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The effect of different sowing depth on the yield and yield-forming elements of maize

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SUMMARY

On a global scale, maize is an important food, feed and industrial crop, with an increasing production area (Nagy, 2007 and 2021). Among the environmental impacts, extreme weathering factors caused by climate change are causing serious problems for crop stability, and maize is no exception.

Precision farming is today's most innovative agrotechnical approach, which can greatly increase crop safety and reduce costs by exploiting the genetic potential of our soils and the hybrids we use (Torres, 2012).

Sowing is one of the most important agrotechnical elements, and with good seeding we can ensure that we have all the requirements of a high yielding, high growing crop (Pepó, 2019). In the case of sowing, it is important to place the seed in moist soil to provide the optimum environmental conditions for the crop to ensure uniform emergence (Széles et al., 2020; Shrestha et al., 2018).

Precision planting is the market leading technology in precision planters in the United States, and when cooperating with them we looked for methods to optimise the depth of sowing and to monitor the effect on yield by studying the initial development of the plants. The seeder was equipped with the company's SmartFirmer soil scanner integrated into the seed drill. Automatic seed depth adjustment based on soil moisture is an exceptional solution for uniform emergence and drought protection.

Keywords: *Zea mays L.; precision planting; precision seeding; SmartFirmer*

INTRODUCTION

Maize is an important food, feed and industrial crop worldwide, including in Hungary (Bocz et al., 1992). As a result, its area of cultivation is increasingly (Csajbók, 2019). Climate change is one of the main reasons for the increasing extreme weather events, causing serious problems for the crops, and maize is no exception (Sárvári, 2005). However, there is a great solution: precision farming, which is the most innovative agrotechnical trend of our time. This innovative technology can help us to reduce costs by reducing the amount of inputs used, furthermore the genetic potential of farmland is better expressed through the use of plant hybrids that we select with precision (EPRS, 2016; Gaál et al., 2017). One of the most important agrotechnical elements is seeding, as a good seeding gives us the opportunity to ensure a high yielding crop with excellent growth (Sárvári and Futó, 2000). It is important to sow the seed in moist soil to ensure optimal environmental conditions for the plants (Csajbók et al., 2015; Illés et al., 2022). Precision farming is an innovative solution that enables accurate and efficient crop production (Zelenak, 2022). I wanted to find out to what extent the application of precision seeding technology affects maize yields in Hungary. In collaboration with Precision Planting from the United States we looked for methods to optimize the depth of sowing and to monitor the effect on yield by studying the initial development of the plants. Precision Planting is the market leader in precision planters in the United States and independently renovates conventional planters. Their technology has few references in Hungary and this is one of their first attempts in the country. The seeder was equipped with the company's SmartFirmer soil scanner integrated into the seed drill, which measures soil moisture in the seed furrow to help find the right sowing depth (Akrea.com and Precision Planting.com). Automatic seed depth adjustment based on soil moisture is an exceptional solution for uniform emergence and drought protection. The uniform emergence achieved with this technology also helps to ensure maize yield stability.

MATERIALS AND METHODS

Location of the Experiment: University of Debrecen Farm and Regional Research Institute of Debrecen (FRRID) Látókép Experimental Station of Plant Production in 2022.

The experimental station, established in 1983, is located on the Hajdúság loess plateau, 11 kilometers away from Debrecen, at the 95th kilometer marker of the 33rd main road (N: 47°33’42”; E: 21° 27’02”).

My research was conducted at the University of Debrecen's Agricultural Research Institutes and Agricultural Farming Visualization.

