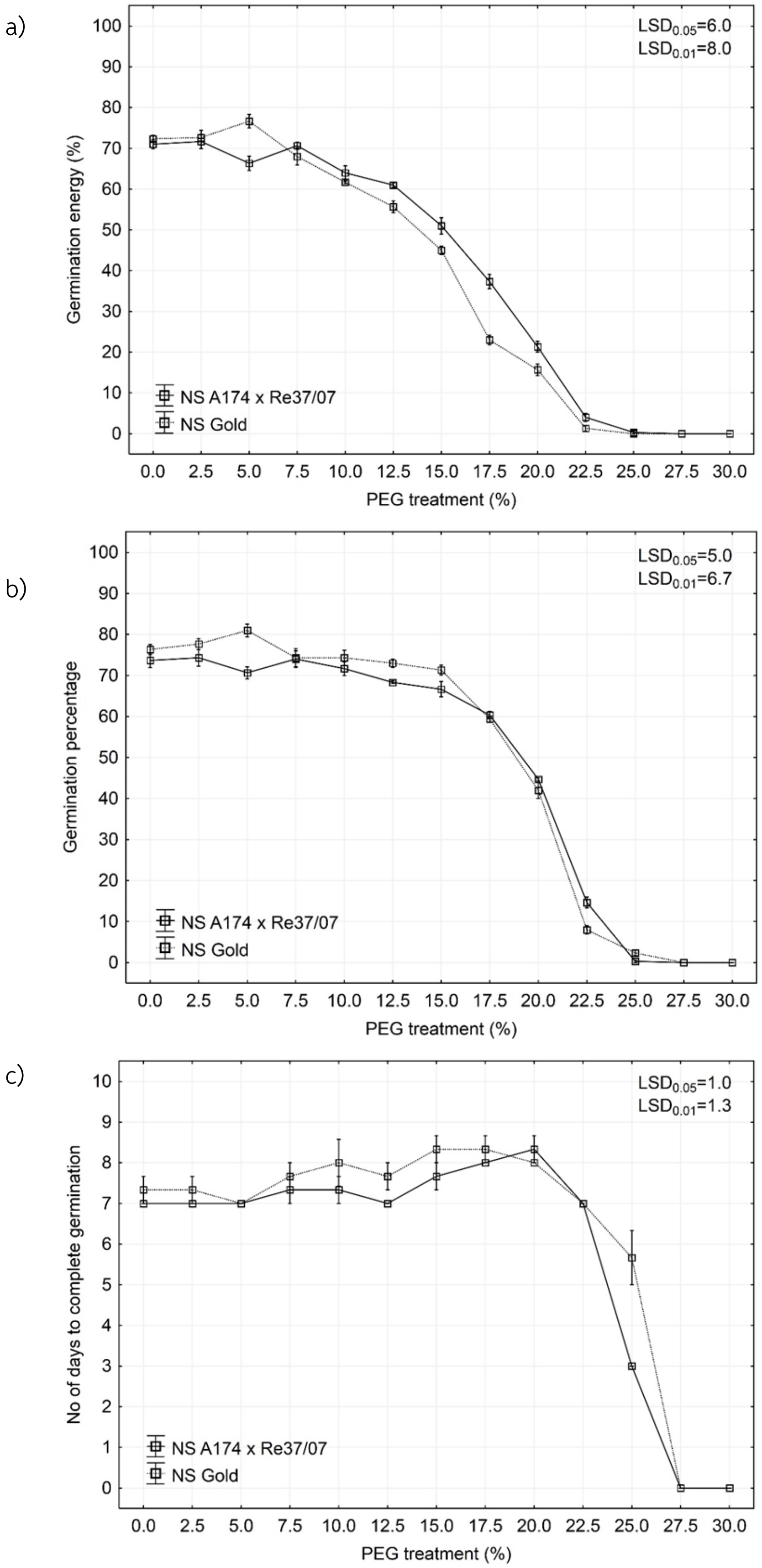
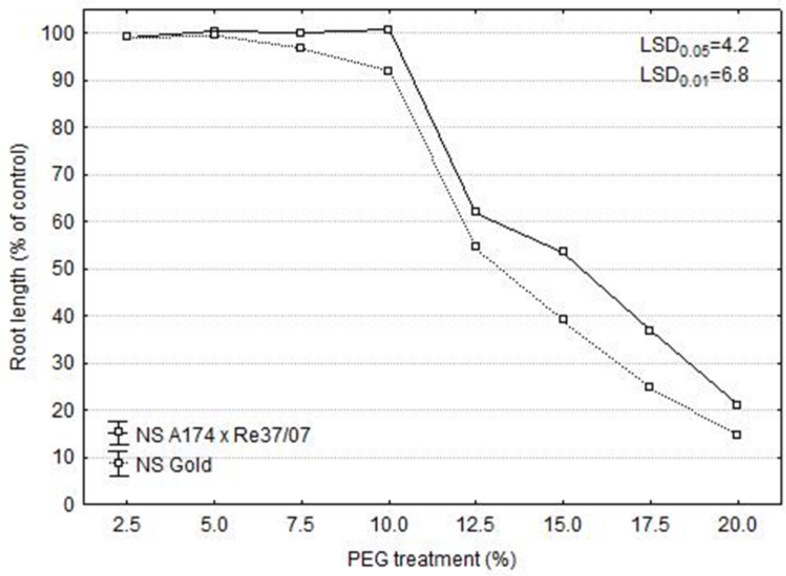


