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Design and Test of Seedling Lifting Device of Korean Pine Seedling Lifting Machine

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Abstract

With the country's gradual emphasis on urban greening and vegetation restoration, Korean pine seedlings have been widely planted, bringing higher economic and ecological benefits to planters. The seedling operation is an important part of the Korean pine seedling planting process. In order to improve the seedling efficiency and ensure the survival rate of the seedlings, a simple seedling lifter is designed in this paper. According to the characteristic parameters of the sandy soil of the Korean pine nursery and the structural parameters of the seedling lifter, the stress condition of the seedling lifter during operation is analyzed; the strength and fatigue analysis of the seedling lifter are carried out using ANSYS to obtain the maximum stress of the seedling lifter , The maximum deformation, fatigue life and safety factor are analyzed, and all parameters meet the requirements of use. After experimental tests, the average seedling damage rate of the simple seedling lifter is 4.59%, which is lower than 6%, which meets the actual operation requirements.

Keywords

Seedling lifter; Seedling raising device; ANSY.

1. Introduction

Korean pine afforestation tree species, it is a good is also an important timber tree species, mainly grown in the northeast China, Korean pine Yin, hardy, lateral root development, absorb nutrition, greening effect is better, so the afforestation tree species in Korean pine is often chosen for large area planted, play an important role in ecological [1-3]. The transplanting of Korean pine seedlings has three steps: seedling, transportation and planting. Seedling is the operation of digging out 3-4 years old Korean pine seedlings in the nursery. The quality of seedling operation affects the efficiency of transportation and planting and determines the survival rate of Korean pine seedlings, which is a very important link. In order to ensure the survival rate of Korean pine seedlings in the subsequent process, it is necessary to protect the taproots of seedlings and cut off the lateral roots of seedlings during seedling raising operation, so as to better dig out the seedlings and reduce the damage to seedlings [4-6]. At present, artificial seedling raising is mainly used in China, which has problems such as high operation intensity, repeated operation, low efficiency and serious root injury, etc., which cannot meet the requirements of seedling raising and ensure the survival rate of Korean pine seedlings [7-8]. Therefore, this paper designed a kind of three-piece shovel excavator for Korean pine seedlings to meet the actual demand.

2. Structure and Working Principle of Seedling Lifting Machine

2.1. Basic Structure

In this paper, the design of three pieces of excavating seedling machine is mainly composed of driver's seat, crawler wheel, operating platform, hydraulic prop, connecting mechanism and seedling device. The seedling raising device is the core part of the seedling raising machine.

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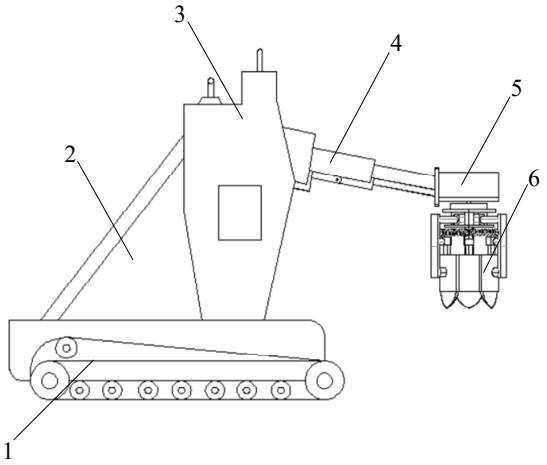
Figure 1 is the overall structure diagram of the three-piece excavator shovel seedling raising machine.



1. Crawler wheel 2. Driver's seat 3. The miao device 4. Hydraulic prop 5. Connecting mechanism 6. Seedling raising device

Figure 1. Schematic diagram of the overall structure of the three spades' seedling lifter

2.2. Working Principle

The three-piece shovel type seedling raising machine is equipped with crawler wheels, which can be used for seedling raising in various complicated road conditions. Before the seedling raising operation, it is necessary to confirm the environment around the operation site, the driving condition of the seedling raising machine and the reliability of the connection between the parts and the body. Up when the seedlings, the operator drove a slice of digging shovel type of three seedlings machine, start the hydraulic prop, through the device moved to a connecting mechanism to control the seedlings seedlings above, according to the width and height of seedling root system, will start up seedling plant seedling roots and planting site soil separation, and cut the weeds around the roots of excess lateral root and seedling, the seedling roots have a certain size of clay ball, Remove the seedlings with earth balls to complete the whole seedling raising operation. At the same time, seedlings of Korean pine seedlings of different diameters were raised by adjusting the opening and closing of the seedling raising device.

3. Structure and Force Analysis of Seedling Raising Device

3.1. Seedling Raising Device

Seedling raising device is composed of motor, rotating disc, supporting round plate, telescopic rod, limit rod, excavator shovel, clamping plate, telescopic spring and hydraulic rod, as shown in Figure 2. Seedling operation, according to the seedling root width, at the same time start three hydraulic rods, three hydraulic rods respectively drive three limit rods, telescopic movement; To determine a good reasonable position, according to the length of the seedling root system, at the same time open three telescopic rod, so that they respectively drive three digging shovel into the soil, the seedling root and planting soil separation; Start the motor and make the whole seedling raising device rotate. In the process of rotation, the shovel will cut off the lateral roots and excess weeds around the root of the Korean pine seedling.

