Method and results of laboratory tests of the device for application of mineral fertilizers

A E Shamin, A R Gerasimov and D N Igoshin

Nizhny Novgorod State Engineering and Economic University, Knyaginino, Russia

E-mail: igoshin.d.n@mail.ru

Abstract. The process of application of mineral fertilizers with simultaneous sowing of sugar beet seeds should ensure timely feeding of root vegetables with nutrients, at the same time creating a favorable zone for comfortable development of the fetus root system. The method of planning research of tight sealing body consists in selecting of certain number of experimental tests to solve the task. However, the number of tests received should be minimal, with the maximum quality of the final result, in order to analyze the obtained data and to report these results in the graphs.

1. Introduction

Laboratory tests of the developed device for applying mineral fertilizers while sowing seeds of sugar beet on the laboratory installation "soil channel" in order to determine the dependence of the traction resistance on the speed parameters, the working depth and preservation of the geometric shapes of the furrows and the seed bed, to create a favorable growth zone of the root system of sugar beet.

According to theoretical prerequisites, the experimental research program included laboratory tests of developed device for application of mineral fertilizers with simultaneous sowing of sugar beet seeds on the laboratory installation "soil channel" in order to determine the dependence of traction resistance from the speed parameters, working depth and preservation of the geometric shapes of the furrows and seed bed for creation of favorable growth zone of sugar beet root system [1, 2].

For the purpose of experimental research, model section for application of mineral fertilizers with simultaneous sowing of sugar beet seeds was designed; novelty of tight sealing working body was confirmed by useful model patent (№ 180133). Design parameters of tight sealing knives were selected according to theoretical calculations [3, 4, 5].

The designed model of section consists of frame, on which installed offered tight sealing working body, the basic wheel. Section is attached to bogie frame by means of parallelogram hinge. Wedge-shaped knives are arranged parallel to each other (figure 1a).

2. Experimental part

Laboratory tests were carried out on the basis of the Training and demonstration center of Institute of mechanization and technical service of Kazan State Agrarian University, in the soil channel (figure 2) «Interdepartmental laboratory of design and testing of small-sized agricultural machines » (figure 1b and 1c) [6].
Figure 1. Study of working body for application of mineral fertilizers: a - laboratory model of section for application of mineral fertilizers; b, c - general view of laboratory installation.

This laboratory installation consists of channel body (5) (inside which there is soil (5)) made of concrete and brick, guide rails installed along the long sides of the channel, bogie (8) moving along the rails (figure 2). The channel is filled with soil. The bogie is attached via cable (6) to which dynamometer DPU (7) is connected. Electric motor (1) drives bogie to which experimental section (9) is rigidly secured via reducer (2), V-belt transmission (3), drum (4) and cable.

The physical and mechanical properties of soil in the channel are as close as possible to soil located in the central part of Nizhny Novgorod region, where it was planned to implement this installation in future.

In the process of research, the following parameters were measured: traction resistance, distance overcome by the working body, speed of the bogie, depth of furrowing knives, profiling of the surface after each pass of the device, moisture and soil density. Each pass of the bogie was recorded by photo and video recording of both the furrows formed by the working body and the dynamometer readings [7,8].

Measurements of obtained data were made using the following measuring instruments:

- metal ruler 1m, GOST 427-75 – for determination of linear dimensions;
- boxes, GOST 23932 – for soil sampling;
- drying cabinet SHSU – for sample drying;
- electronic scales VST 300/10;
- moisture meter Delta-T Devices LTD, sensor SM200 – for direct measurement of soil moisture;
- dynamometer DPU 5-2 – for determination of traction forces.

Comparative tests were also carried out to conduct comparative analysis of designed and serial working bodies on the traction resistance. In order to obtain more accurate data on the same equipment, anchor tight sealing working body and developed furrow-forming knives were connected to one section alternately [9].

The following parameters were introduced for laboratory testing:
The angle of the insert Ugol_RezhPl, grad. Is chosen with respect to the theoretical calculations presented in the second Chapter. Interval ary of funding from 120 to 140, with an interval of 20.

The angle of the furrowing plate is ugol_borozdpl, deg. The same is true of theoretical calculations. This angle varies from 30 to 50. The variation interval is 10

The processing depth t_ obr, mm. is Regulated by the height of the limiter wheel. The depth of the working body was selected depending on the conducted field studies, taking into account the possible increase and decrease in depth, in order to analyze the data obtained on the dynamics of changes in traction characteristics t_ obr = 90....130 mm, the interval of variation is 20 mm.

The speed of movement of the working body V_dv, km / h. due to the combination with the sowing device, the working speed of the laboratory unit was selected within the speeds regulated for sowing the seed of sugar beet, with a possible range of increasing and decreasing the speed from 4 to 8 km/h.

Figure 2. Scheme of laboratory installation for conducting experiments.

