TECHNOLOGICAL AND TECHNICAL SOLUTIONS TO THE PROBLEM OF SOIL COMPACTION AND DEPLETION IN THE SYSTEM OF PRECISION FARMING IN THE CONDITIONS OF NORTHERN KAZAKHSTAN

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Abstract: *In this work have considered the problems of soil compaction and the main nutrition of plant in the system of precision farming in the conditions of the main grain-sowing regions of Northern Kazakhstan. The specific examples show the condition of the soil, the level of their supply with nitrogen and phosphorus. Technological and technical solutions are proposed for the differentiated use of basic doses of mineral fertilizers and soil decompression.*

KEYWORDS: *PRECISION FARMING, MINERAL FERTILIZERS, SITE-CPECIFIC APPLICATION, CULTIVATOR, FERTILIZER*

Introduction

The soil and climatic conditions of Kazakhstan make it possible to produce grain, which which have a particular are in demand in the world market. However, in the cultivation of grain crops in Kazakhstan, soil fertility and productivity are reduced due to the insufficient level of farming culture, including the technology of mineral fertilizer application.

In the market of agricultural machinery of the CIS there is no equipment for subsurface application of the main dose of mineral fertilizers for minimal and zero tillage technologies for the grain crops production. On the KPG-2.2 blade plow-rippers and the GUN-4 ripper-fertilizers designed for this purpose, the fertilizer metering devices did not fully comply with the agrorequirements for uniformity and stability of sowing, and furrow openers for the uniform distribution of fertilizers over the area inside the soil. As a result, these machines did not find used in the production. The development of scientists SPC Research Institute of Grain Management A. Barayev did not reach production, cultivators-fertilizers for band-spreading fertilizer KATU S.Seifullin are at the stage of acceptance tests. Existing machines for the surface application of fertilizers are characterized by high consumption of fertilizers, unevenness application (up to 40-70%), and grain-fertilizer seeders do not provide a basic, increased dose of feeding [1].

With minimal and zero tillage technologies for the cultivation of grain crops there is no technological process of applying the main dose of mineral fertilizers. This results to a decrease in the nutrient content in the root zone of the soil and compaction of the soil. Numerous studies have shown that an increase in soil density in comparison with the optimum by 0.1 ... 0.3 g / cm3 has leads to a decrease in yield by 20-40% [2].

The purpose of the research is the development of technological and technical solutions to the problem of soil compaction and depletion.

Materials and methods

In his the Message to the people of Kazakhstan dated January 10, 2018, the President of the Republic of Kazakhstan Nursultan Nazarbayev, stressing the importance of implementing the integrated program "Digital Kazakhstan" and noting the need for *"the development of agrarian science, drew attention to" intellectual fertilizer application systems ".*

As part of the tasks set in the Message in early 2018, the Kazakh Agrotechnical University. S.Seifullin was determined by the scientific and methodological center of digitization of agriculture and began the scientific and methodological management of the introduction of elements of precision farming in 9 basic farms in Akmola, Karaganda (Naydorovskoye LLP and Shakhterskoye LLP), Kostanay and North Kazakhstan regions.

First of all, soil samples were taken at the end of April and at the beginning of May 2018 on the pilot fields of the pilot farms. The area of each experimental field was 500 hectares. The size of the elementary area was set 1 ha.

The results of agrochemical analysis showed that from 80 to 100% of the areas have low and very low availability of easily hydrolysable nitrogen, Fig.1. As far as phosphorus is concerned, the situation turned out to be even more complicated, from 92 to 100% of the areas of the experimental fields have very low and low security, Fig.2.

It should be noted that the pilot farms are considered advanced in their districts and each year they make initial doses of mineral fertilizers during sowing. An analysis of the state of some fields of pilot farms showed that estuaries appear in certain areas of the fields where they have never been. This indicates compaction of the soil.

