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Harvesting technologies for sea buckthorn fruit

Longsheng Fu, Huidan Su, Rui Li, Yongjie Cui*

College of Mechanical and Electronic Engineering, Northwest A&F University, Yangling, 712100, China

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ABSTRACT

Sea buckthorn is a multipurpose, hardy, and deciduous shrub, and an ideal plant for soil erosion control, land reclamation, and farmstead protection. Its fruit has high nutritional and medicinal values for humans. However, harvesting of the fruit is very difficult since they are very tightly bunched along the branches. Moreover, the trees have large and needle-sharp thorns hiding all along branches. Therefore, it is very important to study mechanized harvesting technologies to promote the development of sea buckthorn industry. This article mainly presented a comprehensive review of the research status on sea buckthorn fruit harvester, introduced structures and working principles of several typical harvesters, pointed out some problems of harvesting the fruit and recommendations or corresponding suggestions for future research.

1. Introduction

Sea buckthorn (SBT) (*Hippophae rhamnoides* L.) is a hardy and deciduous shrub with yellow or orange berries, as shown in Fig. 1, which has been used for centuries in Europe and Asia for its environmental, nutritional, and medical values. SBT occurs as a native plant distributed widely throughout temperate zones between 27° and 69° N latitude and 7° W and 122° E longitude including China, Mongolia, Russia, Great Britain, France, Denmark, Netherlands, Germany, Poland, Finland, Sweden, and Norway (Li and Schroeder, 1996; Zeb, 2004). SBT can be used for many purposes and, thus, has considerable economic potential (Li, 2002). Recently, it has attracted considerable attention from researchers around the world, especially North America and Japan, mainly for its nutritional and medicinal values (Bal et al., 2011; Kanayama et al., 2012).

SBT fruit is rich in vitamins, unsaturated fatty acids, and phenolic compounds, and is used for medicinal purposes and as food in some parts of the world (Zeb, 2004; Ohkawa et al., 2008; Kanayama et al., 2012). The interested reader is directed to Kanayama et al. (2012) for a detailed review of the medicinal and nutritional properties of SBT.

For some other countries, environmental benefits from SBT are more important. The wide adaptation, fast growth, strong coppicing, and sucking habits, coupled with efficient nitrogen fixation, make SBT an optimal pioneer plant in soil and water conservation, desertification control, land reclamation and reforestation of eroded areas (Yang and Kallio, 2002). In China, SBT has proved highly beneficial for controlling soil erosion and water loss, and increasing land reclamation in the Loess Plateau, where is a region of very serious soil and water loss in the world (Wu and Zhao, 2000). Therefore, the Chinese government established the National Sea Buckthorn Coordination Office in 1985. The office is under the leadership of the Chinese Ministry of Water Resources, which is responsible for coordinating all activities related to the development of SBT nationwide. At present, SBT covered an area of 2.5 million hectares (ha) in China, which accounted for more than 80% of the total area in the world (Ruan et al., 2012). Among them, the planted area is around 60%. Moreover, it has been increasing with 10,000 ha every year. In addition, the harvest of SBT has provided value-added industries to support the economy of rural regions of China since the Chinese Government listed it as both a food and a medicine in the Pharmacopoeia of China in 1977 (Yang and Kallio, 2002; Zhao and Han, 2005; Hu et al., 2007).

Encouraged by success stories from China, many South Asian countries, such as Nepal, Bhutan, India and Pakistan, started their own SBT development programs in the 1990s. For example, in 1994, a development organization, the Tree Improvement Program (TIP), was established in Nepal. Supported by the Danish International Development Agency, TIP has made significant efforts to promote the development of SBT in northern Nepal (Nepal et al., 2001). Another project entitled Sea Buckthorn Exploitation and Development in Pakistan was initiated by the National Arid Land Development and Research Institute of the Ministry of Food, Agriculture and Livestock, Islamabad in 1997 (Abdul, 2001).

* Corresponding author.
E-mail address: cuiyongjie@nwsuaf.edu.cn (Y. Cui).

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Fig. 1. Sea buckthorn and its fruit.

Therefore, in 1995, the International Centre for Research and Training on Sea buckthorn (ICRTS) was set up in Beijing, and 11 countries joined the organization (Anonymous, 2001). In 2001, the International Sea buckthorn Association (ISA) was established in New Delhi, India. The first congress of ISA was held in Berlin, Germany in September 2003, and ISA's constitution was approved (Kanahama, 2005).

Besides, Japanese was also trying to plant SBT in Hokkaido (Ishii, 2003), and Iwate (Ohno et al., 2008). For example, the Very Berry Farm Ueda in Hokkaido has planted 2000 trees, which covered an area of 1.8 ha and its SBT ice cream has won the best seller among all its processed products (H. Ueda, personal communication). Some other researchers were studying on making use of all the parts of SBT, not only its fruit. Such as, Shiotsuka et al. (2008) has reported that using SBT strained lees (SL) as Japanese black cattle feed and found that body weight in cattle decreased for SL addition.

