

Effect of priming treatments on emergence and yield of freshly produced and aged maize seeds sown at different depths

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Summary: The aim of this study was to investigate whether different priming treatments could affect emergence, speed of emergence and yield of freshly produced and aged maize seeds sown at different depths. Two lots of parental maize line A634 produced in the previous season were used as seed source, and twenty-year-old seed. After priming with distilled water and 0.5% KNO₃ solution, the seed was sown at four depths. Results showed that freshly produced seeds did not benefit from priming treatments. Reaction of the aged seeds differed depending on the priming treatment. Results indicated that priming with KNO₃ should be avoided in aged seeds of A634 because of its detrimental effect on the emergence and yield. Hydropriming induced higher percentage of emerged plants and faster emergence, but with no effect on yield. Reaction to priming treatments varied with sowing depth, which should not exceed 5.0 cm for parental line A634 according to this study.

Key words: emergence, maize, priming, seeds, yields

Introduction

Successful crop production, defined by high yields, is very much affected by fast and uniform seed emergence, final germination and crop stand. In order to improve germination and early seedling growth, various invigoration treatments can be applied, one of them being seed priming. It includes a number of different techniques of seed improvement, obtained through controlled hydration (Farooq et al., 2006). Some of the most commonly used seed priming treatments are hydropriming (Casenave & Toselli, 2007), osmopriming (Zheng et al. 2015; Badar-uz-Zaman et al., 2012), hormonal priming (Sneideris et al., 2015), and solid matrix priming (Pandita et al., 2010). Improvements in germination and emergence of primed seeds are reported to be the result of early DNA replication, increased RNA and protein synthesis, faster embryo growth and repair of deteriorated seed parts (Giri and Schillinger 2003).

The effect of seed priming is influenced by many factors interacting, such as plant species, seed quality, storage conditions, priming agent, duration of priming, temperature, aeration and light (Parera & Cantliffe, 1994). According to Marcos-Filho, (2015), most species achieve maximum seed quality at the end of seed filling period. There are differences in shelf life among species and seed lots, but after a certain period of time, all start to deteriorate. Seed deterioration is expressed in higher sensitivity to stresses during germination, lower vigour, delayed emergence, decreased seedling growth and loss of ability to germinate (Khajeh-Hosseini et al., 2010; Mohammadi et al., 2011). Quality deterioration and loss of ability to germinate of long-term stored seed is especially problematic for gene banks. According to Babić et al. (2015), regeneration is necessary to maintain seed viability and quantity, but on the other side, it should be performed as rarely as possible, to maintain genetic identity. These authors suggest landrace accessions should be regenerated after 10 years of storage if germination drop is below 85% of the initial germination, and automatically after 20 years of storage.

As it is not always possible to sow highly vigorous seed, and sowing depth is often determined by the soil moisture content, the aim of this study was to determine whether different priming treatments could increase emergence and speed of emergence, as well as to affect yield of freshly produced and aged maize seeds sown at different depths.

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Material and Methods

Two seed lots of parental maize line A634 were used in this study conducted in 2014 at experimental field Rimski Šančevi. Seeds produced in the previous season were used as the seed lot 1, and twenty-year old seeds (produced in 1993) as the seed lot 2. Seed was stored in climatic chamber at constant temperature of 6 °C. For priming treatments, seeds were soaked in distilled water (hydropriming) or 0.5% KNO₃ solution at 25°C for 17h. After each treatment, seeds were rinsed under tap water and then dried on filter paper at room temperature to the original moisture content. Primed seed and control (non-primed seed) were then treated with standard fungicidal treatment and machine-sown in mid-April at four depths (3.5, 5.0, 6.5 and 8.0 cm). All standard agro-technical measures were applied. The experimental field was not irrigated, and total rainfall during the growing period (April- September) was 595.6 mm (www.hidmet.gov.rs).

