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Effect of Different Seed Treatments on Maize Seed Germination Parameters under Optimal and Suboptimal Temperature Conditions

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Summary: The aim of this study was to determine the effect of different seed treatments on germination parameters of three maize genotypes under optimal and suboptimal temperature conditions. Seed was treated with recommended doses of three commercial pesticide formulations: metalaxyl-m 10 g/L + fludioxonil 25 g/L, metalaxyl 20 g/kg + prothioconazole 100 g/kg and thiacloprid 400 g/L. Testing was conducted at 25°C and 15°C. Results of the study indicate that there are differences in response of maize genotypes to applied seed treatments, as well as to a specific treatment at optimal and suboptimal temperatures. Some treatments, depending on the mixing partner and temperature conditions, can affect final germination. In other cases, germination rate can be accelerated or prolonged, but with no effect on final germination. In order to provide fast and uniform emergence under different temperature conditions, further examination of the response of maize genotypes to specific seed treatments would be beneficial.
Key words: germination, maize, seed treatment, seeds, temperatures

Introduction

In recent years in Serbia, maize, one of the world's most widespread crops, has been cultivated at around 1,000,000 hectares (http://www.fao.org). Once planted, seed is exposed to the deleterious effects of the soil pathogens and insects. Hence, majority of the commercially produced maize seed is treated with fungicides and insecticides.

Seed coating with fungicides can significantly reduce fungal colonization, seed and radicle decay, and improve seedling emergence in different crops (Muthomi et al. 2007; Babadoost & Islam, 2003; Munkvold & O'Mara, 2002). Although the primary effect of seed coating is to reduce damage by fungi and insects, it may also have secondary effect on seedling height and stand (Interrante et al., 2015) and shoot and root length (Munkvold & O'Mara, 2002). However, in some cases, fungicide and insecticide seed treatments can cause delayed seedling germination and early seedling growth retardation (Görtz et al., 2008). Also, different response of maize genotypes to certain treatments was detected (Tamindžić et al., 2013).

Most commonly used fungicides for seed treatment in Serbia are based on active ingredient metalaxyl. It is a systemic fungicide effective against *Oomycetes*, by inhibiting protein synthesis (Aleksić et al., 2016). Because of the high risk of resistance in fungi (Taylor et al. 2002; Gisi & Cohen, 2001), and to expand the range of action, metalaxyl can be combined with other fungicides, such as fludioxonil, a non-systemic active ingredient which inhibits mycelium growth of *Fusarium sp.* (Broders et al., 2007), or prothioconazole, systemic fungicide that inhibits fungal sterol biosynthesis (Aleksić et al., 2016).

Intensified agricultural production and decreased possibility of adequate crop rotation led to an increased number of soil insects, and further, to wider use of insecticides as seed treatment. Douglas & Tooker (2015) reported of rapid increase in application of neonicotinoids as seed treatment in the United States in recent years, with an estimated 34-44% of acreage under soybean, and 79-100% under maize being treated in 2011. Neonicotinoids represent one of the most important groups of insecticides, registered for use in more than 120 countries (Jeschke et al. 2011). They are systemic, broad-spectrum insecticides with pronounced residual activity that act as agonists of nicotinic acetylcholine receptors (Aleksić et al., 2016). Neonicotinoids can be used as seed treatment in corn, cereal, sunflower, oilseed rape and sugar beet to protect seed and young plants (Elbert et al., 2008). However, long-term protection in later stages of plant development

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is uncertain (Seagraves & Lundgren, 2012; Magalhaes et al., 2009; Johnson et al., 2008).

Maize is a thermophilic plant, with optimal temperatures for germination between 25 and 28°C (Farooq et al., 2008). As it is cultivated well outside its area of origin, maize is often exposed to suboptimal temperatures which can lead to prolonged germination time (Čanak et al., 2016), cellular and tissue injuries and changes in metabolic activity. Even short-term exposure to temperatures below 0°C can cause irreversible cellular damage and premature senescence in mature plants (Greaves, 1996).

The aim of this study was to evaluate the effect of different seed treatments on maize germination parameters under optimal and suboptimal temperatures, and to determine whether there was a difference in reaction of maize genotypes to applied seed treatments.

