УДК 631.331.5:631.43
DOI: 10.37128/2520-6168-2020-2-4

JUSTIFICATION OF THE METHOD AND DEVICE FOR TREATMENT AND SOWING OF SUGAR BEETS AND THE APPLICATION OF THE RESULTS IN PREPARATION TECHNOLOGIES

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The article describes advanced technological processes of pre-sowing of soil and sowing of sugar beet, which positively influences innovative development of beet-growing and scientific-practical project preparation of future specialists in agro-engineering in higher education institutions. In order to increase the field germination of seeds and to ensure the uniform placement of plants in rows, as well as to reduce the cost of growing sugar beets for pre-sowing soil and sowing, a new method is proposed and a device for pre-sowing tillage in the row area is developed. This method ensures that the topsoil is loosened and compacted while sowing the seed only in the row area without loosening it in the row spacing with successively positioned rotating working bodies, planar paws and rolls.

According to the results of the researches, an approximate model of the optimal composition of the top soil layer in the aisles and in the row area by its fractional composition and density was developed, the parameters of the working bodies for the pre-sowing tillage were grounded. Initial data were also obtained and initial agrotechnical requirements for the unit for pre-sowing soil and sowing beet seeds were developed. Application of technological process with optimally grounded parameters of strip pre-sowing tillage in the area of rows and sowing of seeds in one pass of the unit and technical means for its execution gives the opportunity to qualitatively prepare the soil with formation of the most favorable fractional composition for seed germination. This increases the field germination of seeds and the uniform distribution of plants in rows, reducing the cost of fuel and direct operating costs of growing sugar beets.

The results of the research can be used to improve and optimize zonal technologies and facilities for growing sugar beets, as well as in the educational process and scientific activities of students.

Key words: *sugar beets, seeds, soil, pre-sowing, density, field germination.*

F. 2. Fig. 2. Table. 1. Ref. 11.

1. Problem statement

Scientists and agricultural experts around the world express serious concern about the decline in soil fertility, the development of wind and water erosion, which threatens the food security of the world's population [4]. To a certain extent, this is due to the lack of scientifically based farming systems, including the inappropriate choice of technology, complexes of machines and inventory for tillage in specific conditions. The main factors that determine crop yields include soil cultivation, fertilizing, sowing, crop production and plant protection [1, 4].

Differentiated processing, which depends on the type of soil and crop, contributes to a significant reduction in human and energy costs. The use of machines with active working bodies for fine treatment of clay soils before sowing or at the same time leads to soil dispersal, crusting and worsening of the water-air regime. An important factor, especially for such row crops as corn, soybeans, sorghum, sunflowers, sugar beets, etc., is the uniform distribution of seeds in the row, primarily for technologies with minimal or zero tillage and with the presence of a large number of plant residues on the field surface or in the top layer. This leads to increased requirements for precision seeders to ensure the input of seeds to the required depth while maintaining stubble on the surface [4].

Improving the existing methods of sowing and technical means of precision sowing will reduce the seeding rate by more than two times. By creating optimal conditions for seed germination and plant development, this will increase crop yields by 10 ... 15% [10]. Thus, the justification of the method of sowing in various agroclimatic zones and the search of ways to increase crop yields is of great importance, and therefore requires in-depth study and research [10].

Concerning sugar beets, it is worth noting that this crop is the main sugar crop in Ukraine. Existing technologies and modern technical means used for growing sugar beets do not provide the required quality of technological processes. Poor preparation of the soil and sowing determine an increase in the rate of sowing seeds, sparse sowing, inefficient use of fertilizers, a decrease in yield and losses in the harvesting of sugar beet root crops, which leads to significant costs for their production. In this regard, the development of new and improvement of existing technological processes for pre-sowing tillage and sowing of sugar beet seeds is an urgent problem of great scientific and practical importance.

2. Analysis of recent research and publications

A study of scientists and industrialists from Australia, Italy, the United States, Ukraine and other countries of the world showed that the geometric parameters of the working bodies of tillage machines can be optimized for minimal traction, energy usage and other categories using mathematical models, as well as electronic computers [4].

