[1.]Bogdan ROȘU, [1.]Gheorghe VOICU, [1.]Gabriel Alexandru CONSTANTIN, [1.]Magdalena–Laura TOMA, [1.]Paula TUDOR, [2.]Dragoș–Nicolae ANGHELACHE

CONTROL OF SEEDING RATE AND SEEDING MANAGEMENT IN PRECISION SEEDERS

[1.]National University for Science and Technology Politehnica Bucharest / ROMANIA
[2.]National Institute of Research – Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest / ROMANIA

Abstract: In the current climatological context, where land irrigation is increasingly required and present, the management of sowing in the field becomes a process with an absolute need for precision. Sowing, regardless of the crop, variety or hybrid, must be done with the utmost care and with advanced (performance) technologies to maximize the potential of the plants through the growing season. Thus, the pre–establishment and management of the sowing furrows as well as the performance of the tractor – seeder (sowing machine) gearing (assembly) become essential factors in carrying out this precision operation. Thanks to irrigation under the pivot we distinguish (identify) a new category of sowing, in a circle, which absolutely needs a perfect control of the sowing dose at the section level as well as a self–guiding system, installed on the tractor, with a precision signal under 2 cm – RTK precision signal.
Keywords: precision agriculture, seed drill, double disc opener, soil mapping, sowing management

1. INTRODUCTION

Agriculture represents the totality of the operations and methods of cultivating the land and raising animals in order to obtain plant and animal products for food, which can serve as raw materials for industry or which can be used to produce energy (biomass). Sustainable agriculture aims to optimize productivity and, at the same time, preserve basic natural resources, this means that in agricultural production systems a balance will be maintained between inputs and outputs, between investments and benefits, ensuring the environment quality and promotion of a sustainable economy (*Tanwar K. et al., 2019*). The concept of sustainability in agriculture implies the choice of those technologies that will not compromise, in the future, the decisions taken in the present (*Zimdahl R. 2022*). Increasing the level of soil productivity and maintaining a healthy environment are compatible concepts, despite the perception promoted until recently to the contrary (*Pollock C. et al., 2008; Velten S. et al., 2015*).

Mechanization in agriculture, as in other fields, is associated with the economic progress of a prosperous society, even in low–resource agriculture of small peasant farms, the tractor quickly became a symbol of well–being, conferring a higher social status. Farmers will always be interested in machines with the highest possible reliability (*Upadhyay, G. et al., 2018*). Sowing is an agricultural work that consists of placing in the ground, in proper conditions for germination and growth, plant seeds or reproductive organs (tubers, bulbs) of some plants. The sowing method differs in relation to the plant, the culture method, the purpose of the culture, the natural conditions, etc., and can be classified into two groups: sowing by spreading and sowing in rows (*Vișan A.L. et al, 2015; Pollock C. et al., 2008; Velten S. et al., 2015*).

Precision agriculture consists of a series of tools and strategies that allow farmers to optimize and increase soil quality and productivity by implementing targeted and localized actions, all through modern technologies, sensors and artificial intelligence. The word "precision" is used because the use of state–of–the–art tools allow the most appropriate action to be taken, at the right place and at the right time, responding to the particular demands of crops or certain areas of the plot with a high degree of precision (*Peng J. et al., 2022; Emami M. et al., 2018; https://www.prairielandpartners.com).*

The sowing machine is an agricultural machine that carries out the sowing, ensuring a uniform and well–determined distribution of the seeds (with the help of distributors), burying them to a certain and uniform depth and covering the seeds (*https://vantage–ro.com/; https://vaderstad.com*).

Seeder maintenance is particularly important for farmers working in the low tillage system. Most of the physical responsibility for handling the soil, placing the seed and getting a good layer for the seed to grow falls on the seed drills.

Many producers have found, through much trial and error, that great emphasis must be placed on the importance of the soil engagement components of the seeder, as the planter replaces some tillage equipment operations. Instead of inserting into a prepared seed bed, the seeder can be used to create a furrow of the right depth, place the seed evenly in the furrow, and establish a proper seed–to–soil contact (*Jun G. et al. 2022; Soza E. et al, 2004; Vișan A.L. et al, 2015, Li, X., et al., 2023;* Geng, Y., et al., 2022).