I was carried out at the demonstration plant of Debrecen University in Debrecen, Hungary, on the loess reef of Hajdúság, on chernozem soil with calcareous loess. Physical properties of the soil are classified as loam. It is almost neutral in chemical composition, humus medium humus content, with a humus layer thickness of around 80 cm. Phosphorus

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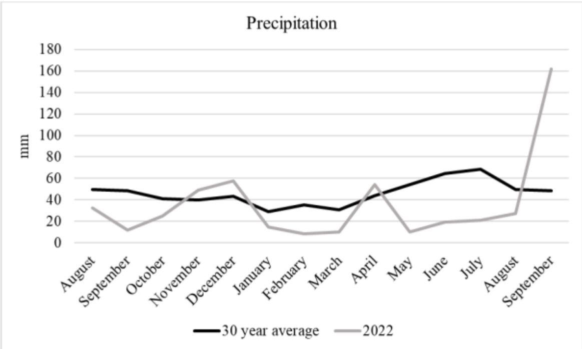
content medium, potassium medium to good. Soil water depth 3–5 m, but does not rise above 2 m in wet years.

The recharge of the water reserve has been steadily decreasing since June (*Figure 1*) period of the winter. In the period up to sowing, the water table was -139 mm less than in the previous year. From sowing to harvest, the rainfall was -70.1 mm less, however, if I exclude the September outbreak - a month in which is already the maize ripening period, so the precipitation that falls in this month has a significant impact on the I found that -177.3 mm less than the previous year's compared to the 30-year average.

Figure 1. **2022 growing season rainfall distribution compared to the 30-year average (Debrecen 2022)**



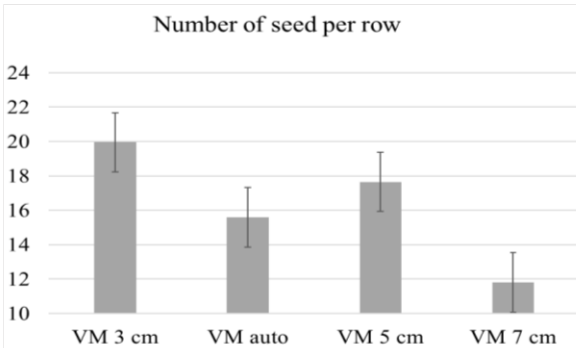
The seed drill used in the experiment is a custom-built design, which was built and customized for the experiments in Hungary. The frame of the seeder is made of an Anglo-French company called Sky. The 4 row planter is equipped with Precision Planting Ready Row Units. The technology used on the seeder is Precision Planting SmartDepth. The hybrid DKC5182 (FAO 450–480) was used in the experiment. Preview was maize, with autumn deep ploughing as the basal tillage on 08.10.2021. Spring (02.03.2022) the ploughing was completed with a combine and then also with a combine 135 kg N was applied on 28.03.2022. Sowing was done on 26.04.2022 Precision Precision Planting drill. Each plot was sown with 4 rows of maize at 75000 plants per 50 m length.

RESULTS AND DISCUSSION

In our research, the first factor we investigated was the change in germination dynamics caused by different sowing depths in maize. The most favourable data were found for maize sown at 3 cm depth, as 91.89% of maize plants hatched within 1 day from the start of emergence. 8.11% of the plants emerged late on the second day compared to the rest of the plants, so that the early development of the crop was uniform and there was no marked difference in the development of the plants. By increasing the sowing depth by only 2 cm, a slight increase in the germination trajectory was observed: the germination within 1 day of the previous 90% was only 70.42%, i.e. 21.47% worse than that of maize sown at the same time but shallower. The following day, a further 23.94% of the crop had already emerged, but here 2.82%–2.82% emerged on days 3 and 4. In some respects, the automatically controlled sowing depth resulted in a shallower germination compared to either the shallow 3 cm or the average 5 cm sowing depth. On the first day of emergence, 62.16% of the maize emerged, followed by a further 35.14% on the second day. It was observed that in this case there were already maize that emerged on the third day, but only 2.7% emerged later and no further maize emergence was observed by day 4. A sowing depth of 7 cm increased the germination trajectory more drastically, as only 43.66% of the maize that had previously germinated on day 1 had developed compared to over 60%, and 38.03% of the maize that had germinated on day 1, 2.89% worse than the automatically controlled sowing, germinated on the following day. However, by the third day, 14.08% of the germplasm had emerged on the test section. On the fourth day, another 4.23% more plants germinated and emerged from the soil.

