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SITE-SPECIFIC PLANT NUMBER CONTROL IN PRECISION SUNFLOWER (*HELIANTHUS ANNUUS L.*) PRODUCTION

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ABSTRACT
We consider sunflower as a plant that uses the soil moisture extremely. Hybrids utilize soil water resources with varying degrees of efficiency, which is also greatly influenced by the planted number of plants. In our study, we examined the applicability of the applied precision sowing technique as a function of the number of seedlings resulting different distance between seedlings, and attempted to determine the sunflower crop density range that best fits the heterogeneous productivity zones of the given crop area. The productivity zones were created using GIS methods. For both sample areas, three well-separable zones in terms of productivity (high, medium, low) were identified. Considering the feasibility aspects of the experiment, three seedling steps were used in each fertility zone in four replicates. Based on the results of the control of the number of plants and the distance between the plants, the accuracy and applicability of the sowing technology decreases inversely with the increase of the number of seedlings. In areas with high and medium productivity, moderately increased number of seedlings resulted higher yields, while in low productivity zones, moderately reduced density did not result lower yields than base planting. The thousand grain weight decreased significantly with increasing the number of seedlings, while the oil content increased significantly with increasing the number of seedlings in each productivity zones.

Keywords: sunflower, productivity zone, crop density, yield, oil content

INTRODUCTION

Nowadays, an important objective of agriculture and food production is to create the conditions for sustainable farming practice. Important elements of the sustainability of farming are the ecological, social and, last but not least, economic approaches. Sustainable development is also increasingly important in arable crop production and requires adaptation to ecological and economic conditions. It has become essential to take into account the features of the production site, the needs of crop production and the coordination of the related environmental protection goals. The aim of sustainable production is to maintain the minimum possible burden on the environment and, at the same time, economy (MONOKI, 2011).
Extreme weather phenomena - especially long periods of drought - are occurring more and more frequently. In addition to the periods of high average temperature, the amount of annual precipitation shows a decreasing trend and its distribution is becoming increasingly hectic (LABANCZ ET AL., 2020). These adverse effects greatly influence and change the soil's water circulation and biological-physical-chemical properties, which force farmers to upgrade the tillage systems that have been used successfully so far. The main direction of today's soil cultivation research is the development of cultivation technology systems and procedures that promote adaptation to changed environmental conditions and are suitable for preventing or mitigating crop damage due

to extreme water balance disturbances. Cultivation technology interventions that save water and energy and use them more economically can give the opportunity to maintain the effectiveness of farming even in the face of reduced yields for farmers (VÁRALLYAY, 2003).

Although we consider the sunflower as a plant that utilizes soil moisture extremely, among the factors limiting the yield of sunflower, if we examine sunflower cultivation in recent years, it is still true that the amount of available water is the primary limiting factor. The quality of the agrotechnical operations carried out is very important: the water resources must be made available for sunflower as much as possible (ANTAL, 1992).

A significant lack of water during the initial development and flowering period of the sunflower results in a significant reduction in yield, while with optimal soil properties, due to the utilization of the precipitation that fell before the growing season, excellent yield results can be achieved even in the drier growing season (DAR ET AL., 2008). The highest yield can be also achieved when the amount of precipitation falling before and during the vegetation period is between 110-130mm and 350-420mm (MIJIC ET AL., 2012). There is a negative correlation between the number of hours of sunlight in the period between sowing and flowering, the amount of precipitation in the period and the yield (GONZÁLEZ ET AL., 2013). The amount of precipitation also has a stronger effect on the oil content of sunflower seed than the temperature (ALESSI ET AL., 1977) and in the case of a dry growing year, a higher oil content is achieved than in a rainy growing year (SUKKASEM ET AL., 2013).

More plants require more water per unit area. The hybrids utilize the soil's water resources with different efficiency, which is greatly influenced by the number of seeds sown. The genotype has a decisive influence on the yield (MRDJA ET AL., 2012), but there is a significant difference between the hybrids in the size of the leaf, stem height, stem diameter, head diameter and the thousand seed weight (FETRI ET AL., 2013).

SZABÓ (2007) states in his publication that the optimal number of seedlings is also an area-, environment- and hybrid-specific property but the productivity of the soil, the heterogeneity of our area, the expected yield, the possibilities offered by our seed drill and the adaptability of the given hybrid also act as modifying factors.

Satellite remote sensing and positioning (MOORE ET AL., 1993), the emergence of sensor measurement, geospatial data analysis and processing software and the possibility of access to their use created the foundations of precision crop cultivation (MESTERHÁZI, 2003).

