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STANDARD GERMINATION AND SEEDLING EMERGENCE OF MAIZE INBRED LINES IN DIFFERENT TEMPERATURE CONDITIONS

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Abstract

Standard laboratory germination seed test provides information on seed performance under defined environmental conditions aiming to estimate field planting value. Purpose of this study was to compare results from the standard germination test with seedling emergence in different outside temperature conditions. Sowing was done in three periods during spring, in trays exposed to outside conditions. Data obtained showed that differences in the germination, detected in the standard laboratory test, were also confirmed in field conditions. Expression of these differences, however, was dependent on temperature conditions during different sowing periods. Low temperatures during the early sowing were more discriminative than later temperature increase which completely reduced differences detected in the standard germination test.

Key words: sowing time, field emergence, laboratory test, *Zea mays* L.

Introduction

Successful crop production implies the use of high-quality seeds (Ghassemi-Golezani et al., 2008). Among all parameters of seed quality, germination plays the most decisive role (Milošević et al., 2011). In order to provide reliable and quick information to producers on germination potential of a certain lot, laboratory standard tests were developed since field tests are "normally unsatisfactory as the results cannot be repeated with reliability" (ISTA, 2019). Methods for testing germination are standardized for each crop where seeds are exposed for the prescribed time to defined temperature, light regime and substrate. After a certain germination time, seedlings are evaluated as normal or abnormal according to the prescribed criteria (e.g. ISTA Rules, AOSA) which are constantly under development (Milivojević et al., 2018). As normal are considered seedlings which have potential to develop into satisfactory plants (ISTA rules, 2019). Seedlings which are undeveloped, weak, damaged, diseased or badly deformed are evaluated as abnormal, without potential to provide a normal plant.

In certain cases, however, lots with a high percentage of abnormal seedlings can provide normal plants in later developmental stages. For example, Babić et al. (2015) have found that a large number of abnormal maize seedlings developed into normal plants in field conditions. Vujošević et al. (2018) showed that a high percentage of abnormal seedlings correlated well with the emergence rate, however, in later stages, these seedlings showed potential to provide a high yield. Both studies were conducted in the optimal field conditions for maize which stimulated maximal germination potential and further seedlings development. In most cases, however, results from the germination test correlate well with field emergence, thus providing a reliable estimation on the ger-

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mination potential of a seed lot (e.g. Kolasinska et al., 2000).

Our study aimed to show how discrepancies between results from laboratory tests are reflected in the germination of maize inbred lines under different temperature conditions. For this purpose, lots of maize inbred lines were sown outside in three different times during spring and seedling emergence was daily monitored.

Material and methods

Three maize inbred lines were selected at the Maize Research Institute "Zemun Polje" stored for 7 years under controlled conditions (T=4°C, RH=45%). These lines are frequently used for the production of ZP hybrids.

Standard germination. Standard germination test was performed using "between paper" method. Seed was germinated in a growth cabinet at the alternating temperature 30⇔20°C and light regime 8h light/16h dark during 7 days.

Germination in suboptimal conditions. Seeds of inbred lines were sown in trays with soil in three different periods: 11th March (first sowing), 17th March (second sowing) and 29th March (third sowing). Each tray was physically separated into three equal parts which were filled with 50 seeds per each line. Sowing was done in 4 trays, thus, each line was represented by four replicates of 50 seeds. Trays were kept outside. Watering was done daily by tap water. Seedling emergence was counted twice per day, at 9 AM and 3 PM until a constant number of seedlings was reached. Seeds were exposed to different temperature conditions as shown in Figure 1.

Statistical analysis. Obtained data were angular transformed arcsin sqrt (%) for performing two-factorial analysis of variance. LSD test was applied for testing differences between mean values. MSTAT computer software was used for performing all statistical analysis.

Results and discussion

Results of the standard germination test are presented in Table 1. Percentage of normal seedlings was similar for lines 1 and 3 and significantly lower in the case of line 2. These data provided a good basis for further research on the capability of the standard germination test to predict seed performance in field conditions.