In our research, we also looked at the yield-forming elements. Maize yield is largely determined by individual production, so I started with the number of kernels per row, from which I found that in the drought year 2022 (*Figure 2*), shallow seeding was more favourable compared to deeper seed placement. Corn seeds sown at a depth of 3 cm yielded an average of 19.95 kernels per row. The 5 cm depth, considered optimal for the calcareous chernozem soil in the Visible, caused a slight grain loss, but the 17.65 number of grains was still considered favourable. For the 7 cm sowing depth, it was already found that only 11.81 grains were averaged in a row, which was the lowest grain yield under the different agrotechnical treatments. Based on the Precision Planting automation, the seeding depth is located between 5 cm and 7 cm depth, as the grain yield per row is lower than that of maize sown at 5 cm depth, but higher than that of the 7 cm depth technology.

Figure 2. **Number of seed per row at different sowing depths (Debrecen 2022)**



We also observed a similar pattern in the number of rows as in the number of stitches in the rows. The shallow sowing of 3 cm resulted in the highest number of rows for maize, with an average of 17.13. For the optimum sowing depth of 5 cm mentioned above, an

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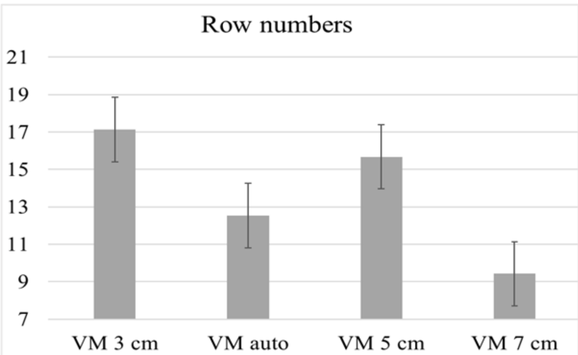
average of 15.67 rows was observed. The 7 cm sowing depth, however, already reduced the number of rows significantly, as only 9.42 rows were observed on average. I also found some maize individuals that did not produce any yields when testing the 7 cm sowing depth. As shown in *Figure 3,* the setting of the sowing depth controlled by the automatics again resulted in a result between 5 cm and 7 cm, as an average of 12.53 rows were found to be affected by the treatment. After sowing, I counted the appearance of the first plants as the first day, which, now observing the number of grains per row on the tubes, led to the following conclusion. The maize plants that uniformly hatched the earliest were those that reached the highest number of eyes per row (20.51) on the 5th day after sowing. In the case of maize that hatched one day later, no more drastic reduction was observed, as an average of 18.68 grains was counted for the individuals that hatched on the second day. However, by day 3, i.e. 7 days after sowing, the hatched individuals could only grow 12.27 grains in the drought year 2022. The maize individuals that hatched by day 4 were few and there were individuals that did not yield, resulting in an average of 5.5 ears per row of commune. The study was also extended to the number of rows we observed that when compared to the number of grains per row, a similar trend was observed. In the early stages of emergence, the number of rows shows a slight decrease, which is not a significant difference. The individuals that hatched on day 3 had 10.6 rows, while the maize that hatched on day 4 had an average of only 6 rows.

Figure 3. **Row numbers at different sowing depths (Debrecen 2022)**



Based on the data collected during the analysis of the yield components, I made a Pearson correlation calculation (*Table 1*), which led to the following conclusions. A significant difference, a strong positive correlation, was found between the number of grains per row and the number of rows. Therefore, these results suggest that in 2022, crops with more number of rows had longer rows on the tubes.

