INNOVATION APPROACHES TO OPTIMIZE THE DRILLING PROCESS

ИНОВАТИВНИ ПОДХОДИ ЗА ОПТИМИЗИРАНЕ НА СЕИТБАТА

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Abstract: *Sowing is the most important of all technological processes and has a serious impact on yields. Failure to observe the basic agro-technical requirements, such as optimum sowing time, proper soil preparation, sowing, sowing depth, etc., leads to irreversible losses. The seed drill, which is a modified version of a factory-made drill for punched wide-row sowing in paired rows. It is part of a machine system used to implement innovative technology in which traditional surface treatment machines are not needed. This requires that a cultivator section be included in its device to prepare the soil at the same time as sowing. Turning the seed drill into a combined machine requires it to check its performance. The inspection was carried out by examining the degree of crushing of the layer, the alignment of the profile of the treated strip and the deviation from the set depth of sowing. Each of these metrics is considered as an optimization parameter involved in three single factor experiments with a single controllable factor in them - machine speed (x).*

Keywords: Sowing, drilling machine, process, cultivation section

Увод

Sowing is the most important technological process and a basic prerequisite for efficient agricultural production [5, 8, 9, 10, 14, 21].

Permanent yields can only be obtained by growing high-productive, benign and resistant to unfavorable external conditions and various diseases and pests [1, 2, 3, 4].

Sowing and sowing seed drilling activities are inextricably linked. Pre-cultivated soil cultivation must comply with the requirements of individual crop types such as:

- for winter crops to reach optimal sizes of soil aggregates, incl. No aggregates larger than 30 mm in the soil, well littered, sufficiently moistened or dry, but not with "colorful" moisture;
- for the spring, the last loosening should be done immediately before sowing and at a depth equal to the seed depth.

Otherwise, in both cases no qualitative sowing can be done, [33, 34, 35, 43, 44, 45].

Timely sowing of agricultural crops is of great importance for the use of soil water both for seed germination and for the rapid development of the root system and the whole plant. It contributes to the proper use of the entire complex of vegetation conditions on which yields depend, [6, 15, 36, 37].

Normally, in early autumn sowing, the plants have enough heat but suffer from water shortages in the soil, and in early spring sowing, on the contrary, the seeds fall on damp, but cold soil and can not rise, [41,42]. Late-sown autumn crops have enough moisture to swell, but often lack the necessary heat to seed germination, and late-spring shoots do not germinate or grow irregularly due to the sharp decrease in soil moisture [37, 38, 39, 40].

Therefore, the best results are the timely sowing, ie the sowing done in such terms, which provide both water and heat and are consistent with the whole complex of vegetation conditions.

Sowing aggregates are complex dynamic systems with a significant number of degrees of freedom [7, 10, 12]. These degrees of freedom meet a number of limitations imposed by the external effects on the seed drill, Z (t), V (t), H (t), Q (t), Y (t). When working in such an environment, seed drills are required to cover certain qualitative and quantitative indicators to be considered as its output streams, Fig. 1. The technology operator is essential and depends on the extent to which the random nature of inputs in the model will be passed on to outgoing flows (ie quantitative and qualitative indicators). This depends, on the one hand, on the capacity of the technology operator (W) on the machine and on the other on on the state of the incoming flows [17, 18, 19].

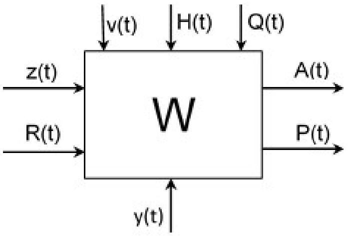

Fig.1. Information model of seeding machine: W - technological operator; z (t), R (t), v (t), H (t) Q (t) and y (t) A (t) - quality indicators; P (t) - quantitative indicators.

Operator W's capabilities are determined by the level of technical solutions and operating principles set in the design engineer. The state of the input streams is predestined by the way they are managed even before they enter the seed drill. In functional terms, the sowing machine can be divided into elementary units, which repeat uniquely to obtain the desired working width (Figure 2), [7, 11, 20, 25, 26]. According to the functional scheme, the operation of the operator W is the result of the transfer of consecutive information flows between the individual units supplemented by internal feedback links. The information interactions between the elementary elements in the functional scheme of the seed drill can be represented in the following dependencies:

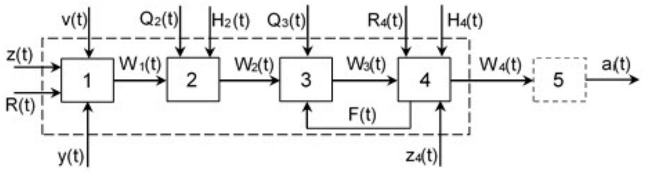

Fig.2. Functional scheme of the seeder:

1-frame; 2 - sowing apparatus; 3 - a conduit; 4 - boot; 5 – soil

$$W_1(t) = \emptyset_1[Z(t), R(t), V(t), y(t)] \qquad (1)$$

where W_1(t) is the technological result of the first unit;

Z(t) – the vector characterizing the field profile;

R(t) – the vector characterizing the soil resistance;

V(t) – the vector that characterizes the motion of the seed drill;

y(t) – the vector characterizing the machine / tractor unit (MTA) .

$$W_2(t) = \emptyset_2[Q_1(t), H_2(t), Q_2(t) \qquad (2)$$

Where W_2(t) is the technological result of thesecond unit;

H_2(t) – the vector of the adjustment effects on the unit 2;

Q_2(t) – The vector characterizing the external effects of biological objects (plant residues, etc.);

$$W_3(t) = \emptyset_3[Q_2(t), Q_3(t), F(t)]$$

(3)

където $W_3(t)$ is the technological result of the third unit;

$Q_3(t) -$ The vector characterizing external effects of biological nature;

F(t) – The vector characterizing the interfering action of the unit 4 on the unit 3.

$$W_4(t) = \emptyset_4[Q_3(t), R_4(t), Z_4(t), H_4(t)] \quad (4)$$

where $W_4(t)$ is the technological result of the fourth unit;

$H_4(t)$- The vector characterizing the adjustment effects on the unit 4;

$Z_4(t)$- The vector characterizing the field profile on the verge 4.

$P_4(t)$- The vector characterizing the impact of soil resistance on unit 4.

$$a_i(t) = \emptyset_i[Q_4(t)] \quad (5)$$

where $a_i(t)$ is a one-dimensional vector, characterizing a particular technological feature of the sowing machine;

$Q_4(t)$ – The vector that characterizes the external effects of a biological nature.

A characteristic feature of chains with sequential connections is that the denial of one element leads to a denial of the whole system. Also, the significant deviations in the technological result W(t) of one unit cause progressive changes in the technological result of the next units. In some cases, deviations occurring can be compensated by the presence of appropriate feedback links between the units. In other cases, these deviations can bring out the entire system of equilibrium and thus interrupt the normal technological process.

If an association is made and the elementary fluxes flowing out of each unit are treated as electric current, and external impacts are seen as resistances on the unit itself, it can be concluded that the equivalent impact of random external flows will have an additive character. Excessive impact of external flows on a link in a chain may cause a severe drop in the machine and operating circuit diagram and may interrupt indefinitely.

Therefore, the more complex and longer the chain of units, the stronger the influence of random processes on the sowing process.

According to the information model of sowing machines, the improvement of the sowing process should be sought in two other mutually opposite directions [22,23,24]. The first one is aimed at complicating the functional scheme of the machine, which aims at reducing the influence of external influences and building many internal relations between the elementary units. Typical representatives in this area are the combined sowing aggregates.

The second, less popular trend is related to the construction of a short circuit circuit of elementary units. By removing a link or links to the chain, external influences are also eliminated. This reduces the impact of their external impacts, thus weakening the cumulative impact of random processes on the seed drill's technological parameters.

The pursuit of seed drills with similar "simplified" schemes requires the application of principally new functional and technical solutions [22].

Generally, in classical sowing, weed seeds present in the soil have a number of advantages such as: - falling into the soil in large quantities and at a favorable moment for them; - successfully pass the acclimatization stage; - take up enough water; - wait for optimum soil temperature to be reached and germinate in optimal conditions. On average, on 1 m2 of arable land there are about 50000 weed seeds, against 8-10 seeds of cultivated plants, fig. 3.

From the point of view of improving process processes in drought conditions and changing climates, it is important to note that weeds are the main competitors of crop plants for the use of water, nutrients and light [3].

The method for accurate sowing of seed crops by fixing them to biodegradable bands and subsequent laying in the soil is characterized in that the seeds are pre-placed on the biodegradable bands according to the technology of production at a predetermined distance, 21, 22]. Where necessary, nutrients and / or protective equipment may be required for the initial and most critical period of their development. Strips are made in stationary conditions using seed and / or nutrient fixtures. On the periphery of the strips, data on the length, type and variety of the cultivated crop can be displayed, as well as the distance between the seeds inside the line [22, 23, 32].