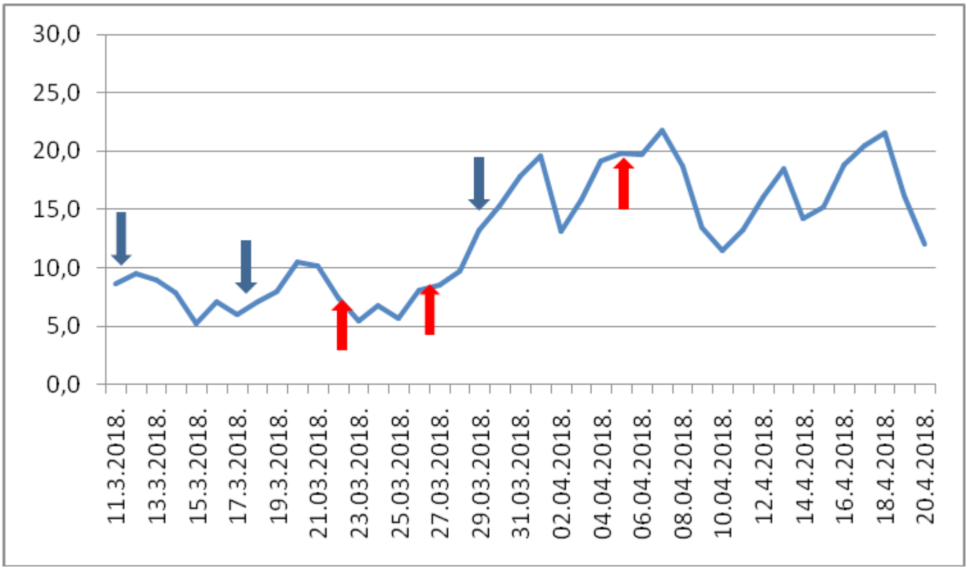


Figure 1: Mean daily outside temperature. Arrows indicate dates of sowing (blue) and seedling emergence (red).

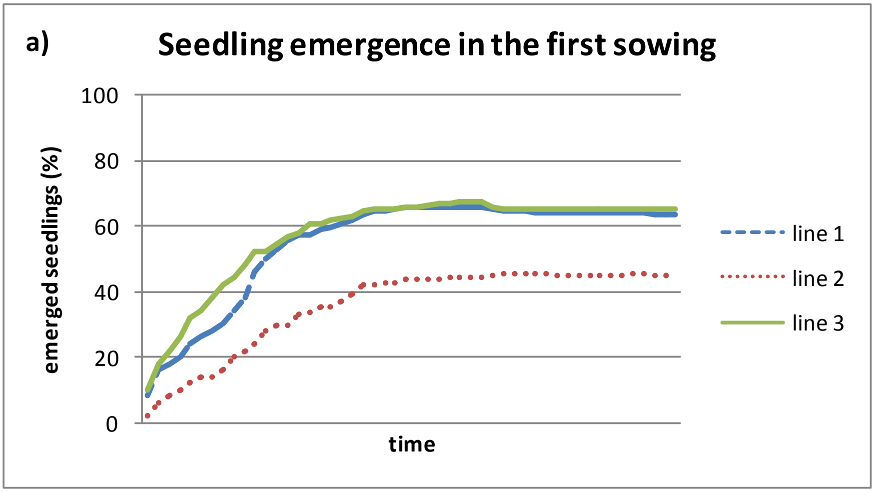
Grafikon 1: Srednje dnevne spoljne temperature. Strelice označavaju datume setve (plave) i pojavu klijanaca (crvene).