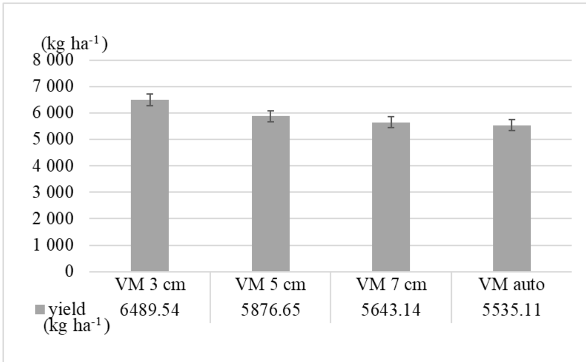
The year 2022 also stands out among the drought years of the past 30 years. Irrigation has allowed us to achieve the yields shown in *Figure 4.* Shallow seeding continued to prove more favorable in 2022, but the yield of 2595.82 kg ha^{-1} was below the multi-year Visual Yield Average. No significant difference was observed between the 5 cm (2350.66 kg ha^{-1}), 7 cm (2257.25 kg ha^{-1}) and the automatic sowing depth (2184.40 kg ha^{-1}).

Table 1. **Pearson correlations between umber of seed per row and row numbers (Debrecen 2022)**

Correlations			
		Number of seed per row	**Row numbers**
Number of seed per row	Pearson Correlation	1	**0.833****
	Sig. (2-tailed)		0.000
	N	286	286
Row numbers	Pearson Correlation		1
	Sig. (2-tailed)		
	N		286

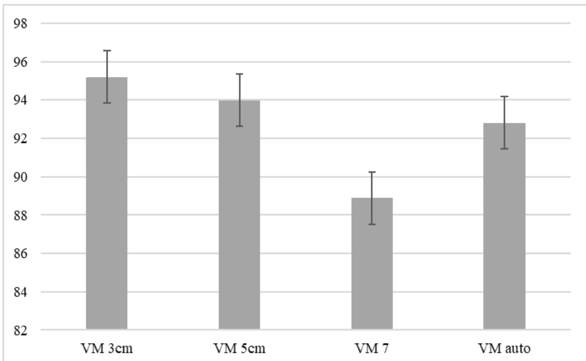
**Correlation is significant at the 0.01 level (2-tailed)

Figure 4. **Yields at different sowing depths in 2022 (Debrecen 2022)**



When evaluating the results measured with the POGO instrument, we found that the best agreement between the planned number of plants and the actual number of individuals was found for the 3 cm sowing depth (*Figure 5*). Two days after sowing, a significant amount of rain (18.5 mm) fell, so that the dry soil conditions until then alleviated the unfavorable germination conditions.

Figure 5. **Sowing results at different sowing depths (Debrecen 2022)**



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By observing the values in *Table 2*, we could conclude that the drought did not allow sufficient differentiation of yields. The grain saturation was not complete and the early death of the stems prevented the plant from feeding the grains. When moisture content at harvest was examined, no significant differences were observed between the sowing depths.

Table 2. **Complex evaluation of data (Debrecen 2022)**

	Number of seed per row (db)	Row numbers (db)	Grain moisture (%)	Yield (kg ha^{-1})
Sowing depth (3 cm)	19.95	17.13	15.68	2595.82
Sowing depth (5 cm)	17.65	15.67	16.22	2350.66
Sowing depth (7 cm)	11.81	9.42	15.46	2257.25
Sowing depth (auto)	15.6	12.53	15.68	2184.40

CONCLUSIONS

The depth of sowing plays a very important role in the development of maize and has an impact on the development in later phenological stages and on the formation of the crop. Due to the favorable early arrival of rainfall, the yield parameters at 3 cm sowing depth were more favorable compared to the other agro-technical variants of the experiment. In a spring with high rainfall, shallow sowing is considered optimal for maize emergence uniformity. The early-developing maize tolerated the summer drought slightly better than the more difficult to grow plants sown at deeper depths. The number of rows was a significant factor in the experiment, as the plants that started from a better position were earlier in development at the peak of the drought and could therefore still yield. The sowing depth can influence the development of the subsequent yield elements based on the tube parameters. The analysis of yield components and yields showed a strong correlation, therefore it is important that there is a balance between individual production and yields at the table level, so that the crop does not compete with itself for nutrients and water due to delayed emergence. I found a correlation between sowing depth and time to emergence, and the depth determined by the Precision Planting drill's automatic system is close to optimum, but further years of research are needed to arrive at accurate findings.

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