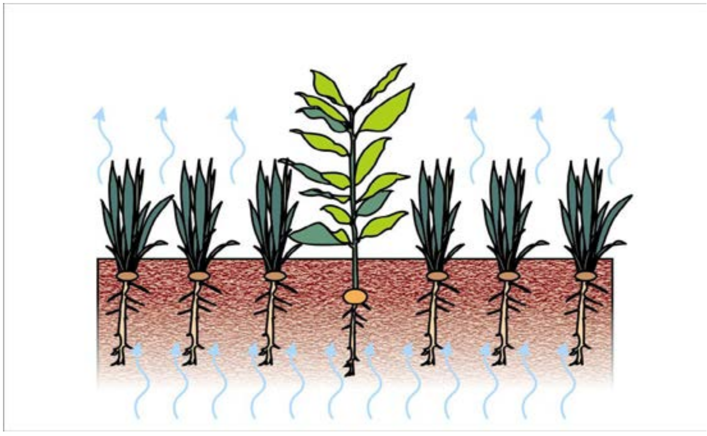

Fig. 3. Principal scheme of distribution of crop and weed seeds in the soil

After the seed has been fixed, the strips are placed in a soil-friendly manner with a length equal to the length of the sowing areas. The laying of strips with pre-fixed seeds is carried out with a simple type of working bodies.

Advantages

The advantages of the method of accurately sowing seed and vegetable crops by applying soil biodegradable tapes to the soil are that the biodegradable seed strips of the seeds are prepared in stationary conditions using seedling and / During the non-annual periods of the year.

As a result of the pre-preparation of the strips and the precise application of the seeds, the maximum quality of the sowing is achieved, as well as the saving of the seeds. The technical solution for tape layout allows sowing of a relatively large length of rows, the bands being able to be joined according to the length of the row.

The device is lightweight, easy to fabricate, and is cheaper than conventional seed drills for precise sowing.

Biodegradable bands can be pre-treated and supplemented with nutrients as well as become hygroscopic when reaching a certain soil temperature in the seed area.

In case of small areas and experimental fields it is possible to completely abandon the need to use the classical seed drills for trenches and vegetable crops.

In classical sowing for the protection of weed plants in the row a number of sprinkler structures are used.

Fig. 4. The evaporation of non-productive water from the soil is high.

When using a biodegradable strip, the water that can evaporate from the soil is at a depth equal to the depth of laying of the strip. The biodegradable tape applied to the soil plays the role of an aperture that stops water from the lower layers of the soil, fig. 5. The weed seeds that are found in this soil layer begin to suffer from a water shortage that reaches the point of withering. Their root system stops their growth and they die, fig. 6.

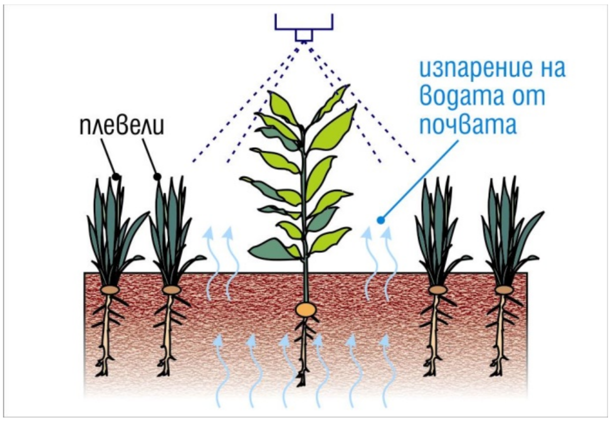

Fig. 4. Destruction of weeds in the order by using herbicides and increasing the rate of evaporation

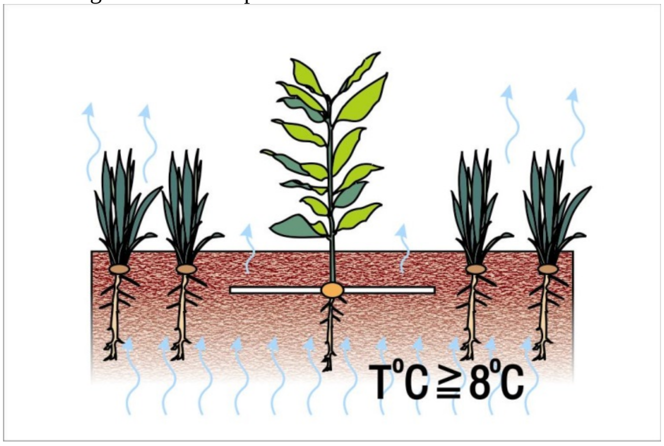

Fig.5. Reducing the evaporation in the row due to limiting the evaporable soil layer

