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A Novel Portable Scissors-Type Fruit Picking Device

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Abstract
At present, the fruit picking in most countries still largely relies on manual operation. Manual fruit picking can protect the fruits from damage during the operation process. However, it is time-consuming and labor-intensive, and poses a potential safety risk to the workers while working at heights not reachable. Therefore, a variety of fruit picking machines and platforms have been developed and incorporated into fruit production to improve the fruit picking efficiency. However, they are very costly in manufacturing and frequently cause damages to fruit during the fruit picking process. Recently various relatively simple mechanical fruit picking devices have been designed and developed as an alternative for these automatic fruit-picking systems to reduce the manufacturing costs. These devices have been used in fruit production. However, they still have some shortcomings such as poor portability and complex operation. They also lack mechanisms sufficient to avoid damages to fruit to ensure fruit appearance and quality. This study was to invent a portable and convenient mechanical tool that could be used in combination with manual operation for fruit picking. A portable scissors-type fruit picking device has been developed, which has two hinged levers designed to drive the closure of the shear blades at the top of fruit picking bowl to cut the fruit pedicel, achieving rapid and safe fruit picking. The portable scissors-type fruit picking device invented here is an innovation, with a purely mechanical design that has the advantages of ingenious design, simple structure, good portability, ease of operation, and low costs of use. This device is suitable for large-scale application in the field of fruit picking in many countries.

Keywords: Portable, Scissors-type, Fruit picking device, Hinged lever, Fruit picking bowl, Shear blade.

Introduction

Fruit picking is a process of involving with a large amount of labor input. It is one of the most time-consuming and labor-intensive operations in fruit production (Xu et al., 2014). Traditionally, manual picking of fruits is a common practice since it can ensure fruit appearance and quality. However, such practice is very time-consuming and labor-intensive, and poses a potential safety risk to the workers when working at heights

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not reachable. To improve work efficiency and avoid these drawbacks, various automatic fruit picking robots and platforms have been developed and incorporated into fruit production. However, these automatic fruit picking systems cannot be widely used globally, especially in the developing countries such as China. Such devices can be very costly for manufacturing and frequently cause damage to fruit during the fruit picking process due to high density of fruit trees and differences in fruit size and the location of fruit on the trees (Liang et al., 2013; Fu et al., 2015). Recently, relatively simple mechanical fruit picking devices have been designed and developed as an alternative to automatic fruit-picking systems to reduce the manufacturing cost (Sangster et al., 2017). These devices have been used in fruit production. However, they still have some shortcomings such as poor portability, complex operation, and limited to certain range of fruit size. They also lack mechanisms to avoid damage to fruit and to ensure fruit appearance and quality (Li, 2016; Li and Xu, 2017). In this work, a novel portable scissors-type fruit picking device has been invented to improve the fruit picking process. This device has two hinged levers that are designed to drive the closure of the shear blades at the top of fruit picking bowl to cut the fruit pedicel, achieving rapid and safe fruit picking. The device has the mechanical design that has the advantages of simple structure, good portability, ease of operation, and low costs. This simple device is suitable for large-scale application in the field of fruit picking in China and other countries.

The Portable Scissors-Type Fruit Picking Device

Mechanical principle of the scissors-type fruit picking device

Two hinged levers are designed to drive the closure of the shear blades at the top of fruit picking bowl to cut the fruit pedicel.

Detailed design of the scissors-type fruit picking device

A potable scissors-type fruit picking device is developed using two hinged levers to drive the closure of the shear blades at the top of fruit picking bowl to cut the fruit pedicel. This would achieve rapid and safe process for fruit picking (Fig. 1).

The fruit picking device comprises the first clamping lever (1 in Fig. 1a) and the second clamping lever (2 in Fig. 1a), which are hinged with the same structure. Fruit picking bowl (3 in Fig. 1a) is oppositely fixed at the top of the two clamping levers. A reset spring (4 in Fig. 1a), which is located between the fruit picking bowl and the hinge point, connects the first clamping lever and the second clamping lever. An extension sleeve (5 in Fig. 1a) with a spiral sleeve structure is set at the lower part of each of the first and second clamping levers to adjust the length of each lever by no less than 200 mm. Two operating handles (6 in Fig. 1a) are set at the bottom of the first and second clamping levers.