The experimental design was split-plot with four main plot treatments (sowing depths) and three sub-plot treatments (priming treatments) in four replicates. Each replicate was planted in four rows, with 25 seeds per row (plot area 15 m²). Seedling emergence was counted daily, and final emergence was recorded when no newly emerged seedlings were observed. Mean emergence time (MET) was calculated using formula (Ellis & Roberts, 1981):

$$MET = \sum Dn / \sum n$$

where *D* is the number of days counted from the beginning of emergence and *n* is the number of seeds that had emerged on day *D*.

Crops were harvested with Wintersteiger Split combine harvester at seed moisture content 20-30% and seed yield was expressed at 14% moisture content. Data were analysed using analysis of variance and seed lots 1 and 2 were tested separately.

Results and Discussion

Results show different response of two seed lots to applied priming treatments and sowing depths.

Analysis of mean values in the seed lot 1 showed no significant differences between priming treatments and control, as well as between the two priming treatments (Table 1). The results are in accordance with conclusions reached in Čanak et al. (2016), where priming treatments showed no significant effect on final germination of maize. Seed sown at 8.0 cm emerged at significantly lower percentage than other sowing depths. Similarly, Chahal & Jhala (2016) reported that the highest cumulative seedling emergence of hybrid maize was recorded at 0.5 to 6 cm sowing depth, without significant difference among them.

The highest seedling emergence was recorded at sowing depth 3.50 cm in hydroprimed seed, but with no significant difference between control and priming treatments. It can be noted that on each tested sowing depth, no significant differences were observed between priming treatments and control. As Čanak et al. (2014) concluded in their research with sunflower, this is probably due to little room for significant improvement of germination percentage in highly vigorous seeds.

In the seed lot 2, mean emergence of hydroprimed seeds was significantly higher than control. Similar to that, Hussain et al. (2015) also recorded significant differences in germination of hydroprimed and non-primed seeds of two rice cultivars, as well as Jafar et al. (2012) in two wheat varieties. Presumably, this is the result of physiological and biochemical changes occurring in primed seed, allowing it to start the germination process before sowing (Basra et al., 2005). On the other hand, mean emergence of KNO₃ primed seeds was significantly lower. Testing 10 maize inbred lines at optimal temperature conditions (25°C), Čanak et al. (2018) reported on two genotypes which reacted with reduced germination when KNO₃ priming was applied. Basra et al. (2005) concluded that poor and

Table 1. Effect of sowing depth and priming treatments on emergence (%) of two maize seed lots

Depth (cm)	Seed lot 1				Seed lot 2			
	Control	Hydro-priming	KNO ₃ priming	Mean	Control	Hydro-priming	KNO ₃ priming	Mean
3.5	93.00 a	93.50 a	93.00 a	93.17 a	31.25 cd	42.50 a	32.00 cd	35.25 a
5.0	90.75 ab	89.75 abc	91.75 ab	90.75 a	32.50 cd	41.50 ab	29.00 cde	34.33 ab
6.5	92.25 ab	89.00 abcd	92.00 ab	91.08 a	32.75 cd	34.25 c	26.25 de	31.08 bc
8.0	84.75 cd	84.50 d	87.25 bcd	85.50 b	35.00 bc	31.00 cd	22.75 e	29.58 c
Mean	90.19 a	89.19 a	91.00 a		32.88 b	37.31 a	27.50 c	

Values with a common letter are not significantly different (p>0.05) Seed lots 1 and 2 were tested separately

Table 2. Effect of sowing depth and priming treatments on mean emergence time (days) of two maize seed lots

