Seed drill used on complex configuration fields

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Abstract. The seed drill moves along the field in a shuttle manner. Non-productive time spent on the seed drill turn at the end of each run increases as the field area decreases. Consequently, the waste of time reaches the greatest value on small-scale fields and complex configuration areas, naturally encircled by forests, shrubs, ravines and swamps. This leads to a marked decrease in the seed drill performance and increased specific fuel consumption. In addition, the use of seed drills in complex areas has revealed a number of limitations associated with agrotechnical indicators. This problem was solved by developing a seed drill capable of uniform sowing, both in straight-line and curvilinear motion. Curvilinear sowing implies that different amount of grain should get into coulters moving with different radii. A fluted roller seed drill has two groups of sowing units, kinematically connected with the left and right support-driving wheels. The sowing units of different groups can be coupled. Tests of the seed drill with a coupled sowing unit showed that its performance when working on complex configuration fields in case of circular motion is 28... 79% higher and specific fuel consumption is 25... 41% less than that of a conventional shuttling seed drill.

1. Introduction
Non-productive waste of time increases when sowing on small-scale fields and complex configuration areas, naturally encircled by forests, shrubs, ravines and swamps. Growth reserves in the seed drill performance may be found in the reduction of shift time waste [1]. These indicators largely depend on the duration of the seed drill turn at the end of each run [2; 3]. Circular motion can eliminate non-productive waste of time typical for a shuttling seed drill. This problem can be solved by uniform sowing, both in straight-line and curvilinear motion [4].

Curvilinear sowing implies that different amount of grain should get into coulters moving with different radii. This can be done with two types of drills: a fluted roller drill featuring linear relationship between the roller working length and the amount of material introduced [5] or a drill with an electric dispenser [6]. The latter is much more expensive and more complicated.

2. Materials and methods
Such a seed drill (Figure 1) is developed based on the SZ-3.6 serial seed drill and includes an additional sowing unit, a driven reduction gear and self-aligning coulters.
The seed drill countershaft consists of right and left parts [7]. Its left part transmits the left wheel torque to the sowing unit shaft through the reduction gear. Its right part transfers the right wheel torque to the shaft of the additional sowing unit through the additional reduction gear. The bottom of the grain box is expanded to house an additional sowing unit. Thus, the seed drill is equipped with two similar sowing units, their shafts being parallel to each other. The fluted rollers of the first shaft provide various flows of seeds introduced. Moreover, there is a linear relationship between these flows. The rollers of the second shaft provide seed flows, which also vary in a linear manner. The total operating length of coupled rollers for one funnel is the same for all coupled sowing units of the seed drill. The roller of the first shaft provides a minimum seed flow into the funnel, which is simultaneously filled from the second shaft roller having a maximum flow of material introduced. Thus, the seed flows formed by the rollers of one shaft differ from those of the other shaft but when combined they give the same total flows to each funnel. This is true for the straight-line motion of the seed drill.

When the seed drill moves along an arc, its support-driving wheels move at different speeds. The sowing unit shafts also rotate at different speeds. Therefore, the total seed flow to each funnel changes. Moreover, the minimum total seed flow enters the coulter, which moves along a minimum radius arc. The maximum flow enters the opposite extreme coulter, moving along a maximum radius arc. There is a linear relation between the seed flows supplied to the coulters as they move away from that with a minimum flow. Therefore, the same amount of seeds is sown per unit of distance travelled when different total seed flows are supplied to each coulter.

The joint hinge provides coulter mobility when turning the seed drill. Self-aligning coulters are fixed together by springs.

3. Results and discussion
The seed drill with a coupled sowing unit is developed to increase its shift performance when working on complex configuration fields. The coupled sowing unit and self-aligning coulter unit of the SZ-3.6 seed drill solve this problem with the minimum possible production and design changes of serial seed drills. Comparative tests of the seed drill with a coupled sowing unit and a serial one were carried out.
on complex configuration fields to determine the effect [8]. Moreover, the former moved in a circular manner along the field while the latter did it in a shuttle way. The gear ratio in the reduction gear was set \( I = 0.616 \). The set depth of seed planting was 60 mm. The field configuration complexity groups are shown in Table 1.

**Table 1.** Field configuration complexity groups.

| Group No. | Complexity group                                                                 | Main feature of the group                                           |
|-----------|----------------------------------------------------------------------------------|---------------------------------------------------------------------|
| 1         | Rectangle-shaped fields, square-shaped ones or similar-form fields                | Correct form                                                        |
| 2.        | Straight-line nonconvex fields                                                    | The smallest angle between adjacent sides is more than 27°          |
|           | Ellipse-shaped and semi-ellipse-shaped fields                                     | The ratio of the major axis to the minor one is less than 2.1       |
| 3         | Straight-line nonconvex fields                                                    | The smallest angle between adjacent sides is less than 27°          |
|           | Ellipse-shaped fields                                                             | The ratio of the major axis to the minor one is more than 2.1       |
|           | Fields with partial convex-concave and straight-line sides                        |                                                                    |
| 4         | Convex-concave fields                                                            | The average value of half the ratio of the largest to the smallest in length and width ranges from 1.1 to 1.8 |
|           | Band-shaped fields, as well as with the beveled convex-concave and straight-line sides |                                                                    |
| 5         | Convex-concave fields                                                            | The average value of half the ratio of the largest to the smallest in length and width is more than 1.8          |
|           |                                                                                  | Fields must have at least three convexities or concavities          |

Studies show the coupled sowing unit meets the requirements of technical guidance documents [9] on the sowing rate unevenness of the units and on the overall sowing instability. As can be seen from Figure 2, the indicator of the sowing rate unevenness of the experimental seed drill units does not exceed 3% on all its trajectories. Whereas, the sowing rate unevenness of the units of the SZ-3.6 serial seed drill exceeds the above limit while moving along a trajectory with a radius \( R <60 \) m [10; 11; 12].
Figure 2. The relationship between the sowing rate unevenness $N$ of the units and the radius $R$ of the trajectory.

