

On The Question Of Mechanized Planting Of Forest Crops On Slopes

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Abstract: This article presents the results of an analysis of conducted scientific research on seedling planting with simultaneous microterracing and determines that to ensure high-quality planting of forest crops on slopes with a steepness of up to 20°, a grader blade should have a cutting edge length of 800 mm.

Keywords: Analysis, seedling, slope, grader, forest, agriculture, slope, machine.

Introduction: In our country, forests occupy more than one-third of the total area and are a vital element of the national economy. They meet the country's growing demand for timber, industrial and food raw materials, and perform protective, sanitary, and hygienic functions. At the same time, forests serve as the most powerful and effective means of preventing and combating soil erosion on slopes.

Successful forestry is associated with the widespread use of mechanization in afforestation of mountain slopes.

METHODS

One of the most labor-intensive tasks in forest cultivation is planting forest crops. Our industry produces the LPA forest planting machine for work in mountainous conditions. However, as practice and our experimental studies have shown, using this machine on non-terraced slopes steeper than 6° does not produce satisfactory results (the number of missed and crooked seedlings increases, the uniformity and straightness of planting is disrupted, the pulling force decreases, etc.).



kN; a) in combination with a 1.4 kN class tractor;



b) front view;

Figure 1: LPA tree planting machine

The forest planting machine is designed for planting seedlings and saplings of subshrub in pre-prepared (plowed or deep-loosened) soils of varying mechanical compositions [1-3].

Number of planted rows, pcs	1
Working speed, km/h	1,4
Productivity per hour of prime time, linear km	1,4
Maximum seedling planting depth, mm	250
Furrow width from coulter, mm	200
Overall dimensions of the implement in working position, mm	
Length	1857
Width	1858
Height	1058
Weight, kg	325

The machine is a mounted implement and is coupled to class 1.4-2.0 wheeled tractors equipped with a hydraulic, split-mounted hitch system and an automatic depth control system (ADS system).

To optimally mechanize vineyard opening, researchers at the M.M. Mirzaev Research Institute of Vineyard Plants and Winemaking, together with designers from BMKB-Agromash JSC, developed the UYOM-1 vine-opening device. This device reduces the number of passes and improves the agronomic performance of vineyard opening (Figure 1).

To ensure high-quality operation of forest planting machines on slopes with a steepness of 20°, it is proposed to combine the planting of forest clumps with simultaneous microterracing. To achieve this goal, we developed an experimental forest planting machine. Comparative studies of the LPA machine and the experimental model were conducted to identify quality indicators. The experimental prototype consists of a LPA machine mounted on a KTG-1-35 trench digger frame using a stand, the pendulum mechanism of which brings the working elements into a vertical position. A grader blade is attached to the same stand

for cutting microterraces.

During the experiments, the length of the grader blade was varied and, based on theoretical studies, was set to 500, 100, and 900 mm.

Prior to the experiments, soil moisture, density, and slope steepness were determined in the test plots.

The performance of the compared machines was assessed using the following parameters: planting spacing, average seedling inclination angle from the vertical, seedling planting depth, and seedling extraction force.

The planting spacing was determined by measuring the distance between 30-50 seedlings with a ruler along the length of each counting run. The number of missed plantings was determined separately: first, missed plantings due to planter error were counted (by observation from the tractor driver's cab); then, after the machine had passed, the total number of missed plantings was determined; and then, the number of

missed plantings due to machine malfunction was determined. The seedling stem inclination angle from the vertical was measured using a ruler and a protractor with a plumb line. The seedling pullout force was determined using a spring balance. It was measured for seedlings whose deviation from the row axis was measured (after determining the planting spacing). The measurement data were processed using variation statistics. The experiment was considered sufficient if the accuracy rate was 2-5%.

The coulter depth was set at 30 cm to ensure a planting depth of 25-29 cm.

As Figure 1a shows, the change in seedling planting depth between the LMG-2 and the experimental model differed.

