Investigation of seed uniformity under field and laboratory conditions

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Abstract. Seed uniformity in the soil at the appropriate seed depth is achieved when the seeds are at an equal distance from each other. This allows to create equal conditions for obtaining by each plant of the same amount of light, heat, water and nutrients affecting seed germination, sprouting, tillering, stemming, ear formation, earing, flowering and ripeness development. The method of sowing seeds and the selection of tillage and seeding machines are critical for fulfilling the conditions listed above.

At present, depending on soil and climatic conditions, the following methods of sowing grain crops are used: ordinary, narrow-row, cross-sowing, scattered sowing, strip and subsoil-spread sowing.

In world practice, there are other ways of sowing, for example, multi-tiered and combined.

The most common method was the ordinary method of sowing cereals with a row spacing of 12 ... 15, 18, 21 cm. The sowing is performed with the help of disc and tubular openers.

A significant disadvantage of the ordinary method is the uneven distribution of seeds over the nutrition area, which has the shape of an elongated rectangle by the ratio of sides from 1:6 to 1:10. This shape of the nutrition area leads to a dense placement of plants relative to each other, causing strong competition, non-use of the entire area, which leads to a decrease in yield.

To reduce the elongated form of the rectangle of the nutrition area, the narrow-row sowing with a row spacing of 7.5 cm is used, approximating to the shape of the square. When the seeding rate is increased by 10-15%, the greatest effect of this sowing is manifested. The subsequent increase in the seeding rate does not lead to an increase in yield. By reducing the distribution of the row spacing by half, evaporation of moisture and weed infestation with weeds decrease. However, openers for narrow-row seeding have a low operational index due to the fact that close-lying working elements are quickly clogged by adhering soil with high humidity, which leads to a decrease in the quality of sowing and an increase in traction resistance, as a result of which this method was not widely used.

The scattered sowing method is the distribution of seeds over the field surface and by the harrowing. This method is the oldest and is not recommended because of the high probability of drying and destruction of seeds by birds and rodents.

With the development of new soil cultivation technologies (minimal and zero) in areas with a predominantly arid climate, the strip and subsoil-spread sowing methods have become widespread, which are a variation of the scattered method.

For the reduction of technological operations, such methods include simultaneously pre-sowing soil cultivation, sowing and using of mineral fertilizers. As working tools, openers based on the cultivator paw are used. This approach allows to reduce the consumption of fuels, lubricants, and increases labor productivity, soil fertility and protects against water and wind erosion.
With the strip sowing method, each opener distributes the seeds in the subsoil space to a certain strip, thereby forming not sown areas. The disadvantage is the uneven distribution at the nutrition area.

Subsoil-spread sowing method differs from others by seeds distribution in the soil not by rows or bands, but over the entire width caught by the seed machine. Thus, the seeds are regularly distributed throughout the field. Such placement of seeds (plants) creates an optimal nutrition area, density of seed placement, amicability and high field germination, which increases the yield by an average of 10 ... 30% in comparison with the ordinary and narrow-row methods.

Thus, based on the analysis of the methods it is recommended to use subsoil-spread sowing method to obtain the uniformity of seeds and a high yield at low economic costs [1].

To study various parameters that affect the quality of seed distribution in the sub-space, a laboratory installation has been made. The general view and the scheme is shown in figure 1.

The laboratory installation consists of a frame (1), on which a movable belt (2) is installed with the tensioning device, a bunker (3), a reel sowing apparatus (4), a seed drill tube (5). Above the belt is an opener stand with a pointed paw (6), in the sub-space of which is placed the experimental distributor [1, 2]. The belt drive is carried out by means of an asynchronous electric motor (7) with a belt transmission and the possibility of regulating the speed of rotation, by changing the gear ratio with replaceable pulleys. The drive of the seeding machine coil is made with a DC electric motor (8) with a belt transmission and the possibility of regulating the speed of rotation through the rheostat of the rectifier (9). The supply of excess pressure (compressed air) to the seed drill tube is made from the compressor with the receiver (10) through the control valve.

The installation works as follows: before starting the experiment, the necessary quantity of seeds is filled in the bunker, the seeding machine reel is set to the required seeding rate (400-550 pieces / m²), the conveyor belt speed is adjusted by the pulley selection by an interval of 1...2, 5 m/s. A thin layer of a sticky substance is applied to the belt. The required air pressure is set using the tap. The drive of the belt and the coil of the sowing unit can be switched on and off simultaneously through the control panel.

