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Research Paper

First trials on mechanical harvesting of apricots at Kargil in Trans-Himalayan region

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ABSTRACT

In Jammu & Kashmir and Ladakh UTs the total area under apricot is 3953 ha producing 6604 MT of fresh apricots. A major part of the area and production come from Kargil and Leh, the twin districts of Ladakh region, with an annual production of 3694 MT from an area of about 1798 ha. Apricot (*Prunus armeniaca* L.) is the primary cash crop for the farmers of Kargil. The harvesting period is very short, around two weeks and hand harvesting of apricots is a time-consuming task, accounting for more than 60% of the total labor time of the crop. Traditionally, apricot fruits are harvested by manually shaking or beating branches with long stick, which results in splitting, bruising, and sticking of dirt, grit, and sand particles to the apricot fruits. Mechanization of fruit harvesting has been the major goal of the agricultural engineering profession. The most serious problem with mechanization of apricots is variability of fruit maturity. Apricots typically have a wide variation in maturity both between trees and within individual trees. Under horticulture technology mini-mission project (HTMM-3.27) an apricot harvest/catch net was developed at the Division of Agricultural Engineering SKUAST-Kashmir and its feasibility to catch the harvested apricots during the harvesting seasons (2012-14) with a Cifarelli make branch vibrator/shaker (SC800, 62 mm stroke) was done at Apricot Research Station Kargil and surrounding villages. It was observed that average harvesting time of each outward branch was 2 to 2.8 seconds as compared to 5-10 minutes/branch by manual harvesting (using long stick) and handpicking, respectively. It was concluded that introduction and adaption of mechanical harvesting of apricots has great prospect and scope in Ladakh region if the apricot trees are properly trained and pruned under modern plantation management system.

Key words: Apricots, economic evaluation, feasibility testing, Himalayan region, mechanical harvesting,

Many major changes in agricultural technology are more a result of external pressures than internal desired to change. With numerous developments in fruit and vegetable marketing, packaging and transportation are the result of dynamic changes in mass merchandising, especially the demands of chain stores, rather than a natural desire by growers to sell large volumes of uniformly graded and packaged products. Similarly, changes in food process technology have dictated the adoption of many adjustments on those farms raising fruits and vegetables for canning and freezing. The rapidity of adoption of harvest mechanization is the most closely tied to the availability of labour, because labour prefers alternative employment. Apricot (*Prunus armeniaca* L.) is the second most important temperate fresh fruit crop of the erstwhile state of Jammu and Kashmir including Ladakh, grown on an area of 3,953 ha producing 6,604 metric tonnes of fresh apricots. Apricots are severely restricted in their ecological adaptation. The native apricot genotypes of Ladakh possess unique and important characteristics, such as high TSS content, late and extended flowering and fruit maturity, and white seed stone phenotype, which offer opportunity for Ladakh to emerge on the world map for apricot production (Tsering *et al.,* 2021). Apricots grown in Kashmir are of central Asian group. Varieties grown in sub-temperate areas of Jammu region are of little or no importance because of their limited commercial value. However, in Ladakh region (cold arid zone), apricots enjoy an outstanding position. Kargil forms the major production hub of the fruit crop. The crop is intimately associated with the culture and traditions of the cold arid region. Because of scarcity of fruits and vegetables during harsh winters almost every part of the fruit is used by the local inhabitants. Ripe apricot is an excellent dessert fruit and is also used as dried and processed into jam, jelly, squash, bar candy and many other processed products. The crop being perishable requires timely harvest without any delay (Shaheen and Ali, 2020). The scarcity of labour is relatively more in the Ladakh region as compared to rest of the state. At farm level, labour scarcity was found 70 per cent to that of requirement in case of apricot crop (Baba *et al.,* 2011). Harvesting of apricot is either carried through hand picking or by beating the twigs with long sticks and collecting the fallen fruit in the basket from the ground (Fig.1). Apricots of Ladakh are small. Fruit weight ranged from 7.1-53.7 g with mean weight of 21.6±9.3 g. For every 100 m increase in elevation the fruit weight decreases by 0.5 gm (Naryal *et al*. 2020) The former method is time consuming and labour expensive, whereas, the latter method makes the fruit bruised and unhygienic with adsorption of dust particles and other impurities, thus reducing significantly its quality, shelf life and market value. The fallen fruits have to pass through twigs and branches and thus get bruises. The damaged fresh fruits result in decrease in their shelf life as well as the quality of their dried form. Hence, an effective machine to harvest apricots suiting to field conditions was imperative and it was in this backdrop, that the apricot harvesting/catching net and main frame were fabricated under the Horticulture mini mission mode- I project whereas, the vibrator/shaker was purchased from the market.