In order to be able to obtain the best return on investment, greater attention must be paid to the implementation of all the necessary steps, both for the preparation but also for the maintenance and proper adjustment of the settings of the sowing machines (*Karunathilake E.M.B.M. et al., 2023*).

The objective of this work is the control of sowing doses and the management of the work of crop sowing using precision sowing machines, as well as the determination of some physical parameters of the coulter discs of the sowing sections, establishing their behaviour in operation.

2. MATERIALS AND METHODS

The experimental research was carried out in the field, and the determination of the measurements was carried out with a Vaderstad crop seeder, model Tempo TPF 8, with which sowing works were carried out in Giurgiu and Teleorman counties (107.38 ha sown) and in Prahova and Buzau counties (261.19 ha sown).

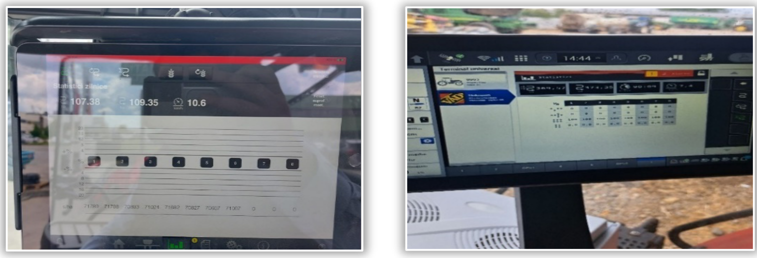

Figure 1 – Photo of the display with number of hectares sown

The equipment used for the measurement was as follows: 5 m tape measure, digital caliper with measurement range between 0 – 500 mm, outdoor micrometer kit with measurement ranges between 0 – 100 mm, electronic balance with d = 0.1 g.

To determine the mass of the furrow opening discs or the coulter discs in the row unit, proceed as follows: the adjusting wheel arm was dismantled from the left side, respectively the right side of the row unit; the scrapers that come applied over the ditch opening disc on both sides have been removed; protective caps of disc hubs were removed; the nuts of the bearings were unscrewed, taking into account the fact that the nuts have the thread applied according to the side where they are mounted on the row unit; the discs were extracted and cleaned of any plant debris and/or rust by mechanical brushing; the discs of each row section (left/right) were weighed individually using an electronic balance placed on a flat surface (for which planarity was checked); assembly was carried out in the reverse order of the operations described above; after completion, the trencher discs should touch but not too close to each other, rotating the disc should be a little difficult as if a "business card" is inserted between the discs. If the diameter of the disc mounted on the seeder falls below the value of 350 mm, it must be replaced.

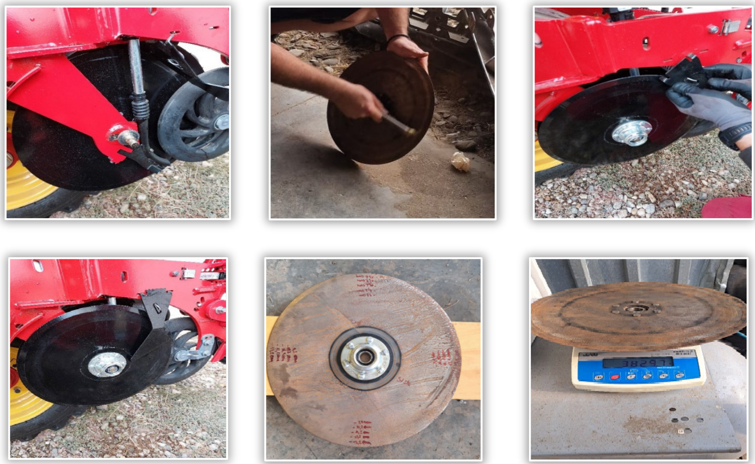
Figure 2 – The method of making the measurements

Figure 2 shows illustrations during the measurement on the sowing discs.

