AJEMA GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 4, Issue 05, 2026 ISSN (E): 2993-2637

Substantiation of the Parameters of the Soil Loosening Chisel of A Seedling Transplanter

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Abstract. This article presents the results of theoretical and experimental studies aimed at determining the optimal shape of the ripper chisel for a machine designed to plant perennial cuttings. The primary objective of the research is to identify a ripper chisel shape that minimizes draft resistance during soil tillage, ensures effective soil loosening, and creates favorable conditions for the planting of cuttings.
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Keywords: ripper chisel, cuttings, seedling, tetrahedral, energy-and resource-saving, wedge, planting.

Introduction

In recent years, the rapid global development of intensive horticulture and seedling production has sharply increased the demand for high-quality seedlings. Modern intensive orchards require establishment with seedlings that are high-yielding, disease-resistant, and possess uniform biological characteristics. For this reason, the method of propagating seedlings from cuttings of grapes, pomegranates, figs, mulberries, and other perennial fruit crops is widely used in practice. The development of horticulture and viticulture is a priority area of the state agrarian policy in the Republic of Uzbekistan. The annual establishment of thousands of hectares of new intensive orchards and vineyards is increasing the demand for millions of high-quality seedlings. Since seedlings must primarily be planted during the short spring season, creating highly efficient mechanized planting technologies is an urgent scientific and practical task.

The sprouting of cuttings and the subsequent formation of a strong root system are, first and foremost, directly dependent on the physical and mechanical properties of the surrounding soil. Excessive soil compaction slows root development, worsens air exchange, reduces moisture absorption, and lowers the survival rate of the cuttings. Therefore, the soil around the cuttings must be finely tilled and sufficiently loosened to achieve a proper air-water regime. Although most planting machines currently in use create a planting furrow, they cannot adequately loosen the compacted soil beneath the layer where the cuttings are placed. As a result, the deep development of roots is hindered, the energy consumption of the unit increases, and the uniform development of the seedlings is not ensured. For this reason, improving the design of the loosening implement that operates in conjunction with the planting apparatus is considered an important scientific problem.

Significant results have been obtained in foreign research on optimizing the design of deep rippers and chisels, the influence of curved and flat working surfaces on soil deformation, the influence of the shape of the working element on energy consumption, and the use of numerical modeling methods. However, these studies are primarily focused on the technology of growing grain and industrial crops, and the issue of creating special working elements for the spring sowing technology of cuttings has not been sufficiently addressed. Thus, an analysis of existing scientific literature shows that there are insufficient scientifically grounded recommendations regarding the complex influence of the form of the loosening working element used for the spring mechanized sowing of cuttings, the degree of soil crushing, traction resistance, and the quality of the sowing furrow. This study is aimed at filling this scientific gap by studying three different forms of softening working organs in laboratory conditions.

Materials and methods

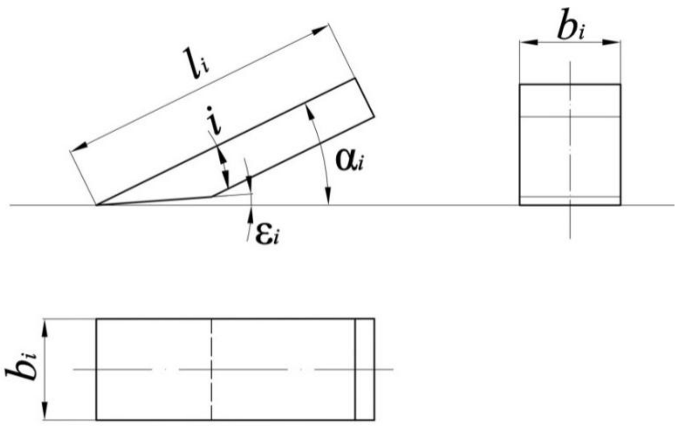


Figure 1. Main parameters of a loosening chisel

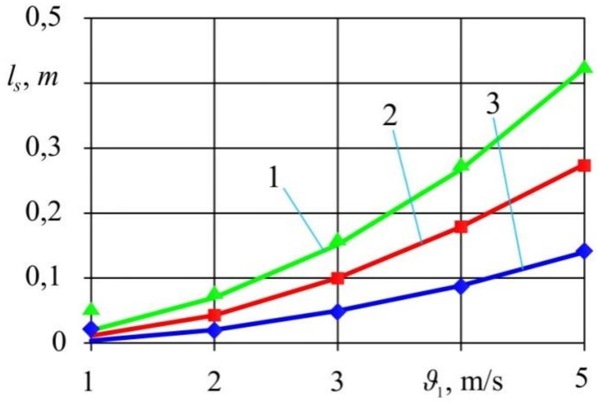
The main parameters are the wrapping width b, the crushing angle αi, the length li, the sharpening angle i, and the back angle εi (Fig. 1). Let us consider the movement of a soil layer along a loosening chisel.

