Two-Cotton Sowing Soundry of Grain Crops with Different Mineral Fertilizer Level

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Abstract. Opener device and operating principle for double-sow crops of cereals with a multilevel mineral fertilizers application are given. Proposed coulter main parameters are determined, in which mineral fertilizers are located 30...40 mm below main crop seed level and are covered with soil moist layer, which eliminates direct contact of seeds and fertilizers, and, consequently, seedchemical burn.

1. Introduction

Grain crops stable harvesting in modern agricultural production requires resource-saving technologies development and implementation, including a set of measures to optimize arable land use structure, plant protection products use, productive sowing units adapted to the soil and region climatic conditions. Grain crops yield increase largely depends on production intensification by cultivation technology improving [1].

Optimal conditions for plants growth and development depend on sowing method, which in turn is chosen depending on climatic conditions, soil and the correlation of nutrients, seed quality, and cultivated crop requirements in various nutrients.

Qualitative sowing is characterized by two components: seed uniform distribution according to nutrition area and embankment depth; and mineral fertilizers introduction below main crop seeds level.

Attention to seeds uniform distribution by feeding area is explained by increasing yields potential while seeding rate reducing. The germination, development and yields depend on the seed placement quality in the soil. The greatest yield is obtained when plants number is placed on the area so that each of them will be provided with sufficient moisture and nutrients. With the same seed rate, the seeds can be placed differently in the field area, so the same feeding area can have different geometric shapes.

In research course it was established that the circle is the rational area for feeding cereals, and plants rational arrangement along the field area is triangulation (Figure 1), which is characterized by equidistant plants and a row structure with 600 between rows [2].
When these parameters are provided, the seeds are provided in sufficient nutrients supply and do not exert a depressing effect on each other.

Particular attention should be given to sowing fertilization. To achieve the maximum use effect, the following requirements must be observed: embedding optimum depth and spatial placement relative to plants root system, to avoid the contact of fertilizers large doses with seed material, in order to exclude damage to the latter, as well as placement of fertilizers in the upper (drying) layer soil, observe fertilizers uniform distribution according to embedding depth and application area. If these requirements are met, the best shoot density and yield increase are ensured [3].

Most domestic sowing machines make the introduction of the starting dose of fertilizers together with seeds, while the trends of the world development of planting technology are directed to a multilevel sowing [4, 5].

When applying together with seeding, when fertilizers are placed in the same bed with seeds, only small fertilizers doses are needed to ensure a plants powerful start, but they are not enough for the entire growing season, so this method must be combined with the main application or further top dressing that leads to an increase in labor costs for production. If large fertilizers doses are introduced together with the seeds, which ensure plants nutrition for entire development period, then it is possible to damage the seed material and substantially reduce the yield [3].

It is established that the joint fertilizers application with seeds can lead to a salt effect and a toxic fertilizer effect (chemical burn). Some seeds are killed during toxic effects period, which leads to seedlings decrease, yield and, as a result, enterprise profit. The most favorable is the separate fertilizers and seeds application, this allows plants roots to develop in food source direction, forming a branched root system [6, 7].

When the seeds are sown together, the seeds lie on the compacted bed created by the opener, and mixed with the fertilizer. The NO3 nitrate formed in a small amount, as an external diffusion result, begins its movement in the direction from where the fertilizer was introduced. Within 24 hours, ammonia tape (NH3) and ammonium (NH4) increases to 75 mm in diameter.

In two weeks, the nitrogen band expands to 125 mm, while the nitrogen concentration decreases and approximately 50 ... 60% of nitrogen is expressed by useful nitrate form (NO3). Toxic nitrogen effects and salt effect, slow down sown crop development, and some sprouts in this case die.

In four weeks, tape width increases to 200 mm. About 90% of the nitrogen takes useful nitrate form (NO3). Nitrogen concentration is reduced, and salt effect effect on plants is weakened. In the period of fertilizer toxic effects and salt effect, some plants die. The remaining plants begin to recover and gain strength (Figure 3, a).

When sown at different depths, the seeds are at a safe distance from nitrogen effects when it is in ammonia form (NH3) and ammonium (NH4). Introduced at this stage fertilizers have a lower concentration and are less seedlings risky, and nitrate gradual perception promotes the accelerated root system development. The roots develop radiantly to produce nitrate, which extends from the center of the nitrogen strip. In four weeks, culture roots grow into introduced nitrogen ribbon, the root system develops significantly towards the available nitrate (Fig. 2, b). Usually, over a four-week development interval, the plant receives 20% of nitrogen from the full rate required throughout the entire growth cycle [8].
Based on the foregoing, it can be concluded that the development and development of high-productive, resource-saving and environmentally friendly technologies, as well as new working seeding machines tools, is an urgent task.

