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Effect of Seed Priming on Yield and Yield Components of Soybean

Shahram Mehri

Department of Agronomy and Plant Breeding, Pars Abad Moghan Branch,
Islamic Azad University, Pars Abad Moghan, Iran

Abstract: This study was carried out in order to evaluate effect of seed priming on seed yield and yield components of soybean (*Glycine max* var Williams) in Islamic Azad University, Pars Abad Moghan Branch, Iran, in 2013. The experimental design was two factors factorial on basis of randomized complete block design with four replications. The first factor was priming methods (control, $ZnSO_4$, KH_2PO_4, KNO_3 and H_2O) and the second factor was priming duration (control, 6, 12, 18 and 24 hours). Results showed that priming methods and duration increased germination percentage, germination rate, number of pods per plant, seed numbers per pod, 1000-seed weight, biological and seed yields. According to the results of this experiment, seed priming by H_2O with 18 hours had an appropriate performance and could increase seed germination, seed yield and yield components to an acceptable level. Therefore, hydro-priming is a simple, low cost and environmentally friendly technique for improving seed yield in soybean.

Key words: Soybean · Priming · Seed yield · Yield components

INTRODUCTION

Soybean (*Glycine max* L.) is one of the most important oil seed crops, which is planted in many areas of Iran, Such as Ardebil, Golestan and Mazandaran Stats. One potential way of improving establishment is to develop seed treatments that can increase seed vigor or germination rates. A common method employed is seed priming. Seed priming is a controlled hydration process followed by re-drying that allows seed to imbibe water and begin internal biological processes necessary for germination, but which does not allow the seed to actually germinate. On the other hand, on seed priming the amount of water absorption is controlled so as necessary metabolic activities occurred for germination but radical emergence is prohibited. Seed priming is beneficial technique to improvement seed germination and growth in stress condition. Nowadays, various seed priming techniques have been developed, including hydro priming (soaking in water), halo priming (soaking in inorganic salt solutions), osmo priming (soaking in solutions of different organic osmotic), thermo priming (treatment of seed with low or high temperatures), solid matrix priming (treatment of seed with solid matrices) and bio priming (hydration using biological compounds) [1].

Seed priming has been successfully demonstrated to improve germination and emergence in seeds of many crops, particularly seeds of vegetables and small seeded grasses [2,3]. In fact, this technique is a treatment that applied before germination in a specific environment that seeds are partially hydrated to a point where germination processes begin but radical emergence does not occur [2,4,5]. This technique used for improvement of germination speed, germination vigor, seedling establishment and yield [6,7]. Improvement in priming is affected by some factors such as plant species, water potential form priming factor, priming duration, temperature, vigor and seed primed storage condition [8].

Several investigations confirmed that seed priming has many benefits including early and rapid emergence, stand establishment, higher water use efficiency, deeper roots, increasing in root growth, uniformity in emergence, germination in wide range of temperature, break of seed dormancy, initiation of reproductive organs, better competition with weed, early flowering and maturity, resistance to environmental stresses (such as drought and salinity) and diseases (*Sclerotium rolfsii* L.): Higher grain yield in wheat (*Triticum aestivum* L.) [4], corn (*Zea mays* L.) [9],

Corresponding Author: Shahram Mehri, Department of Agronomy and Plant Breeding, Pars Abad Moghan Branch, Islamic Azad University, Pars Abad Moghan, Iran.

canola (*Brassica napus* L.) [10], pearl millet (*Pennisetum glaucum* L.), chickpea (*Cicer arietinum* L.), rice (*Oryza sativa* L.) [11,12], lettuce (*Lactuca sativa* L.) [13], is reported from field and laboratory studies.

Misra and Dwivedi [14], reported that seed soaking in 2.5% KCl for 12 h before sowing increased wheat grain yield for 15%. Paul and Choudhury [15], observed that seed soaking with 0.5 to 1% solutions with KCl or K_2SO_4 significantly increased plant height, grain yield and its components in wheat genotypes. Kulkarni and Eshanna [16], stated that pre-sowing seed treatment with IAA at 10 ppm improved root length, rate of germination and seedling vigor.

