Influence of priming on germination, development, and yield of soybean varieties

Abstract: A two-factorial field experiment with soybean (Glycine max (L.) Merill) was conducted in a randomized block design, with four replications. The tested factors were seed priming method and genotype responses. There had been seven soybean varieties (Aldana, Aligator, Annushka, Augusta, Lissabon, Mavka, and Merlin) and each of them had control (unprimed) and seed primed groups. The aim of this study was to determine the effect of hydropriming on germination ability and emergence under field conditions, on the growth and development of selected soybean varieties. Shortly before harvest, 10 randomly selected plants were collected from each plot, and their morphological and yield-related traits were measured. In addition, the seed yield was assessed. On the basis of statistical analysis, significant differences were found between the applied hydropriming method and the control group in regard to morphological traits. Seed treatment resulted in a slight increase in harvested seed yield, which is within error margin. The seed yield of Aligator increased significantly by 0.5 t ha⁻¹, indicating a genotype-specific different reaction to seed priming in terms of yield.

Keywords: soybean, seed priming, germination, emergence, yield

1 Introduction

Soybean (Glycine max (L.) Merr.) is a globally important crop providing fixed N and high-quality protein and oil (Holmberg 1973; Kamp et al. 2010; Kusano et al. 2015; Lewandowska and Michalak 2019). Crop rotation with soybean increased yield of many crops (Lauer et al. 1997; Kelley et al. 2003), improved the energy of crop production systems (Rathke et al. 2007), and reduced weed occurrence (Jedrusczak et al. 2005). According to Lewandowska (2016), for many farmers the production of this plant is a “godsend” of defective rotation to which belongs mainly cereals, maize, and rapeseed. The inclusion of soybean cultivation in crop sequences is an important and valuable element (Michalak et al. 2018). However, one of the important issues that still needs to be improved is seed emergence (Wang et al. 1996). One of the possibilities to improve this aspect is seed priming known as a process of regulating the germination by managing the temperature and seed moisture content. Then the seed is taken through the first biochemical processes within the initial stages of germination. The process involves advancing the seed to an equal stage of the germination process, to enable fast and uniform emergence when planted. Seed priming involves taking seed through the early stages of the germination process (Varier et al. 2010). Therefore, new methods with plant growth-promoting/stimulating properties are being sought. This paper focuses on priming, which is known as one of the solutions that can stimulate plant growth. Stimulation of seeds using different methods of priming as a way to increase their vigor for fast and strong plant development, optimized harvest efficiency, and quality of stimulation has caught the interest of many scientists. Crop yield can be maximized by the establishment of an adequate and uniform plant population for which...
good quality seed is a prerequisite. The gains from agro-
nomic inputs are drastically reduced if the seed is of poor
quality, resulting in a poor stand. Pre-sowing seed treat-
ment including priming is known to improve seed per-
formance in the field (Pill et al. 1991; Parera and Cantiliffe
1994; Pill and Necker 2001; Nawaz et al. 2013; Paparella
et al. 2015). Seed priming is a treatment commonly applied
in agriculture, horticulture, and forestry to improve the
germation of the seeds. This technique involves con-
trolled seed hydration sufficient to permit pre-germina-
tive metabolic events to proceed, but insufficient to allow
radicle protrusion (Lutts et al. 2016). Radicle protrusion
is considered as the completion of germination. After
priming, seeds are dried back to their initial water con-
tent. Such treated seeds can be stored and/or sown via
conventional techniques. Priming treatment has benefi-
cial effects on the vigor and viability of seeds which is
manifested by improved germination performance
(increased germination rate, reduced time to achieve
50% germination –T50, increased total germination per-
centage, and greater uniformity of germination) and
seedling growth especially under adverse environmental
conditions. A wider discussion on the impact of priming
on seed germination, seedling growth, and development
was addressed by Kubala et al. (2013). The effectiveness
of the priming process depends mainly on the selection of
appropriate conditions for seeds of a given species or
even a genotype. Factors affecting the success of condi-
tioning include the following: light, temperature, time,
and drying method of seeds after application (Cantiliffe
et al. 1981; Chiu et al. 2005; Di Girolamo and Barbanti
2012; Rajjou et al. 2012). It is necessary to add that the
amount of time it takes to prime seeds is also dependent
on the plant species, because the priming process is
customized to each relevant crop (Kubala et al. 2013).
According to McDonald (2000), drying affects the effi-
ciency of seed conditioning more than any other factor.
Storage of seeds after priming precedes their drying
process to the initial level of moisture content. It should
be emphasized that both the time and temperature
of drying have a decisive influence on the subsequent
development of seeds, because benefits of conditioning
may be lost during the dying process (Schwember and
Bradford 2005).

