Units mechanization for improving mountain slope areas

I.E. Soldatova[1] and *L.R.* Gulueva[1*]

[1]North Caucasian Research Institute of Mountain and Foothill Agriculture, Branch of the Federal State Budgetary Institution of Science Federal Scientific Center “Vladikavkaz Scientific Center of the Russian Academy of Sciences”, Vladikavkaz, Russia

Abstract. The authors presented the results of scientific developments and devices for improvement and restoration of mountain pasture areas on degraded mountain slopes. The aim of the research is to develop a method and produce a small-size laboratory sample of block-module for grass seed sowing and surface application of mineral fertilizers on the basis of MTZ-82 tractor after paraploughing. In connection with the lack of small-sized units for the mountain zone, the laboratory unit was created, the process technology was substantiated, the designs of working bodies and units were designed and manufactured. Technical expertise and tests of the machine and technology were conducted in the mountain zone of the Republic of North Ossetia-Alania (Dargavskaya Basin, the reference point of SCNIIGPSH) at an altitude of 1540 meters above sea level, on a ragged section of the northern slope steepness of 13-10 in the area “Sugsadtanrag”. The indicators of testing conditions and functional indicators of the machine performance were determined according to the industry standard OST 10.5.1-2000, according to the industry standard, OST 10.7.1.-2000. “Testing of agricultural machinery. Machines for application of mineral fertilizers, lime materials and gypsum. Methods of evaluation of functional indicators. Ministry of Agriculture and Food of Russia”. The results of observations showed that the use of the aggregate makes it possible to increase both the yield of dry mass and fodder units (0.79 fodder units in 1 kg of dry mass) from 0.81-1.68 thousand/ha to 4.49-4.98-4.06 thousand/ha of fodder units, to extend the period of pasture maintenance in the mountains by 40-45 days, to additionally prepare winter fodder in the form of hay and haylage. Practical application of the small-size aggregate will provide reduction of degradation processes of slope areas by accelerated restoration of quality and quantity of perennial grasses of fallow fodder lands.

1 Introduction

The solution of the food program is impossible without providing livestock farming with cheap and high-quality fodder, which can be obtained only on highly productive hayfields and pastures. It is known that in the formation of a sustainable agro-landscape, fodder

* Corresponding author: luda_gulueva@mail.ru

accounts for more than half of the costs of livestock production [1]. In this regard. the development of modern systems of grassland farming, taking into account the directions of development, conservation and improvement of soil fertility, as well as ensuring the sustainability of agro-landscapes and environmental conservation, is the most significant in the current conditions of agro-industrial complex in the mountain zone [2, 3].

Taking into account these aspects of the problem, scientists have faced the need to develop methods of accelerated restoration of degraded forage lands [4, 5].

It is known that unsystematic use of hayfields and pastures results in compaction of the surface soil layer of the mountain zone. This compaction does not make it possible to preserve moisture during spring snowmelt in mountainous areas [6, 7]. It is the preservation of moisture in the soil that is one of the important agrotechnical practices.

To solve the problem of moisture conservation, the authors propose to slit compacted mountain soil across the slopes. This agrotechnical method will make it possible not only to accumulate moisture for phytocenosis development, but also prevent water and wind erosion. And sowing grass seeds and applying granular fertilizers on mountain pastures after paraploughing will ensure ecological sustainability of mountain ecosystems by introducing them into the soil in such a way that nutrients are fully used by vegetation.

One of the methods of sparing attitude to natural forage lands of mountain territories is the use of special small-size multifunctional machinery adapted for ecologization of works on mountain meadows and pastures. The use of such equipment will make it possible to solve the problem of negative impact of water and wind erosion in mountainous areas of meadows and pastures.

In order to increase the survival rate of seedlings and young plants growing from sown seeds, it is necessary to include feeding with mineral fertilizers in the technological method [8, 9]. In addition, sowing grasses into the turf of natural meadows without its preliminary treatment turns out to be ineffective, because the seeds not incorporated into the soil do not sprout or the sprouts die, notwithstanding the competition with natural grasses in the struggle for nutrient environment, which entails the need for turf cultivation.

