RELATIONSHIP BETWEEN WATER SUPPLY AND CROP YIELD COMPONENTS ON TWO SOYBEAN VARIETIES

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Abstract

Water stress is one of the most significant abiotic stress factors that leads to the loss of soybean production worldwide. The objective of this study was to quantify the water stress effects on two indeterminate type soybean varieties, *Sinara* (*Sn*) and *Sigalia* (*Sg*). Two water treatments were used: unlimited watering and 50% water withdrawal compared to optimal one. The experiment was set up in a modified evapotranspirometer. Seed yield, total dry matter, number of pods and seeds were measured during the harvest. Our results showed that water depletion significantly reduced the examined examined crop yield components. However, the varieties did not always react the same way to the lack of water: *Sn* produced higher yield with optimal water supply, while *Sg* produced higher number of pods and seeds.

Key Words: soybean, *Glycine max* L., water stress, unlimited watering, evapotranspirometer

Összefoglalás

A vízstressz az egyik legjelentősebb abiotikus stressz tényező, amely a szója termeléskiesését eredményezi világszerte. A vizsgálat célja volt, hogy meghatározzuk két indeterminált szójafajta, a *Sinara* (*Sn*) és a *Sigalia* (*Sg*) vízstresszre adott válaszát. Két vízellátást alkalmaztunk: korlátlan vízellátást és 50% -os vízmegvonást az optimálishoz képest. A kísérletet átalakított evapotranspirométerekben állítottuk be. A termésmennyiséget, a teljes szárazanyagot, a hüvelyek és magok számát a betakarítás során mértük. Eredményeink azt mutatták, hogy a vízmegvonás jelentősen csökkentette a vizsgált elemeket. A fajták azonban nem mindig reagáltak ugyanolyan módon a vízhiányra: az *Sn* az optimális vízellátással magasabb terméshozamot produkált, míg az *Sg* több hüvelyt és magot nevelt.

Kulcsszavak: szója, *Glycine max* L., vízstressz, korlátlan vízellátás, evapotranspirométer

Introduction

Drought is one of the most important environmental stresses in agriculture (Pardo et al., 2015). Soybean is the most widely grown oil and protein crop in the world. Extremely hot weather and water stress – as the impacts of global climate change - negatively affect the soybean production (Ergo et al., 2018). Furthermore, soybean yield losses due to unpredictable variability of precipitation and limited ground water reservoirs continue to exist (Le et al., 2012). Many efforts have therefore been made to improve crop productivity under water-limited conditions.

One of our options for preventing soybean yield loss is to increase irrigated areas (Heatherly, 1983), while the other one is the growing of drought-tolerant genotypes (Chapman 2008). In the future, the combination of the two previously mentioned possibilities is likely to achieve optimum yield and its high quality. It is crucial to develop strategies for coping with the effects of biotic stress to assist in stabilizing yield under stress conditions (Ries et al., 2012). To realize the expected yield production, it is necessary to know more about the specific soybean water stress response in more details.

The objective of this work was to determine the amount of crop yield, numbers of pods and seeds and total dry matter in two drought tolerant soybean varieties in evapotranspirometers (*Sinara, Sn* and *Sigalia, Sg*) exposed to water deficit during the growing season in 2018 and compared to that obtained under unlimited watering.

Materials and Methods

The experiment was conducted during the growing season of 2018 at the Agrometeorological Research Station of University of Pannonia, Georgikon Faculty, located in Keszthely (Hungary). Two soybean varieties from Karintia Ltd. *Sn* and *Sg* (of maturity group 0 and indeterminate growth habit) were sowed on April 26th. These varieties were chosen because of their wide use by Hungarian farmers, the similar length of their reproductive phases and their good drought tolerance. The seeds were hand-planted in evapotranspirometers with a stand density of 60 plants m^{-2}.

The evapotranspirometers are 2x2 m^2 surface area and 1 m deep open tanks, sunken under the ground, which are filled with soil (Ramann-type brown forest soil) and covered with seeded or planted vegetation (Figure 1). A water table is maintained in the soil at a given depth to secure optimal water supply. In our experiment, four of the eight evapotranspirometers were used for water withdrawal, so that only half of the optimal water supply was given to the plants, while unlimited watering was given to the other four tanks (Anda et al., 2018).

Figure 1. The evapotranspirometers with soybean

In each water supply level and variety, 5-5 plants were selected and harvested randomly for determining the average yielding characteristics. Plants were cut by hand, all pods of these plants were counted. Pods were opened by hand, retrieved seeds were dried until constant weight.

Differences in seed yield, total dry matter, the number of seed yield and pods in the two water supplies and varieties were examined by the least-significant difference approach of t-test and regression analysis using Microsoft Office Excel 2016.

Results and Discussion

The relationship between seed yield/plant and total dry matter/plant was positive and highly significant in the two varieties and two water treatments (Figure 3). The optimal water supply resulted in a proportional increase in seed yield and total dry matter. This relationship was linear ($R^2 = 0.75$; $p < 0.001$). Compared to optimal level, seed yield and total dry biomass in half-water supply decreased significantly in both varieties. In the case of *Sn*, the dry matter decreased by 27.6% ($p < 0.001$) and seed yield by 47.8% ($p < 0.001$). Reductions of dry matter (18.2%, $p < 0.001$) and seed yield (41.4%, $p = 0.001$) in *Sg* were lower than in *Sn*, under water shortage. No difference was found in dry matter between the two varieties for unlimited watering ($p = 0.095$) and water withdrawal ($p = 0.176$). There was no difference between the two varieties in the seed yield of the water deprivation ($p = 0.452$), but besides the unlimited water supply there was a significant difference ($p < 0.001$) for the benefit of *Sn*. This means that *Sn* under unlimited water supply had higher seed yield compared to *Sg*, but did not respond worse to water withdrawal than *Sg*.