Fig. 1: Traditional method of harvesting apricots at Kargil Ladakh

MATERIALS AND METHODS

The first trials in India on mechanical harvesting of apricots using a branch shaker and a developed fruit catch/harvest net was done during harvesting season from 2012-14 at apricot research station (KVK Kargil) and demonstrated in adjoining villages. The specifications of the developed apricot catch net is given in Table 3 along with its manufacturing cost and operational expenses. The machine consists of three parts, i.e., catch net (Fig.2) with diameter ranging from 6 – 7 m main frame made of iron with three auto wheels (10-inch diameter) for its mobility attached with drawer type collecting plastic basket /crate (Fig.3) having dimensions 540 × 380 × 340 mm (LBH) and the vibrator/shaker as shown in Fig.4 (Cifarelli make branch vibrator/shaker; Model SC800,

62 mm stroke) fitted with telescopic type lance. The harvesting net is mounted on the main frame and rounded at the trunk of apricot tree making a bowl/inverted umbrella. Then with the help of vibrator/shaker, the branches are gripped with lance and shaker. Within a fraction of 2 – 5 seconds, all the fruits of the branch get detached with shaking and fall on the catch net (made from shade net) which move down with gravity and get collected in the basket fitted at the base of main frame. Once basket gets filled, it is detached, emptied, and again put at the base of main frame.

Fig. 2: A view of the developed apricot catch net (inverted Umbrella)

Fig. 3: Detachable plastic rectangular crates for collection of harvested apricots

Performance evaluation and cost economics of mechanical harvesting of apricots: Feasibility testing and demonstration of mechanical harvesting of apricots using vibrator/shaker with catch net (Fig.5) was done at KVK Kargil and adjoining villages (*Shilikchay, Gongma, Kargil and Manjee*). The vibrator shaker (SC800, 62 mm stroke) along with apricot harvesting net was operated at the farmer's apricot orchard at 62 mm stroke length. Performance assessment of the machine was carried out on apricot fruit trees at constant stroke rate and compared with the traditional method of fruit harvesting. Hand-carried shade net structure to catch the fruits together with a hand-held branch shaker with the following specifications: 2.1 kW, 11kg mass, 0.062 m stroke, maximum vibrational frequency of 18.5 Hz at full throttle. The shaker was with a 2.5 m carbon fiber pole finished with a rubber-coated steel hook measuring 40 mm in free width, which transmitted the vibration to the branches. The direction of vibration was almost perpendicular to branch direction. The field performance of the machine was assessed in terms of shaking time required per tree, fuel consumption, fruit detachment efficiency per tree, weight of harvested fruits, and percentage distribution of mature, immature, and damaged fruits. The team was organized with two operators for the hand-carried catch net and one for the shaker. Between 7 and 10 attachment points were set in each tree. The catch net designed for this study measured 6-7 meter in diameter and weighed 18.5 kg. Adjustable arms allowed changes in diameter. Within a fraction of 2 –5 seconds, all the fruits of the branch get detached with shaking and fall on the catch net (made from shade net) which move down with gravity and get collected in the basket fitted at the base of main frame. Once basket gets filled, it is detached, emptied, and again put at the base of main frame. Erdogan *et al.* (2003), reported that vibration times of 5 s were necessary to detach apricots in Turkey, in our study we found that more than 90 % of the fruits fell in less than 3 s, and in less than 3.8 s, all the detachable fruits of the branch were removed. The harvest rate and harvesting cost of each system (Traditional and hand-held vibrator shaker) are summarized in Table 2, with traditional trees producing 70-80 kg/tree. For traditional hand harvesting system, an average harvest rate of 50-60 kg/h obtained from the producers was considered. Mechanical harvesting proved to be a reasonable option for small and medium growers in traditional and in intensive plantations. The cost was reduced eight-fold compared to hand harvesting. Moreover, it was the system that caused the least amount of damage to the fruits.