Favorable conditions for seed establishment are also achieved by sowing seeds on bare areas and then rolling them in. Therefore, it is necessary to constantly carry out surface improvement of meadows and pastures.

Research objective is a new method and a prototype sample of a multifunctional machine that performs three operations after the process of paraploughing: sowing grasses, applying mineral fertilizers and rolling of sown seeds.

Objectives of research: to study the optimal distance between the spring struts of slitters chisel cultivator KChG-2,4, to give a characteristic of the developed block - module multifunctional unit KChG-2,4, performing after the process of paraploughing three operations: grass seeding, mineral fertilizers and rolling of sown seeds and granular fertilizers in the soil; to determine the effectiveness of the developed agro-techniques.

The research results can be formulated as follows. A prototype sample of multifunctional machine KCHG-2,4 (Fig.1) was developed [10], with the use of spring struts “Viderstadt”, used for soil clearing of mountain meadows and pastures on slopes up to 200, having stony inclusions or rocky protrusions above the soil surface. The used spring struts make it possible to bypass rocky ledges encountered on the path of travel and return to the working condition without damage without undermining the slot edges [12, 13].

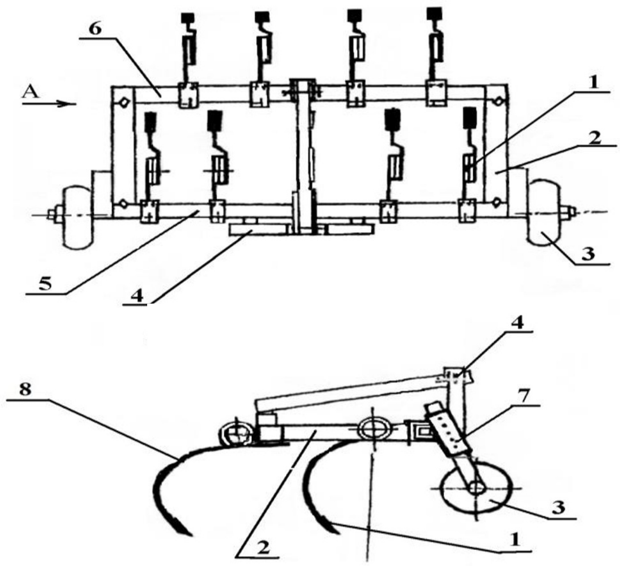

Fig. 1. Mining chisel cultivator KChG-2.4: 1 - paraplough; 2 - cross beam; 3 - support wheel; 4 - auto coupler CA-2; 2 - frame; 5 - front frame beam; 6 - rear frame beam; 7 - telescopic connection for adjusting the working depth; 8 - working tool post.

The design of the prototype makes it possible to install the slitters at any distance from each other and in any number at a width of 2.4m Blade parameters: blade sharpening angle 400, thickness -25mm, width-50mm, cutting angle -1200 in the direction of travel.

When using a prototype sample of the machine, it is necessary to take into account the steepness of the slope, the degree of soil erodibility [11], the state of vegetation cover, the depth of the sod layer. It is known that the steeper the slope, the more exposed to soil erosion and less projective coverage of soil by plants, and the greater the distance between slits should be. Paraploughing was done in the fall, at the end of the growing season, with observations from the spring following.

Discussion of the principle of operation of the machine. In order to carry out the following operations- seeding of grasses by scattered method [12], on mountain meadows and pastures with subsequent application of granular fertilizers on the surface of the seeded area for the first time on the basis of a mountain cultivator KChG-2,4 a prototype of the unit was created, which performs after small adjustments three operations: sowing grass seeds in a scattered manner on slope meadows and pasture areas, application of granular fertilizers on the surface of the sown area, rolling of sown seeds and granular fertilizers into the soil.

A grass sowing machine is installed on the frame of the sample for sowing seeds, and for the subsequent pressing of seeds into the soil there are rolling ring rollers on spring-loaded stands (Fig. 2).

Fig. 2. Design scheme of the prototype of the grass seeding machine prototype

The prototype is automatically attached to the tractor and the support wheels make it possible to adjust the depth of travel of the machine's working bodies. The position of the support wheels can be changed vertically by means of telescopic struts and locking pins.