The objective of this study was to test whether seed priming methods would affect seed emergence and yield of soybean in field.

MATERIALS AND METHODS

Experimental Treatments and Field Design: This study was carried out at the Experimental Farm of Islamic Azad University, Pars Abad Moghan Branch, Iran (latitude 39°40' N, longitude 47° 31' E, elevation 50m above mean sea level) in 2013. The soil has sand loam texture with low organic matter and some physical and chemical properties are shown in the Table 1.

The experimental design was factorial on basis of randomized complete block design (RCBD) with four replications. The seed (10% seed moisture) of soybean cultivar Williams was primed using hydro-priming, halo-priming (solutions of 1% KNO_3) and osmo-priming (solutions of $ZnSO_4$ with 10 mM Zn and KH_2PO_4 with 50 mM P). Dry seed was used as control.

Growth Experiment: Individual plot consist of 6 rows, 5 m long and spaced 50 cm apart. The experimental fields were mould-board ploughed and seedbed preparation consisted of two passes with a tandem disk. Seeds were planted 3 to 3.5 cm deep at a rate of 40 seeds m^2 on 30th April 2013. For all treatments, N:P:K fertilizers applied at a rates of 100:100:50 kg, respectively. P, K and one-third of N were applied per plant and incorporated. Other two-third of N was split equally at the 8 leafed and flowering. Weeds were also hand weeded during the season. Final harvests were carried out at the 21th October 2013.

Estimation of Traits: Data on days to 50% emergence were calculated from the date of sowing and date of 50% emergence by counting seedling emergence in each plot daily. Emergence data was recorded by counting number of plants emerged in one meter row length at three randomly selected rows in each plot. The data were then converted to emergence m^2.

Data collected included seed yield determined after drying at 70°C for at least 48 h (obtained by combining the three center rows at each experimental unit), dry matter was in an air oven. The following measurements were carried out: seedling emergence percentage, seedling emergence rate, pods number per plant, seeds number per pod, 1000-seed weight, biological yield, seed yield and harvest index.

Statistical Analysis: The data were statistically analyzed using analysis (ANOVA) procedure. Means were separated using Duncan test at 0.05 level of probability.

RESULTS

Germination Percentage and Rate: Effects of priming method and priming duration on germination percentage and germination rate were significant (P=0.01). The results indicated that germination percentage and germination rate of primed seeds were higher than those of unprimed seeds (Table 2). Data regarding the effect of priming method and priming duration on germination percentage and rate are given in Table 3. In general, the maximum germination percentage and rate (78.6 and 0.087) were obtained to priming with H_2O, while the least value (61.2 and 0.052) were recorded at control treatment, respectively. Increase in germination percentage and germination in the field due to seed priming clearly indicate that all priming treatments have positive effects on soybean seed germination and rate. Priming seeds with water, KH_2PO_4, $ZnSO_4$ and KNO_3 resulted in advanced metabolic processes and higher germination percentage

Table 1: Soil physical and chemical properties of experimental area.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil texture	pH	E.C (ds/m)	Organic Carbon (%)	Total N (%)	Available P (ppm)	Available K (ppm)
0 - 30	15	60	25	Clay loam	7.6	3.4	0.49	0.06	9.6	240
Optimum				loam	6.5-7.5	2.0<	>1.0	1.0>	10 - 15	200 - 300