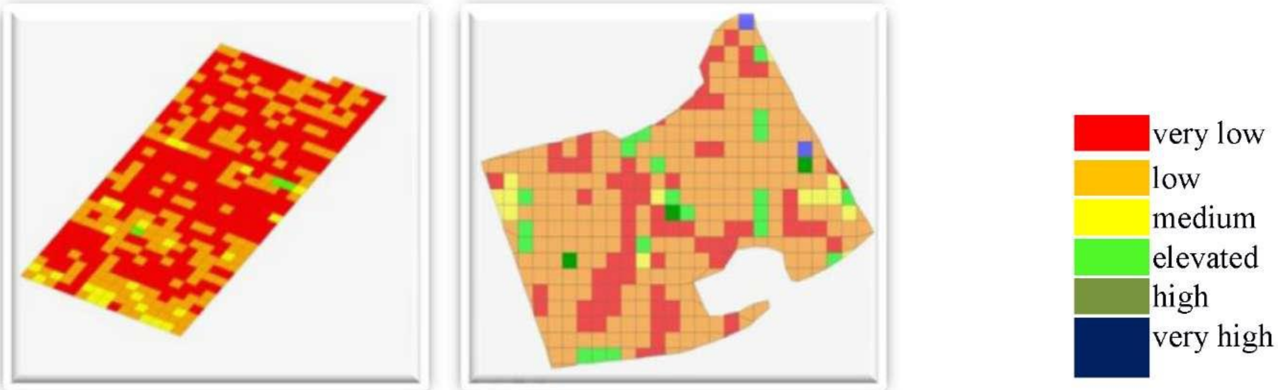

Figure 1 *- Cartograms of the content of hydrolysable nitrogen in Akmola-Phoenix JSC and Shagala-Agro LLP, mg / kg*

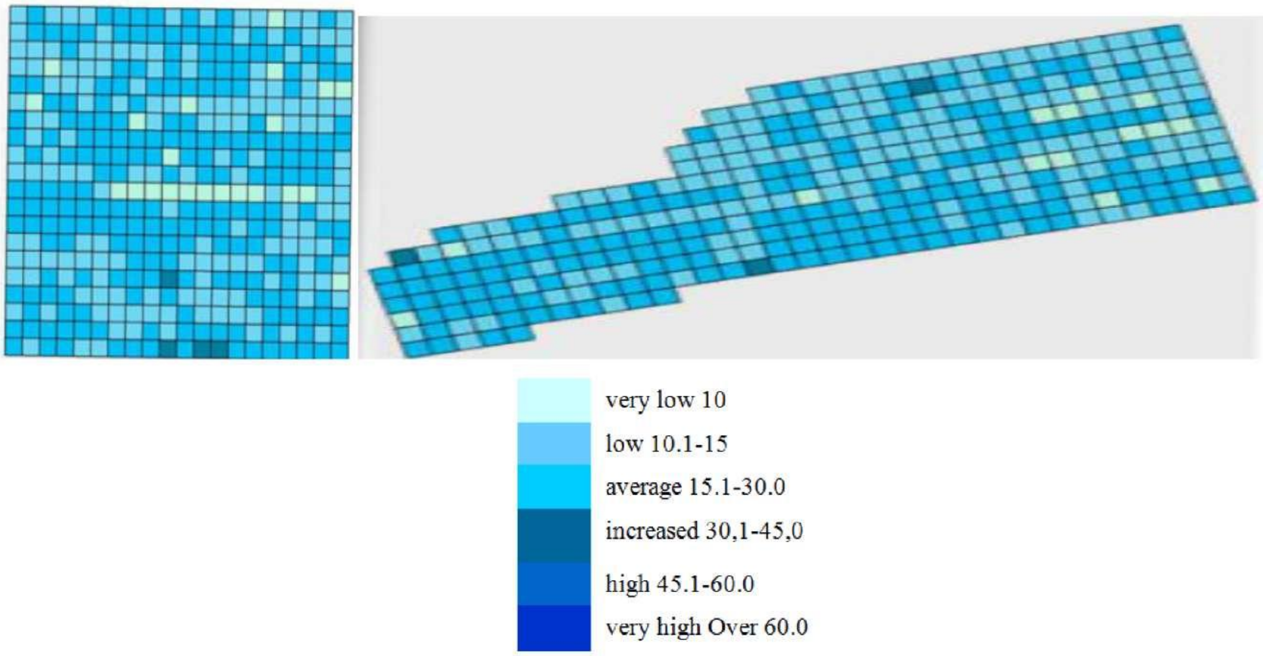

Figure 2 *- Cartogram of the content of mobile phosphorus in LLP "Troyana" and LLP "Miners", mg / kg*

It follows from the foregoing, that all the major nutrients - nitrogen and phosphorus - are removed from the soil. Hence the answer to the question: why is the quality and quantity of the harvest reduced? Because it is very low in phosphorus. Starting doses of fertilizers do not solve the problem. Without a basic dose of mineral fertilizers, it is impossible to achieve the optimal level of nutrient content in our fields. One of the main deterrents to this issue is the lack of the necessary equipment for the intra soil application of the main dose of mineral fertilizers and soil loosening. To solve these problems, it is necessary to develop a special technique.