The seeding units are driven from the support wheel by a chain drive. The drive is additionally equipped with interchangeable sprockets for different sowing rates of mineral fertilizers. The prototype sample of the machine is coupled with MTZ-80/82 (H, M) row crop tractors [13].

The attachment of ring rollers to spring struts provides rolling of seeds and fertilizers into the soil, bypassing the stones encountered in the soil without breaking the struts.

After made calculations the capacity of hoppers was determined by the maximum rate of application of mineral granulated fertilizers and grass seeds, respectively - 200 kg/ha and 40 kg/ha, assuming the time of the machine continuous work 1-1,5 hours.

The process of spreading seeds or granules by the prototype machine is carried out under the action of gravitational force. Since the seeding process is most effective in the vertical position of the seeding tube, the seeding tubes are suspended from the seeding unit articulated, with the possibility of maintaining the vertical position when the seeding unit works on slopes up to 16º. Taking into account the norms of grass seeding and the design of the basic multifunctional aggregate KCHG-2,4 of SKNIIGPSKh design, the left section of the seeding unit of the bobbin-type seeding device of the serial seeder SZT-3,6 for grass seeding on meadows and pastures in the mountain zone was chosen as the seeding module of the prototype aggregate.

To realize the scattering method of seeding, seeding tubes with seed cones forming a directed seed flow and scattering it [14] were developed, manufactured and installed on the grass seeding machine. This eliminates the need for seed pipes and coulters, which significantly reduces the weight of mounted equipment and reduces the material intensity of the seeding unit, simplifies its design, maintenance and reduces the cost and pressure of the unit on the soil. All these positive factors make the machine preferable and convenient for use in the mountains. At the same time, such a constructive solution for realization of the scattered method of sowing seeds makes it possible to evenly distribute a given rate of seeds over the surface of the sown field [15, 16].

In this case, the drive of the coil seeding unit is carried out by chain transmission from the right support-drive wheel of the base machine - a chisel mountain cultivator KChG-2,4.

The prototype machine has spring-loaded, floating packer sections, which process the field with scattered grass seeds.

Among the measures for surface improvement of mountain fodder lands the fastest and highly effective is the use of grass seed sowing with mineral fertilizers, which make it possible to increase the yield of meadows 3-4 times and significantly improve the nutritional value of fodder.

For the first time for work on sloping areas with a slope up to 16º on the basis of a mountain cultivator KCHG-2,4 a block-module of the experimental unit was created, which performs the application of granular fertilizers on the surface of the under-sown area on the background after slitting the soil (Fig.3).

Fig.3. Pilot sample of the block-module of the unit for mineral fertilizer application

2 Materials and Methods

The research of the prototype was conducted in the mountain zone of RNO-Alania (Dargavskaya Basin, the reference point of SCNIIGPSH) at an altitude of 1540m above sea level of southeastern exposure with a slope steepness to 150. The selected pasture plot is highly degraded. The following scheme of the experiment was applied: 1 - control without improvement, 2-splitting after 1.5m without improvement, 3-splitting after 1m + seeding + N60P45K20, paraploughing at 1.5m intervals + seeding + N60P45K20, paraploughing after 2.4m + seeding + N60P45K20.

The experimental plot was divided into three replications. The width of each replication was 2.4m, length 10m, dividing strips 1m, side strips 2.4m. The total area of the experimental plot across the slope was 184.2m2. Research was conducted to find out the optimum slot spacing. The results showed that the higher yield for three years of observation was established in the variant with a distance between the slits of 1.5m. In the first year of observations (in relation to the control variant), the gain in this variant was 8.9 c/ha of dry mass, and in the third year this indicator increased to 12.5 c/ha, while in the variant with slits through 1m this indicator was 5.2-6.7 c/ha, respectively, and at a distance of 2.4 m - 4.3-5.1 c/ha (42% soil coverage) (Fig.4).