Our research aim is to increase grain crops yield by coulter using for different seeding level of fertilizers and seeds.
To achieve this goal, it is necessary to solve two main tasks:
1. To develop a vomer, which provides for multilevel seeds and mineral fertilizers sowing.
2. Substantiate proposed opener main parameters.

2. Research object and methods
Most openers common disadvantage is increased soil waste to the side and, as a consequence, uneven seed sealing in depth and feeding are. To eliminate the above-mentioned shortcoming, it is possible to create coulters based on soil volume deformation, the essence of which lies in the fact that the undercut soil is compressed from the sides and squeezed upwards, and then without any turnover is put back into its original place. According to this principle, coulters made according to the "catamaran" scheme [9] work.
Research object is multilevel seeds and mineral fertilizers sowing providing process with a developed opener.
As practice shows, laboratory studies results differ from field studies, therefore, in order to obtain more accurate data, it is necessary to bring the experimental conditions in laboratory conditions closer to field conditions. For this purpose, opener coulter laboratory studies were carried out in technical service faculty soil channel in the agro-industrial complex of Omsk State University (Fig. 3).
In laboratory studies, soil layer width between seeds and fertilizers was chosen as the function to be studied, but as variable factors: \( l \) is the distance between the lower edges of the working element and the post, mm; \( \tau \) - profile angle of the lower column edge, deg. (Figure 4, a); \( h \) - crop culture depth, mm.

The following parameters were accepted as permanent parameters: seeding rate \( N = 200 \) kg/ha, fertilizer application rate \( T = 200 \) kg/ha, plant speed \( V = 2.5 \) m/s, vas deferens diameter \( d = 32 \) mm.

3. Experimental studies

In research courses, a coulter was developed, for different-level seeds and mineral fertilizers sowing (Fig. 4, b) [10]. The opener includes working elements 1 and hollow struts 2. The tuchnakers 3 are installed at working elements top, and the seed guides 4 are at racks top. Each post in the horizontal plane is installed at attack angle \( \alpha \), hence the distance between the posts, at the entrance, at the front, is greater than the outlet, at the rear. In the vertical plane, the posts are inclined at an angle \( \beta \) to the sides, which ensures distance change between the posts in height.

At the top of the racks are connected by bracket 5 in a transverse horizontal plane. In the lower part, on pillars back, notches 6 with a convergence angle \( \gamma \) directed forward are formed. On post lower edge profile outside there is a cutout 7. The work elements and the posts are fixed, while working elements lower edges straight profiles are located below posts lower edges profiles.

When working due to pointed socks, the working elements 1 crash into the soil. The soil, cut from both sides, moves along the working elements. Mineral fertilizers are fed into the resulting grooves through fertilizer guide 3 and the working elements 1. Due to the fact that the working elements and racks are located at attack angle \( \alpha \), the soil is displaced to opener symmetry axis, simultaneously, due to roll angle presence of \( \beta \), the soil rises, crumbles and in the loosened state moves along the lateral working elements internal planes.

When the soil passes from the working elements to the racks, due to the fact that working elements lower edges straight profiles are located lower than racks lower edges profiles by an amount \( l \), and cutout presence with an angle \( \tau \), (Fig. 4), soil partial shedding and mineral fertilizers fall. Cropped not crumbling soil passes further into the interstitial space. At the same time, column lower inner edges for furrow bottom, forming a densified bed, on which seeds are fed through the seed guides 4 and the posts 2 and placed on furrow bottom. The soil, when leaving the interstitial space, crumbles and falls sown grooves.

![Figure 4](image_url)

**Figure 4.** Different level seeding and mineral fertilizers coulter: a - scheme; b - prototype; 1 - working element; 2 - the rack; 3 - fertilizer guide; 4 - seeder; 5 - bracket 6, 7 - notch

In laboratory studies, measurements were made of soil interlayer width with angle change \( \tau = 0 - 600 \) and a distance \( l = 20 \ldots 40 \) mm.
When opening soil longitudinal section (Figure 5), the boundary between seeds and fertilizers is clearly visible. For a fixed $l$ (the distance between working element and the post lower edges) equal to 20 mm, soil interlayer average thickness between the seeds and fertilizers is 17...18 mm.

Figure 5. Realization of measurements in open soil furrow

In experimental studies course, soil interlayer thickness values were obtained as angle function $\tau$, the distance $l$, and soil seed placement depth $h$ (Table 1).