Based on the measurements made and recorded in a table, the deviation from the average of the outer diameters recorded at the seeder mentioned above was determined, as well as for the weight of the coulters. It turns out that there are some significant differences for some of the seeder discs, especially for the discs on the compute side:

$$E_i = \frac{x_i - x_m}{x_m} 100 \ [\%] \tag{1}$$

where: x_i is the measured value of the parameter to be recorded (disk diameter or thickness); x_m – average value of the measured parameter.

3. RESULTS AND DISCUSSION

Determinations regarding the physical parameters of coulter discs

The determinations were made both for the existing coulters on a seeder that worked about 380

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

hectares, as previously stated, and for a set of 20 new coulters.

Figure 3 shows the deviation from the average of the outer diameter of the seeder discs. It is noted that there are some differences between the coulters, both in terms of the outer diameter and the mass of the coulters. Overall, the differences are not large, but they do exist.

The authors assume that the working environment of the disks (soil that has heterogeneous characteristics, even if it is assumed to have been uniformly processed) is the main factor that determines these differences, but the differences between the disks themselves must also be taken into account, as can be seen from table 1.

Table 1. Experimentally determined values for new precision seed coulter discs

Disc No.	Mass [g]	Outer diameter [mm]	Disc thickness [mm] (measured in 4 points)				
			132	122	112	102	92
1	4041.60	380.42	4.24	4.20	4.25	4.08	4.17
2	4058.80	380.66	4.22	4.23	4.21	4.00	4.18
3	4045.10	380.35	4.23	4.24	4.21	4.06	4.29
4	4043.80	380.68	4.21	4.25	4.22	4.16	4.27
5	4040.30	380.37	4.24	4.21	4.68	4.17	4.23
6	4036.60	380.18	4.19	4.26	4.74	4.75	4.14
7	4042.20	380.44	4.14	4.18	4.19	4.50	4.60
8	4053.10	380.44	4.26	4.27	4.26	4.22	4.16
9	4055.60	380.52	4.27	4.26	4.28	4.25	4.24
10	4050.90	380.23	4.24	4.21	4.19	4.18	4.10
11	4014.60	380.51	4.17	4.12	4.10	4.08	4.59
12	4053.30	380.63	4.27	4.22	4.21	4.17	4.10
13	4066.00	380.64	4.21	4.19	4.16	4.17	4.12
14	4049.70	380.44	4.29	4.26	4.26	4.24	4.25
15	4016.50	380.38	4.23	4.17	4.23	4.19	4.10
16	4017.50	380.42	4.19	4.19	4.11	4.11	4.20
17	4021.20	380.53	4.17	4.17	4.16	4.13	4.16
18	4028.60	380.43	4.19	4.24	4.19	4.19	4.18
19	4049.20	380.49	4.28	4.23	4.24	4.24	4.34
20	4041.30	380.48	4.17	4.18	4.20	4.19	4.16

Furthermore, no differences can be made between the left and right discs in terms of the data presented, even though some graphs might suggest so.