Thanks to the technological developments of precision plant production based on location, GIS applications and cultivation tools have become available to growers, which can be used to significantly increase the efficiency of farming (MILICS, 2008).

The research and application of several technological elements of precision crop cultivation are already in a relatively advanced phase, however, analyzes and the development of precision technologies related to soil cultivation and sowing are still in an early stage. The application of different tillage systems on soil types with different properties and their effect on the cultivated plant and the yield within a given agricultural plot can have a great impact on the effectiveness of farming (LENCSÉS, 2013). While there is increasing interest in differentiated nutrient application, the results of site-specific controlled seeding (TÓTIN AND PEPÓ, 2016) still act as a novelty for many and many questions await clarification among farmers, even though the basis of its usability and efficiency is the realization of greater benefits through cost reduction.

The aim of our research is to determine, with the tools available for precision crop cultivation, the sunflower density that best fits the heterogeneous productivity zones of the given fields, which directly influence the success of sunflower cultivation, and to determine the extent of economically justifiable seeding changes.

MATERIALS AND METHODS

In the year of 2021, we carried out a site-specific plant number controlled sowing experiment in two production areas with different soil properties, by sowing significantly different amounts of seeds within the given zones. During the experiment, we examined the characteristics of the growing site, the soil properties of the individual zones, the characteristics of the applied sowing technique (nominal and germinated number of seedlings, uniformity of plant spacing) and the quantity and quality of the crop. The number-controlled seeding experiments were set up in two different soil type areas: the C14-1 area is a bound meadow type, while the C4-7 area is a potting soil with a shallow fertile layer, interspersed with gravelly patches. The sowing experiment was carried out in three zones with different productivity, using three steps in the number of seeds per zone, in four repetitions per number of seeds.

When creating the productivity zones of the experimental sowings, we took into account that the three productivity categories (low, medium, high) should be separated from each other as much as possible, and the size of the productivity zones would allow the experiment to be carried out. The size of the required experimental area within each zone is 100x126m. It was an important aspect that the relief conditions were not extreme and areas were not sloping did not affect the results of the experiment, and that there were no natural or artificial obstacles within the zones.

The productivity zones were created using our own GIS method. When creating the zones, we took into account the geological characteristics of the areas included in the experiment based on the data of the Kreybig soil map, the data of the space images taken by the Sentinel-2 satellite in the period between 2017-2020, and the yield and height data of the combines recorded between 2017-2020 (*Figure 1*).

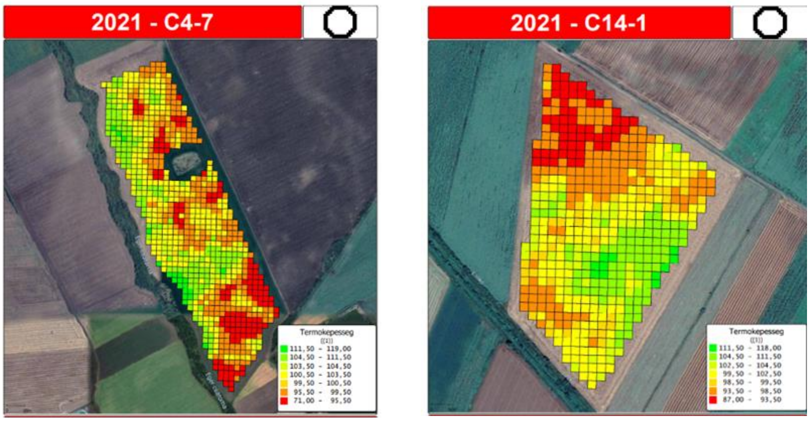

Figure 1. Productivity map of fields C14-1 and C4-7

After the selection of the field and the productivity zones, we set up three categories of production sites: low, medium and high productivity zones.

The area designated for experimental sowing was created within the area of the zones classified according to the category of production location, in which each experimental strip was 100 m long and 9m (12 rows) wide, totally 126m (168 rows) of each field.

The applied cultivation technology is the same throughout the fields, only the number of seedlings has changed. The sunflower was sown with a Horsch Maestro 12.75 SW type

drill adapted for precision sowing, which, however, was carried out with a Precision Planting sowing unit built on a John Deere sowing cart, which enables the most precise sowing possible. The seed number changes of the experimental sowing were carried out automatically by the tractor's on-board computer based on a pre-written sowing plan.
The experimental sowing was planned according to the productivity zone categories as follows:
According to the seed manufacturer's recommendation, the seeding rate of the SY Bacardi CLP sunflower hybrid is 55-58,000 seeds/ha. Accordingly, we considered the proven number of 55,000 plants/ha in our cultivation environment as the standard of the plant number experiment. Taking into account the feasibility aspects of the experiment, in each productivity zone, we used three seed number steps repeated in four repetitions (*Figure 2*).
In the low productivity zone, we used the base number of seeds per hectare (55,000) and the number of seeds reduced by 20 (44,000) and 40% (33,000).