The fruit picking bowl (3 in Fig. 1a, b and c) is bowl-shaped, hollow, and hemispherical, with a radius of 60 to 70 mm and a thickness of 1 mm. It is made of aluminum alloy or hard plastic. A shear blade (9 in Fig. 1a, b and c) is attached to the top of the fruit picking bowl. The cutting edge of the shear blade is disposed toward the mouth of the fruit picking bowl. The shear blade has a blade length of 30 to 40 mm and a blade width of 10 mm and is fixed to the fruit picking bowl by a screw (10 in Fig. 1c). The shear blade protrudes from the fruit picking bowl by 1 to 2 mm. Since the shearing blades are closed to the fruit picking bowl, the fruit pedicel can be effectively cut using the scissors-type fruit picking device. The inner surface of the fruit picking bowl is provided with a flexible lining (11 in Fig. 1c) made of ethylene-vinyl acetate (EVA) foam, which can protect the fruit from damage during the picking process. An arc-shaped connecting

steel plate (8 in Fig. 1a and b) has one end fixed to the outer part of the fruit picking bowl by a set bolt (12 in Fig. 1b). It has the other end fixed to the first clamping lever or the second clamping lever by another set bolt (12 Fig. 1b).

The reset spring (4 in Fig. 1a and b) can ensure that the fruit picking bowl can be automatically separated after cutting the fruit pedicel. The first and the second clamping levers are not excessively separated when not cutting the fruit pedicel, so as to make it more convenient for the operator to carry and use this device (Fig. 1a and b).

The operating handle (6 in Fig. 1a) is externally equipped with an anti-slip rubber sleeve, and each of the first clamping lever and the second clamping lever is provided with an earmuff (7 in Fig. 1a) with an arc structure on the outer side of the operating handle. The operating handles with anti-slip rubber sleeves and the earmuffs enhance the operator's grasp of the fruit picking device, thus greatly improving the safety of use (Fig. 1a).

When using this fruit picking device, the operator first adjusts the extension sleeve (5 in Fig. 1a) to the height that can reach the target fruit, so that the height of the clamping levers matches the height of the fruit. Then, the operator holds the first clamping lever (1 in Fig. 1a) and the second clamping lever (2 in Fig. 1a) with two hands to open the fruit picking bowl (3 in Fig. 1a), encases the fruit and further closes the first and the second clamping levers to cut the fruit pedicle by the shear blades (9 in Fig. 1a). As a consequence, the fruit will drop into the fruit picking bowl. Finally, the operator opens the first and the second clamping levers to separate the fruit picking bowl and place the picked fruit in a collection box. At this point, the process of fruit picking is completed.