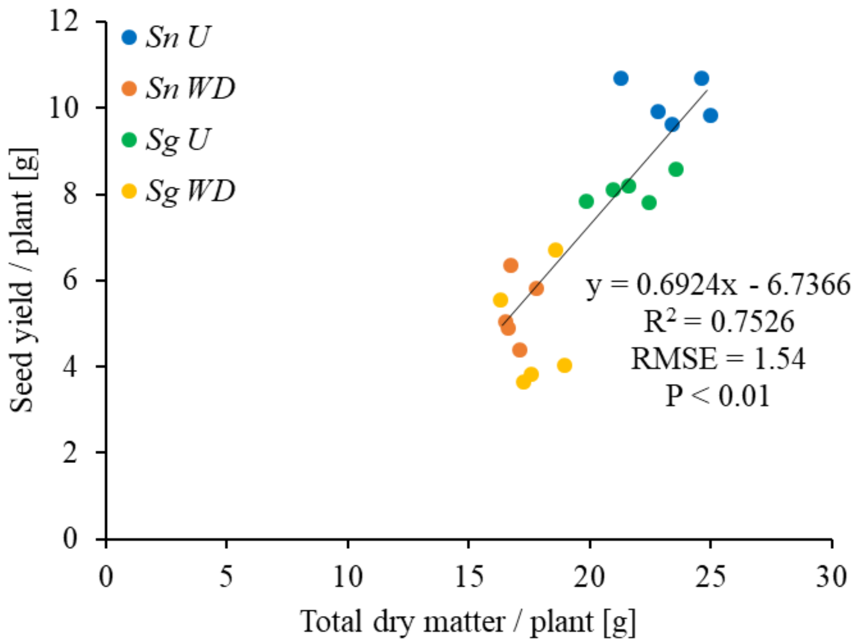

Figure 2. The relationship between seed yield and total dry matter for each water supply level (U – unlimited watering; WD – water deprivation) and variety (Sn – Sinara, Sg – Sigalia)

A linear relationship (Figure 3) was also found ($R^2 = 0.82$; $p < 0.001$) between the number of seeds and the number of pods tested in the two water supplies and varieties. Water withdrawal proportionally decreased the number of pods (*Sn* $p = 0.003$; *Sg* $p < 0.001$) and seeds (*Sn* p = 0.041; *Sg* p < 0.001). In addition in optimal water supply, *Sg* had 17.3% (p = 0.006) more pods and 17.7% (p = 0.003) more seeds, than *Sn*. In water deprivation there was a small difference between the two varieties in the number of pods (0.8%, p = 0.915), but there was a significant difference in the number of seeds: *Sn* produced 24% more seeds than *Sg* (p = 0.007). It can be concluded, that *Sg* developed more seeds and pods in the optimum water supply as compared to *Sn*, but the number of seeds was very sensitive due to water withdrawal.

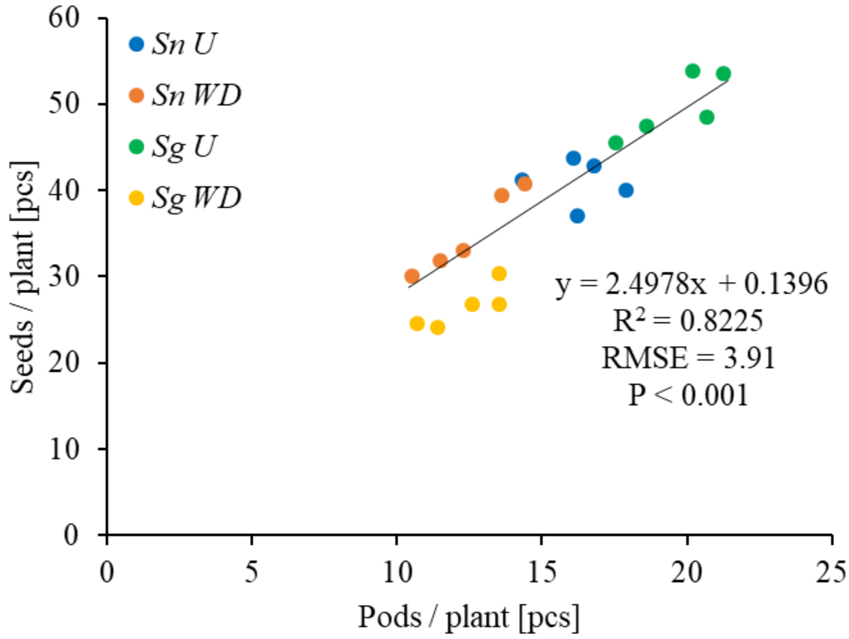

Figure 3. The effect of the number of seed yield and pods for two varieties (Sn – Sinara, Sg – Sigalia) and two water supplies (U – unlimited watering; WD – water deprivation)

In the experiment of Ergo et al. (2018), yield decreased by 43% under water stress (the number of seeds by 24% and their weight by 25%) in comparison to controls (non-heat-stressed and non-water-stressed plots). However, no difference was found between the two soybean genotypes (Syngenta Company SPS4×4 RR and SPS4×99 RR) in the yield, weight of grains and number of grains they used in different water availabilities. Dornbos and Mullen

(1991) had similar results when plants were grown under severe drought conditions. Karam et al. (2005) studied soybean using three deficit irrigation treatments (R2, R5 and R7 phenological stages), besides, a control was designed to receive a full irrigation at 100% of field capacity with no water restriction. According to their results, the water loss in the R5 phenophase resulted in a high deficit against to other water treatments. Compared to the control seed yield (28.1%), total dry matter (6.9%), number of pods (17.8%) and seeds (19.0%) decreased

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