Material and Methods

Seed of three maize hybrids (NS 640 ultra, NS 444 and NS 609 b), developed at the Institute of Field and Vegetable Crops, Novi Sad were used in this study conducted in 2016. Seed coating was performed with laboratory seed coater (Wintersteiger Hege type 11). For seed treatment, three commercial pesticide formulations were used: metalaxyl-m 10 g/L + fludioxonil 25 g/L (M+F), metalaxyl 20 g/kg + prothioconazole 100 g/kg (M+P) and thiacloprid 400 g/L (T). All treatments were applied in doses recommended by the manufacturer: 1L/t of seed for M+F, 100 ml/100kg of seed for M+P, and 62.5 ml per 25000 seeds for T. These three pesticide formulations were combined in four treatments: M+F, M+P, M+F+T and M+P+T. Untreated seed was used as control (N).

After treatment, seeds were sown in plastic pots (21 × 15 cm) containing sterile moistened sand (7% distilled water), at the depth of 10 mm. The experiment design was completely randomized design with six replicates. Testing was carried out in growth chamber, with 50 seeds per replicate, and the photoperiod was maintained at 16 h (light)/8 h (dark). During the whole period of study one set of pots was placed at 25°C (optimal temperature), and the other at 15°C (suboptimal temperature). Seedling germination was recorded daily. Germination was counted when seedling coleoptile peeked from moistened sand. Final germination (FG) was recorded on the 7th day.

Mean germination time (MGT) was calculated using formula (Ellis & Roberts, 1981):

$$MGT = \sum Dn \ / \ \sum n$$

where D is the number of days counted from the beginning of germination and n is the number of seeds that had germinated on day D.

Time to 50% germination (T_{50}) was calculated with the formula of Coolbear et al. (1984), modified by Farooq et al. (2005):

$$T_{50} = t_i + (N/2 - n_i)(t_j - t_i) \ / \ (n_j - n_i)$$

where N is the final number of germinating seeds, n_j and n_i are the cumulative number of seeds germinated by adjacent counts at times t_j and t_i, respectively, when $n_i < N/2 < n_j$.

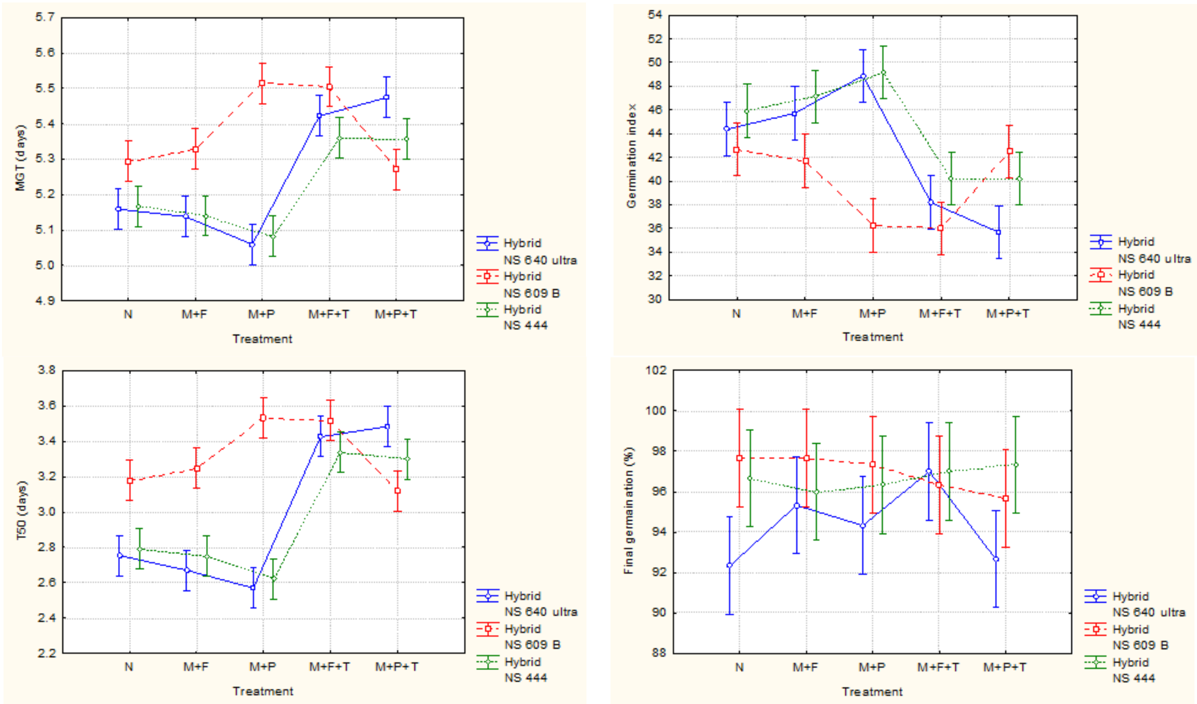

Figure 1. Mean germination time (MGT), germination index, time to 50% of germination (T_{50}) and final germination of differently treated hybrid maize seed (N: non- treated; M+F: metalaxil + fludioxonil; M+P: metalaxil + prothioconazole; M+F+T: metalaxil + fludioxonil + thiacloprid; M+P+T: metalaxil + prothioconazole + thiacloprid) at optimal temperature (25 °C). Vertical bars on figure denote 0.95 confidence intervals (Hybrid x Treatment interaction).