The aim of the present study was to examine the
effect of one of the physiological methods, hydopriming
on germination ability and emergence under field condi-
tions, on the growth and development of selected soy-
bean varieties.

2 Methods

Soybean seeds cv. Aldana, Aligator, Annushka, Augusta,
Lissabon, Mavka, and Merlin were used in the present
study, because they were of different maturity groups
and were most popular among farmers. Based on the
seven soybean varieties, the examined factors were in
order as follows: I – control group (unprimed seeds)
and II – tested group (hydoprimed seeds). The seeds
were subjected to the hydopriming process at 25°C.
Twenty-five seeds were sequentially placed in plastic
cuvettes on a moistened sand substrate between two
microfiber layers covered by another sand layer. For a
single sample tested for 24 h, 25 of the seeds were sown
in 1,000 g of dry sand mixed with 0.1 dm³ of water. The
microfiber layers in the experiment were used to separate
sand from seed material. Then the seeds were covered
with a second microfiber layer, the sand was again laid
down, and the sample was gently pressed. In addition, to
limit water evaporation, the cuvette was covered with
food foil. After priming, the seeds were sown in field
conditions.

In 2017 at the Agricultural Experimental Station in
Pawlowice belonging to Wroclaw University of Environ-
mental and Life Sciences (Poland), a two-factorial field
experiment was carried out in randomized block design
in four replications (Table 1). The experiment was estab-
lished on autogenous soil made of light clay. Soil pH in
1 M KCl was slightly acidic, and the content of phosphorus,
potassium, and magnesium (Mehlich-3 method) was from

| Table 1: Experimental design | Unprimed and primed (‘) seeds of seven varieties |
|-----------------------------|--------------------------------------------------|
| Replications | IV | 1’ | 1 | 6’ | 2’ | 3’ | 5’ | 4’ | 7 | 7’ | 3’ | 5’ | 6 | 2 | 4 |
|             | III | 7’ | 3’ | 1 | 5 | 4 | 7 | 5’ | 6’ | 3 | 2 | 2’ | 1’ | 6 | 4 | 4’ |
|             | II | 5’ | 2’ | 4’ | 1 | 3 | 2 | 5 | 1’ | 6 | 4 | 6’ | 3’ | 7’ | 7 |
|             | I | 1 | 5 | 2 | 6 | 7 | 5’ | 2’ | 3 | 4’ | 7’ | 3’ | 4 | 1’ | 6’ |
high to very high (Table 2). Winter wheat was a previous crop to soybean. The size of a single plot was 6 m² (1.5 × 4 m). The field experiment consisted of 56 plots in total (28 plots unprimed seeds and 28 primed seeds of seven tested varieties). Sowing density was 70 seeds/m², row spacing – 15 cm, and sowing depth – 3 cm. The experiment was sown on 27 April with the plot seeder Tool Carrier 2,700. Directly before sowing the seeds were inoculated additionally by HiStick containing the beneficial bioactive organisms – *Bradyrhizobium japonicum*. Boxer 800 EC herbicide at 4 dm³ ha⁻¹ (3,200 g ha⁻¹ prosulfocarb) was used for the first time straight after soybean sowing and the second time a month later with Corum 5,024 SL at 0.625 dm³ ha⁻¹ (300 g ha⁻¹ bentazone and 14 g ha⁻¹ imazamox) and Select Super 120 EC at 0.8 dm³ ha⁻¹ (96 g ha⁻¹ clethodim). The harvest was done on 29 September 2017 by plot combine Wintersteiger Elite.