RESULTS

With increasing slope steepness, the planting depth

when using the LMG-2 decreases, and on slopes above 9°, it is below the permissible agricultural requirements. With the experimental model, the planting depth increases within the permissible limits, except when the grader moldboard length is 500 mm. Here, with a slope above 9°, it is greater than the permissible agricultural requirements. It is known that when working transversely, the agricultural machine shifts downslope; i.e., in our case, the longitudinal axis of the LPA forest planting machine deviates from the tractor axis, and the coulter operates like a grader. As a result, the planting slit opened by the coulter is much wider, and the loosened soil does not cover the seedlings. As the slope steepens, this shift increases, leading to an increase in the planting slit. The soil of the lower ridge slides down the slope, reducing the volume of soil removed by the coulter and intended for seedling embedment [4-7].

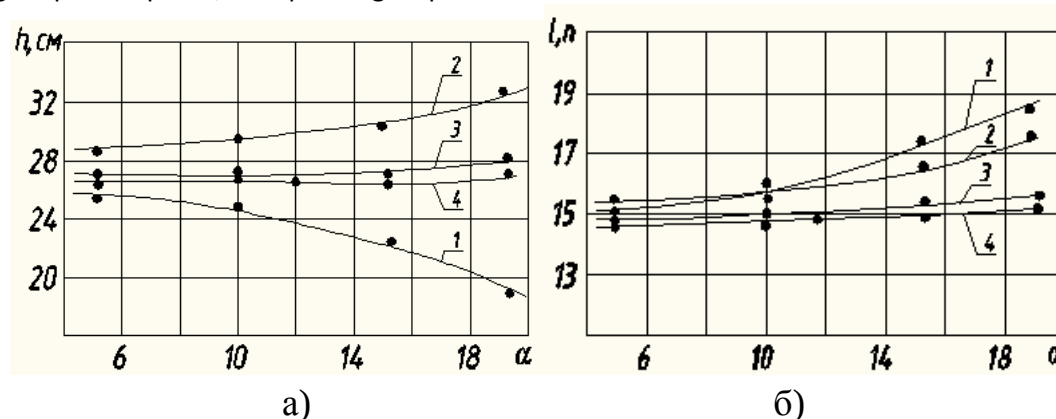


Figure 1. Changing the depth and spacing of seedlings depending on the slope steepness: 1. L = 500; 2. L = 700; 3. L = 900 4. LPA

Furthermore, on steep slopes, soil from the upper ridge crumbles into the planting slit before the seedling is planted. As a result, planting depth decreases with increasing slope steepness.

When using the experimental model, the length of the grader moldboard proves to be a decisive factor. When the moldboard is 500 mm long, planting depth increases with increasing slope due to the increased seedling placement depth. This occurs because the ridges formed by the moldboard and coulter overlap due to the narrow moldboard width, resulting in an increased volume of soil for seedling root system placement. At the same time, the lower roller, passing over the ridge, also scatters it and covers the seedlings, increasing the root collar placement depth, i.e., the overall planting depth. The soil removed by the coulter is completely utilized by the press rollers to seal the root collar, ensuring a consistent planting depth.

With moldboard lengths of 700 and 900 mm, conditions are identical to those on flat land, as they are free of the negative factors encountered with the

LPA and the experimental model with a 500 mm grader moldboard.

The planting pitch changes differently when operating the LPA and the experimental model. As the slope steepens, the planting pitch increases for both the LPA and the experimental model. This is because the machine's offset causes the press wheels to be positioned at an angle to the direction of travel and are dragged, resulting in wheel slippage, which increases the planting pitch. It should be noted that the effect of slope on changes in planting pitch was particularly noticeable when operating the LPA, with the drive roller (with lugs) moving along the uphill side of the slope. The graph (Figure 16) shows the average planting pitch values for two passes of the machine, with the lug roller moving along the uphill and downhill sides of the slope.

As can be seen from the graph, when operating the LPA and the experimental model with a 500 mm grader blade, starting from a slope of 11°, the planting pitch exceeds the limits permitted by agricultural requirements. When working with a cultivator, when

the roller with lugs (driven) is positioned in the direction of the slope rise, as a result of the upper roller crumbling into the planting gap formed by the coulter, the adhesion of the roller to the soil is insufficient, which leads to an increase in slippage and, thus, the planting step.

The increase in planting spacing when using the experimental model with a 500 mm moldboard length is explained by the fact that, due to insufficient upslope movement of the soil cut by the grader moldboard and the formation of a ridge formed by the coulter, the difference in the height of the ridges under the upper and lower rollers increases, creating unequal operating conditions for the rollers, leading to their slippage.