Academician M.K. Suleimenov notes that in the system of conservation agriculture, the best place to apply phosphate fertilizers is the summer fallow field. This is explained by the fact that in the Northern regions of Kazakhstan, the first limiting factor in yield increase is poor moisture supply of plants, the second is the lack of phosphorus, the third is debris. For a summer fallow field of good reserves of productive moisture and field purity provide relatively stable yields of spring wheat, even in dry years.

Based on the status of pilot fields of pilot farms, the experience of cultivating grain crops of managers and specialists of these farms, the following **basic requirements for technological and technical solutions can be distinguished:**

-the working part of the ripper-fertilizer should fertilizing longline, at different depths;

-should provide deep loosening of the soil;

-should be able to aggregate with trailed air seed drills (with a system of fertilizer dose differentiation) and work autonomously;

-in the case of autonomous use, it should have an intelligent system of fertilizer dose differentiation;

-must have a large width.

Research results and their analysis

For the differentiated application of fertilizers with a longline inclined band at different levels, an inclined working part was developed, Figure 3.

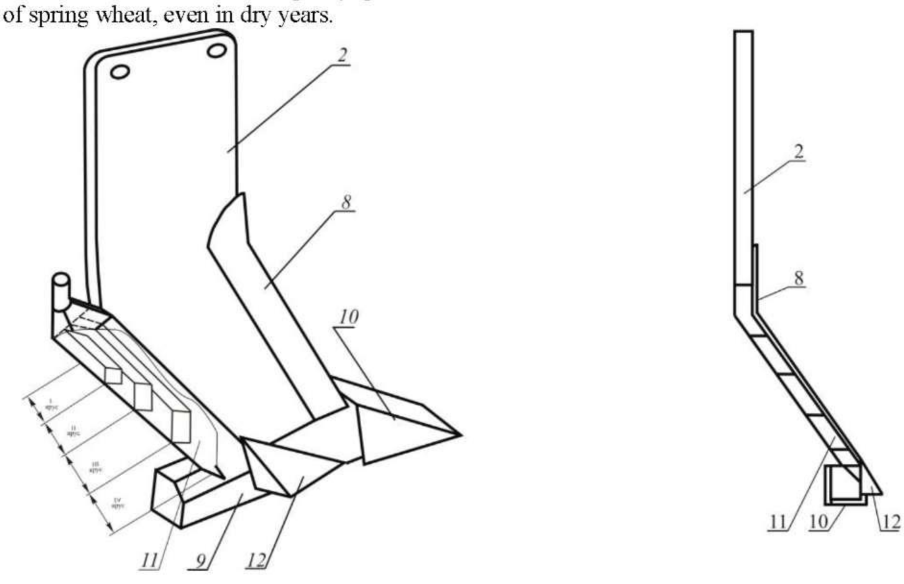

Figure 3 *- The working body of the experimental chisel fertilizer*

The proposed design of the working body of the chisel-fertilizer provides for the placement of fertilizers from 5...6 cm from the soil surface to a depth of 25...27 cm with a band width of 25...29 cm.

On a frame of the implement 12 ... 22 working parts shall be mounted. The total width of the operation is 4.6 ... 7.6 m. The inclined angle of the shanks is 40-45 °. The distance between the shanks is 400 mm, between the inclined bands of fertilizers - 140 mm, figure 4. Dailyoutputis 30-50 ha.

The fertilizer can work together with the bin of the air grain drill as a cultivator-fertilizer with a central metering system, autonomously with its own bin with individual metering devices and as an implement for the primary tillage.