Unfortunately, it is difficult to harvest the SBT fruit because it does not readily form an abscission layer and the fruit is tightly clustered on two- or three- old, thorn-covered branches (Li and Schroeder, 1996). In Sakatchewan, Canada, the total labor cost for harvesting an orchard of 4 ha was estimated to be 58% of the total cumulative production cost over 10 years (Li, 2002). In Asia, harvesting is still mainly completed manually or with the use of simple, hand-held tools. This difficult and labor intensive process requires about 1500 h/ha (Liang et al., 2008). Therefore, the development of mechanical or other harvesting techniques for SBT has attracted considerable attention. The concepts that have been tried include direct juicing harvesters (Stan, 1995; Dolgosheev and Varlamov, 1998; Ishii, 2003), tree shakers (Gaetke et al., 1991), branch shakers (Stan et al., 1985; Bantle et al., 1996; Mann et al., 2001; Xu et al., 2011; Olander, 2012), vacuum suctions units (Varlamov and Gabuniya, 1990; Yun et al., 2003; Liang et al., 2008; Mu et al., 2012), quick freezing units (Wegert and Wolf, 1990; Gaetke and Triquart, 1993; Lanauskas et al., 2010; Olander, 2012), hormone treatments (Demenko et al., 1983, 1986a, 1986b; Demenko and Korzinnikov, 1990; Zhang et al., 1991; Zhu, 1991), and whole branch harvesters (Gaetke and Triquart, 1992; Olander, 1995).

The objectives of this review are to present an overview of the recent progress on the existed harvesting methods of SBT and their further development. It also examines the relative advantages of those technologies and considers prospects for further research and practical industrial applications. Our hope is that this review will spark the renewal of a research or development process which will move the technology another step forward.

2. Harvesting of SBT fruit in developed countries

Techniques for the mechanical harvesting of SBT have been studied in a range of countries, including, but not limited to, Russia, Germany, Sweden, and Canada. Mechanical fruit harvesters can be classified as either direct harvesters or indirect harvesters (Olander, 1995). A direct harvester relies on direct contact with the fruit, while an indirect harvester causes the fruit to be removed without physically touching it.

2.1. Direct harvesters

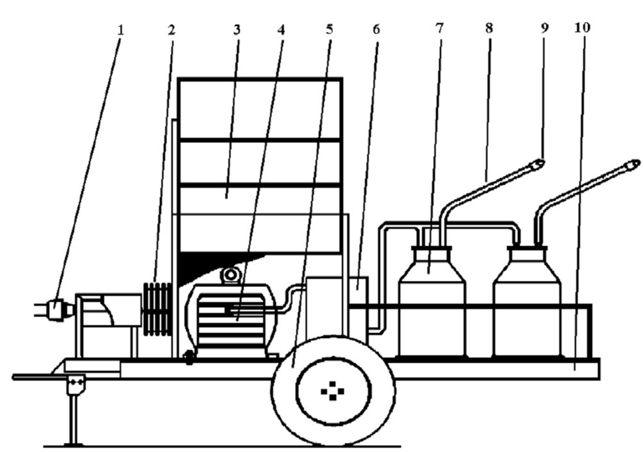
Direct harvesters can be very effective at removing the fruit, for example, vacuum suction harvester. A representative model of this type of equipment is the MII 70-6 vacuum suction SBT harvester that was developed by the Moscow Research Institute of Agricultural Machinery (Yang et al., 2002). It was coupled to a tractor and had a power of more than 36.6 kW. It included universal shaft, pulley assembly, vacuum pumps, fruit tank, fruit boxes, vacuum tubes, and picking heads, as shown in Fig. 2. During harvesting, negative pressure generated from the vacuum pump, which was powered by the tractor through the universal shaft, formed a flow in the special picking head to suck the SBT fruit into the harvester's container. Once the container was full, the fruit could be transferred to fruit boxes. Generally, this type of harvester has six picking heads available for six people to work at the same time, which could harvest up to 1000 kg of fruit in one day. However, it only suitable be used for the harvesting of the fine SBT variety from Russia that with big fruit.

2.2. Indirect harvesters

Indirect harvesting is usually accomplished by shaking a portion of the plant. Forces applied to either the trunk or branch of the plant cause the fruit to be detached from the stem. This mainly includes vibration harvesting and cutting harvesting.

2.2.1. Vibration harvester

A trunk vibration harvester was developed by the Department of Agricultural Machinery in the Russian Institute of Medicinal Plant



1. Universal shaft, 2. Pulley assembly, 3. Fruit boxes, 4. Vacuum pump, 5. Wheel, 6. Inflation container, 7. Fruit tank, 8. Vacuum tube, 9. Picking head, 10. Stander

Fig. 2. Structure of suction harvester for SBT fruit.