CZU 631.332; 631.332.53

THE INFLUENCE OF SEEDLINGS' PLANTING DEPTH ACCURACY ON THEIR SURVIVABILITY

V. Badiul, *PhD student;*
M. Cătană, *PhD student;*
A. Melnic, *university assistent*
Technical University of Moldova, Chisinau, Republic of Moldova

Agricultural production is one of the main economic sectors of the Republic of Moldova and Ukraine, therefore improving crop cultivation technologies is of utmost importance in the context of increasingly fierce competition. Along with this, vegetable growing is also one of the main branches of agriculture in these countries, however, in recent decades, due to the reduction of markets for the sale of products and a number of other reasons, vegetable growing has not been going through the best of times, which has ultimately led to a reduction in the area for growing the main vegetable crops of the region [1]. In Moldova, the area for growing vegetables has decreased threefold [2].

One of the reasons that led to the reduction in vegetable production is climate problems, which made cultivation unprofitable, and the lack of water and modern irrigation systems led to a sharp reduction in sown areas and an increase in import dependence [1, 2, 3]. However, this led to an increase in the area under other agricultural crops such as wheat, corn and sunflower, the products of which are well exported, since as a result of improvements in the production technology of these crops and technical means, their yields have increased significantly [4, 5, 6].

Production problems are also aggravated by existing problems associated with the technology of growing vegetable crops, which do not allow for maximum mechanization of technological processes, such as sowing seeds and planting seedlings [1, 7, 8].

One of the most important and labor-intensive technological operations in vegetable growing is planting seedlings and the shortage of workers involved in agricultural vegetable production is becoming increasingly noticeable. Therefore, in the current situation, mechanization of work during seedling planting plays an increasingly important role [1, 7].

Transplanting machines do not fully meet the agronomic requirements for the seedling planting process. The working parts of imported transplanters do not always match the physical and mechanical properties of the soil in which vegetables are to be grown. The consequence of that is significant wear of the working bodies of seeders or breakdowns associated with machine failure in the field during work [9, 10, 11].

Studying the fundamental problems of seedling planting technology is an important task in improving the design of seedling planting machines. The main problems with mechanization of the planting process are the low operating speed of seedling planting machines and the poor quality of seedling planting [13, 14]. The stability of planting depth is one of the most critical agronomic parameters, directly affecting the seedling survival rate, uniformity of development, and yield of agricultural crops grown from seedlings.

Traditional transplanting machines using mechanical contour following systems demonstrate insufficient accuracy, especially when operating at high speeds and on heterogeneous soils [6, 13, 15]. Deviations from the specified optimal depth exceeding +/- 5-10 mm can lead to significant yield losses and a decrease in the economic efficiency of production [16, 17].

Uneven planting depth leads to a number of negative consequences, such as [15, 18]:

- too shallow planting, which leaves the root system vulnerable to drying out and temperature fluctuations, which reduces the survival rate of seedlings;

- planting too deep, causing root collar rot (hypoxia) and weakening plants;
- uneven plant development due to uneven start of development, leading to competition between plants and a decrease in overall field productivity [19].

The aim of the study is to provide a theoretical justification and analysis of the problem of the influence of uneven seedling planting depth on its survival rate.

The work used methods of analyzing scientific literature, mathematical modeling of the dependence of survival on deviation in planting depth, and a comparative analysis of the accuracy characteristics of existing stabilization systems.

The influence of the deviation of the actual planting depth (h_{real}) from the optimal (h_{opt}) on the survival rate (P) can be approximated by a mathematical model based on a normal distribution, where the maximum survival rate is achieved at $\Delta h = 0$ [20].

$$\Delta h = h_{real} - h_{opt} = 0. \tag{1}$$

The model of plant survival depending on the deviation in seedling planting depth is as follows:

$$P(\Delta h) = P_{\max} \cdot e^{-\frac{1}{2}(\frac{\Delta h}{\sigma})} + P_{\min} \tag{2}$$

where: $P(\Delta h)$ – survival rate in case of deviation Δh, %;
P_{max} – maximum survival rate (e.g. 98%);
P_{min} – minimal survival rate (for example, 2%);
Δh – deviation from optimal depth, mm;
σ – standard deviation characterizing the sensitivity of the culture to changes in depth.

Table 1.