Table 1. Soil layer thickness experimental studies results

| L, mm | $\tau = 0^\circ$ | $\tau = 30^\circ$ | $\tau = 45^\circ$ | $\tau = 60^\circ$ |
|-------|-----------------|-----------------|-----------------|-----------------|
|       | Seeding depth 6 cm | | | |
| 20    | 9               | 11              | 18              | 18              |
| 30    | 19              | 20              | 24              | 23              |
| 40    | 21              | 26              | 32              | 30              |
|       | Seeding depth 8 cm | | | |
| 20    | 10              | 12              | 19              | 18              |
| 30    | 17              | 22              | 26              | 25              |
| 40    | 20              | 27              | 33              | 32              |
|       | Seeding depth 10 cm | | | |
| 20    | 12              | 14              | 19              | 19              |
| 30    | 18              | 21              | 26              | 25              |
| 40    | 21              | 29              | 35              | 33              |

Figure 6. Seeding depth soil layer thickness dependence $h = 6$ cm
Analyzing the obtained dependences (Figures 6-8), we can conclude that soil layer thickness index has a distinct regularity.

With an increase in column lower edge profile angle \( \tau \), to a value of 45 degrees, soil layer thickness \( L \) increases with all the considered seed depth indices. Moreover, with a further increase in \( \tau \), soil layer thickness begins to decrease.

With an increase in the depth of seeding, the thickness of the soil layer \( L \) also increases.

4. Conclusion

1. A coulter is developed which allows two-belt sowing obtaining, while mineral fertilizers are located below main crop seed level not 10...30 mm and are filled with soil moist layer, which eliminates seeds and fertilizers direct contact, and, consequently, seeds chemical burn. Seeds are laid on a compacted bed, evenly over food area and seal depth, the top is filled with soil moist layer.
2. Soil interlayer thickness between seeds and fertilizers is 30...40 mm, achieved at an angle of \(\tau = 45\) degrees and a distance \(L = 40\) mm. Consequently, it is these values that we take as proposed coulter rational parameters.

**References**

[1] Kem A.A. Sowing complexes comparative evaluation in cereals cultivation in western Siberia / A.A. Kem, L.V. Yushkevich // Bulletin of OmGAU. 2015. No. 4. - P. 61-65.

[2] Domrachev V.A. Selection, farming and plant growing mechanization: Monograph / V.A. Domrachev, A.A.Kem, V.E. Kevtunov, E.V. Krasilnikov, A.P. Shevchenko. - Omsk: Publishing house of Federal State Budget Educational Institution of Higher Education "Omsk State Agrarian University named after P.A. Stolypin". 2011. 190 p.

[3] Mullenkov E.V. Analysis of methods for sowing grain seeds with fertilizers simultaneous application / E.V. Mullenkov, V.V. Shumaev // In the collection: Young scientists′ contribution to Russian agro-industrial complex innovative development. Young Scientists′ International Scientific and Practical Conference articles collection, dedicated to the 65th anniversary of the FGBU VO Penza State Agricultural Academy. 2016. P. 186-189.

[4] Ewbank N., Buckby L.Lynx, Engineering contract seed drill market with the seedline system // Landwards. 2002. Vol.82. No. 1. P. 153-155.

[5] Development and testing of a seed-cum-fertilizer, a drilling attachment to a tractor-driven cultivator. Gupta R. A., Mohnot Pramod, Satasiya R. B. Agr. Mech. Asia, Afr. And Lat. Amer. 2004. 35. No. 2. P. 15-20.

[6] Petukhov D.A. Innovative projects, new technologies and equipment. Petukhov, M.E. Chaplygin, A.N. Nazarov // Engineering and equipment for the village. 2013. No. 4. P. 10-14.

[7] 7. Nogtikov A.A. Sowing machines combined working bodies design development / A.A. Nogtikov, V.P. Bychkov //. Science and technology achievements in agroindustrial complex 2002. No. 1. P. 25-26.

[8] Kem A.A Two-row sowing grain crops sowner with mineral fertilizers multilevel application / A.A. Kem, V.L. Miklashevich, M.S. Chekusov // Bulletin of Omsk State Agrarian University. 2017. No. 2 (26). Pp. 105-111.

[9] Patent for utility model No. 32963 of the Russian Federation, IPC A01S7 / 20. Drill coulter / VV Mal'tsev, IV Maltsev, PP Isheev - No. 2003107178/20; claimed. 18.03.2003. publ. 10.10.2003. Bul. № 28 (IIIp.) 521 p.

[10] Patent for utility model No. 166955, RF, IPC A01S7 / 20 (2006.01) / Drill coulter of seed drills // Demchuk, I.D. Kobyakov, R.A. Braulik. No. 2016108357/13; claimed. 03/09/2016; publ. 12/20/2016.