In the technological processes of pre-sowing tillage and sowing, it should take into account the mechanical-technological properties of the main objects with which the working bodies of agricultural machines interact – soil [3], seeds, mineral fertilizers, plant residues etc.

The quality of preparation of the seed canal has a great influence on the quality and simultaneity of seed germination, plant growth and development, the formation of high crop yields in various soil and climatic zones. According to the research results of L. Henrikson from Sweden, optimization of rational parameters of the seed canal is important for the simultaneous germination of seeds for many reasons and criteria. Several factors should be taken into account, including the fact that in the spring, moisture evaporation is high, and the amount of precipitation is often small and insufficient. Careful preparation of the seed canal is necessary with limited moisture reserves in clay, sandy and other soils. Such a maximally effective seed canal can be formed under the condition of a combination of pre-sowing tillage and sowing. The practice of growing sugar beets shows that many factors affect the germination of seeds, the further growth and development of plants. For example, differences in the design of the harrows, such as mass, shape and size of teeth, the distance between them, the width of the sections affect the quality of soil preparation for sowing, the formation of the seed channel and the optimal gravitational state, and as a result, the uniformity and intensity of plant emergence in the future - and yield [4].

Sinchenko V.N. notes [8] that, considering the need for small-scale input of seeds, a complex of tillage operations should prevent mixing of the upper dried layer with the lower wet layer. The depth of cultivation should be no more than 3 ... 4 cm, which will ensure that the seeds are laid at the bottom of the seed canal, where a high capillarity of the soil is formed with a keeled opener, which will provide sufficient moisture from the lower layers to the seeds for germination. Sinchenko V.N. believes that, among a complex of means of mechanization seedbed preparation that offers the market the most successful is the compactor “LEMKEN»” firms [8].

The agrophysical properties of root crops and sugar beet productivity significantly depend on the density and uniformity of plant distribution over the field area [2]. Studies have established that with an increase in plant density, due to an increase in the number of substandard root crops, their losses during harvesting increase. Moreover, with an increase in the uniformity of beet placement over the area, their loss during harvesting decreases [2, 5].

3. Purpose of the research

The aim of the research is to optimize the parameters of the working bodies of machines for pre-sowing tillage and sowing seeds of sugar beet based on the methods of mathematical analysis of experimental data from the proposed method and the developed device to ensure the implementation of an innovative technological process.

4. Results of the research

To increase the field germination of seeds and, in connection with this, to increase the uniformity of plant placement in rows, as well as to reduce the cost of growing sugar beets, a device for presowing tillage and sowing has been developed, the principle of which is described in [6].

According to an integrated approach to solving the scientific and industrial problem of preparing the soil for sowing sugar beets, studies were conducted to study the scientific and technical features of the design of disk tools for innovative technologies for the production of sugar beets as a methodological component in the formation of professional competencies of agricultural engineers [11].

Also, according to the program of scientific research data, a method for pre-sowing tillage in the zone of rows of sugar beets has been proposed [9]. During sowing, this method provides loosening and compaction of the top soil layer only in the row zone (without loosening it in the row spacing), which is carried out by successively arranged needle-type rotary working bodies, which are flattened by paws and rollers (Fig. 1).

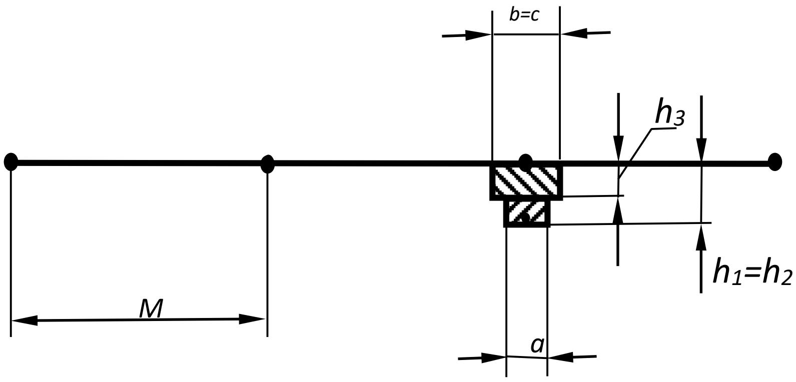

Fig. 1. Scheme of pre-sowing soil in the row area

The width of the strip of the topsoil in the area of the row, which is loosened and crushed by a needle rotary working body (b, cm) and a roll (c, cm), is 0.2… 0.3 row spacing (M, cm), greater than 1, 5 times the width of the strip, which is loosened by a planar paw (a, cm), and is determined by the ratio