The effect of planting depth deviation on seedling survival rate

Deviation from optimal depth Δh, mm	Seedling survival rate P, %	Decreased survival rate ΔP, %
±5	97.5	0.5
±10	95.0	3.0
±15	90.0	8.0
±20	80.0	18.0
±30	65.0	33.0

Analysis of the data from Table 1 shows that with the typical accuracy of mechanical systems (+/- 10-15 mm), survival losses can reach 8%. Increasing the deviation to +/- 20 mm, which often occurs on heterogeneous soils, leads to a drop in survival of 18% or more. This directly reduces potential yields and increases the costs of subsequent care.

To maintain the set planting depth, transplanting machines use stabilization systems based on parallelogram suspension [21], including:

1) Mechanical systems;
2) Hydraulic systems.

Disadvantages of mechanical systems include high inertia and passive control. Typical accuracy is +/- 10-15 mm, which is insufficient to minimize survival losses.

Disadvantages of hydraulic systems [22]:

a) Force is regulated, not precise vertical position;
b) Positioning accuracy is limited by valve sensitivity and fluid compressibility;
c) Typical accuracy in the range of +/- 5-10 mm, which still does not allow to completely eliminate the negative influence of depth unevenness.

Table 2.

Comparative analysis of the accuracy of landing depth stabilization Systems

System type	Mechanism regulation	Typical accuracy of depth maintenance, mm
Mechanical	Passive copying	+/- 10 - 15
Hydraulic	Active force control	+/- 5 - 10

The insufficient accuracy of existing stabilization systems (Table 2) results in a significant portion of seedlings being planted with deviations exceeding the critical 10 mm (Table 1). Increasing the accuracy of existing stabilization systems will improve survival. Reducing the standard deviation σ in formula 1 to 2-3 mm will virtually eliminate seedlings from falling into the critical deviation zone, which is predicted to increase survival rate by 10-20%.

This creates an urgent need to develop and implement systems that can ensure the accuracy of maintaining the planting depth within +/- 1-2 mm.

Conclusions

1. Increasing the accuracy of existing stabilization systems will improve survival. Reducing the standard deviation σ in formula 1 to 2-3 mm will virtually eliminate seedlings from falling into the critical deviation zone, which is predicted to increase survival rate by 10-20%.

2. Reducing uneven planting depth ensures that all plants begin to develop at the same time, which is the basis for obtaining a high and uniform yield.

3. A key task of modern agricultural engineering is the transition from systems that regulate the pressing force from the pressing wheels of seedling planting machines to systems that provide high-precision positional regulation of planting depth.

References

1. MELNIC, IU., MELNIC, A., BADIUL, V. Vegetable growing: study of mechanized planting seedlings. In: *Proceedings of the XIV International Scientific and Practical Conference "Problems of design, development and operation of agricultural technology", November 8-10, 2023. Kropyvnytskyi: CNTU, 2023. (Ukraine)*
2. In Moldova, the area for growing vegetables has decreased threefold. Moldavskiye Vedomosti. Nr. 41 (2420), 2024. https://nubip.edu.ua/node/137127
3. MELNIC, IU., CORONOVSCHI, A., CEBAN R., MELNIC, A. The research of the rain intensity adaptation to the conditions of hydrophysical characteristics of the soil for ecological and economical improvement of the irrigative equipment. *VII International Scientific Conference "Conserving soils and water"*

Burgas, Bulgaria, 28-31 august 2019. In: *International Scientific Journal "Mechanization in agriculture & Conserving of the resources", nr.6.* 2019. pp.207-208, ISSN print 2603-3712, ISSN web 2603-3704. http://www.evedomosti.md/news/v-moldove-ploshadi-dlya-vyrashivaniya-ovoshej-sokratilis-vtr

4. ȚENU, I., MELNIC, IU., ROȘCA, R,, CÂRLESCU, P. Research on the impact of tillage operations for autumn wheat crop set up over some soil properties. In: *Ştiinţa agricolă, nr.2.* Chişinău: UASM, 2018, pp.122-127, ISSN 1857-0003. https://stumejournals.com/journals/am/2019/6/207

5. SZYMANEK, M., TANAS, V., MELNIC, IU. Sweetcorn grain production technology. In: *International Scientific Journal "Mechanization in agriculture & Conserving of the resources", Issue 1, 2025. pp.3-5.* ISSN print 2603-3704, ISSN web 2603-3712. https://press.utm.md/index.php/as/issue/view/2018-2/full-issue