The operating speed of the sowing units was found to decrease when the field configuration gets complicated (Table 2). The sharp drop in speed has been noted for the serial seed drill, where the average operating speed decreased from 10.1 km/h to 7.9 km/h. The average operating speed reducing of the unit is explained by the decrease in the run length when the field configuration gets complicated. Therefore, the performance of the sowing units also decreases with the increase in the complexity group of the fields. The coupled sowing unit shows higher performance compared to the serial seed drill sowing unit.

Table 2. Seed drill study results.

| Indicator                          | Indicator value                       |
|------------------------------------|---------------------------------------|
| Complexity group                   |                                      |
| Seed drill with a coupled sowing   | SZ-3.6 seed drill                     |
| unit                               |                                       |
| 1 Unit composition                 | A tractor and a seed drill            |
| 2 Type of work                     | Sowing                               |
| 3 Way of motion                    |                                       |
| 4 Working conditions: Field Area, ha | 1.74 1.80 1.68 1.60 1.74 1.80 1.68 1.60 |
| 5 Operating mode:                  |                                       |
| A) operating speed km/h            | 9.42 9.42 9.33 8.90 10.1 9.39 9.36 7.92 |
| B) working width m.                | 3.6 3.6 3.6 3.6 3.6 3.6 3.6 3.6 |
| Performance, ha/h:                 |                                       |
| A) Main                            | 3.39 3.39 3.36 3.2 3.63 3.38 3.37 2.85 |
| B) Shift                           | 3.28 3.27 3.2 3.01 2.56 2.32 2.15 1.68 |
| Shift time performance increase, ha/h | 0.72 0.95 1.05 1.33 0 0 0 0 |
% 28.1 40.9 48.8 79.1 0 0 0 0

Specific fuel consumption kg/ha 1.51 1.53 1.55 1.61 2.01 2.18 2.3 2.73

Reduction in specific fuel consumption kg/ha % 0.5 0.65 0.75 1.12 0 0 0 0

Specific fuel consumption kg/ha

Studies of the seed drill with a coupled sowing unit have shown that its performance when working on complex configuration fields in case of circular motion is 28... 79% higher and specific fuel consumption is 25... 41% less than that of a conventional shuttling seed drill. At the same time, the crop yield remained equal for the seed drills compared.

4. Conclusions

1. There is linear relationship between the roller working length and the amount of material introduced.
2. The indicators of the sowing rate unevenness of the units and of the overall sowing instability when operating the seed drill with a coupled sowing unit do not exceed 3%.
3. The crop yield is almost equal for both the seed drill with a coupled sowing unit and the SZ-3.6 seed drill.
4. Shift performance of the seed drill with a coupled sowing unit when working on complex configuration fields is 28 ... 79% higher than that of the serial seed drill.
5. The seed drill with a coupled sowing unit when working on complex configuration fields in case of circular motion has its specific fuel consumption 25... 41% less than that of the serial shuttling seed drill.

References

[1] Khorunzhenko V E 1987 Technological grounds for designing sowing machines and prospects for seed drill development. Tractors and agricultural machinery 11
[2] Klenin N I, Levshin A G and Kiselev S N 2008 Agricultural Machinery (Moscow: KolosS) p 816
[3] Lyubushko N I and Khorunzhenko V E 1986 Development trends of the technical level of seed drills. Tractors and agricultural machinery 8
[4] Kornev A I 1958 Study of the influence of the working trajectory on the agricultural unit performance: PhD (Eng) thesis (Moscow)
[5] Semenov A N 1960 Theoretical grounds and methods of technological calculation of seed drill working units: DSc (Eng) thesis (Kishinev)
[6] Kamgar S, Noei-Khadabadi F and Shafaei S M 2015 Design, development and field assessment of a controlled seed metering unit to be used in grain drills for direct seeding of wheat. Information Processing in Agriculture 2169–76
[7] Plyaka V I and Vinogradov Yu A 1987 Copyright certificate of the USSR No.1299533, MKI A 01 C 7/16. Seed drill sowing unit / Plyaka V I and Vinogradov Yu A / B.I. 12
[8] Udachin S A 1962 Land / Land Use Essays (Moscow)
[9] GOST 31345-2017 Agricultural machinery. Tractor seeders. Test methods INTERSTATE STANDARD
[10] Gurashvili G V 1970 Research of curvilinear motion influence on operational indicators of arable and sowing units: PhD (Eng) thesis (Tbilisi)
[11] Plyaka V I 1989 Working process background of a coupled sowing unit of the seed drill. "Technical means for providing intensive technologies for crop cultivation and harvesting." Collection of papers of Moscow Institute of Agricultural Engineers (Moscow)
[12] Plyaka V I 1989 Seed drill for complex configuration fields Scientific and technical information digest 3 (Moscow: AgroNIHEETIITO)