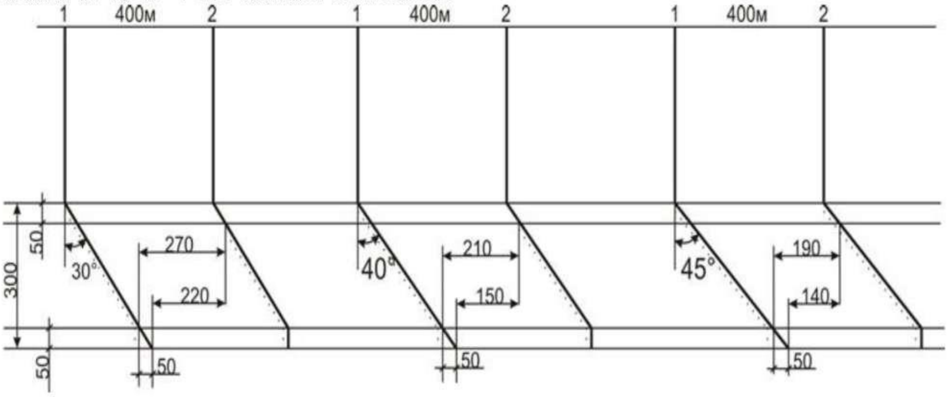

Figure 4 *– Variants of the location of the working body*

Analyzing the action of forces when moving the working parts of the ripper-fertilizer inside the soil, the dependence of the tractive effort on its design parameters and the physical and mechanical properties of the soil is obtained:

$$P_л Sin(\alpha+\varphi) = JSin\frac{\alpha}{2} + G_л Sin(\alpha+\varphi) + G_б Sin\varphi + Q \quad ; \quad (1)$$

$$J = 2\upsilon^2 bh\rho \cdot Sin\frac{\alpha}{2} \cdot Cos\alpha \, ; \; G_л = \frac{N_л}{Cos\varphi} \, ;$$

$$G_б = l_б \cdot h \cdot \frac{\sigma_{comp}}{Cos\varphi} \, ; \; Q = b \cdot h \cdot \sigma_{comp} \, , \quad (2)$$

where J – dynamic, pulsating soil resistance; α - cutting angle; φ - friction angle; b - operation width; h - loosening depth; ρ - soil density; $l_б$ - wedge side length; σ_{comp} - temporary soil resistance to compression.

Analysis (1) shows that the draft force practically has a linear dependence on the cutting angle and the speed of movement of the unit itself and varies from 42.45 to 180.15 kg with a loosening depth of h = 50 cm and a working width of 25 cm. Based on conditions of the minimal of the traction effort can be considered optimal values of the cutting angle α = 16–20° and the front speed υ = 1.8–2.0 m / s.

On the basis of these parameters of the working parts, as well as at the request of farmers in Northern Kazakhstan, a prototype of a chisel-fertilizer was developed for the longline site-cpecific application of the main dose of mineral fertilizers in the precision farming system, Figure 5.

Production inspection showed that the chisel-fertilizer provides of loosens the soil up to 35 cm and at the same time applicated fertilizer granules to depths of 8 ... 10, 16 ... 18 and 23 ... 25 cm. In doing so, the stubble conservation was 79 ... 84,3%.

Figure 5 *- A prototype of a chisel-fertilizer*

For the effective use of mineral fertilizers, we also substantiated and developed ***the technology of its three-layer differentiated application***, Figure 6.

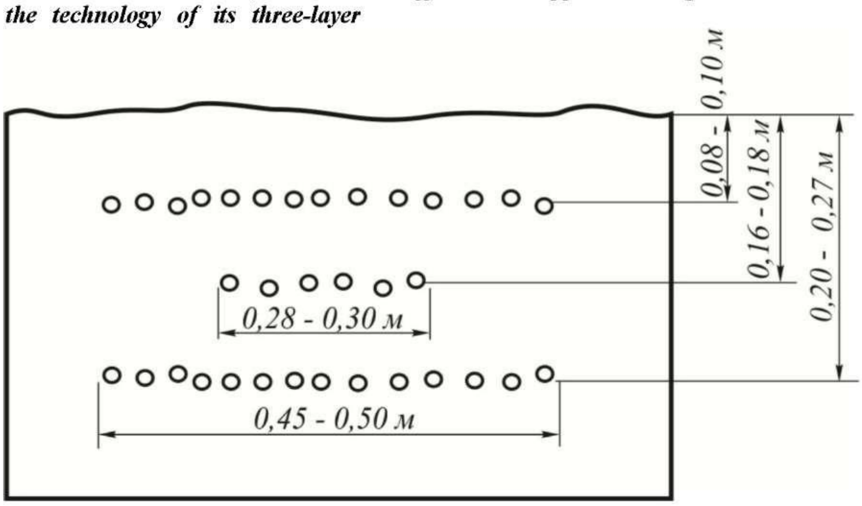

Figure 6 *– Technological scheme of fertilizer distribution inside the soil*

Theoretical studies have established that with longline mineral fertilization in the soil there are several options for placing V-shaped blade on the shank. It was found that for two-tier application, the best option is where the lower V-blade is shifted with respect to the upper back, at a distance of δ = 15 cm, and for three-tier introduction, the layout is most suitable, where the V-blade sweep of the first shank goes at an average depth = 16-18 cm, the lower V-blade of the back second shank goes at the maximum depth = 25-27 cm, and its upper sweep - at the very minimum depth = 8-10 cm.

