

# Improvement of the technological process of surface application of mineral fertilizers

A. V. Shemyakin\*, S. N. Borychev, I. A. Uspenskiy, K. P. Andreev, and V. V. Terentyev

Ryazan State Agrotechnological University named after P. A. Kostychev, Ryazan, 390044, Russia

**Abstract.** The article presents a study of centrifugal distributors. The advantages and disadvantages of their use are identified. Based on this, in order to improve technological means for the surface application of mineral fertilizers, it was proposed to develop a self-loading distributor for solid mineral fertilizers from soft containers, which in an aggregate with energy means would perform the functions of transporting mineral fertilizers to the field, loading them into the distributor bunker and their distribution over the surface of the field. It proves that the topic is relevant and is of great economic importance. This article offers a description of the device, the principle of operation and its technical characteristics. It also presents the sequential operations of the technological process: loading, transportation of fertilizers to the field and the very introduction of mineral fertilizers. The purpose is to improve the operational and technological characteristics of the self-loading fertilizer distributor, which is provided by the knives installation scheme, their shape, which allows obtaining a consistently large opening for the release of fertilizers and is equipped with a dressing grid. The proposed design and technological solution allows the distributor being self-loaded with solid mineral fertilizers packed in soft disposable containers weighing up to 1 ton, using a lift installed at the rear of the tractor frame, cutting the bottom of this container and uniform feeding of fertilizers to the spreading disc. In this case, the upper part of the cover of the soft container acts as a part of the distributor bunker, increasing its useful volume

## 1 Introduction

The desire of farmers to obtain maximum yields is the basis for the widespread use of fertilizers. The diversity of soil and cultivated crops, and the difference in their fertility require an almost unlimited combination of types and doses of mineral nutrition. The solution to this problem is carried out by the successive introduction of each type of nutrients, the introduction of complex fertilizers or their mixtures of various forms and composition (organic-mineral mixtures, mixtures of solid and liquid fertilizers and a number of others). Comprehensive mechanization includes the consistent use of machine systems, mechanisms and devices in all technological operations and stages of the production process, which allows complete replacement of manual labor with machine labor in both basic and auxiliary agricultural work. As a result, one of the most important tasks of agrarian science is to create, investigate and test new types of agricultural machines. A significant part of solid mineral fertilizers is applied by scattering them on the surface of fields using centrifugal distributors. The widespread use of centrifugal distributors is due to a number of their advantages: high productivity, a wide range of application rates, a fairly simple and compact design and the possibility of using solid mineral fertilizers with different physical properties [1]. One of the drawbacks of centrifugal distributors is the large

uneven distribution of fertilizers in the field. A characteristic feature of the use of mineral fertilizers has become their supply in packaged form in soft disposable containers with a mass of from 0.5 to 1.0 tons. In these containers, mineral fertilizers are transferred to agricultural enterprises and stored in them until being used. This ensures the best preservation of mineral fertilizers [2].

To load mineral fertilizers into bunkers, the distributors use the available or attracted lifting devices on the farm. In this regard, a very promising and relevant direction seems to be the design of a self-loading solid mineral fertilizer distributor from soft containers, which in an aggregate with an energy tool would perform the functions of transporting mineral fertilizers to the field, loading them into the distributor bunker and distributing them over the field surface. The task of the improvement of technological means for the superficial application of mineral fertilizers is relevant and of great economic importance. For this purpose, it is rational to combine mineral fertilizer distributors and soft containers in one unit [3].

## 2 Objects and methods

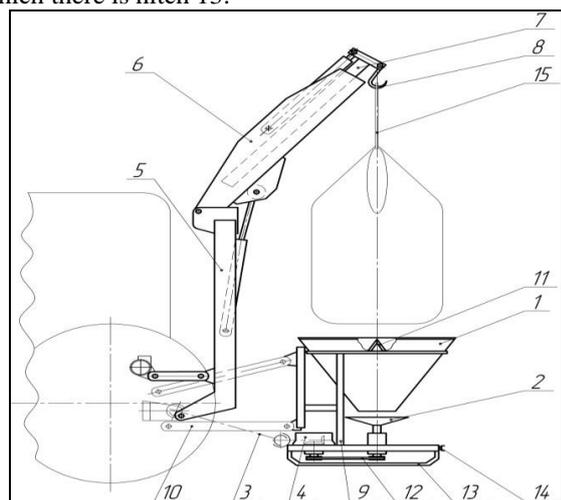
The designed mounted self-loading distributor of solid mineral fertilizers (Figure 1) consists of bunker 1 and a