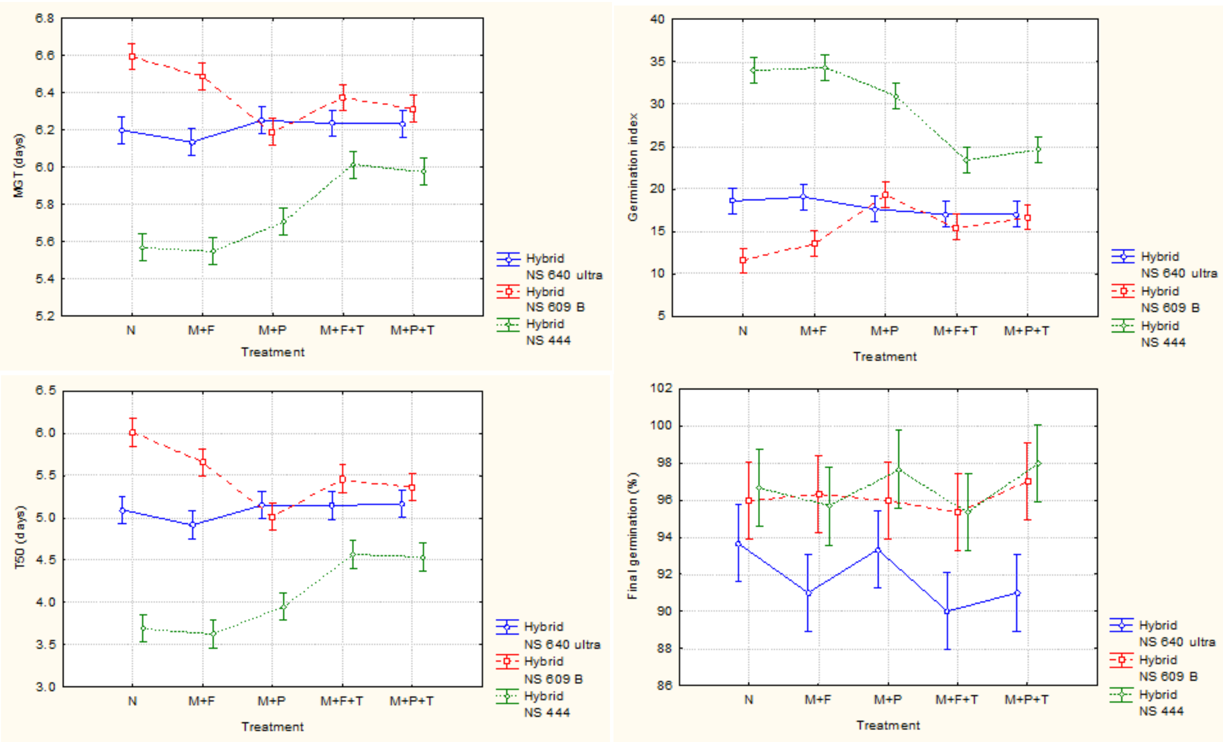

Figure 2. Mean germination time (MGT), germination index, time to 50% of germination (T_{50}) and final germination of differently treated hybrid maize seed (N: non- treated; M+F: metalaxil + fludioxonil; M+P: metalaxil + prothioconazole; M+F+T: metalaxil + fludioxonil + thiacloprid; M+P+T: metalaxil + prothioconazole + thiacloprid) at suboptimal temperature (15 °C). Vertical bars on figure denote 0.95 confidence intervals (Hybrid x Treatment interaction).

Germination index (GI) was calculated according to The Association of Official Seed Analysis (1983) formula:

GI = No. of germinated seeds / Day of first count + … + No. of germinated seeds/Day of final count.

Data were analysed using two-way ANOVA (software STATISTICA 12). Means were compared using LSD test.

