

## ANNOTATION

**for the dissertation of Tanbaev Khozhakeldi Kuvandykovich  
on the theme: «Rationale of the main parameters of the working tool for  
intra-soil application of liquid mineral fertilizers», submitted for the degree of  
Doctor of Philosophy (PhD) on educational program  
8D08701-Agroengineering**

**Relevance of the topic.** Preservation and increase of soil fertility remain the key problem in agriculture of Kazakhstan, as fertility of arable soils and humus composition are annually decreasing. According to the research data of scientists in the northern regions of Kazakhstan soils are severely depleted, during the past virgin land development period that carried out for more than half a century 1.4 million tonnes of humus was lost, which is 1/3 of the initial state. On average, annual losses of humus in Kazakhstan are 0.5–1.4 tonnes/ha, these losses are especially intensified on eroded lands. The level of soil fertility decreases on slightly eroded soils by 30%, on moderately eroded soils by 50% and on highly eroded soils by 70%. The process of dehumification is also observed on chernozem soils of Northern Kazakhstan. Compared to 1956, the humus content of ordinary chernozem decreased by 12.3% in 1992-1996 and by 21.5% in 2003-2006. In southern chernozem, compared to 1956, humus content decreased by 18.2% in 1992-1996 and by 38.2% in 2003-2006.

The problem of maintaining and improving soil fertility can be solved by applying organic, solid and liquid mineral fertilisers (LMF). At present, the mechanic-technological basis of liquid mineral fertilisers application into the soil during deep tillage is not fully developed.

Based on the above, the development of a working body for intra-soil application of liquid mineral fertilisers and justification of its main parameters is relevant.

**Extent of study of the topic.** To date, scientists of the country have accumulated a large of theoretical and practical material for justification of design and technological parameters of tillage machines and working bodies. They are mainly aimed at the development and improvement of technical means used in the technologies of continuous tillage. Methods of solid-mineral-fertilizer-application in soil and technology of differentiated application in this direction are in the state of development. However, means and technological process of intra-soil application of liquid mineral fertilisers are poorly studied, standards and methods in this direction are practically absent.

The analysis of domestic scientific works indicates the embryonic state of research in the field of hydrodynamics, which considers the flow of fluid passing through holes of very small (micro-) dimensions, and atomisation processes. The method of computational fluid dynamics (CFD) and discrete elements used in modern science, as well as the basics of their use for scientific purposes are also just beginning to be applied in our country's science, where once again emphasises the relevance of scientific work and its transdisciplinary nature.

**The hypothesis** of the study is that the economic and ecological efficiency of liquid mineral fertilisers can be achieved by applying them into the soil at a certain depth in the form of a uniform band.

**Purpose of research:** reduction of uneven distribution of liquid mineral fertilisers inside the soil by substantiating the design scheme and rational parameters of the working body with a sprayer.

To achieve the purpose of the research the following **tasks** were solved:

- research of technological processes, determination of factors influencing uniform atomisation of liquid fertilizers under the soil during its treatment, and substantiation of constructive and technological scheme of working body atomisers;

- theoretical and experimental substantiation of rational constructive and technological parameters of the working body and its sprayers.

- determination and justification of the shape and size of atomisation, and the required feed rate;

- performance test of the of the working body and atomisers for intra-soil application of liquid mineral fertilizers in field conditions and technical and economic assessment of the sprayer application effectiveness.

**Object of research.** Technological process of intra-soil application of liquid mineral fertilizers.

**Subject of research.** The regularities of influence of design and technological parameters of the working body with sprayers on the spraying band formation across the width of the working body and on the spraying uniformity.

**Scientific novelty of the work:**

- the influence dependence of the design parameters of the working body for in-soil application of LMF and deep tillage on the traction resistance has been established;

- the dependence for determination of spray angle and uniformity from the flat fan sprayer with a semicircular impact surface has been derived;

- a method for determining the subsoil space (cavity) shape and the soil (soil particles) fall line formed during the movement of the tillage knife, which shows the relationship between the knife/equipment velocity and atomization angle, has been proposed.