Depth (cm)	Seed lot 1				Seed lot 2			
	Control	Hydro-priming	KNO ₃ priming	Mean	Control	Hydro-priming	KNO ₃ priming	Mean
3.5	13.20 cd	13.20 cd	13.16 d	13.19 d	14.77 bcd	14.38 f	14.48 ef	14.54 c
5.0	13.24 bc	13.26 bc	13.23 bcd	13.25 c	14.98 ab	14.55 def	14.71 cde	14.75 b
6.5	13.48 a	13.41 a	13.29 b	13.36 b	14.98 ab	14.81 abc	14.95 ab	14.91 a
8.0	13.41 a	13.46 a	13.43 a	13.43 a	15.05 a	14.92 abc	14.97 ab	14.98 a
Mean	13.31 ab	13.33 a	13.28 b		14.95 a	14.67 b	14.78 b	

Values with a common letter are not significantly different (p>0.05)
Seed lots 1 and 2 were tested separately

slow germination in primed rice and wheat seeds is probably due to KNO₃ toxicity and injuries to the cellular organelles and membranes. Analysing mean value of emergence in the context of increased sowing depth, significant drop is recorded at 6.5 and 8.0 cm.

The highest seedling emergence was recorded at sowing depth 3.5 cm in hydroprimed seed, with no significant difference from when seed was sown at 5.0 cm. Compared to control, hydropriming resulted in significantly higher emergence when seed was sown at 3.5 and 5.0 cm, but had no effect at 6.5 and 8.0 cm. On the other hand, KNO₃ priming had no effect on emergence at 3.5, 5.0 and 6.5 cm, but at 8.0 cm, primed seeds emerged in significantly lower percentage. On each sowing depth, results indicate significantly lower emergence in KNO₃ primed seed compared to hydroprimed. This is in collision with findings of Nawaz et al. (2017), who tested the effect of KNO₃ and hydropriming on maize seed germination. In this study, no significant differences were observed in germination percentage and emergence index of hydroprimed and KNO₃ primed maize seeds.

In the seed lot 1 mean values of MET averaged across sowing depth show no significant improvement of priming treatments compared to control (Table 2). However, KNO₃ primed seed emerged significantly faster than hydroprimed. Results also indicate significant drop in emergence speed with each increased sowing depth.

The lowest MET value (indicating fastest emergence) was recorded in KNO₃ primed seeds sown at 3.5 cm, but with no significant difference as compared to control and hydropriming. In all cases but one (KNO₃ at 6.5 cm), priming treatments at each sowing depth caused no significant effect on this trait, as compared to control.

In seed lot 2 mean values of MET show that both priming treatments significantly increased speed of emergence. Ghassemi-Golezani & Esmaelpour (2008) also found that KNO₃ priming induced significantly faster emergence of cucumber seed, but in contrast, Jafar et al. (2012) concluded that hydropriming of wheat varieties showed no significant difference in MET under saline conditions. Observed by sowing

Table 3. Effect of sowing depth and priming treatments on yield (kg/basic plot) of two maize seed lots

Depth (cm)	Seed lot 1				Seed lot 2			
	Control	Hydro-priming	KNO ₃ priming	Mean	Control	Hydro-priming	KNO ₃ priming	Mean
3.5	7.66 ab	8.36 ab	8.12 ab	8.06 a	3.75 abc	3.80 abc	3.07 c	3.54 ab
5.0	8.53 a	8.41 ab	8.52 a	8.48 a	4.13 ab	3.79 abc	4.03 ab	3.98 a
6.5	8.42 ab	8.54 a	8.59 a	8.52 a	4.44 abc	3.63 abc	3.54 bc	3.87 a
8.0	8.40 ab	7.97 ab	7.38 b	7.92 a	3.43 bc	3.14 c	2.99 c	3.19 b
Mean	8.25 a	8.33 a	8.15 a		3.94 a	3.59 ab	3.41 b	

Values with a common letter are not significantly different (p>0.05)
Seed lots 1 and 2 were tested separately

depth, the lowest mean value of MET was recorded at 3.5 cm, and highest at 8.0 cm, indicating faster emergence of shallow planted seed.