$$b = c = 1{,}5\ a = (0{,}2\ldots0{,}3)\ M. \qquad (1)$$

Depth of loosening of the soil in the row area with a needle rotary working body (h3, cm) is determined depending on the set optimum depth of wrapping of seeds (h1, cm) and depth of loosening of the soil with a planer paw (h2, cm) according to the formula

$$h3 = (0{,}5\ldots1{,}0\ )\ h2 = (0{,}5\ldots1{,}0)\ h1. \qquad (2)$$

Thus, at widths between rows 30 cm and 45 cm, the width of loosening and grinding of soil in the row area with a needle rotary working body and a roll is 6.0… 9.0 cm and 9.0… 13.5 cm, respectively, and the width of loosening the soil with a planer paw is 4.0… 6.0 cm and 6.0… 9.0 cm, respectively.

At a depth of seed wrapping of 3 cm, the depth of loosening of the soil with a planer paw is 3 cm, and the depth of loosening of the soil with a needle rotary working body is 1.5… 3 cm.

Based on the results of theoretical and experimental studies on the determination of operating conditions of technical means and performance indicators of technological processes of pre-sowing soil cultivation and sowing of seeds in different ways of basic tillage (conventional plowing, planning, surface cultivation), a rational design and manufacturing scheme was developed and a sample device of the seed drill for pre-sowing soil in row area was developed. The use of such a device ensures loosening, covering and compacting of the topsoil during the sowing of the seed only in the row area (without loosening it in the row spacing) with needle rotary working bodies, planar paws and rolls placed in series in front of the seed drill.

According to the results of studies on the use of a sowing unit equipped with needle rotating working bodies sequentially located in front of the seeders of the seeder, with flat-horizontal paws and rollers for the strip method of pre-sowing soil cultivation it was found that it provides an increase in the number of agrotechnical useful soil particles in the row area up to 10 mm (Table. 1).

After the passage of the research unit, the mass fraction of agrotechnical useful soil particles increased by 37.5% compared with their share in the passage of the unit and by 21.4% compared with the mass fraction after the passage of the combined tillage unit of serial production, and the mass fraction of lumps of size 10...20 mm decreased respectively by 15.9% and by 14.1%.

Based on the results of laboratory studies, it was found that for better germination of sugar beet seeds, the mass fraction of soil particles with a size of 0.26...10 mm in the area of its incorporation should be at least 90%, the offspring – at least 75%, and under the seeds – solid seed bed (not loose soil). The soil density ρ in the seed placement layer and in the upper-seed layer should be 1.0…1.2 g / cm^3, in the under-seed layer – 1.2… 1.3 g / cm^3. Soil moisture in the seed wrapping zone should be 20%. The thickness of the lower soil layer h, which is additionally crushed, should be about 0.25 of the depth of pre-sowing cultivation of soil H. In the upper soil layer (with a thickness equal to the depth of seeding), the row-spacing zones should be 95% by weight of soil particles up to 30 mm in size, and 80% - up to 20 mm in size. The soil density should be 1.1...1.3 g / cm^3, which is ensured by early spring tillage without carrying out its pre-sowing treatment.