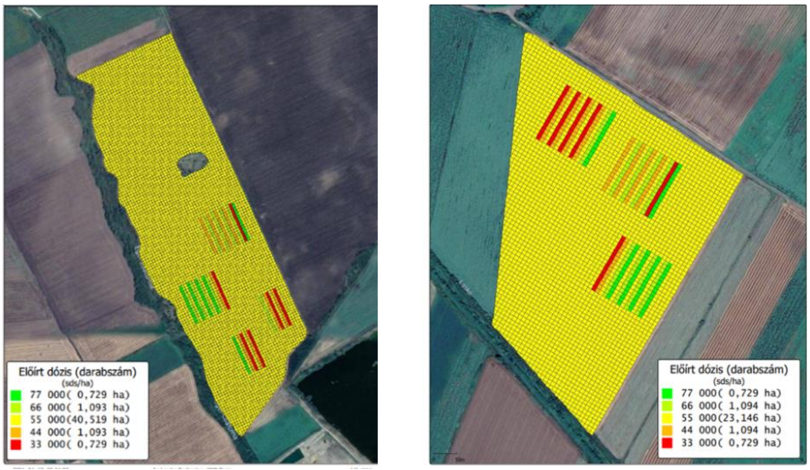

Figure 2. The productivity zones and sowing plan of the experimental sowing of fields C14-1 and C4-7

In the medium productivity zone, the base number of seeds (55,000) and the number of seeds increased by 20% (66,000) and reduced by 20% (44,000) were used.
In the high productivity zone, we used the base number of seeds (55,000) and the number of seeds increased by 20 (66,000) and 40% (77,000).
Additionally, in the case of all three productivity zones, we also took one strip with a seed number that is not included in the given zone, but is in one of the other two. Thus, 66,000 and 77,000 rows were sown in the low productivity zone, 33,000 and 77,000 in the medium productivity zone, and 33,000 and 44,000 in the high productivity zone in one repetition only to see if there is some unexpected information pops up which experiments are noticeable on the shown figures but does not take into account in this recent research.
Within the 100m long area of the experimental sowing, a 10m long sample area was designated at any point in the entire width of the sowing. After hoeing, we selected 6 rows out of the 12 rows of the different number of planted strips within this area, in which the distance between the plants found in the rows was recorded.
After the sunflower ripening, the parts of both fields outside the experimental plots were harvested earlier. Harvesting of experimental areas was done by cutting each plot separately and the quantity of cut sunflowers was emptied onto the transport vehicle and measured per plot with a mobile measuring unit. We took samples from the drained

sunflower at five points, from which an average sample weighing about 1 kg was formed for the laboratory tests. The moisture and oil content of the average samples were examined and measured in the Laboratory of the Agricultural Instrument Center of the University of Debrecen.

The statistical data analysis was carried out using the IBM SPSS Statistics 22 program package.

RESULTS

The following results were obtained during the analysis of the data from the sowing experiment of field C14-1 in 2021: within all the productivity zones, with the increase in the nominal number of seedlings, the difference between the nominal and observed density increased significantly, as well as the uniformity of the seed spacing showed a larger standard deviation and was more imprecise. Data on the quantitative and qualitative parameters of the sunflower harvested from the experimental areas are shown in *Figures 3 and 4.*

In the low productivity zone, the seed moisture of sunflower was the lowest at 55,000 seeds/ha, and the oil content was the highest, but the yield did not differ significantly from the values of 33,000 and 44,000 seeds/ha. In the zone of medium productivity, the seed moisture of sunflower was the lowest at 66,000 seeds/ha, and did not show a significant difference between 44,000 and 55,000 seeds/ha.

The oil content was the highest at 44,000 seeds/ha, which was 0.5 m/m% higher than 66,000 seeds/ha and 1.23 m/m% higher than 55,000 seeds/ha. There was no significant difference in yield between the 55,000 and 44,000 seeds/ha sowings, but the 66,000 seeds/ha sowing exceeded the yield of the previous two plantings by about 3%.

In the high productivity zone, the grain moisture of sunflower increased significantly with the increase in the number of seeds, the oil content was the highest in the case of 77,000 seeds/ha. In terms of yield, 77,000 seeds/ha yielded the highest yield (5,445 kg/ha), while 66,000 seeds/ha yielded 1.67% and 55,000 seeds/ha yielded 5.9% less.