Figure 1. Germination energy (a), percentage (b) and time (c) in two grain sorghum genotypes under the increasing PEG treatments

a)



b)

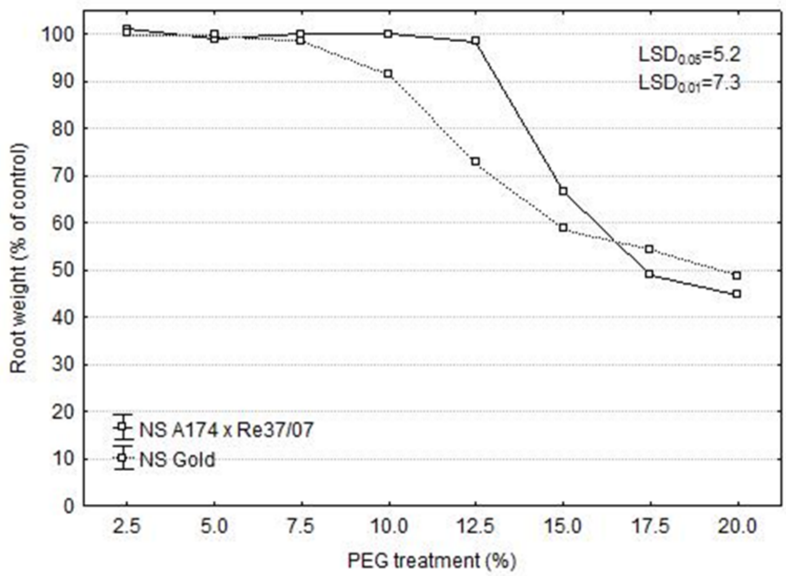


Figure 2. Root length (a) and weight (b) in seedlings of two grain sorghum genotypes under the increasing PEG treatments, expressed as % of control (100.0%)

Therefore, for clarity, the results are depicted in Figures 2 and 3 as percentages of control (100.0%).

Generally, the treatments had a stronger effect on the root length than on the root weight. The root length halved at PEG concentrations between 12.5 and 15.0%, and weight halved at 17.5%. The differences between the genotypes were the most noticeable at treatments ranging from 10.0 to 15.0% PEG. The positive effect of low PEG concentrations expressed on NS Gold seed germination was not observed on the parameters of its' seedling growth.

The shoot growth was more susceptible to the PEG-imposed drought than the root growth; similar to the results reported by Bibi et al. (2012). The shoot height was significantly reduced at the mildest treatment of 2.5%, and the shoot weight at 5.0%. The differences between the genotypes were also more pronounced than in the case of the root growth. The discriminative treatments were in the range 7.5-15.0% PEG. A slightly stronger effect of approx. 6.0% PEG on root growth than on shoot growth was reported by Rajendran et al. (2011), however it refers to a mean effect on a large number of sorghum genotypes of different drought tolerance.

Taking into account all analyzed parameters, the seedlings of NS A174 × Re37/07 were less affected by the imposed drought than those of NS Gold. However, multi- year and location field experiments should be set in order to confirm the presumed better drought tolerance of NS A174 × Re37/07.

CONCLUSIONS

Starting from 10.0%, the increasing PEG treatments affected germination parameters in the analyzed grain sorghum genotypes. The most discriminative treatment was 17.5%, and NS A174 × Re37/07 was more drought tolerant than NS Gold.