Results and Discussion

Under optimal temperature conditions (25°C), when seed was treated with fungicide and insecticide combination M+F+T and M+P+T, both hybrids NS 640 ultra and NS 444 reacted with significant increase of T_{50} and MGT compared to all other treatments, while M+P treatment reduced those parameters in comparison to N (Figure 1). Prolonged T_{50} and MGT were registered when seed of hybrid NS 609 b was treated with M+P and M+F+T, compared to other treatments and N.

Seed treated with M+F+T and M+P+T on hybrids NS 640 ultra and NS 444 resulted in lower GI, while this parameter was increased when seed was treated with M+P, compared to N. Seed treated with M+P and M+F+T on hybrid NS 609 b resulted in decreased GI, compared to all other treatments.

Regardless of the seed treatment applied, there was no significant difference in FG of the two hybrids, NS 444 and NS 609 b. Compared to N, seed treated with M+F and M+F+T resulted in a significantly higher FG of hybrid NS 640 ultra.

Low GI and high values of T_{50} and MGT indicate slower germination (Dezfuli et al., 2008). It can be observed that, when treated with fungicide-insecticide treatments, seed of two hybrids, NS 640 ultra and NS 444, reacted with delayed germination, which is in consistency with results obtained by Tamindžić et al. (2013). On the other hand, seed treated with M+P had accelerated germination. As one of the triazole fungicides, which can act as plant growth regulators, prothioconazole may have been the cause of different response of hybrid NS 609 b to M+P and M+P+T treatments. Görtz et al. (2008) also reported of differences in barley seed emergence when treated with triazole fungicides, depending on mixing partner and temperature conditions. Results of testing on optimal temperatures indicate that, with few exceptions, applied seed treatments had no significant effect on final germination.

At suboptimal temperatures (15°C), compared to N, no significant differences of MGT and GI of hybrid NS 640 ultra were detected (Figure 2). However, T_{50} was significantly decreased when seed was treated with M+F. All seed treatments applied on NS 609 b induced significant decrease of T_{50} and MGT, as well as higher

GI, in comparison to N. Seed treated with M+P, M+F+T and M+P+T on hybrid NS 444 resulted in prolonged T_{50} and MGT, and lower GI, while no difference was detected between seed treated with M+F and N.

Compared to N, no significant differences in FG of NS 609 b and NS 444 were registered. Seed treated with all treatments, except M+P, in hybrid NS 640 ultra, resulted in lower FG.

At low temperature hybrids reacted differently to applied treatments, which in NS 609 b resulted in accelerated germination, in NS 444 prolonged, and in NS 640 ultra, treatments had no significant effect. Since sowing of maize in Serbia usually starts in early April, when temperatures are often below optimum, these results more reliably describe the reaction of different genotypes to seed treatments in field conditions.

Conclusions

Results of the conducted study indicate that there are differences in response of maize genotypes to applied seed treatments, as well as to a specific treatment at optimal and suboptimal temperatures. Some treatments, depending on the mixing partner and temperature conditions, can affect final germination. In other cases, germination rate can be accelerated or prolonged, but with no effect on final germination. Although primary goal of seed treatment is to protect seed from soil pathogens and pests, prolonged germination and emergence exposes it to longer infestation period. Therefore, in order to provide fast and uniform emergence under different temperature conditions, further examination of the response of maize genotypes to specific seed treatment would be beneficial.

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Efekat različitih tretmana semena na parametre klijanja semena kukuruza u uslovima optimalnih i suboptimalnih temperatura

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Sažetak: Cilj istraživanja je bio da se utvrdi efekat različitih tretmana na parametre klijanja semena tri hibrida kukuruza na optimalnim i suboptimalnim temperaturama. Seme je tretirano preporučenim dozama komercijalnih pesticidnih formulacija: metalaksil-m 10 g/L+ fludioksonil 25 g/L, metalaksil 20 g/kg + protiokonazol 100 g/kg i tiakloprid 400 g/L. Ispitivanja su vršena u pesku, na 25°C i 15°C. Rezultati ispitivanja ukazuju da postoji razlika u reakciji genotipova kukuruza na primenjene tretmane, kao i na dati tretman u uslovima optimalnih i suboptimalnih temperatura. Neki tretmani, u zavisnosti od preparata koji se mešaju i temperaturnih uslova, mogu uticati na konačnu klijavost. S druge strane, brzina klijanja može biti promenjena, ali bez uticaja na konačnu klijavost. Kako bi se obezbedilo brzo i ujednačeno nicanje u različitim temperaturnim uslovima, dalja analiza reakcije različitih hibrida na date tretmane bi bila od koristi.

Ključne reči: klijanje, kukuruz, seme, tretman semena, temperatura

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