3. Results and considerations
Measurements of traction resistance were carried out with the use of an electron dynamometer for tension/compression DOR-3-and with an indicator WI-4 connected to a computer through the software interface R-232, in three speed ranges (4, 6 and 8 km/h), at three values of the depth of mineral fertilizers (90, 110, 130 mm). The magnitude of the penetration anchor tukanalipao working on was 180, 220, 250 mm. The speed was selected empirically by changing the frequency of rotation of the electric motor using a frequency Converter MFC710 (up to 15 kW).

In the process of laboratory tests of the influence of angles of cutting and profiling plates, as well as the value of the working body on the traction resistance, regression equations were obtained.

In order to determine the optimal geometric parameters of the sealing working body, the obtained parameters of laboratory testing on the traction resistance are entered into the software package STATGRAPHICS Plus 5.1, with the help of which the dependence of the traction resistance relative to the factors and the regression equation are obtained.

When you build zones of response surfaces according to the obtained regression equation, depending on the angle of the cutting plates (Ugol_RezhPl), angle boristheblade plate (Ugol_BorozdPl), the depth of processing (t_ obr) and the speed of movement of the working body (V_dv) received.

With the selected parameters of the depth of treatment t_ obr = 0,0 (110 mm) and the speed of movement of the working body V_dv = 0,0 (6 km/h), the least resistance to the working body of the
soil is provided at Ugol_BorozdPl = -0.4...-0.3 which is 37, Ugol_RezhPl = 0, which is 130 degrees.

With these indicators, the traction resistance is 330 N.

When reducing the processing depth to t_obr = -1.0 (90 mm) and the same speed, the lowest coefficient of traction resistance is 310 N. This result is achieved when Ugol_BorozdPl = -0.1...0.0 which is 39, Ugol_RezhPl = 0, which is the same as the previous time is 130 degrees.

Increasing the processing depth to t_obr = +1.0 (130 mm) while maintaining the speed of the working body 6 km/h shows an increase in the lowest resistance index to 390 N. The most optimal angles of inclination of the cutting plates, in this case, are: Ugol_BorozdPl = -0.8...-0.6 which is 33, Ugol_RezhPl = 0,0 (130).

When reducing the speed of movement of the working body to the value V_dv = -1.0 (4 km/h) at t_obr = 0.0 (110 mm), the lowest value of the traction resistance (310 N) is observed at Ugol_BorozdPl = -0.6...-0.5 which is 35, Ugol_RezhPl = 0.0...-0.1 which is 129 degrees. When considering the angles in large directions " + " and " − " the values of the traction resistance grow to 450 N.

1. As a result of laboratory tests, it follows that for reduction of traction resistance of offered construction of working body, the following parameters can be recommended: the angle of the cutting plate is 130°, the angle of the furrowing plate is 37°, the depth of application of mineral fertilizers – 0.11 m.

2. In the process of comparison of theoretical calculation and practical data obtained as a result of laboratory experiments, the traction resistance revealed that the smallest range of error of design and test traction resistance is observed at the depth of introduction of the working body 110 mm at speed movement of the working body in the range 6 – 8 km/h.

3. Comparative studies of traction characteristics of developed device and serial anchor showed reduction of traction resistance by 35–40%.

4. As a result of laboratory tests, the optimal values of geometric parameters of collapse zone of walls of seedbed were determined; the optimal values were 0.194 m obtained at the angle of inclination of the cutting plate Ugol_RezhPl = 0.1...0.2 (131°) and the angle of inclination of the furrowing plate Ugol_BorozdPl = 0 (40°), the depth of processing t_obr = 0 (110 mm) and the speed of movement of working body V_dv = 0 (6 km/h) (figure 3).

![Figure 3](image-url)  
**Figure 3.** Dependence of traction resistance at t_obr = 0.0 (110 mm) V_dv = +1.0 (8 km/h).

4. Conclusion

Laboratory tests have shown that the developed method for application of mineral fertilizers and tight sealing working body fully meet the requirements of soil treatment and reduce economic investment in sugar beet cultivation. The process of application of mineral fertilizers with simultaneous sowing of sugar beet seeds provides timely feeding of root with nutrients, while creating a favorable zone for comfortable development of the fetal root system.
References
[1] Vasilyev A A et al 2019 IOP Conf. Series: Materials Science and Engineering 516 012027
[2] Vasilyev A A et al 2018 IOP Conf. Series: Materials Science and Engineering 450 062008
[3] Igoshin D N, Vasilyev A A, Kotov A A 2018 Rural mechanic 9 16–7
[4] Igoshin D N, Gorin L N, Kotov A A 2019 Sugar beet 1 20–3
[5] Uvarov V P, Levshin A G, Maistrenko N A 2016 Agricultural machinery and technology 4 38–43
[6] Kosolapov V V, Kosolapova E V, Igoshin D N, Skorokhodov A N, Rudenko A A 2019 Acta Technologica Agriculturae 22 31–7
[7] Kosolapov V V, Skorokhodov A N 2013 Bulletin NGIEI 4(23) 73–86
[8] Kosolapov V V, Skorokhodov A N 2013 Bulletin NGIEI 8(27) 34–41
[9] Igoshin D N, Vasilyev A A, Gorin L N 2017 International scientific research 2 38–44