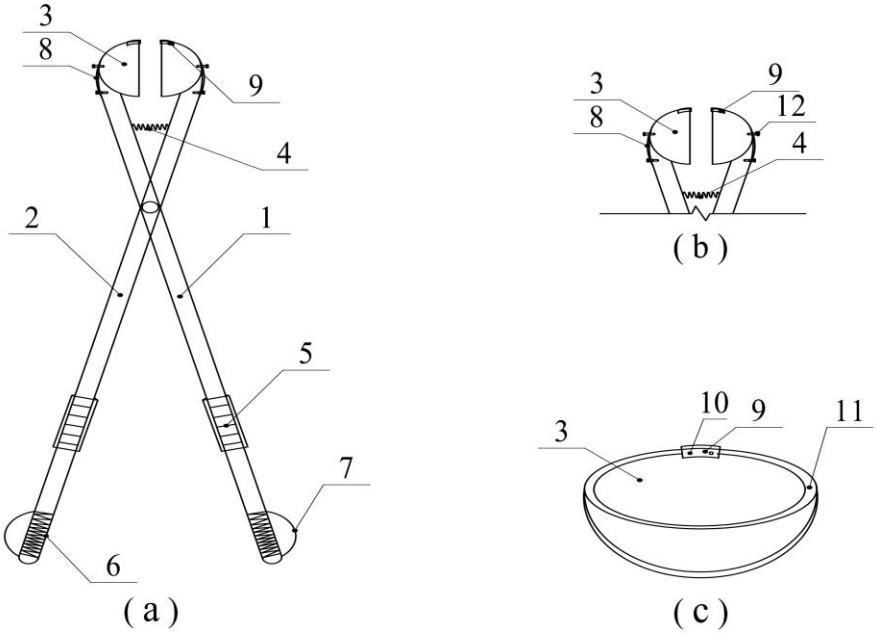

Fig. 1. A novel portable scissors-type fruit picking device.

(a) Structural representation of the scissors-type fruit picking device; (b) Structural representation of the upper structure of the scissors-type fruit picking device; and (c) Structural representation of the fruit picking bowl of the scissors-type fruit picking device. 1. The first clamping lever; 2. The second clamping lever; 3. Fruit picking bowl; 4. Reset spring; 5. Extension sleeve; 6. Operating handle; 7. Earmuffs; 8. Connecting steel plate; 9. Shear blade; 10. Screw; 11. Flexible lining; and 12. Set bolt.

The portable scissors-type fruit picking device invented here is an innovation. It has the features that are able to avoid the damage to fruit frequently caused by the operation of automatic fruit picking systems. The use of this scissors-type device can significantly reduce the time and labor cost for the fruit picking process as compared to the manual fruit pricking method. It can also reduce the potential safety risk to the operator when working at heights that are not reachable. This device has simple structure, ingenious design, easy to use, good portability and low costs. The operator can easily open and close the fruit picking bowl by controlling the operating handles.

Device Test and Economic Analysis

This fruit picking device was tested with established apple growers for its performance in apple orchards in Fufeng county, Shaanxi province, China. Apple is one of the most popular fruits produced in Fufeng county, with more than 15,000 ha of apple production. In these studies, on average, an apple grower picked 1,500 kg of apples a day when using this fruit picking device. On contrast, this person could only pick 500 kg of apples a day manually. Economically, the labor cost of using the fruit picking device would be USD 4.6 per day as compared to the higher cost of USD 13.8 per day by the manual method. The use of this fruit picking device could save up to USD 9.2 per day in the labor costs as compared to the manual fruit picking method. In addition, the incidences of fruit damage caused by the device during the field tests were not statistically significant ($P = 0.05$) from those caused by the manual fruiting picking method.

The results of the tests demonstrate that the fruit picking device developed here is of high efficiency of fruit picking and provides ease of operation. The major feature of this device is to enable the operators to readily pick the apple fruit at heights not reachable. Such process with no support of any ladders can increase work efficiency and reduce safety risks associated the fruit picking operation as compared to the ordinary manual fruit picking method.

Current & Future Developments

A novel potable scissors-type fruit picking device has been developed using the hinged levers to drive the closure of the shear blades at the top of the fruit picking bowl to cut the fruit pedicel. This would facilitate a rapid and safe fruit picking process. Future work is needed to compare the economic benefits of using this device to process different fruit crops.

When using this fruit picking device, the operator should pick the fruit with an appropriate force, so as not to cause damage to the shear blades and the fruit picking bowl. When the shear blades are blunt, it can be easily detached for sharpening. After being mounted, the shear blade can be used repeatedly; when damaged, it can be detached and replaced with a new one. The fruit bowl, when damaged, can also be easily detached and replaced with a new one.

Intellectual Property

The scissors-type fruit picking apparatus has been awarded with Chinese Utility Model Patent (Patent No. ZL201820155140.X).

Conflict of Interest

The authors confirm that this article content has no conflict of interest.

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