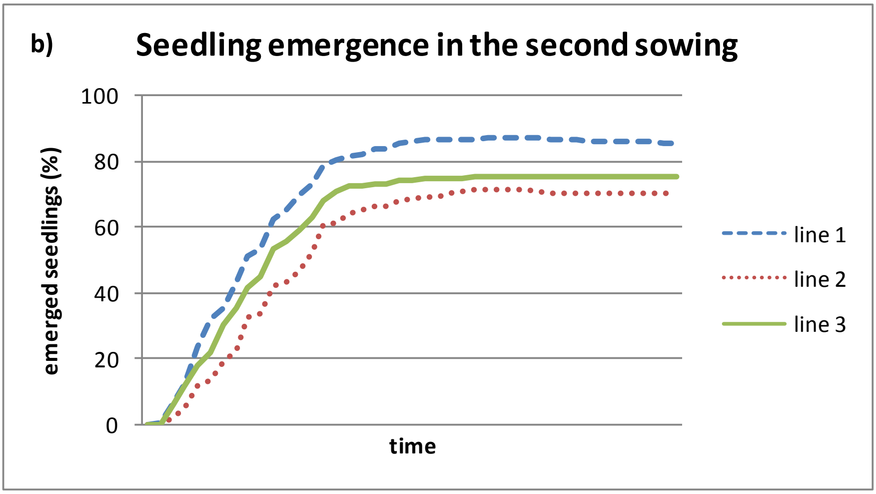
Table 1: Results from the standard germination test
Tabela 1: Rezultati standardnog testa klijavosti

Line	Normal seedlings (%)	Abnormal seedlings (%)	Non-germinated seeds (%)
1	98[a]	1[a]	1[b]
2	93[b]	1[a]	6[a]
3	97[a]	1[a]	2[b]

The lowest values for outside temperatures were recorded during the first sowing time (Figure 1). In the second sowing, the temperature was still low, however, seeds were shorter exposed than during the early (first) sowing. The last sowing took place when the temperature was considerably higher. A period between sowing and appearance of first seedlings was progressively shortening by later sowings: 11, 9 and 7 days, respectively, as indicated by blue and red arrows in Figure 1.

Dynamics of seedling emergence is presented in Figures 2a-c and the output from the ANOVA test on the percentage of emerged seedlings in Table 2.





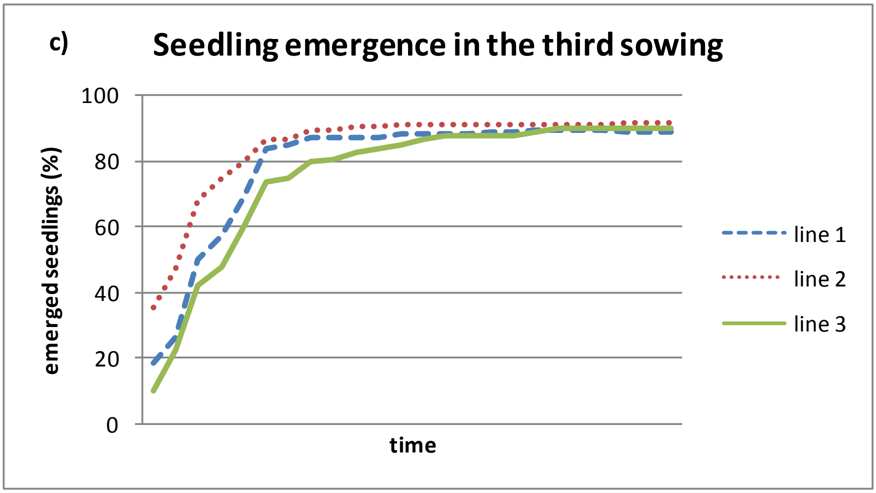


Figure 2 (a-c): Percentage of emerged seedlings during the first (a), the second (b) and the third (c) sowing time.
Grafikon 2 (a-c): Procenat izniklih klijanaca tokom prvog (a), drugog (b) i trećeg (c) setvenog perioda

Dynamics of seedling emergence was apparently the lowest during the first sowing period (Figure 2a) when the lowest percentage of emerged seedling for all lines was also recorded (Table 2). Among lines, noticeable is the lowest dynamics and percentage of emerged seedlings for the inbred line 2 which even did not reach 50% emergence. The lowest performance in field of this line is comparable to the output from the standard germination test (Table 1). Line 1 and 3 displayed similar emergence rate in this sowing period (Figure 2a), which is also in agreement with the germination data from the laboratory test (Table 1).

