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THE EFFECT OF DROUGHT STRESS ON THE YIELD AND SOME QUALITY TRAITS OF SOME SOYBEAN (*Glycine max* (L.) Merr.) GENOTYPES

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Abstract

Soybean (Glycine max (L.) Merr.) is one of the most grown legumes in the world. It has a very high protein content, and a relatively high oil content. Soybean production is affected by many abiotic stresses, especially drought stress. This study compared the yield and the percentage of protein and oil of three different soybean genotypes when subjected to drought stress. The results suggest that the genotype plays an important role in soybean reaction to drought stress.

Keywords: soybean, drought stress, yield, protein percentage, oil percentage.

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) has the greatest global area-harvested seed legume; it is a relatively-cheap protein and vegetable oil source (Mutava et al., 2015). Compared to other legumes, soybean seeds are the highest in protein composition, and are one of the highest in oil composition, they also contain carbohydrates, minerals and other components (Miransari, 2016). Soybean yield is greatly affected by several abiotic stresses; one of the major abiotic stresses affecting soybean is drought stress (Fan et al., 2013), which intensively increased over the past decades affecting the world's food security (Vurukonda et al., 2016). In order to achieve food security, increasing the knowledge of plant responses to abiotic stresses is needed (Morison et al., 2008). Drought negatively affects quantity (yield) and quality (seed content) in plants (Vurukonda et al., 2016).

Soybean is considered sensitive to drought stress, especially during certain periods of plant lifecycle (Liu et al., 2004), consequently, the timing and the duration of the drought stress lead to different rates of yield loss; for instance, water stress during the seedling stage decreased soybean yield by 20% (Ohashi et al., 2006), compared to 43.9% during flowering stage (Cui *et al*. 2013). Bord and Hartville, (1998) suggested that drought stress during flower formation led to a shorter flowering period and produced fewer flowers, fewer pods, and consequently, significantly smaller number of seeds per plant. Gutierrez-Gonzalez et al., (2010) reported 15.2% reduction in the weight of 100 seeds grown under drought stress during R5 (beginning of seed filling) stage compared to control plants; this decrease could be due to a loss in seed assimilates (Yordanov et al., 2003), or to a shortened seed filling period (Demirtas et al., 2010).

Although many researchers reported soybean seed yield, when exposed to drought stress, to be reduced (Rose, 1988; Kokubun et al., 2001; Sadeghipour and Abbasi, 2012; Li et al., 2013), yield reduction was found to be genotype-dependent (Bellaloui and Mengistu, 2008; He et al., 2016). Moreover, severe drought stress resulted in soybean seed yield reduction more than did moderate drought stress (Dornbos and Mullen, 1992).

Protein and oil concentrations of soybean seeds are the most important parameters determining the nutritional value (Chung et al., 2003). Under drought stress conditions, there was no effect on protein concentration (Sionit and Kramer, 1977) or lower protein concentration (Rose, 1988; Specht et al., 2001; Boydak et al., 2002; Carrera et al., 2009) due to the timing (stage) and severity of applied drought stress (Carrera et al., 2009).

In general, protein content in soybean seeds is negatively correlated with oil content (Chung et al., 2003). Few papers reported oil content to be increased under drought stress (e.g. Specht et al., 2001; Boydak et al., 2002). Moreover, some papers reported a significant effect of drought stress applied at different stages on the oil content; applying drought stress during the seed filling stage resulted in the lowest oil percentage (Dornbos and Mullen, 1992; Smiciklas et al., 1992; Maleki et al., 2013).

The aim of this paper was to study the effects of drought stress on the yield and the protein and oil composition of three soybean genotypes.

MATERIAL AND METHODS

Three soybean genotypes, *Bólyi 612*, *Bokréta* and *Krisztina*, were grown in Debrecen University's experimental farm (Látókép) (N. latitude 47^{o} 33', E. longitude 21^{o} 27') in 2017. The soil type is calcareous chernozem, the average annual precipitation is 565.3 mm, whereas the precipitation between sowing and harvesting dates was 213.3 mm.

To study the drought stress effects, two treatments were applied with four replications: the first treatment was to grow the studied soybean genotypes without drought stress (control plants), and the other treatment was to grow the three genotypes under rainfed conditions (no irrigation). The statistical analysis was made using SPSS ver.22 software, and Independent Sample T-Test was used to compare the means.

RESULTS AND DESCUSSION

The yield of the three genotypes did not respond similarly to drought stress conditions; the yield of two genotypes, *Bólyi 612* and *Krisztina*, was reduced under water deficiency compared to control plants; however, the difference was not significant. On the contrary, the yield of the genotype *Bokréta* was increased under drought stress conditions (2895 kg ha^{-1}, compared to 2747 kg ha^{-1} for control plants), but also not significantly (table 1). Bellaloui and Mengistu, (2008) reported no significant differences in the yield of one of the studied genotypes, *Freedom*, when the drought stress was applied after the early reproductive stage, suggesting that the soybean genotype has a role on yield loss; similar results was presented by Heatherly et al., (1999).

The mean protein percentage in the genotype *Bólyi 612* was the same (33.53%) for the two treatments, and was a little bit lower for the stressed plants of the genotype *Krisztina* with no significant difference for both. Sionit and Kramer, (1977) results indicated that the percentage of protein in the seeds was not significantly affected by drought stress, regardless of the timing of the applied stress. However, the protein percentage of the genotype *Bokréta* seeds was significantly higher in the stressed plants (32.83%, compared to 31.43% for control plants) (table 1), which is consistent with many previous papers (e.g. Specht et al., 2001 and Boydak et al., 2002; Carrera et al., 2009).

Table 1

The mean yield (kg ha^{-1}), protein percentage (%) and oil percentage (%) of the three studied soybean genotypes under drought stress

Independent Samples Test												
	Bólyi 612				*Bokréta*				*Krisztina*			
	Mean		t	Sig. (2-tailed)	Mean		t	Sig. (2-tailed)	Mean		t	Sig. (2-tailed)
	Non-Irrigated	Irrigated			Non-Irrigated	Irrigated			Non-Irrigated	Irrigated		
Yield	3390	3680	-1.76	0.13	2895	2747	0.82	0.44	3307	3365	-0.35	0.74
Protein	33.53	33.53	0.00	1.00	32.83	31.43	2.57	**0.04**	32.70	33.20	-0.48	0.65
Oil	23.93	24.83	-1.41	0.21	25.68	26.18	-1.60	0.16	25.78	25.33	1.06	0.33

Protein composition is negatively correlated with oil composition (Chung et al., 2003); in the present study, this was noticed for the three studied genotypes. There was no significant difference in the oil percentage under water deficit conditions (Sionit and Kramer, 1977). The oil percentage decreased insignificantly under drought stress in the genotypes *Bólyi 612* and *Bokréta*, whereas it slightly increased in the genotype *Krisztina*, also insignificantly (table 1).

CONCLUSIONS

The effect of drought stress on the soybean yield, protein and oil percentage is genotype-dependent. The time of the drought stress application and the severity of it are also important factors. Further and more precise studies should be done to determine the effects of drought stress on soybean, including different local genotypes, different stress timing applications and different stress severities.

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