Having considered the movement of the experimental V-blade working part of the cultivator-fertilizer for the differentiated three-tiered application of mineral fertilizers in the soil, an analytical dependence of the tractive effort on the parameters of the working part was obtained. Analysis of the equation shows the direct dependence of the traction force on the width of the tillage of the working body and the depth of treatment and the quadratic dependence on the speed of the cultivator-fertilizer. Increasing the depth of processing from 0.15 m to 0.27 m and the width of the processing of the plowshare from 0.10 to 0.30 m increases the tractive effort 1.85-2.07 times, and the increase in speed from 1 to 2.8 m / c increases the pulling force 6.91-7.86 times.

Laboratory field studies have shown that the cultivator-fertilizer provides tillage at depths of 8.3 ... 13.7, 14.8 ... 16.8 and 25.2 ... 28.7 cm with an installation of 8-12 cm, 16 ... 18 and 20-27 cm, figure 7. The working parts are not clogged with soil, technological failures are not marked. The uneven distribution of fertilizers across the width of the capture amounted to 14.2%, which is within the agrotechnical requirements. On uneven seeding between the devices, the experimental machine exceeds the baseline by 30%. The width of the distribution of fertilizers for the experimental machine reaches 0.5 m, and for the baseline 0.05-0.06 m. The excess is a dozen times. The basic fertilizer machine is located at one depth - about 20 cm, and the experienced one - distributes into three tiers, from 8.3 to 28.7 cm. Storing the stubble on the field after passing the unit does not decrease and varies from 50.2 to 65, 9 %.

Figure 7 *- A prototype blade plough-ripper-fertilizer*

It is known that most of the feeding fields of the Republic of Kazakhstan are located in areas with insufficient moisture supply and low productivity. They are characterized by a thinned grass stand and intensive loss of the most valuable forage plants from it. As a result, feeding fields become of bare and large areas of hayfields and pastures degrade. The main reason for this negative situation is the lack of a scientifically based system of use of feeding fields and effective technologies and technical means for their restoration and improvement.

To solve the problems outlined, a new technology is proposed to improve forage and grazing land and the design of an automated grain-fertilizer-grass seeder for differentiated direct sowing of crops for cover crops and in turf with simultaneous application of mineral fertilizers. The new technology consists in the simultaneous sowing of grass seed and mineral fertilizer application on two levels of the soil horizon, without exception, the forage land from exploitation. At the first level, grass seeds are sown to a depth of 40 mm, and at the second level, mineral fertilizers are applied to a depth of 120 mm. The depth of sowing of seeds and application of fertilizer adjustable, and the width of their banding - up to 40 mm. The norms of sowing of seeds and fertilization are automatically controlled in the adopted positioning system and are differentiated by taking into account the current state of the forage land in the presence of prescription maps.

The developed grain-fertilizer-grass drill contains a frame 1 on which a seed-fertilizer box is located, including a seed bin 2 and a bin for fertilizer 3, a seed metering device 4, a petal agitator 6, a metering devices for fertilizer 5, a seed tube 7, a fertilizer tube 8; the working part is a coulter-slotter with a stand 9 and fixed on it below the front in the direction of movement of the seeder with a chisel 10 with its edge pointed at the front at an angle of 600, and also the press roller 13 located behind the stand in the direction of movement of the seeder; , figure 8. The width of the opener-snapper is up to 20 mm.