The seeds used in the experiment are fed from the bunker to the seed drill tube by means of a coil seeder, where some distance travels under the influence of gravitational forces, and then they are picked up by the air flow and transported to an experimental distribution device that distributes the seeds throughout the width of the sub-space. Seeds on leaving the seed drill tube are fixed and remain on the surface of the mobile sticky tape, which approximates the pattern of seed distribution to real conditions. On the entire area of the movable belt, registration squares with a size of 5×5 cm are made, which make it possible to reduce the laboriousness of assessing the quality of seed distribution.

To assess the quality of seed distribution in the sub-space, a coefficient of variation was determined by the formula:

\[ v = \frac{\sigma}{x} \times 100\% \]  

(1)
To study subsoil-spread sowing with experimental working organs under real conditions, we conducted field studies [3]. For this purpose, a prototype of an experimental seeder aggregated by a tractor of 0.6-1.4 class was designed and constructed. The experimental seeder is made in a hinged variant for sowing both on a preprocessed agrophone and on stubble.

A hinged experimental seeder (Fig. 2) consists of a frame (1) on which a seed box (2) is mounted, a seeding device (3) driven by a support wheel (4) with soil hooks and the possibility of adjusting the seed depth with a screw mechanism. On the underside of the frame four openers (5) consisting of cultivator paws with a width of 410 mm fixed on the shortened posts are rigidly fixed. As a traction vehicle, the T-25A tractor was used. At the rear of the rack, a seed drill tube (6), an airline (7) and a distributor (8) are mounted. The source of compressed air on the experimental seeder is the receiver (9), mounted on the frame brackets. To regulate the air supply to the pneumatic drive (7), the RPO-5 gear (10) is used. The pressure gauge on the gear has a scale division of 0.02 MPa, which is quite enough for the stepwise setting of air pressure. For stability of the opener stroke, an additional support wheel (11) is installed on the seed drill.

The coil-sowing device of the experimental seeder (figure 3.4) is similar to the sowing machines of grain seeders. The regulation of the seeding rate is carried out according to the frequency of rotation and the length of the working part of the coil. The drive of the seeder is from the chain drive with the ratio \( i = \frac{z_1}{z_2} = \frac{16}{8} = 2 \).

The diameter of the support wheel (4) and the gear ratio are matched in accordance with the parameters of the drive of the base seeding machine “Ob-4-ZT”.

To obtain a comparative analysis, the following main indicators were used: the dynamics of field germination, the uniformity of seed distribution over the field area and the depth of embedding, yield.

The dynamics of field germination was determined from three allocated sites of 1×1 m in size located diagonally at each site.
From the day of the first appearance of young growth, the number of plants was counted at intervals of one day, with the cumulative total to the point when for two to three days the number of young growth remained constant or increased to 1...2 plants.

The obtained data were recorded in the field report, which were compiled in graphs, and the field germination was determined (2)

\[ P = \frac{n_1}{n_2} \times 100\%, \] (2)

where \( n_1 \) is the number of germinated plants, pcs/m\(^2\); \( n_2 \) - the number of seeds actually sown, pcs/m\(^2\).

The seed depth was determined by directly finding the seeds in a row and by etiolated part of the plant, after the appearance of 3...4 leaves or at least 75% of the young growth (figure 3).

![Figure 3. Determination of seed depth and sieving width.](image)

To do this, on the area outside the tractor's trail, the above-ground part of at least 100 plants is cut off. The remaining underground part was excavated, and using a ruler the distance from the place of the plant to the grain was measured. According to the obtained data, the average actual depth of embedding, unevenness, minimum and maximum depth of embedding were calculated.

The width of the sown strip by each opener was determined immediately after sowing and after emergence of the young growth, by measuring in the transverse direction of the distance between the marginal plants relative to the center of the strip with triplicate repetition.

The uniformity of seed distribution was determined after full emergence of the young growth by imposing a 0.5×0.5 m frame on a 0.05×0.05 m square section and counting the number of sites (cells) with plants (figure 4).

![Figure 4. Determination of the uniformity of the plants distribution.](image)

As a result of laboratory and field studies to determine the uniformity of seed distribution by the subsoil-spread sowing method of sowing grain seeds with experimental openers, we obtained graphs of the uniformity of the seeds distribution along the length and width of the sowing strip, which averaged 72...76.8% with the seeds sowing norm of 4...5.5 million pieces/ha. (figure 5).
Figure 5. Dependences of the seeds distribution coefficient along the length of $R_l$ (a) and width $R_w$ (b) of the sowing strip from the seeding rate $N$.

The method used to determine the uniformity of seed distribution makes it possible to determine the most effective opener design for subsoil-spread sowing method of sowing grain seeds, which ensures an improvement in the quality of seed distribution over the width and length of the sowing strip.

Acknowledgments
The work was supported by RFBR, project No 18-416-210001 p_a.

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