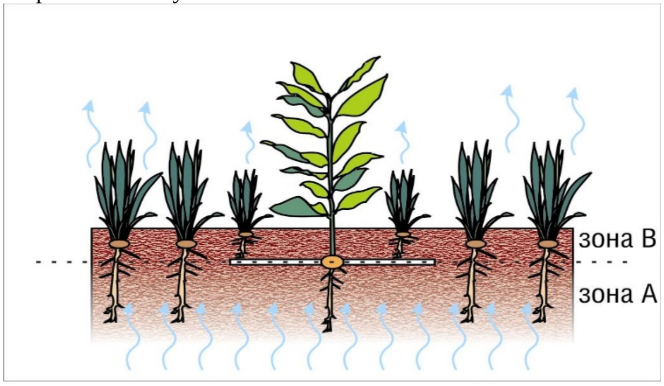

Fig. 6. Biogasable strain placed in the soil stops the growth of weeds within 2 weeks from the time of application

The best seed distribution in the sown area is what gives the emerging plants equal opportunities to use the provided food and climate resources. A prerequisite for this in the first place is to provide the possibility of the root system of plants to develop in a less competitive environment. This is possible if the seeds are placed in rows with spacing equal to $b = r\sqrt{3}$, fig.7. The distance between the rows is equal to $2r$, where r is the radius of the required food zone [9].

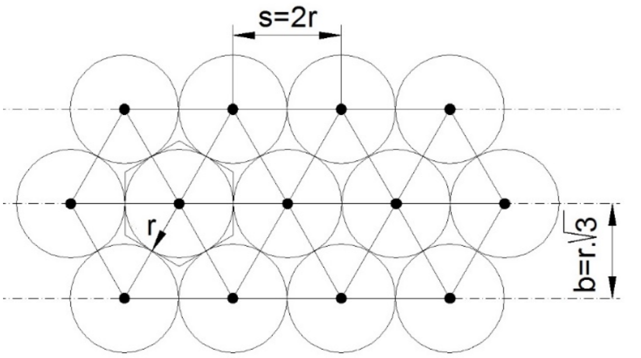

Fig.7. Theoretical distribution of seeds to obtain a level playing field for growth and development

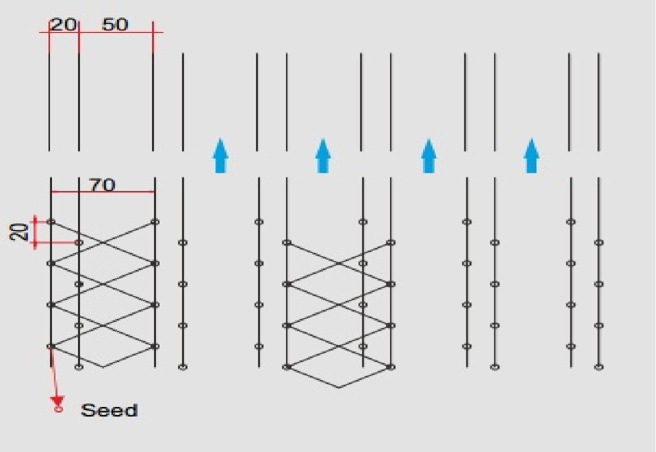

Fig. 8. Scheme of seed application in the soil in paired rows for trenches

The above-described method of sowing is applicable to crops grown on a fused surface. Such are winter cereals and forage crops.

For trenches, this principle is applicable in the following way, fig. 8.

At an intersection distance of 0.70 m, another row is placed, located at 0.20-0.22 m from the main one. Thus, the line spacing remains 0.48-0.50 m. The sowing sections are of a double construction and have the option of stacking the seeds staggered or in parallel. This reduces the distance between plants, hence the competition for light and volume for the development of the root system.

Conclusion

According to the information model of the sowing machines, the improvement of the sowing process must be sought in two other mutually opposite directions. The first one is aimed at complicating the functional scheme of the machine, which aims at reducing the influence of external influences and building many internal relations between the elementary units. Typical representatives in this area are the combined sowing aggregates.

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The pursuit of seed drills with similar "simplified" schemes requires the application of fundamentally new functional and technical solutions.

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