6. MELNIC, IU., SCLEAR, P. Theoretical research of tractive resistance of rotary type seeders. VII International Scientific Congress "Agromachinery" Burgas, 26-29 june 2019. In: International Scientific Journal "Mechanization in agriculture & Conserving of the resources", nr.3. 2019, pp.85-87, ISSN print 2603-3704, ISSN web 2603-3712. http://www.agrimachinery.net/programa.pdf

7. MELNIC, IU., BADIUL, V., MELNIC, V., CĂTANĂ, M. Study of the technological process of operation of transplanting machines. *XII International Scientific and Technical Congress "AGRICULTURAL MASHINERY" 26.06-29.06 2024, Varna, Bulgaria.* In: International Scientific Journal "Mechanization in agriculture & Conserving of the resources", Issue 2, 2024. pp.30-32. ISSN print 2603-3704, ISSN web 2603-3712. https://stumejournals.com/journals/am/2019/3/85

8. СЕРБИН, В., МЕЛЬНИК, Ю., ЛЫСЫЙ, Р. Экспериментальные исследования транспортирования семян к заделывающим органам. В: Design, production and operation of agricultural machines. All-state interdepartmental scientific and technical collection. Issue 47, part I. Kropyvnytskyi: TsNTU, 2017. pp. 211-220. ISSN 2414-3820. https://stumejournals.com/journals/am/2024/2/30

9. MIHOV, M., MELNIC, IU. Correction of the inter-repair period of aggregates /nodes /of the machines. *International Scientific Journal "Mechanization in agriculture & Conserving of the resources", Issue 2, 2024. pp.56-57.* ISSN print 2603-3704, ISSN web 2603-3712. https://press.utm.md/index.php/as/issue/view/2016-2/full-issue

10. MUNTEANU, C., MELNIC, IU., ISTRATE, B., LUPU, F., VIȘANU, V., BADIUL, V., ZÎRNESCU, C. Study of harrow discs coated by plasma-thermal method. In: *International Scientific Journal "Mechanization in agriculture & Conserving of the resources", Issue 2, 2025. pp.46-48.* ISSN print 2603-3704, ISSN web 2603-3712. https://stumejournals.com/journals/am/2024/2/56

11. MELNIC, IU., MELNIC, V. Mathematical modeling of the operating system of the carousel type transplanting machine. *III International Scientific Conference "Mathematical modeling", Borovets, Bulgaria, 11-14 decembre 2019.* In: *International Scientific Journal "Mathematical modeling", Vol.3, Issue 4.* 2019. pp.124-126, Print ISSN 2535-0986, Web ISSN 2603-2929. https://stumejournals.com/am.htm

12. MELNIC, IU. Повышение рабочей скорости движения рассадопосадочного агрегата. In: Design, production and operation of agricultural machinery. Collection of scientific papers, issue 39. - Kirovograd, 2009. - pp. 356-362. https://stumejournals.com/journals/mm/2019/4/124

13. MELNIC, IU., BUMACOV, V. Seedling planting machine. Patent no. 2371 of 29.02.2004. - Chisinau: BOPI no. 2/2004.

14. IVANOV, P. The influence of seed and seedling placement accuracy on the yield of row crops // Bulletin of Agrarian Science. 2022. No. 3. pp. 45-52.

15. PETROV, A. Precision farming technologies in vegetable growing: review and prospects // Agricultural machinery and technologies. 2023. Vol. 17. No. 1. pp. 12-20.

16. SIDOROV, K. Analysis of the designs of transplanting machines for vegetable crops In: News of higher educational institutions. Series: Technology and equipment of the agro-industrial complex. 2021. No. 5. pp. 78-85.

17. NIKOLAEV, E. Justification of optimal parameters for planting vegetable seedlings In: Agrophysics. 2019. Vol. 15. No. 2. pp. 91-98.

18. ZAKHAROV, R. Dynamics of operation of tillage implements at high speeds. In: Agroinzheneriya. 2022. No. 4. P. 60-67.

19. Talia Humphries, Bhagirath S. Chauhan, Singarayer K. Florentine. Environmental factors effecting thegermination and seedling emergence of twopopulations of an aggressive agriculturalweed; Nassella trichotoma. PLOS One, July 2018, 13(7):e0199491 DOI:10.1371/journal.pone.0199491

20. KOVALEV, D. Calculation and optimization of the parameters of the parallelogram suspension of working bodies of agricultural machines // Tractors and agricultural machinery. 2020. No. 10. P. 33-38.

21. SMIRNOV, V. Hydraulic systems for active control of downforce in seeding equipment // Hydraulics and Pneumatics. 2021. No. 1. pp. 15-22.