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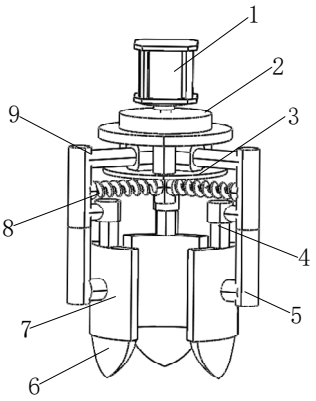

1. Motor 2. Rotating disc 3. Supporting round plate 4. Expansion rod 5. Limit rod 6. Shovel 7. Clamp plate 8. Expansion spring 9. Hydraulic prop

Figure 2. Simplified structure of seedling device

A certain size of earth ball is left at the root of the seedlings to protect the taproot of the seedlings; At the same time, three hydraulic rods are started to drive the three limit rods for telescopic movement, control the three clamping boards to clamp the earth ball, the seedlings with the earth ball removed, in order to reduce the impact of clamping boards on the seedlings, the limit rod is evenly equipped with three telescopic springs, to ensure a lower rate of seedling injury.

3.2. Force Analysis of Seedling Raising Device

As different kinds of soil have different soil parameters, soil parameters determine the stress of the seedling raising machine during operation and affect the operation results of the seedling raising machine. Investigation and analysis of the characteristic parameters of the seedling raising soil is the premise and basis for research and design of a better seedling raising machine [9]. According to relevant literature, Korean pine seedlings were mostly planted in sandy soil with suitable wetness and slight acidity. The humidity of sandy soil was 20.54%, cohesion was 9.31kpa, internal friction Angle was 32.54°, density was 1.396g/cm3, and hardness was 423.9kpa. The main force of the lifting device comes from the shovel, which cuts and squeezes the soil during the lifting operation, so the shovel is affected by the shear resistance and friction resistance of the nursery soil. According to the basic parameters of sandy soil in the nursery, the force of the shovel in the process of seedling lifting was calculated [10].

In the process of seedling raising, friction resistance Ff between the shovel and the nursery soil is:

$$F_f = K_a R \beta \mathrm{bh} \rho \tan\theta \tag{1}$$

In the formula,

Ka -- resistance coefficient, 0.01745;

R -- seedling radius (mm);

β - rotation Angle of the shovel (°);

b -- The width of the shovel (mm);

h -- The digging depth of the shovel (mm);

ρ -- density of nursery soil (kg/m3)

θ -- The internal friction Angle of the nursery soil (°).

The shear resistance Ft of the shovel subjected to soil is equal to the maximum shear force Wa of the soil, so:

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$$W_a = N_q T_u A_m \tag{2}$$

$$T_u = P + K_b \rho h \tan\theta \tag{3}$$

$$N_q = \left[\tan^2\left(45 + \frac{\theta}{2}\right) \exp\left(\pi \cdot \tan\theta\right) - 1 \right] \cos\theta \tag{4}$$

Where, Nq is shear resistance coefficient;
T_u -- shear strength (kpa) of nursery soil;
A_m -- the surface area of the shovel (mm2);
P -- Cohesion of nursery soil (kpa);
K_b -- pressure coefficient of soil. The pressure coefficient of sandy soil is 0.35~0.5.
According to the above formula, it can be concluded that the shear resistance of the shovel is:

$$F_t = W_a = \left[\tan^2\left(45 + \frac{\theta}{2}\right) \exp\left(\pi \cdot \tan\theta\right) - 1 \right] \cos\theta \cdot \left(P + K_b \rho h \tan\theta\right) \cdot A_m \tag{5}$$

In the process of seedling raising, the total resistance of nursery soil on the shovel is:

$$F = F_f + F_t \tag{6}$$

According to the root length and the number of lateral roots of Korean pine seedlings, the width and depth of seedlings should be about 300mm and 200mm, so as to ensure the root system of seedlings can be distributed evenly and naturally in the soil to the maximum extent [11] and improve the survival rate of seedlings. The partial parameters of the seedling machine are: the seedling radius R of the shovel is 150mm, the depth h of the shovel is 200mm, the width B of the shovel is 70mm, the rotation Angle β of the shovel is 20°, the shovel surface area Am is 130 mm2. Combined with the parameters of the seedling lifting machine and sandy soil, the total resistance of the shovel in the process of seedling lifting was calculated. As some parameters in the formula are selected based on experience, appropriate safety factors should be selected to assist in the final solution [12]. The friction resistance Ff and shear resistance Ft were 206.1N and 668.7N respectively, and the total resistance F of soil on the shovel was 874.8N.

4. Prototype Test

In order to verify the rationality of the design of the three-piece excavator shovel type seedling raising machine, the scheme was drawn and the prototype was built, and the quality of the three-piece excavator shovel type seedling raising machine was tested and verified.

During the experiment, 3 test sites were selected in the Nursery of Korean pine, and 5 test sites were randomly selected in each test site for seedling raising test, and the root and stem damage of Korean pine seedlings after seedling raising operation was observed. In the process of operation, the three-piece shovel type seedling lifting machine runs stably and no other abnormal situation occurs. By observing the seedlings of Korean pine after seedling raising, it was found that the damage to the roots of seedlings during seedling raising was mainly concentrated in the lateral root, and the damage to the main root was relatively low, and the damage rate to seedlings was relatively low. The mean injury rate of seedlings measured by the

test was 4.59%, lower than 6%. The whole damage of Korean pine seedlings after the three-piece excavator shovel seedling raising machine is small, which does not affect the normal growth of subsequent seedlings in the planting ground, and the seedling raising effect is good, which can provide basic data for the study of Korean pine tree seedling raising equipment.

5. Conclusion

According to the experimental data analysis, the mean injury rate of seedlings of the three shovel excavator is 4.59%, lower than 6%, and the seedling raising effect is good, which does not affect the subsequent normal growth of seedlings, and provides reliable guarantee for the cultivation of fine Korean pine species.

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