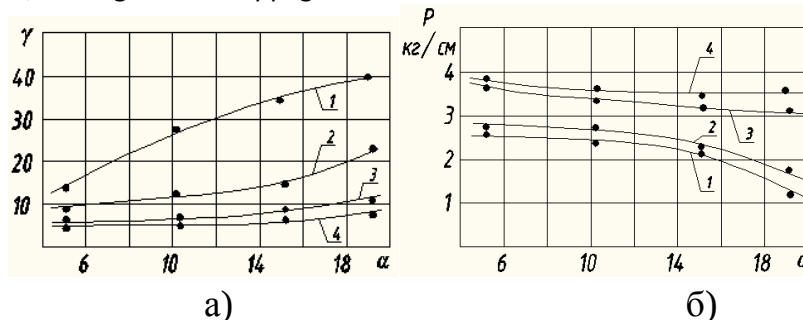


Figure 2. Changes in slope and seedling uplift force depending on slope steepness: 1. LPA; 2. L = 500 mm; 3. L = 700 mm; 4. L = 900 mm.

This is explained by the fact that when operating a tractor-tiller, whose working element operates in a field perpendicular to the slope, seedlings are planted at an angle to the vertical equal to the slope's steepness.

Furthermore, as a result of the tractor-tiller linkage shifting, the symmetry of the planted seedling relative to the press rollers changes, leading to a difference in pressure on it and an increase in the slope. On steeper slopes, the upper press roller directly runs over the seedling.

As for the difference in the absolute values of γ during operation of the tractor-tiller and the experimental model, it is explained by the fact that in the experimental model, regardless of the terrain slope, the working element with the planting unit is installed vertically. The graphs in Figure 2 also show that the grader blade length has a significant impact on the magnitude of the change in γ , both in terms of the rate of increase and in absolute value. It should be noted that with a blade length of 500 mm, the increase in seedling slope angle is more pronounced than with blade lengths of 700 mm and 900 mm. Thus, if at $L = 500$ mm, for every degree increase in slope steepness, the slope increases by an average of 1 degree, then at $L = 700$ mm and $L = 900$ mm, it increases by 0.21 and 0.30 degrees, respectively.

Thus, when assessing planting quality based on

With moldboard lengths of 700 and 900 mm, both rollers pass along the terrace surface, and the planting spacing is affected only by the relative displacement of the longitudinal axes of the tractor and machine.

Another indicator characterizing planting quality is the inclination of the above-ground part of the seedlings.

Figure 2 shows that the increase in inclination of seedlings with increasing slope steepness differs between the LPA and the experimental model. When the latter is in operation, it changes within acceptable limits, whereas when the LPA is in operation, starting from 12° , it goes beyond the limits permitted by agricultural requirements.

seedling slope angle, we can conclude that the influence of slope steepness on the change in value for blade lengths of 700 and 900 mm is insignificant. Consequently, these blade lengths are the most acceptable. From the graphs (Figure 2) it is evident that with an increase in the steepness of the slope of the seep for pulling out seedlings, P decreases both during the operation of the LPA and the experimental sample, and with a grader blade length of 700 and 900 mm this decrease is insignificant.

The significant decrease in P during operation of the LPA and the experimental model with a 500 mm long grader blade can be explained by the fact that, during LPA operation, as the slope increases, due to the redistribution of the unit's weight, the lower tractor track penetrates comparatively further into the soil. Consequently, the lower press roller exerts greater pressure on the seedling, starting at a slope of $12-13^\circ$; seedling compaction is performed only by the lower roller. However, when operating the experimental model with a 500 mm long blade, due to the difference in the heights of the ridges formed on the sides of the planting slit, the press rollers operate under uneven conditions.

Furthermore, as a result of the lateral displacement of the compacting machines, the lower roller moves further and further away from the seedling, thereby reducing the pressure on it. When operating the

experimental model with blade lengths of 700 and 900 mm, the force P changes within acceptable limits. The slight decrease in this force is explained by the increased dynamic factors affecting the unit's operation.

CONCLUSIONS

Planting seedlings with simultaneous microterracing and vertical drive of the tillers creates conditions identical to those on flat land and significantly improves planting quality. To ensure high-quality planting of forest crops on slopes up to 20°, the grader blade should have a cutting edge length of 800 mm.

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