Since the chisel is two-sided, the movement of soil particles to the side occurs not due to a geometric parameter, but due to natural dispersion under the influence of gravity; that is, the chisel does not impart a lateral displacement impulse to the soil particles, while the particle rises upward under the influence of the chisel and spreads to the sides under the influence of gravity. The cause of lateral displacement is the force of gravity, the lifting of soil particles from the bottom up by the chisel, and the reduction of resistance to lateral movement after reaching the field surface.

$$\ell_s = \frac{2\eta(\vartheta_1 \cdot sin\alpha_i)^2}{g} \quad (1)$$

From this expression, it can be seen that the distance of upward movement of soil particles l_s is directly proportional to the lateral velocity coefficient η, velocity α_i, and the chisel crushing angle αi.

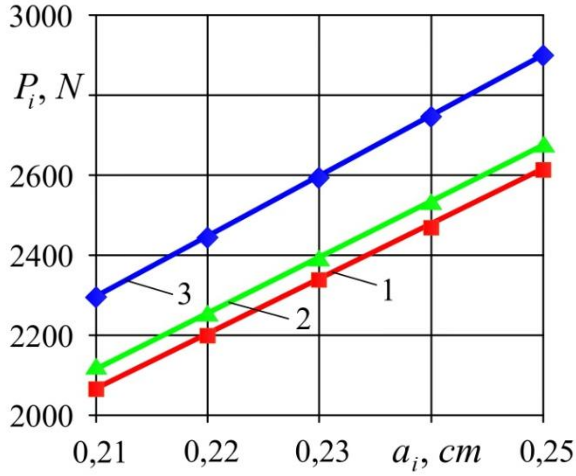
Figure 2 shows the dependence $\ell_s=f(\vartheta_1)$ η =0.1; 0.2; 0.3



α_i=30° for 1- η =0,1; 2- η =0,2 ;3- η =0,3.

Figure 2. Dependence of soil particle uplift distance l_s on velocity

The draft resistance of the loosening shank consists of the forces required to separate the soil slice from the undisturbed soil mass, overcome the friction between the soil and the working surface of the shank, break the soil slice into smaller aggregates, and impart kinetic energy to the soil particles. Figure 3 shows the dependencies $P_i=f(a, \alpha_i, b)$.



L_p=1-0,30 m; L_p=2-0,35; L_p=3-0,40

Figure 3. Dependence of chisel draft resistance on machining depth

Due to the low processing speed, the kinetic energy supplied to the soil particles can be neglected.

Proposed method

Experimental studies were conducted to verify the results of theoretical research and to determine the rational parameters of the device's working parts. The research was conducted at the experimental farm and in laboratory conditions of the Samarkand State University of Veterinary Medicine, Animal Husbandry, and Biotechnology. The main purpose of the experiments was to determine the influence of the shape of the loosening working element used for sowing cuttings in the spring season on the degree of soil crumbling, traction resistance, and the quality of the sowing furrow. The experimental plot was prepared for spring sowing after autumn plowing; the mechanical composition of the soil was medium-sandy, the bulk density was 1.60–1.90 g/cm3, and the moisture content was 18–22%. These indicators correspond to the agrotechnical requirements recommended for planting cuttings.

Conclusion

As a result of theoretical research, it was established that the geometric shape of the tiller bit significantly affects the degree of soil crumbling, traction resistance, and the quality of sowing groove formation.

The introduction of the proposed design into practice in nursery farms will improve the air-water regime of the soil, increase the degree of cuttings, reduce the energy consumption of the unit, and increase the efficiency of mechanized planting. The results of this study serve as a theoretical and practical basis for further scientific research on improving the working components of seedling planting machines.

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