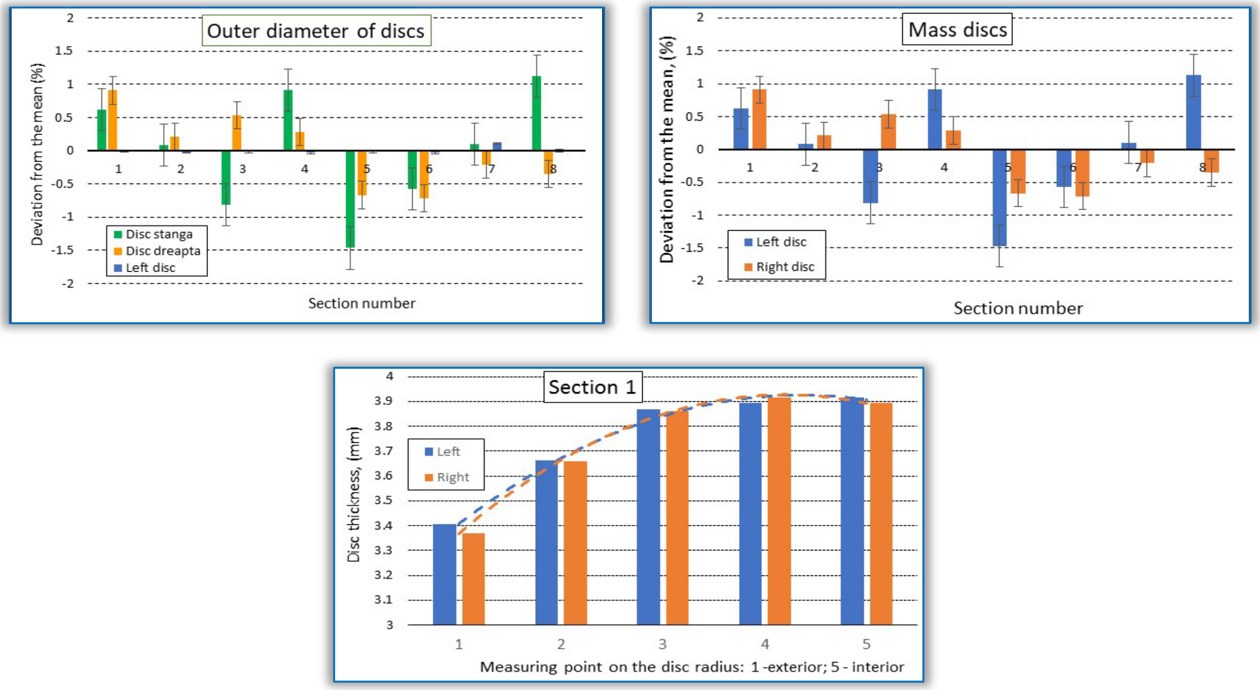

Figure 3 – The deviation from the average of the outer diameter and the mass of the disc

For a set of 20 new disks, determinations were also made regarding the mass of the disks, their outer diameter and their thickness at five diameters (in four diametrically opposite points, as shown in Figure 2).

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

From the analysis of the data in table 1, it is found that there are some differences in terms of the mass of the discs (which present deviations from the average between ±0.001% and ±6.135 %), more than in terms of the outer diameter (which presents deviations from the average within $\pm 4.4\times10^{-7}$ – $\pm 6.1\times10^{-6}$%). It is also observed (Figure 3) that the thickness of the discs is reduced towards the outside of the disc due to working in the sowing field.

Management of the sowing work

The first step in variable rate seeding is to perform a soil analysis with the advanced SoilXplorer scanning system and its agrochemical mapping. The SoilXplorer scanned to a depth of 1 meter, determined the soil texture, moisture and degree of compaction which is very important because depending on the level of the compaction layer we can determine the depth to which the basic work can be carried out (scarification in the case of the analysed soil).

Figure 4 – Scanning of the soil, regarding its degree of compaction, texture and humidity

Equally important is the determination of soil texture to find out what texture the soil has over the entire surface and in which areas we have the same texture.

Figure 5 – Agrochemical mapping of the soil

In the second stage, fertilizers were applied using a variable rate spreader; for this it was necessary to draw up a complete map with the amount and content of fertilizer optimized for each area, the amount varying between 170 – 240 kg/h. After overlaying the maps, a map with attributes (variable application map) was determined which was processed by the fertilizer manufacturer through specific programs with specific algorithms that transformed the maps generated by the sensor together with the soil analysis report. This variable rate was later applied using a 12 section fertilizer machine with a working width of up to 44 metres.

Figure 6 – Variable rate of soil fertilization

Figure 7 – Planting with variable rate and PowerShoot

Stage 3 was dedicated to variable rate circle seeding using the Vaderstad Tempo TPF 8 seeder, a seeder that benefits from the most advanced high–speed precision seeding technology coupled to a tractor equipped with the integrated self–guiding system ACCUGUIDE with high precision signal provided by RTK+ network ISOBUS terminal XCN 1050 Case IH RTK+ for application of variation map.

