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Design of Fruit Picking Machine for Camellia Oleifera

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Abstract

Aiming at the problems of high leakage rate and high damage rate in mechanized picking of Camellia oleifera fruit, a branch shaking type picking machine was designed. According to the working principle of picking, the structure design of key components was completed, and the orthogonal test of three factors and three levels was designed. The results showed that the best combination of operating parameters was: picking time 45s, vibration frequency 8Hz, amplitude 5cm of picking head. The field test of Camellia oleifera fruit picking machine was carried out, and the picking rate was 91.2%, and the damage rate of flower bud was 18.2%.

Keywords

Camellia Oleifera; Picking Machine; Leakage Rate; Damage Rate.

1. Introduction

Camellia oleifera, as a unique woody oil tree species in China, is selected as the raw material of healthy edible oil by FAO. The fruiting period of Camellia oleifera is about one year. The fruit picking time is in the middle of October every year, and the harvest time is short [1-2].

At present, there is no mature machine for Camellia oleifera fruit picking in China, and large-scale cultivation of Camellia oleifera mainly relies on manual picking [3]. The branches of Camellia oleifera have high toughness, weak bearing capacity and softer tender branches [4-6]. It is easy to break the branches and leaves when picking by hand, and the picking operation cycle is long [7]. If the picking is not timely, the quality of Camellia oleifera fruit will decline due to wet weather [8-9]. Camellia fruit picking machine can reduce the cost of the whole agricultural production and promote the development of local agriculture [10]. Based on the current situation of complex working environment, high damage rate and high leakage rate of Camellia oleifera fruit picking, this paper designs a branch shaking type Camellia oleifera fruit picking machine with small contact area with Camellia oleifera trees, low damage to fruit trees, high picking rate, low manufacturing cost and compact structure [11-14].

2. Structure and operation principle

The harvester designed in this paper is 2m long, 1.5m wide and 3.2m high. The structure is shown in Figure 1, including walking system, driving system and picking device. The structure of the picking machine is compact, which can meet the requirements of walking and picking in Camellia oleifera forest.

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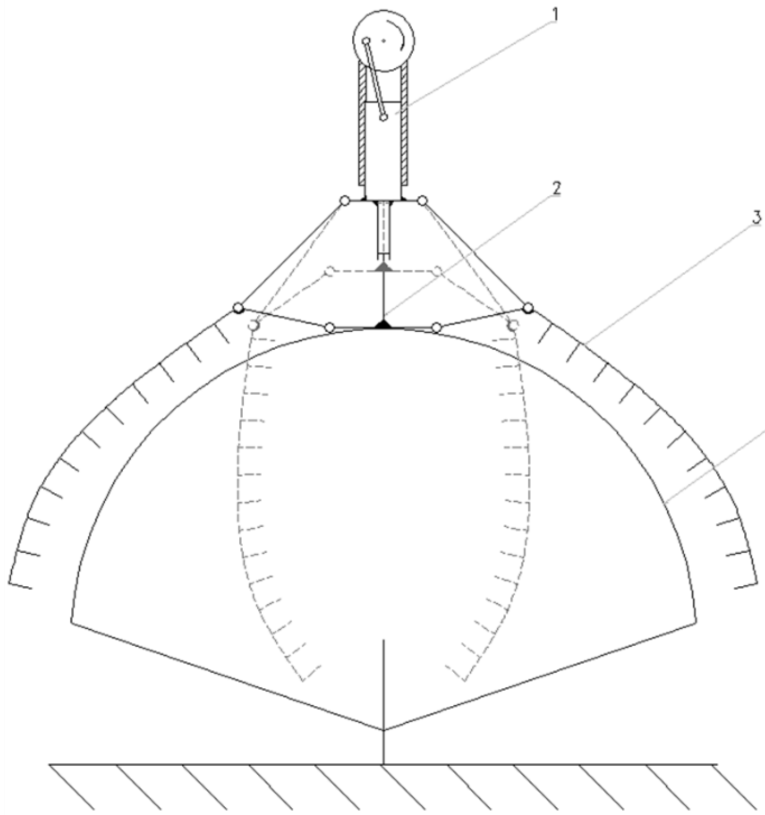

1.Reciprocating vibration mechanism 2.Telescopic mechanism 3.Comb mechanism 4.Camellia oleifera tree

Fig. 1 Structure diagram of picking device

2.1 Working principle

The picking equipment is connected at the end of the excavator as a tool, and the reciprocating vibration mechanism and telescopic mechanism are powered by the excavator chassis. When working, the telescopic mechanism extends and the comb mechanism expands. After the picking equipment falls on the top of the target tree, the telescopic mechanism shrinks appropriately according to the tree shape, and the comb mechanism surrounds the top of the target tree. Then the reciprocating vibration mechanism starts to drive the comb mechanism to work. The dialing rod on the comb mechanism drives the branches of the target tree to vibrate, which causes the fruit to fall and realizes the fruit picking function.