\* Corresponding author: [shem.alex62@yandex.ru](mailto:shem.alex62@yandex.ru)

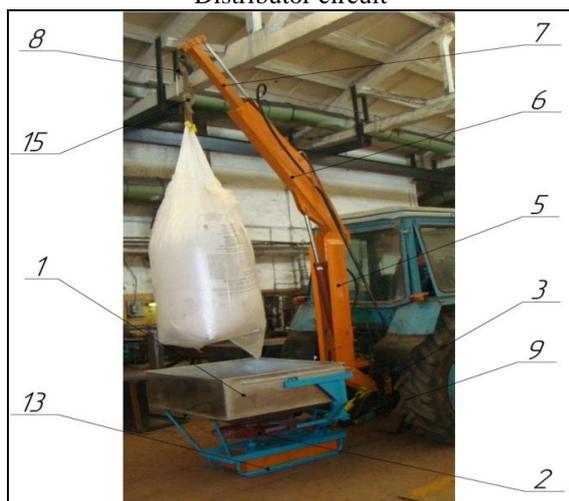
working body for spreading mineral fertilizers, made in the form of centrifugal disk 2 with a drive mechanism that includes driveshaft 3 and bevel gear 4, a lifting device consisting of vertical rack 5 with hinged lever element 6 and sliding section 7, on the outer end of which hook grab 8 is mounted. The movement of elements 6 and 7 is provided by power cylinders associated with the hydraulic system of the tractor.

Bunker 1 by means of supporting frame 9 is pivotally mounted on rods 10 of the tractor mounted system. Knife 11 is installed in the lower part of the bunker. The bunker ends with an outlet with adjustable flow rate, under which spreading disc 2 is installed.

Supporting frame 9 of the bunker in the lower part is made in the form of ski-supports 12, on the cross-link of which there is hitch 13.



Distributor circuit



Appearance of the distributor

**Fig. 1.** Self-loading mineral fertilizer distributor with the lift of soft containers “Big-Bag” weighing up to 1 ton

The purpose of the study was to check the quality of the experimental machine for fertilizer application, as well as the process of distribution of solid mineral fertilizers within the specified limits, according to agronomic requirements. An improved agitator is installed inside the machine's bunker, which during rotation ensures the destruction of lumps and locally compressed masses of the bulk material, reducing the

likelihood of coking. In the process of fertilizer application, the agitator affects the outflowing masses until the fertilizer of the bunker is completely emptied and contributes to a uniform supply to the spreading bodies, which ultimately leads to an increase in the quality parameters of the mineral fertilizer application process [4].

The uniformity of distribution and the dose of fertilizer when centrifugal machines operate largely depend on the supply of fertilizer to the dosing device. To study the effect of the supply of granular fertilizers on the parameters of the metering and spreading devices, some laboratory studies were conducted. The uniformity of fertilizer feed to the spreading disc and the exception of crushing fertilizer granules make possible to increase the uniformity and width of distribution.

The experimental machine is designed for the surface application of solid mineral fertilizers, lime material and sowing the seeds of grain crops and grass in fields, pastures, hay fields and gardens, followed by embedding them with soil-cultivating tools. The machine can work on all types of soils in different climatic zones, as well as on stubble and vegetative crops, involving the use of mineral fertilizers in a dose of up to 1,000 kg/ha.

The proposed design and technological solution of the block-modular construction principle of the unit allows the distributor being self-loaded with solid mineral fertilizers packed in soft disposable containers weighing up to 1 ton, using a lift installed in the back part of the tractor frame, cutting the bottom of this container and uniform feeding of the fertilizer to the spreading disc. In this case, the upper part of the cover of the soft container acts as a part of the distributor bunker, increasing its useful volume [5].

A self-loading mineral fertilizer distributor, including a lifting device mounted on the tractor frame and a mounted mineral fertilizer distributor in the proposed arrangement, causes a load on the tractor with a lower tilting moment. This makes it possible to aggregate them with tractors of 1.4 class (MTZ-80, 82) [6].

Figure 2 shows the main elements of the technological scheme of using a self-loading solid mineral fertilizer distributor.