The weather conditions during the growing period were not favorable for soybean cultivation because in spring low temperatures and high rainfall were noted, which decreased soybean emergence in the field. Average monthly temperatures were higher than the long-term mean for period 1981–2010 in March, May, June, July, and August. Total monthly sums of rainfall were higher compared to long-term average in April, July, and September. Particular attention should be paid to low average temperature in the first and third decade of April and May, as well as the high rainfall in the third decade of April and first of May (Table 3). Excessive rainfall straight after sowing caused soil crust that impeded seedling emergence.

The effectiveness of priming was assessed on the basis of morphological and yield-related traits: plant height (cm), number of first branches, first pod height (cm), pod number per plant, seed number per plant, seed number per pod, seed weight per single pod (g), seed weight per plant (g), and 1,000 seed weight (g). Shortly before harvest 10 randomly selected plants were collected from each plot. The data of the studies were statistically analyzed by analysis of variance (ANOVA), at the significance level of 0.05 by using Fisher’s test.

| Replications | pH in 1 M KCl | P | K | Mg |
|--------------|--------------|---|---|---|
| I            | 5.7          | 83.0 | 200.4 | 141.9 |
| II           | 5.7          | 92.0 | 219.9 | 132.0 |
| III          | 5.6          | 83.5 | 223.8 | 148.6 |
| IV           | 5.7          | 88.8 | 223.8 | 123.6 |

The AWA program (Bartkowiak 1978) was applied for calculations.

### 3 Results and discussion

The field trial showed significant effects of both the genotype and the seed treatment (priming) (Table 4), although a significant interaction between the cultivar and the seed treatment was only observed with regard to the grain yield of soybeans (Figure 1). Seed priming resulted in a significant increase of 1.7 cm in first pod height on average for the cultivars, which should help eliminate losses during harvest. This trait is very desirable from the agronomic point of view (Kowalczuk 1999; Milan et al. 2005) as it still generates losses during harvesting period. Therefore, a continuous breeding study has been carried out aiming to increase first pod height (Thompson and Nelson 1998; Mikel et al. 2010). On the contrary, seed priming significantly reduced the number of productive pods per plant, the number of seeds per plant, and the seed weight produced per plant (Table 4).

However, the mean plant height, the number of branches, the number of seeds per productive pod, the seed weight per productive pod, and 1,000 seed weight were not affected by priming. For six soybean cultivars, seed treatment resulted in a slight increase in grain yield. However, the grain yield of Aligator increased significantly by 0.5 t ha⁻¹ (Figure 1), indicating a genotype-specific different reaction to seed priming. Similar conclusions were made by Arif et al. (2008), Mohammadi (2009),
and Nawaz et al. (2013). They indicated that priming was always better than non-treated seeds. The higher grain yields of the seed treated soybeans must be a consequence of higher plant density at the time of plot harvest sown with primed soybeans. On the contrary, the higher insertion of the first pods of primed soybeans may also have led to a lower retention of unrecorded pods in the field. With the exception of the number of seeds per productive pod, significant variety differences were found between the varieties for all parameters tested (Table 4 and Figure 1). These results demonstrate the comparatively large genetic variability that exists between the tested varieties of different maturity groups.

Soybean sowing was carried out in difficult conditions. The very wet weather caused problems with soil cultivation. After sowing, because of rain, soybean emergence was further complicated, forming a crust in the top layer. However, of the assumed 70 seeds/m², the final density decreased to half. It was worth mentioning that when soybean is sown in very low density per square meter, it has strong ability to produce lateral branches. As a result, the number of pods increases visibly (Ball et al. 2001; De Bruin and Pedersen 2009; Liu et al. 2010; Carciochi et al. 2019). Therefore, it is impossible to estimate the yield by multiplying the assumed plant density by seed weight per plant.

**4 Conclusions**

The study revealed that seed priming method affected significantly on first pod height which is a desired trait from breeding point of view. Furthermore, a positive reaction of genotypes to priming was noted. Seven tested...
cultivars showed an increase in seed yield but only Alligator responded statistically significant. Therefore, specific procedure precisely adapted to the cultivar is required to achieve an increase in yield through priming.

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