The variation rates were determined following detailed reports on the evolution of crops preceding the last five years, the sum of temperatures and precipitation recorded over the same period of time over these areas and soil characteristics. These maps, produced only by the seed suppliers, were imported into the XCN 1050 ISOBUS terminal. From the XCN 1050 control and self–guidance display with the help of the section control unlocks and the multi–product variable rate application, the sowing command was applied to the preset rates from the variation map to the control computer of the Vaderstad seeder, model Tempo TPF 8. Using the planter's unique PowerShoot technology, fixed rates were set in numbers of seeds per radius, sowing at a depth of 6 cm at an average forward speed of 12 km/h.

In traditional seed drills, the seed falls freely through the seed tube from the direction of the seed counter down into the soil. With the increase in speed comes vibrations and the seed jumps in the seed tube and much of the accuracy of the seed counter is lost. Thanks to PowerShoot technology, which uses air pressure to maintain total control of the seed down to the ground, gravity, vibration and slopes are taken out of the equation, making speed a non–issue for the Vaderstad Tempo seeder.

The Vaderstad Tempo planter will ensure the same conditions for all plants and plant spacing results in a crop that matures at an even rate and is more likely to reach its full potential. Tempo is able to plant a full range of crops with excellent results. By easily changing the row spacing and machine configuration for different crops, Tempo offers high versatility on the farm. The result is increased efficiency and minimal machine costs per hectare. Changing the seed discs is done in seconds without the need for tools.

Figure 8 – Planting in the circle with variable rate and PowerShoot

4. CONCLUSIONS

Today's precision seed drills are equipped with disc coulters that open the furrows in which the seeds to be sown are deposited. These discs seem to wear less than the roller coulters, but after large sowing areas their diameter decreases and so does the thickness. Moreover, even new discs have different variations from the average values of diameters, weights and thicknesses.

For a seeder with eight sections (8 open furrow coulters, with 16 discs) the graphs presented in the paper show small deviations from the average of the outer diameter of the discs (below 0.11%), but larger deviations from the average for the mass of the coulters, these reaching up to about 1.5%.

The paper presents the mentioned deviations, including for 20 new discs, deviations calculated based on the calculation relationship presented in the paper. In addition, the thickness of the discs at five different diameters (average of four diametrically opposite points) was also determined.

For a proper seeding operation, including fertilizer application, good operation management is required, starting from soil mapping in terms of degree of compaction, soil texture after preparation/shredding operation and soil water content in portions of the plot, but also agrochemical mapping in order to distribute fertilizers with a variable rate.

Precision agriculture aims to improve crop efficiency and reduce financial costs while maintaining quality. Although the innovative technologies implemented may be expensive, in the long term the savings will be much greater, this is due to the fact that farmers can determine precisely the amount of fertilizers needed and which variants are optimal for certain areas of the land. The strategy will be able to be planned over an extended period and, in case of force majeure, it can be adjusted according to the situation.

The implementation of precision agriculture, regardless of the branch, can be divided into three distinct phases, namely: data collection, analysis and application of the necessary measures.

Precision agriculture requires certain equipment, sometimes requiring specialists or the training of farmers for them to be used properly. The adoption of innovative tools, technologies and procedures is the optimal solution for increasing productivity.

Acknowledgement

This work has been funded from the project "Development of the practical application base for agricultural, mechatronic and environmental mechanics in vineyards, orchards and solariums (DEMEVILISO)", CNFIS–FDI–2023–F–0277, from the Ministry of Education through the Executive Agency for Financing Higher Education, Research, Development and Innovation.