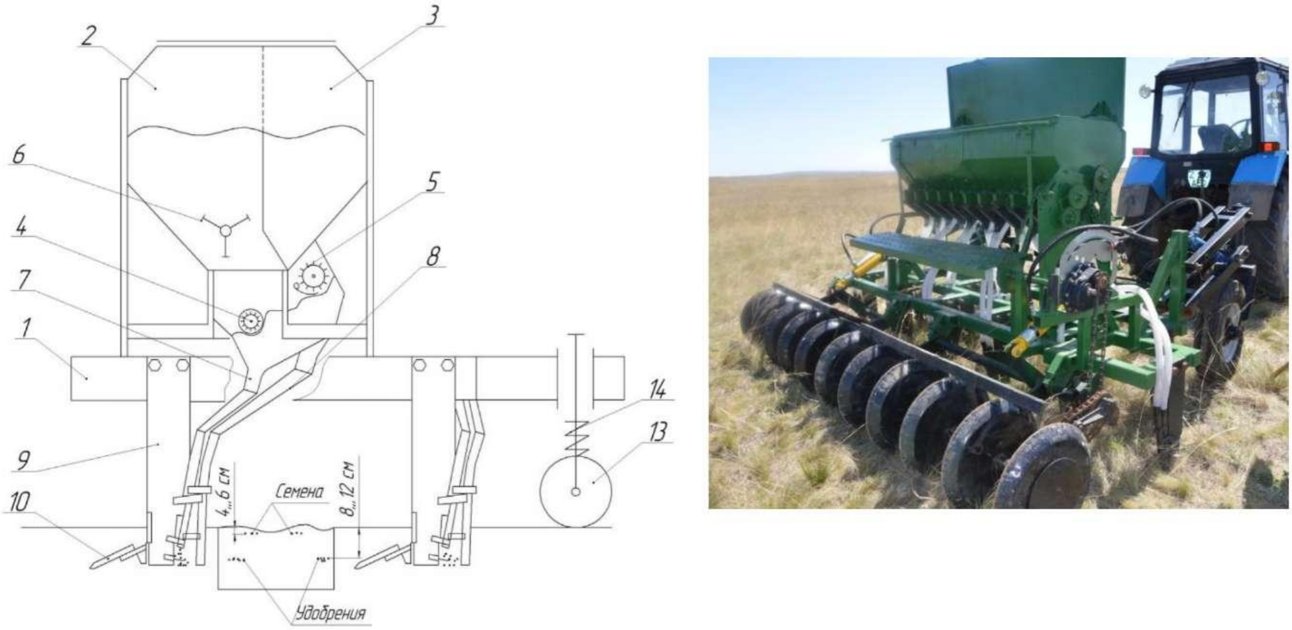

Figure 8 *- Constructive-technological scheme and frame with the working parts of the experimental grain-fertilizer-grass drill*

The opener-slotting 9 cuts a vertical slot in the turf, up to 2 cm wide, and knife 12 - a horizontal slot on the right, counting in the direction of travel of the unit, the side wall of the vertical slot, and the seeds, rolling down from the upper peak 11, are located in this horizontal slot on depth up to 4...6 cm. At the same time, mineral fertilizers from the bin 3 through the seed meteringdevice for 5 through the fertilizer tube 8 are fed to the lower visor 15, evenly crumbles into the wake of the point 10 of the opener-slotting 9, and are located at a depth of 8...12 cm left-side of seed, assuming the course of the movement unit. After the coulter-slotting 9 is followed a press roller 13, which cover up a soil slot.

In the above technological process, the formed slots contribute to loosening the stagnant and compacted stratum of the feeding soil, enhances air and moisture circulation between the horizons and promotes moisture accumulation in the spring-autumn, rainy periods and the rise of moisture from the lower moisture horizons to the plant root system in the dry summer period. The location of the seeds above and to the leftside of the fertilizer horizon eliminates their suppression by chemical reactions and contributes to the gradual feeding of the root system of the plant, and the lower, closer to the wet horizon, the location of the tuk - their better dissolution and migration in the soil environment. Covering the slots with special rolling-on rollers excludes evaporation of moisture through of them, removal of land from feed, possible injury to livestock during pasturing and obstacles to the passage of subsequent machine.

Re-improvement of the feeding fields should be made in perpendicular directions.

Conclusion

Based on the analysis of the application of mineral fertilizers, a solving of technologies and technical solutions for subsurface differentiated application of the main dose of mineral fertilizers and sowing of grain crops and grass seeds with simultaneous application of fertilizers are proposed to solve the problem of plant nutrition and soil decomposition. The developed technical solutions are implemented in prototypes, production inspections are carried out and the small-scale production of rippers-fertilizers begins at the request of farmers.

Acknowledgments. The authors wish to express their gratitude to the Ministry of Education and Science and the Ministry of Agriculture of the Republic of Kazakhstan for funding scientific work. The studies were carried out within the framework of the project of the MES RK AP05134800 "Development of automated grain-fertilizer-grass seeder for variable rate direct sowing of agricultural crops undercover crops and sod with simultaneous application of mineral fertilizers" and under the Agreement No. 33 of the Ministry of Agriculture of the Republic of Kazakhstan on the implementation of applied scientific research in the field of agriculture for the years 2018-2020.

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