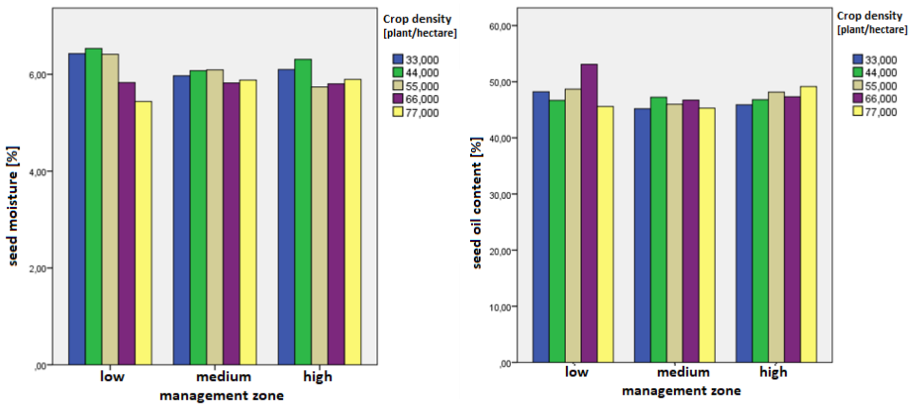

Figure 3. Seed moisture and oil content data of sunflower harvested from field C14-1

In the case of field C4-7 in 2021, the following results were obtained during the analysis of the data from the sowing experiment: within all productivity zones, the smallest difference between the nominal and observed density was found in the case of sowing with a number of 33,000 seeds/ha. In the case of sowings with 44,000 55,000, 66,000, 77,000 seeds/ha, no significant differences were observed. With regard to the uniformity of the plant spacing, the analysis did not show a sufficiently reliable result.

Based on the examination of the quantitative data, we obtained the following results: in the low productivity zone, sowing with a number of 33,000 seeds/ha yielded the highest average yield (2418.92 kg/ha), the yield of 44,000 seeds/ha was 7.9%, while that of 55,000 seeds/ha was 6% for less.

In the zone with medium productivity, the highest average yield (3351.15 kg/ha) was harvested from the sowing of 44,000 seeds/ha, with 55,000 seeds/ha (-1.9%) and 66,000 seeds/ha (- 2.35%) differed slightly in yield.

In the high productivity zone, sowing with 77,000 seeds/ha yielded the highest average yield (4,016.31 kg/ha), from which the sowing with 66,000 seeds/ha differed only slightly (-0.7%), while the sowing with the number of 55,000 seeds/ha yielded 3.6% less.

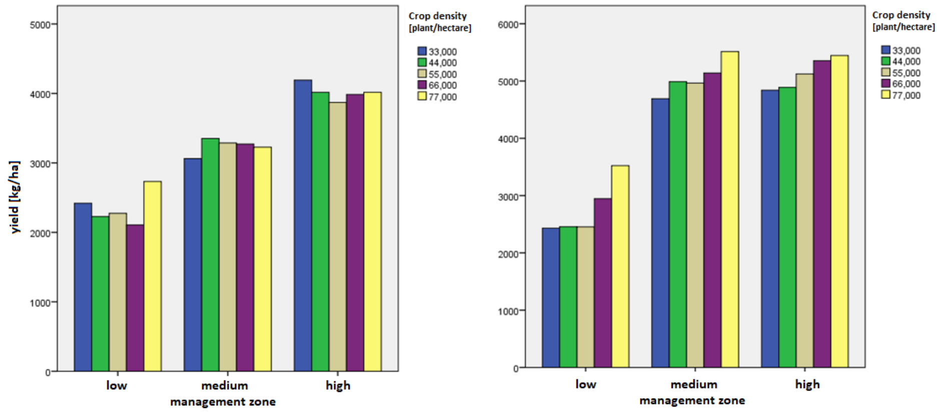

Figure 4. Data on the average harvested quantity of the C14-1 and C4-7 fields

DISCUSSION

Within all zones, with the increase of the nominal number of seeds, the difference between the nominal and observed density increased significantly, and the uniformity of the plant spacing also showed a larger deviation and became more imprecise.

In the zones with high and medium productivity, increasing the number of seeds resulted in a higher yield, while in the zones with low productivity, sowing with a reduced number of seeds did not yield less than the standard number of seeds.

In the case of the moisture content, no practical difference could be detected between the number of seeds, while in the high productivity zone the oil content increased significantly with the increase in the number of seeds.

In areas with high productivity, it is worthwhile to carry out further economic calculations regarding the profitability of sowing with a higher number of seedlings.

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