Table 2: Analysis of variance for experimental traits

Treatment	df	MS Germination percentage	Germination rate	Seeds number per pod	Pods number per plant	1000-seed weight	Biological Yield	Seed Yield	Harvest Index
R	3	90.4^{ns}	0.2^{ns}	8.2^{ns}	110.7^{ns}	1154.2^{ns}	2.2^{ns}	1.7^{ns}	8.4^{ns}
Priming method (P)	4	522.1^{**}	0.8^{**}	23.1^{**}	342.3^{**}	4247.5^{**}	5.4^{**}	3.2^{**}	45.9^{**}
Priming duration(D)	4	612.3^{**}	0.7^{*}	31.7^{**}	372.1^{**}	4711.3^{**}	4.3^{**}	2.5^{**}	39.3^{**}
P*D	16	82.5^{ns}	0.3^{ns}	6.2^{ns}	78.1^{ns}	1012.4^{ns}	1.7^{ns}	1.4^{ns}	10.2^{ns}
Error	72	61.4	0.2	5.14	61.4	926.8	1.8	0.8	9.1
C.V		18.3	14.1	15.1	25.2	10.2	19.6	19.6	7.2

ns, *: and **: Non significant and significant at the 5 and 1% levels of probability, respectively

Table 3: Growth and yield components affected by different priming method and priming duration levels.

Treatment	Germination percentage (%)	Germination rate (day)	Pods number per plant	Seeds number per pod	1000-seed weight (g)	Biological Yield (ton/ha)	Seed Yield (ton/ha)	Harvest Index (%)
Priming method levels								
Control	61.2^{c}	0.052^{d}	85.91^{c}	1.94^{c}	116.37^{c}	10.29^{d}	4.13^{d}	40.13^{a}
$ZnSO_4$	70.8^{b}	0.069^{c}	109.98^{b}	2.34^{b}	132.19^{b}	11.18^{c}	4.27^{bc}	38.19^{ab}
$KH2PO_4$	72.3^{b}	0.074^{b}	132.8^{a}	2.52^{a}	140.33^{a}	12.35^{b}	4.61^{ab}	37.32^{b}
KNO_3	69.1^{b}	0.056^{d}	107.49^{b}	2.41^{b}	129.02^{b}	11.42^{c}	4.06^{c}	35.55^{c}
H_2O	78.6^{a}	0.087^{a}	124.5^{a}	2.59^{a}	142.23^{a}	13.19^{a}	4.96^{a}	37.60^{b}
Priming duration levels								
Control	59.4^{d}	0.059^{c}	83.42^{c}	1.98^{c}	121.72^{c}	9.97^{c}	3.73^{c}	37.41^{a}
6 hour	65.5^{c}	0.062^{c}	108.73^{b}	2.41^{b}	134.79^{b}	11.89^{ab}	4.01^{b}	33.72^{c}
12 hour	68.6^{bc}	0.079^{b}	120.77^{ab}	2.47^{b}	139.44^{ab}	11.25^{b}	4.27^{b}	37.95^{a}
18 hour	76.1^{a}	0.092^{a}	136.95^{a}	2.61^{a}	144.23^{a}	12.57^{a}	4.71^{a}	37.47^{a}
24 hour	71.1^{b}	0.085^{ab}	127.41^{ab}	2.41^{b}	132.74^{b}	11.64^{ab}	4.1^{b}	35.22^{b}

For a given means within each column of each section followed by the same letter are not significantly different ($p<0.05$)

and germination rate, compared with unprimed seeds (Table 3). This suggests that there is no toxic effect of KNO_3, $ZnSO_4$ nor KH_2PO_4, due to ion accumulation in the embryo [17]. Similar results were reported for barley, maize and oat [18] and sunflower [19]. Basra *et al.* [20], showed that in canola, germination percentage as well as germination rate were increased in response to priming. The suitable conditions of the beginning of germination ensure to the seeds quickly emerge. Subedi and Ma [9], noted that one of the most important conditions for crop potential performance is fast and uniform germination which is a resultant of priming in the farm.

Pods Number per Plant: Priming method and priming duration significantly increased the pods number in soybean. Data regarding the effect of priming method and priming duration on number of seeds rows are given in Table 3. In general, the maximum pods number per plant (132.8) was obtained to priming with KNO_3, while the least value (85.91) was recorded at control treatment.