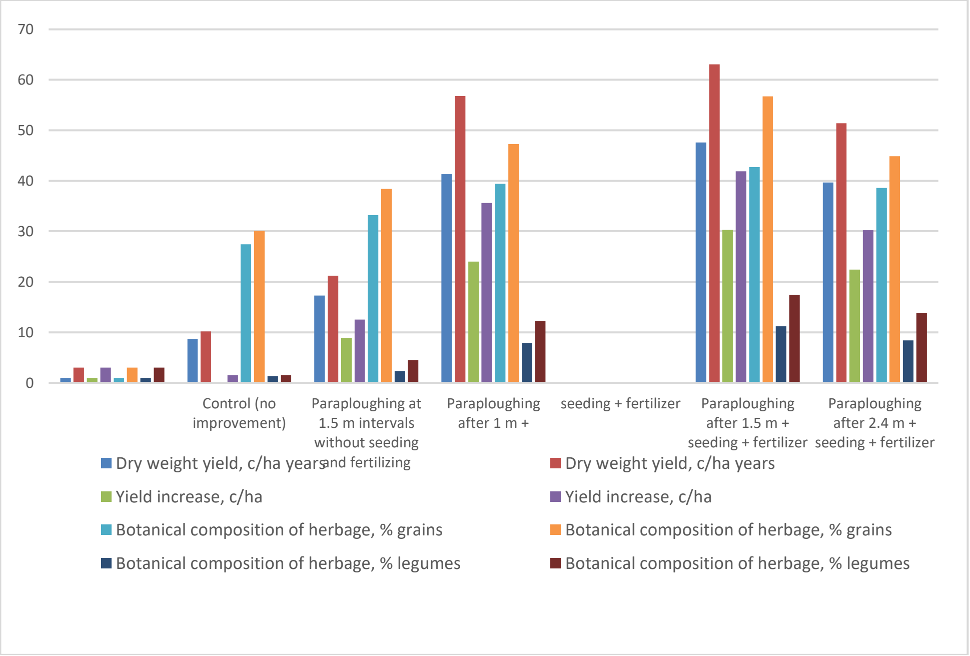

Fig. 4. Effect of spreading, grass seeding and fertilizer application on yield and botanical composition of the meadow (for three years)

The grass of the degraded meadow (before paraploughing) contained a large amount of rhizomatous vegetatively propagated grasses. Paraploughing provided better development of these plants compared to loose-brush grass species with low productivity and quality. In this regard, a three-component grass mixture of loose-bush grasses with seeding rates of: meadow timothy (Phleum pratense L.) - 4 kg/ha; cock's foot grass (Dáctylis glomeráta L.) - 5 kg/ha; red clover (Trifolium praténse L.) - 6 kg/ha; in total 15 kg/ha was proposed for grass seed sowing [17, 18].

Grass reseeding and mineral fertilizer application were carried out in early spring, when stable positive temperatures were established, at the beginning of the vegetative period of the following year after paraploughing.

According to observations, by the end of the first year of vegetation, the highest yield was observed at paraploughing through 1.5 m with seeding and fertilizer application, amounting to 47.6 kg/ha, increasing the increment, compared with paraploughing through 1.5 m (variant 2), which is higher than variants №3 and №5, respectively, by 15.2 - 19.9%.

3 Conclusions

As a result of application of a small-size cheesel cultivator, there was a noticeable change in the structure of economic-botanical groups of phytocenosis. In these phytocegnoses, the share of cereal and legume grasses, as well as the share of native medium-growing cereals, which formed a dense grass stand, increased significantly.

Thus, the content of cereals from 27.4% in the control and 33.2 in the second variant increased to 42.7% in the fourth variant, and the legume component from 1.3-2.3 to 11.2%.

The calculations of effectiveness showed that the use of the prototype sample of the aggregate in mountain conditions made it possible to increase both the yield of dry mass and fodder units (0.79 fodder units in 1 kg of dry mass) from 0.81-1.68 thousand/ha to 4.49-4.98-4.06 thousand/ha of fodder units.

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Consequently, the use of mountain modification aggregate KCHG-2,4, performing sequentially 3 operations: paraploughing, grass seeding and fertilizer application (with mandatory rolling) contributes to the restoration of degraded mountain fodder lands, increasing productivity, the formation of the planned structure of phytocenosis environment-forming role, preserving the ecological stability of mountain agrolandscapes.

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