2.2 Design of picking equipment

The function of picking equipment is to clamp and excite Camellia oleifera. The crank slider mechanism composed of eccentric mechanism, connecting rod and actuator transforms kinetic energy into excitation. Take the connecting shaft of worm gear reducer and eccentric disc as the origin O, the hole distance l_{OA} on the eccentric disc as the crank, the connecting rod length of connecting hole A and upper claw plate as l_{AB}, and the actuator B as the slider.

In actual production, because the length of the connecting rod l_{AB} is much larger than the hole distance l_{OA}, the exciting force F is expressed as:

$$F = -ml_{OA}\omega^2 \cos(\omega t)$$

Where m is the mass of the crank slider mechanism (kg), ω is the angular velocity of the eccentric disk (rad/s), t is the time (s).

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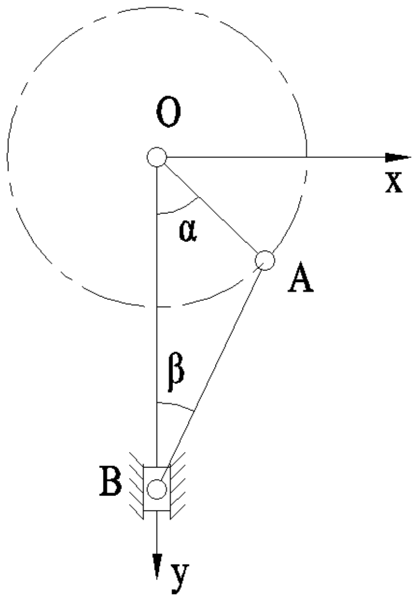

Fig. 2 Structure diagram of crank slider mechanism

3. Research on technology

The main influencing factors affecting the vibration of the camellia branch are the vibration amplitude of the camellia branch and the output frequency of the motor. According to the force of the camellia branch, the force analysis is carried out on the camellia fruit. The condition for the shedding of the camellia fruit is that the combined force is greater than the binding force of the stem. The shedding conditions in the radial and normal directions are:

$$F_2 + G_2 > F_a$$
$$F_1 + G_1 > F_b$$

Where F_2 is the radial component force of Camellia oleifera branch(N), G_2 is the radial component force of Camellia oleifera fruit(N); F_a is the radial binding force of fruit stalk(N); F_1 is the radial component force of Camellia oleifera branch; G_1 is the radial component force of Camellia oleifera fruit (N); F_B is the radial binding force of fruit stalk(N).

4. Result and analysis

4.1 Analysis of roller screen sieve design parameters

According to the results of pre-test and vibration analysis of Camellia oleifera branches and fruits, the picking machine can basically meet the demand of picking. At the same time, the picking time, motor output frequency and vibration amplitude of the picking device are determined as the main influencing factors of Camellia oleifera fruit picking rate and bud damage rate. The picking machine needs to reduce the damage to the flower bud of Camellia oleifera while achieving high net picking rate of Camellia oleifera fruit. The number of flower buds of Camellia oleifera will affect the fruit setting in the next year, so the fruit picking rate and the damage rate of flower bud are the main factors to judge the performance of the harvester. Through three factors and three levels orthogonal test on the three controllable factors of picking time, motor output frequency and vibration amplitude of the picking device, the operation parameter combination of the highest fruit picking rate and the lower bud damage rate of Camellia oleifera was determined. The ratio of the motor output frequency to the vibration frequency of the picking head is equal to the deceleration ratio. Through the analysis of the results of orthogonal experiment, the influence degree of different operation parameters on the fruit picking rate and bud damage rate of Camellia oleifera was obtained.

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Table 1. Orthogonal test results

Numble	Horizontal combination	Picking time (A/s)	Frequency (B/Hz)	Amplitude (C/cm)	Picking rate (/%)	Damage rate of flower bud (/%)
1	A1B1C1	40	5	4	83.6	15.1
2	A1B2C2	40	7.5	6	87.5	15.3
3	A1B3C3	40	10	8	89.2	19.5
4	A2B1C2	50	5	6	90.3	18.2
5	A2B2C3	50	7.5	8	91.3	19.1
6	A2B3C1	50	10	4	93.5	18.2
7	A3B1C3	60	5	8	88.6	17.2
8	A3B2C1	60	7.5	4	95.6	18.6
9	A3B3C2	60	10	6	94.3	19.5
k1	A1B1C1	88.7	89.7	89.6		
k2		90.5	92.6	90.8		
k3		87.6	90.1	87.9		

5. Conclusion

A camellia fruit picking machine was designed. The adjustable range of the picking device's amplitude is 4~8cm; the adjustable range of output frequency is 5~10Hz. The factor that has the greatest impact on the clean picking rate and bud damage rate of Camellia oleifera is the output frequency B, which is the vibration frequency of the picking head, followed by the picking head amplitude C, and the less influential factor is the picking time A. The best operating parameter combination of the picking machine is: the picking time of the picking device is 45s, the output frequency of the motor is 8Hz, and the amplitude of the picking head is 5cm. At this time, the net harvest rate of camellia fruit is 91.2%, and the bud damage rate is 18.2%.

Acknowledgments

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