Table 1

The influence of methods of pre-sowing soil on its fractional composition and density and field germination of seeds

Indicators	Mass fraction (%) in the loosened layer of soil particles, mm:				Density of the soil, g/cm3	Field germination of seeds, %
	up to 10	10…20	20…30	30 and more		
Before the passage of units	42,6	35,8	18,4	3,2	1,2…1,3	–
In the row area after the passage of the combined tillage unit	58,7	34,0	7,3	0	1,1…1,2	79,1
In the row area after passing the experimental unit	80,1	19,9	0	0	1,0…1,2	88,7

Based on the results of the research, an indicative model of the optimal composition of the upper soil layer in the row spacing and row area according to its fractional composition and density was developed (Fig. 2). The parameters of the working bodies for pre-sowing soil cultivation have been justified, the initial data have been obtained and the initial requirements for an aggregate for pre-sowing soil cultivation and sowing beet seeds have been developed.

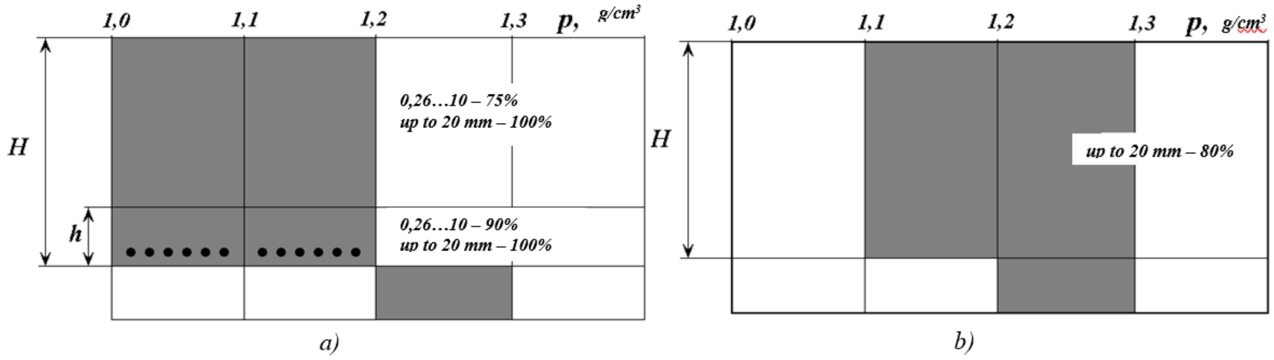

Fig. 2. Indicative model of the topsoil for sowing sugar beet seeds: – in the row area; b) – in the row spacing; H – the thickness of the loosened soil layer to the depth of seeding, cm; h – thickness of additionally loosened soil layer, cm; ρ – soil density, g/cm^3.

The obtained results can be used both in scientific-industrial and in educational-pedagogical activity.

5. Conclusions

The use of an optimized technological process of strip pre-sowing tillage in the row zone and sowing seeds in one pass of the unit and the technical means for its implementation makes it possible to qualitatively prepare the soil with the formation of the most favorable fractional composition for seed germination, and provides an increase in field germination of seeds by 8 - 20% (up to 90%), uniform distribution of plants in rows (from 53.4 ... 62.1 to 44.8 ... 51.3% in terms of variation coefficient), reduction in direct operating costs of funds for testing Eating pre-sowing tillage and sowing beet seeds 1.3 times, fuel consumption - 20%.

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ОБҐРУНТУВАННЯ СПОСОБУ І ПРИСТРОЮ ДЛЯ ОБРОБІТКУ ҐРУНТУ ТА СІВБИ ЦУКРОВИХ БУРЯКІВ Й ЗАСТОСУВАННЯ РЕЗУЛЬТАТІВ У ТЕХНОЛОГІЯХ ПІДГОТОВКИ АГРОІНЖЕНЕРІВ

У статті викладено удосконалені технологічні процеси передпосівного обробітку ґрунту та сівби цукрових буряків, що позитивно впливає на інноваційний розвиток буряківництва та науково-практичну проектну підготовку майбутніх фахівців з агроінженерії у закладах вищої освіти. З метою підвищення польової схожості насіння і забезпечення рівномірності розміщення рослин у рядках, а також для зменшення витрат на вирощування цукрових буряків для передпосівного обробітку ґрунту та сівби запропоновано новий спосіб і розроблено пристрій передпосівного обробітку ґрунту в зоні рядків. Цей спосіб забезпечує розпушування та ущільнення верхнього шару ґрунту під час сівби насіння лише в зоні рядків без розпушування його в зоні міжрядь послідовно розміщеними голчатими ротаційними робочими органами, плоскорізальними лапами та котками.