The treatments affected shoot growth to greater extent than root growth. Root length

a)

b)

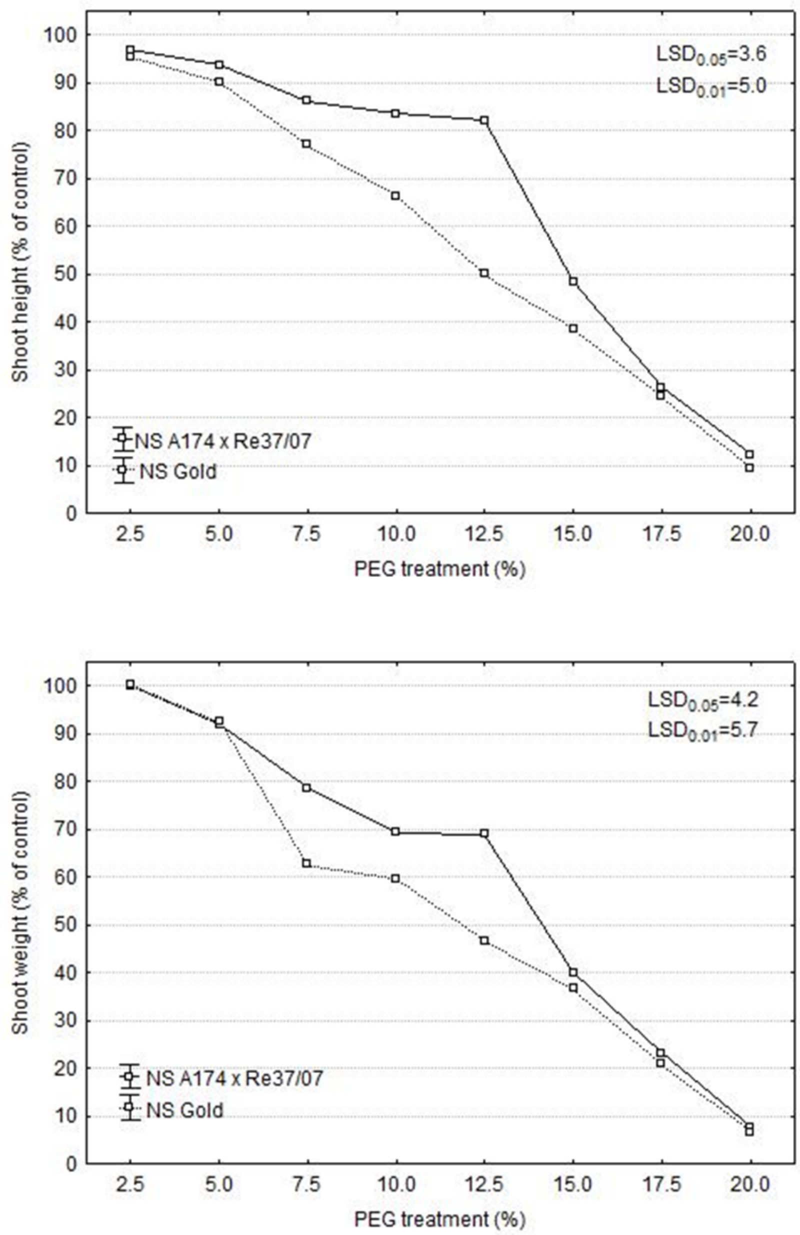


Figure 3. Shoot height (a) and weight (b) in seedlings of two grain sorghum genotypes under the increasing PEG treatments, expressed as % of control (100.0%)

and height decreased starting from 10.0% PEG, whereas 2.5 and 5.0% significantly decreased shoot height and weight, respectively. The shoot growth parameters provided better differentiating between the genotypes than those of root growth. The discriminative treatments were in the range of 7.5-15.0% PEG.

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SAŽETAK

KLIJANJE SIRKA U USLOVIMA SUŠNOG STRESA IZAZVANOG PEG-om

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Cilj rada je bio da se ispita efekat rastućih polietilen glikol – PEG koncentracija (2,5; 5,0; 7,5; 10,0; 12,5; 15,0; 17,5; 20,0; 22,5; 25,0; 27,5; 30,0%) na klijanje i rani porast klijanaca genotipova sirka za zrno NS A174 × Re37/07 i NS Gold. Ogled je uključivao destilovanu vodu kao kontrolu, gde za ispitivane parametre nisu uočene značajne razlike između genotipova. Tretmani sušom počevši od 10,0% PEG-a su snizili energiju klijanja i klijavost, a najveće razlike među genotipovima su se ispoljile kod tretmana od 17,5%. Parametri rasta nadzemnog dela klijanca su omogućili bolju procenu tolerantnosti na sušu od parametara rasta korena. Kod tretmana u opsegu 7,5-15,0% PEG-a su se razlike među genotipovima u pogledu ranog porasta klijanaca ispoljile u najvećoj meri. Tretmani su u manjoj meri uticali na NS A174 × Re37/07 nego na NS Gold, međutim potrebno je izvesti poljski ogled da bi se potvrdila tolerantnost na sušu ovog hibrida.

Ključne reči: klijanje, polietilen glikol, sirak, suša