The process operations are as follows:

1. Loading soft containers into the vehicle.

1.1 The knife is removed in the bunker of the distributor.

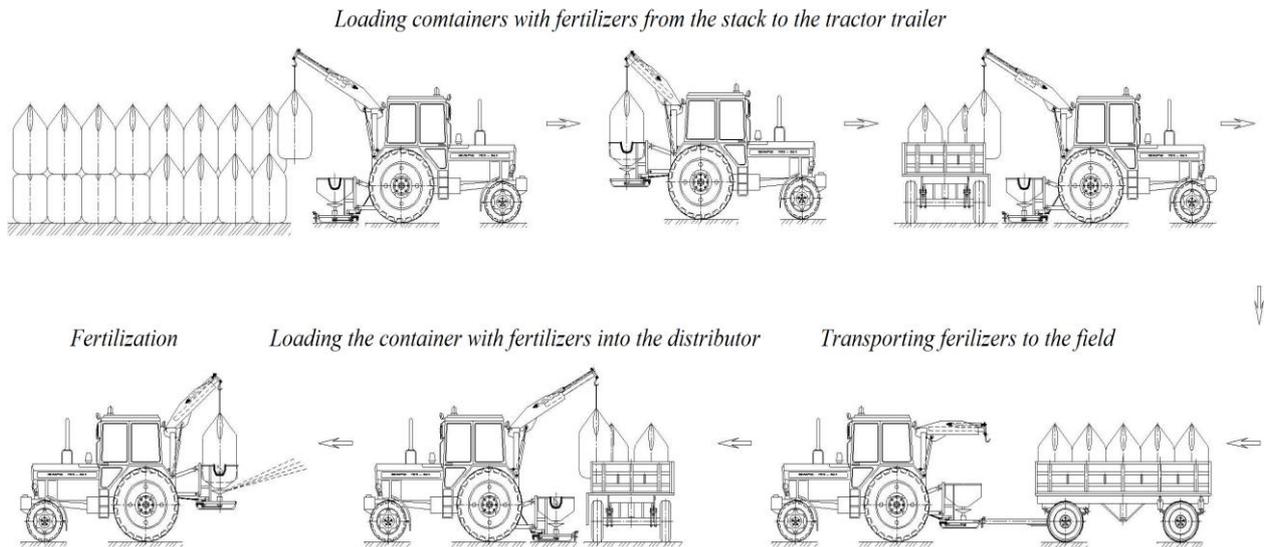
1.2 The tractor drives up to the stack of soft containers and the distributor bunker is lowered to the ground.

1.3 The required working radius and height of the lift for slinging the soft container in the cargo loops is set. The soft container rises and moves to the distributor bunker. After lowering the container, the tension of the lifting elements is relaxed, and the distributor is moved to the transport position.

2. The supply of soft containers and their installation on the platform of a tractor trailer.

2.1 The tractor moves up to the trailer.

2.2 By moving the elements of the lifting boom lift the soft container is lifted and transferred to the free space of the tractor trailer body.



**Fig. 2.** Technological scheme of mineral fertilization

These operations are repeated until the body is fully loaded.

3. Aggregating the tractor with a loaded trailer and transporting it to the field.

4. Uncoupling the tractor and the trailer, putting the distributor into the working position.

4.1 Installing the distributor bunker knife to the working position and the tractor approaching the trailer.

4.2 Roping and installing a soft container with the help of a lift in the distributor bunker on the knife. At the same time, by moving the lifting boom down, the tension of the roped elements is weakened.

4.3 Driving the tractor to the plot, turning on the tractor's PTO to drive the centrifugal disc of the distributor and start applying mineral fertilizers.

4.4 After emptying the soft container from the fertilizers the tractor's PTO is switched off, and the tractor moves to the trailer for another soft container.

The operations of clauses 4.2–4.4 are repeated.

If there are special lifting devices on the farm where the soft containers are stored, the tractor trailer is loaded with fertilizers with their help [7, 8].

The purpose of the research is to determine the time spent on loading the Big-Bag soft containers with fertilizers from the stack to the trailer (Figure 3) and from the tractor trailer (Figure 4), for transportation of fertilizers to the field and fertilization, as well as the study, synthesis and dissemination of rational methods and ways of work of advanced workers: checking the possibility of combining and synchronizing work in order of full load of aggregates, equipment and working operators. Timing study of the process of delivery and application of mineral fertilizers was carried out in farm "Zorka".