Seeds Number per Pod: Seeds number per pod is a major yield component and determines the final seed yield. It significantly contributes to the seed yield and represents reproductive efficiency of a crop. Priming method and priming duration significantly increased the seeds number per pod (Table 2). The maximum seeds number per pod was produced by seed primed with H_2O. Seed primed with KH_2PO_4 recorded same seeds number per pod. Seed priming duration of 18 hour recorded maximum seeds number per pod followed by 24 hour, 12 and 6 hour which recorded same seed number per pod. Similar results were reported by Basra *et al.* [20] and Rashid *et al.* [21], that primed seed plants produced more seeds number per pod.

One Thousand Seed Weight (1000-seed weight): The effect of priming method and duration on 1000-seed weight was significant (Table 2). The maximum 1000-seed weight (142.23 g) was observed in seed priming of H_2O which was not significantly different from seed priming of

KH_2PO_4 treatment and the minimum 1000-seed weight (116.37 g) in control treatment. The maximum 1000- seed weight (144.23 g) was produced by 18 hours priming duration, while the minimum (121.72 g) by control. These results support the findings of Basra *et al*. [20], who reported greater thousand grain weight for primed seed and observed greater amount of dry matter accumulation for priming treatments.

Biological Yield: Biological yield is major contributor to total output of any crop and depends upon species, growing season and various other factors. Data regarding biological yield (ton ha^{-1}) are presented in Table 3. The data indicated that seed priming significantly affected biological yield of soybean. Seed primed in H_2O produced the highest biological yield (13.19 ton ha^{-1}) followed by seed primed in KH_2PO_4 (12.35 ton ha^{-1}). The minimum biological yield (10.29 ton ha^{-1}) was produced by control treatment. The increase in biological yield might be due to better early seedling growth and plant nutrition as reported by Zhang *et al.,* [22]. These results are in agreement with those obtained by *Chhipa et al*., [23], who reported an increase straw yield for priming as compared with no soaking. These results endorse the findings of Rashid *et al*., [21], who reported that priming treatment significantly increased total biomass and dry weight as compared with the control. The results also are in line with Harris *et al*., [12], who reported that faster emergence following seed priming could result in better resource capture that might contribute to the growth and yield advantages associated with priming.

Seed Yield: Seed yield is the ultimate output of a crop around which all the other factors revolved. The seed yield was significantly affected by priming method and duration. Seed priming with H_2O significantly increased the seed yield in comparison with the other treatments. The seed yield varied between 4.13 ton ha^{-1} in without priming till 4.96 ton ha^{-1} in seed priming with H_2O (Table 3). The maximum seed yield was produced by 18 hours duration (5.71 ton ha^{-1}), while the minimum by control (3.73 ton ha^{-1}). The improved yield of primed seed plots may be due to early and improved emergence, more pods per plant or heavy seeds produced in the priming treatments that finally increased total yield. Similar reasons were reported by Sharma *et al*., [24], who primed seed in salicylic acid and related increase yield to early floral initiation, more flowers and pods per plant. The increase in yield of primed seed plots may be due to the fact that primed seed emerge faster and more uniformly and seedling grows more vigorously, leading to a wide range of phonological and yield related benefits [12]. The results are in agreement with those obtained by Harris *et al*., [11], who reported that primed crops produced higher yields than non primed crops. The Pre-sowing treatment with inorganic salts not only promotes seed germination of most crops, but also stimulates faster growth, metabolic processes and hence, ultimate crop yield [25]. Harris *et al.,* [11], found that hydro-priming enhanced seedling establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. The resulting improved stand establishment can reportedly increase drought tolerance, reduce pest damage and increase crop yield [11]. These results suggested that hydro-priming is a useful method for improving seedling vigor, establishment and yield of soybean in the field.

CONCLUSION

On the basis of these observations, it may be concluded that soybean seeds positively responded to treatments of priming. Nevertheless, priming generally improves the most parameters of soybean through improving germination percentage, germination rate, pods number per plant, seeds number per pod, 1000-seed weight, biological yield and seed yield. The highest benefit of priming can be obtained from seeds primed with H_2O treatment for 18 hours.

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