References

[1] Emami, M., Almassi, M., Bakhoda, H., Kalantari, I. (2018). Agricultural mechanization, a key to food security in developing countries: strategy formulating for Iran, Agriculture & Food Security, vol. 7, 24

[2] Geng, Y., Wang, X., Zhong, X., Zhang, X., Chen, K., Wei, Z., Lu, Q., Cheng, X., Wei, M. (2022). Design and optimization of a soil–covering device for a corn no–till planter, Agriculture 12(8), 1218

[3] Jun, G., Yue, Y., Memon, M.S., Chuang, T., Linyu W., Pei, T. (2022). Design and simulation for seeding performance of high–speed inclined corn metering device based on discrete element method (DEM). Scientific Reports, 12, 19415

[4] Karunathilake, E.M.B.M., Tuan Le, A., Heo, S., Chung, Y.S., Mansoor, S. (2023). The Path to Smart Farming: Innovations and Opportunities in Precision Agriculture, 13(8), 1593

[5] Li, X., Zhang, Y., He, H., Wang, B., Zhou, H.,Geng, D., Zhang, Y. (2023). Design and experiment of row cleaner with staggered disc teeth for no–till planter, Agriculture, 13(7), 1373

[6] Peng, J., Zhao, Z., Liu, D. (2022). Impact of Agricultural Mechanization on Agricultural Production, Income, and Mechanism: Evidence from Hubei Province, China, rontiers in Environmental Science, vol.10

[7] Pollock, C., Pretty, J., Crute, I., Leaver, C., Dalton, H. (2008). Introduction. Sustainable agriculture, Philosophical Transactions of The Royal Society B Biological Sciences, 363,445–446

[8] Soza E., Botta, G. Tourn, M., Hidalgo, R.J. (2004). Sowing efficiency of two seeding machines with different metering devices and distribution systems: a comparison using soybean, Glycine max (L) Merr, Spanish Journal Of Agricultural Research, 2(3):315–321

[9] Tanwar, K., Dagar, H., Malik, K. (2019). Sustainable Agriculture, In book: Research Trends In Agriculture SciencesPublisher: AkiNik Publications

[10] Upadhyay, G., Raheman, H. (2018). Comparative analysis of tillage in sandy clay loam soil by free rolling and powered disc harrow, Engineering in Agriculture Environment and Food, 12(1):118–125

[11] Velten, S., Leventon, J., Jager, N., Newig, Jens. (2015). What Is Sustainable Agriculture? A Systematic Review, Sustainability, 7:7833–7865

[12] Vișan, A.L., Bogdanof, C.G., Milea, D., Mircea, C. (2015). State–of–the–art seeding equipments used in precision agriculture technologies operated by pneutronics systems, Conference: 23rd International Scientific and Technical Conference CYLINDER 2015 Testing, Designing, Manufacturing And Operation of Hydraulic Systems, Poland

[13] Zimdahl, R. (2022). Agricultural sustainability, In book: Agriculture's Ethical Horizon

[14] *** Prairie L. and Partners, (2021). The benefits of agricultural mechanization, https://www.prairielandpartners.com/blog/the–benefits–of–agricultural–mechanization—33391

[15] *** Precizion farming, Farm management, https://vantage–ro.com,

[16] *** Where farming starts, Vaderstad International, Väderstad Collection Shop, https://vaderstad.com

Note: This paper was presented at ISB–INMA TEH' 2023 – International Symposium on Technologies and Technical Systems in Agriculture, Food Industry and Environment, organized by University "POLITEHNICA" of Bucuresti, Faculty of Biotechnical Systems Engineering, National Institute for Research–Development of Machines and Installations designed for Agriculture and Food Industry (INMA Bucuresti), National Research & Development Institute for Food Bioresources (IBA Bucuresti), University of Agronomic Sciences and Veterinary Medicine of Bucuresti (UASVMB), Research–Development Institute for Plant Protection – (ICDPP Bucuresti), Research and Development Institute for Processing and Marketing of the Horticultural Products (HORTING), Hydraulics and Pneumatics Research Institute (INOE 2000 IHP) and Romanian Agricultural Mechanical Engineers Society (SIMAR), in Bucuresti, ROMANIA, in 5–6 October, 2023.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665