Compared to control, both priming treatments caused significant decrease in MET values when seed was sown at 3.5 and 5.0 cm, but had no effect at 6.5 and 8.0 cm.

In the seed lot 1, observing mean values of seed yield across sowing depth and priming treatment, no significant differences were recorded (Table 3). Similar to this, Subedi & Ma (2005) concluded that priming treatments of maize seed with water, osmotic solution and plant growth regulators had no beneficial effects on grain yield. Giri and Schillinger (2003) also reported of limited practical worth of different priming treatments for yield of winter wheat planted deep in fallow.

The highest yield was recorded in KNO₃ primed seed, sown at 6.5 cm. However, compared to control, neither treatment caused significant difference, at all sowing depths. This result is expected, as in the seed lot 1, in most cases, priming treatments had no significant effect on emergence and MET.

In the seed lot 2, mean values show that hydropriming caused no significant effect on yield, while KNO₃ priming had detrimental effect on this trait, as compared to control. Subedi & Ma (2005) also found that soaking maize seed in tap water had no significant effect on grain yield, but in contrast, Soleimanzadeh (2013) found that both hydropriming and KNO₃ priming significantly increased yield, compared to control. Observed by sowing depth, yield was significantly lower when seed was sown at 8.0 cm, as compared to 5.0 and 6.5 cm, but not when seeds were sown at 3.5 cm.

The highest yield was recorded in control seed sown at 6.50 cm. As well as in the seed lot 1, observed by each specific sowing depth, there were no significant differences in yield of primed seed and control.

Conclusions

Results of this study show that freshly produced, vigorous seed did not benefit from different priming treatments, as in most cases, emergence, speed of emergence and yield were not affected. Increased sowing depth induced lower final emergence and slower emergence in primed as well as in non-primed seed, but it did not affect grain yield.

Reaction of the aged seeds differed depending on the priming treatment, expressing both beneficial and detrimental effects. In case of this particular maize line, results indicate that KNO₃ priming of aged seeds should be avoided, because of its detrimental effect to percentage of emerged plants and yield. On the other hand, although hydropriming had no beneficial effect on the yield, percent of emerged plants was higher and

speed of emergence faster, providing shorter period of time during emergence when seeds and seedlings are exposed to pathogens and insects.

Results of the tested parameters also show that the effect certain priming treatment can induce in seeds may vary with sowing depth. Analysing all data collected in this study, in all cases but one, no significant drop of values for the tested parameters was recorded when seeds were sown at 3.5 and 5.0 cm. Therefore, it can be suggested that for this particular parental line sowing depth should not exceed 5.0 cm.

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Efekat predtretmana na nicanje i prinos sveže proizvedenog i starijeg semena kukuruza sejanog na različitim dubinama

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Sažetak: Cilj ovog istraživanja je bio da se ispita da li različiti predtretmani mogu uticati na broj niklih biljaka, brzinu nicanja i prinos sveže proizvedenog i starijeg semena kukuruza, posejanog na različitim dubinama. U ispitivanju su korišćene dve partije linije kukuruza A634 proizvedene u prethodnoj sezoni i 20 godina starije seme. Za predtretman su korišćeni destilovana voda i 0,5% rastvor KNO₃. Setva je izvršena na četiri različite dubine. Kod sveže proizvedenog semena nije bilo mnogo mesta za poboljšanje ispitivanih parametara primenom predtretmana. Reakcija starijeg semena je zavisila od vrste primenjenih tretmana. Rezultati pokazuju da kod linije A634 za predtretman starijeg semena treba izbegavati KNO₃ zbog štetnog uticaja na broj niklih biljaka i prinos. Predtretman sa vodom nije imao uticaja na prinos, ali je povećao broj niklih biljaka i brzinu nicanja. Efekat predtretmana zavisio je i od dubine setve, koja za ovu liniju ne bi trebalo da bude veća od 5 cm.

Ključne reči: kukuruz, nicanje, predtretman, prinos, seme

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