The novelty of technical solutions is protected by patents issued for invention (№ KZ B 35768, KZ B 36425, KZ B36482).

**Practical significance of the work:** application of the working body will allow to combine intra-soil application of liquid mineral fertilizers with fallow and winter ploughing. The developed 3D model and experimental sample of the working body, sprayers, which allows to inject liquid fertilizers directly into the zone of root system development; device and measuring mini-flask for testing the performance of the sprayer; experimental device for determining the subsoil space and the line of soil fall (soil particles) on the trail of the tillage knife during its movement in the soil channel can be used in future prospecting works.

The proposed sprayer can also be used in surface application of liquid fertilizers, pesticides and for general technical purposes in other industries.

**Theoretical significance.** The obtained dependence of the working body and tillage knife tractive force on its main design and technological parameters will allow to determine the parameters of the implement for tractors with different traction classes. The revealed analytical and geometrical dependences between spraying parameters and the speed of the working body, spraying angle and flow thickness on the impact surface of a flat sprayer with a semicircular shape, 3D-model of the liquid flow area created using ANSYS Fluent® program, theoretical solutions, equations and relations used in optimization calculations, the basis of the performance assessing of the sprayer will contribute to the further development of research in the field of intra-soil liquid fertilizer distribution.

**The main points to be defended:**

- design scheme, parameters and 3D model of a flat fan sprayer for intra-soil application of liquid mineral fertilizers;
- dependences of spraying angle and non-uniformity on design parameters of the flat fan sprayer with semicircular shape.
- theoretical dependence of traction resistance on the parameters of the working body with tillage knives;
- CFD models, calculation and graphical dependencies characterizing the interaction of liquid fertilizers flow with sprayer and optimization conditions.

**Personal contribution of the author.** The author prepared the plan, programme and objectives of the research work. He developed a three-dimensional model, schematics of the presented working body and atomizer, manufactured them in the factory and in the laboratory. Independently carried out laboratory and field experiments. Performed modelling of fluid flow area and optimization calculations using software such as Ansys Fluent®, KOMIAC-3D®, Solidworks Flow Simulation®. He carried out mathematical and statistical processing and reasoning of the obtained results. Prepared texts of publications and the dissertation.

**Approbation of the work.** The results of the study were presented at the following international scientific conferences:

1. International Scientific and Practical Conference «Seifullin Readings-19» dedicated to the 110<sup>th</sup> anniversary of M. A. Gendelman.
2. International Scientific and Practical Conference «Seifullin Readings-18»: Youth and Science – a look into the future».

Implementation of the research results into production were carried out on the fields of the A.I. Barayev Research and Production Centre for Grain Farming.

**Information about publications.** In total 10 scientific works have been published, including 4 articles in international scientific editions included in Scopus (Web of Science) database, 4 articles in editions recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan, 2 articles in materials of international and republican scientific-practical conferences. In total 5 patents of the Republic of Kazakhstan for inventions have been obtained.

**Application of the research results.** The main details of the working body were produced and assembled at «Agritech-KATU» LLP. Field experiments carried out on the fields of the «A.I. Barayev Research and Production Centre for Grain

Farming». In 2020-2021 years, the deep loosener-fertilizer with suggested working body was also tested in LLP «Karabalyk Agricultural Experimental Station» (AES), where the results showed that as a result of winter tillage the excess yield was 2.7 centners per hectare.

The proposed agrotechnological sprayer is suitable for applying LMF in both, intra-soil and surface methods, as well as for use with a pointed paw. They can also be used in other areas of industry, such as air humidification, fire protection, etc.

**The structure and scope of the dissertation.** The dissertation consists of an introduction, five chapters, a general conclusion, a list of references with 135 sources and appendices. Volume – 144 pages, number of figures – 92, tables – 33. The appendices consist of 29 pages.