During the second sowing, speed of emergence (Figure 2b) and the percentage of emerged seedlings (Table 2) were considerably higher for all lines. In this sowing, the percentage of emerged seedlings was similar for lines 2 and 3 while line 1 displayed significantly higher values (Table 2). Dynamics of the seedling emergence of line 2 was still somewhat lower in comparison with the other two, but to a lower extent than during the first sowing time. In contrast to the first sowing time, the difference in the dynamics of seedling emergence increased between line 1 and 3 (Figure 2b).

In the last (third) sowing, all lines displayed similar emergence from the aspect of both percentage (Table 2) and the dynamics of emerged seedlings (Figure 2c).

Statistical analysis showed that irrespective on the sowing period, the line 1 showed the highest percentage of emerged seedlings (79.33%), followed by the line 3 (74.58%) and the line 2 (69.00%). However, these differences were not identified for all sowing periods indicating, thus, the interaction between genotype and the sowing time. For example, the line 2 had significantly lower seedling emergence only during the first sowing. In the second sowing, dynamics of seedling emergence of the line 2 was slightly lower in comparison with the other two lines, while the percentage of emerged seedlings was comparable to line 3. In the last sowing, however, both percentages of emerged seedlings and dynamics of seedling emergence were comparable to the other two (Table 2). It can be assumed that an optimal outside temperature compensated lower vigour of the line 2 what has been already suggested by Vujošević et al. (2018). On the other hand, seedling emergence of the line 1 was affected only during the early sowing (Figure 2, Table 2), indicating that the vigour of these seeds supported full germination potential in last two sowings. Line 3 displayed similar performance during the first two sowings with a significant increase only during the last period (Figure 2, Table 2). Interestingly, germination of this line in the standard test was almost the same as for the line 1 (Table 1). This may suggest that seeds of the line 3 were less vigorous than line 1 and that sub-optimal conditions of first two sowings were more discriminative in identifying this. The last is in accordance with findings of Finch-Savage (2016) who found that seed lots of sugar beet with similar data from the standard germination test displayed different field performance due to differences in seed vigour.

In summary, seedling emergence of all lines was highly dependent on temperature conditions during sowing. Observed lines were differently responding to changes in temperature during sowing. Differences between lines detected in the standard germination test were the most obvious in the sub-optimal temperature conditions during the first sowing. The negative effects of suboptimal temperature on maize germination parameters and early seedling growth have been previously reported (Čanak et al., 2016). Exposure to higher temperatures resulted in the similar performance of all lines suggesting that optimal field conditions could overcome lower seed vigour suggesting, thus, that growers may expect good performance even from lots with slightly lower results from the standard germination test.

Conclusion

The standard germination test is designed to enable comparison of seed lots by detecting discrepancies in their germination potential. Our study confirmed this ability, especially in the early sowing conditions. In later sowings, when temperature conditions became more favourable, discrepancies in quality disappeared due to almost full expression of the germination potential. For seed growers it is very important to be on the safe side during the selection of seed lots due to unpredictable field conditions, therefore, the output from the standard germination test still remains the most reliable and irreplaceable source of information on seed quality.

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STANDARDNA KLIJAVOST I NICANJE KLIJANACA SAMOOPLODNIH LINIJA KUKURUZA U RAZLIČITIM TEMPERATURNIM USLOVIMA

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Sažetak

Standardni test klijavosti pruža informacije o ponašanju semena u definisanim uslovima klijanja sa ciljem procene poljske setvene vrednosti. Svrha ovog istraživanja bila je poređenje rezultata standardnog testa klijavosti sa nicanjem klijanaca u polju pri različitim spoljašnjim temperaturnim uslovima. Setva je obavljena tokom tri vremenska perioda u proleće, u posudama izloženim spoljašnjim uslovima. Dobijeni rezultati su pokazali da su razlike u klijavosti, detektovane pomoću standardnog laboratorijskog testa, potvrđene i u sub-optimalnim spoljnim uslovima. Međutim, ispoljavanje ovih razlika zavisilo je od temperaturnih uslova tokom različitih setvenih perioda. Niske temperature u ranom periodu setve su bile diskriminativnije od kasnijeg porasta temperature koji je potpuno umanjio razlike detektovane u standardom testu klijavosti.

Ključne reči: vreme setve, nicanje u polju, laboratorijski test, *Zea mays* L.

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