За результатами досліджень розроблена орієнтовна модель оптимального складу верхнього шару ґрунту в міжряддях і в зоні рядків за його фракційним складом і щільністю, обґрунтовано параметри робочих органів для проведення передпосівного обробітку ґрунту. Також отримано вихідні дані та розроблено вихідні агротехнічні вимоги до агрегату для передпосівного обробітку ґрунту і сівби насіння буряків. Застосування технологічного процесу з оптимально обґрунтованими параметрами смугового передпосівного обробітку ґрунту в зоні рядків і сівби насіння за один прохід агрегату та технічного засобу для його виконання дає можливість якісно підготувати ґрунт із формуванням найбільш сприятливого фракційного складу для проростання насіння. Це забезпечує підвищення польової схожості насіння та рівномірності розміщення рослин у рядках, зменшення витрат пального і прямих експлуатаційних витрат коштів на вирощування цукрових буряків.

Результати досліджень можуть бути використані для удосконалення та оптимізації зональних технологій і технічних засобів для вирощування цукрових буряків, а також у навчальному процесі та науковій діяльності студентів.

Ключові слова: *цукрові буряки, насіння, ґрунт, передпосівний обробіток, щільність, польова схожість.*
Ф. 2. Рис. 2. Табл. 1. Літ. 11.

ОБОСНОВАНИЕ СПОСОБА И УСТРОЙСТВА ДЛЯ ОБРАБОТКИ ПОЧВЫ С ОДНОВРЕМЕННЫМ ПОСЕВОМ САХАРНОЙ СВЕКЛЫ И ПРИМЕНЕНИЕ ПОЛУЧЕННЫХ РЕЗУЛЬТАТОВ В ТЕХНОЛОГИЯХ ПОДГОТОВКИ АГРОИНЖЕНЕРОВ

В статье изложены усовершенствованные технологические процессы предпосевной обработки почвы и посева сахарной свеклы, что положительно влияет на инновационное развитие свекловодства и научно-практическую проектную подготовку будущих специалистов с агроинженерии в учреждениях высшего образования. С целью повышения полевой всхожести семян и обеспечения равномерности размещения растений в рядках, а также для уменьшения затрат на выращивание сахарной свеклы для предпосевной обработки почвы и посева предложен новый способ и разработано устройство предпосевной обработки почвы в зоне рядков. Этот способ обеспечивает рыхление и уплотнение верхнего слоя почвы во время сева семян только в зоне рядков, без рыхления его в зоне междурядий, последовательно расположенными игольчатыми ротационными рабочими органами, плоскорезными лапами и катками.

По результатам исследований разработана ориентировочная модель оптимального состава верхнего слоя почвы в междурядьях и в зоне рядков за его фракционным составом и плотностью, обоснованно параметры рабочих органов для проведения предпосевной обработки почвы. Также получены исходные данные и разработаны агротехнические требования к агрегату для предпосевной обработки почвы и посева семян свеклы. Применение технологического процесса с оптимально обоснованными параметрами полосовой предпосевной обработки почвы в зоне рядков и посева семян за один проход агрегата и технического средства для его выполнения дает возможность качественно подготовить почву с формированием наиболее благоприятного фракционного состава для прорастания семян. Это обеспечивает повышение полевой всхожести семян и равномерности размещения растений в рядках, уменьшение расхода топлива и прямых эксплуатационных расходов средств на выращивание сахарной свеклы. Результаты исследований могут быть использованы для усовершенствования и оптимизации зональных технологий и технических средств для выращивания сахарной свеклы, а также в учебном процессе при подготовке будущих агроинженеров до инновационной проектной деятельности.

Ключевые слова: *сахарная свекла, семена, почва, предпосевная обработка, плотность, полевая всхожесть.*
Ф. 2. Рис. 2. Табл. 1. Лит. 11.

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