### 3 Results

The total time spent on the technological process was determined on the basis of timing to study the content of operations, the sequence of their execution and the

measurement of the cost of working time to perform some cycle basic and auxiliary elements of operations.

A time study was conducted by specialists having experience with check meters and familiar with the technology of fertilization. After getting acquainted with the operations that were subject to timing, their structure and methods of implementation were studied. Then operations were divided into elements to determine the technological sequence of each element and the possibility of eliminating unnecessary techniques or elements.



**Fig. 3.** Loading of Big-Bag soft containers into a trailer

The timekeeping process consisted of several stages. When preparing for timekeeping, they substantiated the choice of a workplace according to the structure of operations and their compliance with equipment, working conditions and worker's qualifications

(according to operation elements – loading, moving, transporting and depositing), determining the most important factors affecting the duration of each element and the required number of measurements.

This stage ended with the inclusion of the listed information and elements of the operation under study in their rational technological sequence with the establishment of fixing points in the time-observation sheet.

After time observation, measurement and fixation of the duration of each normalized element of the operation, the processing and analysis of the results of observation during the timing took place [9]. The results are presented in Table 1.



**Fig. 4.** Loading fertilizer SZMVU-0.5 in the field

**Table 1.** Results of a time study of the technological process of fertilization.

	Operation	Parameter	Loading / reloading parameter		
			From the stack to the field	From the tractor trailer	From the hangar
1	Container loading	Time spent on approaching and lowering the machine for fertilization	20 sec	20 sec	20 sec
		Time to seize the container	10 sec	10 sec	10 sec
		Time spent on raising and moving into the bunker of the fertilizer distributor	15 sec	15 sec	15 sec
2	Container delivery and setting to the tractor trailer	Time spent on approaching the trailer	–	32 sec	–
		Time spent on setting the container into the trailer body	–	25 sec	–
3	Loading the container from the stack into the distributor and its setting	Time spent on approaching and lowering the machine for fertilization	45 sec	–	–
		Time to seize the container	10 sec	–	–
		Time spent on raising and moving into the bunker of the fertilizer distributor	15 sec	–	–
4	Container loading from the tractor trailer	Time spent on approaching and lowering the machine for fertilization	–	45 sec	–
		Time to seize the container	–	10 sec	–
		Time spent on raising and moving into the bunker of the fertilizer distributor	–	15 sec	–
5	Transportation to the field and across the field	Time spent on the move for the next soft container	5 min	3 min	20 min
6	Fertilization	Time for fertilization	22 min	22 min	22 min
7	Total		28 min	27 min	42 min
			55 sec	32 sec	45 sec

The analysis of the results showed that the most effective will be the technology of work organization with the use of a trailer, which reduces the time of loading and transportation, especially when the field is far from the fertilizer warehouse. Fertilizers are applied with SZMVU-0.5 with a bunker capacity of 1,000 liters and a working width of 17 m. The working speed is 7 km/h and the average transport speed is 10 km/h. Fertilizers are in containers “Big Bag” of 0.85 tons each. The capacity of the unit in the field without the loads will be approximately 8.02 hectares/hour. One container will be spent in 22 minutes. The download will take a maximum of 5 minutes. Thus, one cycle, taking into account non-production time losses, is 29 minutes. For the 8-hour shift, this will amount to 4 full working cycles, or about 32.08 hectares.

## 4 Conclusion

Time studies of the technological process of mineral fertilization showed that the use of a mounted self-loading mineral fertilizer distributor precludes the use of specialized machines for loading mineral fertilizers. In addition, the developed container lift does not occupy the tractor’s hinged system, which increases the versatility of its use and provides the ability to be aggregated with other machines, for example, trailers, planters, cultivators. The most effective will be the organization of work with the use of a trailer for transporting and storing fertilizers, which shortens the time of loading and transportation, especially when the field is far from the fertilizer warehouse.

The self-loading fertilizer application machine allows increasing productivity due to the mechanization of the process of unloading mineral fertilizers and increasing the volume of the bunker due to soft containers. Combining the process of mechanized loading of soft containers with mineral fertilizers into the bunker and their preparation – unpacking, separation, destruction of packed lumps and removal of inclusions, improves the performance and quality of work of the distributor.

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