RESULTS AND DISCUSSION

The economic efficiency and potential saving on part of mechanized harvesting in relation to manual/ traditional harvesting was worked out and is presented in Table 2. Traditionally, one labour harvests 15 to 17 kg of apricots per hour through hand picking while as it ranged between 300-350 kg/hour in mechanized operation showing an increase in the output capacity to the tune of 1900 to 1985 per cent over manual operation. Furthermore, harvesting cost gets reduced by 140 to 310 per cent through mechanized to that of manual operation. Similar

studies have shown substantial cost reduction due to use of mechanization methods in groundnut (Govindaraj & Mishra, 2011) and soybean (Karale *et al.,* 2008) under Indian conditions. Farmers can effectively minimize the operational cost by moving towards mechanized operations. With the present level of apricot fruit production (14501 MT), there is a potential saving worth INR 29 million as whole for the state. To fully mechanize the operation for the fruit crop, there is a potential demand of 223 apricot harvesters with present designed capacity. One apricot harvester was found to replace 480 labours in the harvesting operation.

Fig. 4: A view of mechanically harvesting of apricots at Kargil Ladakh

Fig. 5: Feasibility testing and demonstration of mechanically harvesting of apricots using shaker and catch net

Table 1: Economic efficiency and potential saving of mechanised apricot harvesting *vis-a-vis* manual operation

Contents	Traditional/ Manual	Mechanized	Difference/Ratio/Change (%) (Mechanized over manual)
Output capacity (kgs hr^{-1})	15 - 17	300 - 350	+ 1900 to 1958
Harvesting cost (INR/hr)	50	215	+ 165
Harvesting cost (INR/kg)	2.95 – 3.34	0.72 – 1.40	- 140 to 310
Apricot harvesting cost for the State (INR)	43.5 million	14.5 million	29 million
Labour Requirement (Potential labour replacement/saving)	1.13 lakh mandays	5577 mandays	1.07 lakh mandays is potential labour replacement/ saving
Per machine harvesting capacity / year	-	65000 kgs	-
Apricot Harvesters required (No.)	-	223	-
Machine-Labour Replacement Ratio			1: 480

Fabrication cost of apricot harvester is relatively higher than those of other designed machines and may not be affordable for an individual farmer to keep. Apricot farmer groups can own and operate on collective basis and may also be provided on custom hiring services by large farmers who can afford to purchase. A good scope lies for entrepreneurship development in the mechanized farm service sector of the state, wherein, these newly designed machines may be owned by entrepreneurs to provide farmers on custom hiring basis or act as Service Provider Company for harvest and post-harvest operations. The machine has been tested and demonstrated at

farmer's field level in different villages around KVK Kargil and had attained great satisfaction among the apricot growers and people associated with the business of the apricots.

Table 2: Some orchard, tree and fruit properties

Area under apricot (Leh +Kargil), ha	2303
Training system	No pruning
Number of trees/Kanal	15-18
Yield, kg/tree	70-80
Fruit mass, g	17-33
Total tree height, m	5-7
Canopy area, m^2	16-18

Table 3: Specifications, fabrication cost and operational cost of apricot harvester with catching net

Specification	**Observation**
Machine	**Apricot Harvester**
Diameter of harvesting net	6 – 7 meters Inverted Umbrella shaped
Main Frame Dimensions	(LXBXH) 2800 × 660 × 670 mm
Wheels	Three tyres (auto wheels) Rim diameter: 240 mm
Power source (Petrol Engine)	Vibrator/Shaker (2.1kW)
Transmission unit	Lance – telescopic shaft type
Collecting tray	(l×b×h) 540 × 380 × 340 mm
Cost Analysis	
Particulars	
Fabrication/ manufacturing cost of Apricot Harvester	Rs. 75,610
Salvage/junk value (@10% of Manufacturing cost)	Rs. 7,561
Useful life	1800 hrs (9 years)
Annual working (hrs/year)	200 hrs
Amortized cost of machine per working hour	Rs. 37.81
Interest charge per working hour on capital investment of machine	Rs. 2.23 (@14% interest rate)
Fuel charge per working hour of machine	Rs. 75
Labour charge per hour of operation	Rs.100
Total operational cost (hr^{-1})	Rs. 215

CONCLUSION

Hand harvesting apricots is a time-consuming task, accounting for more than 60% of the total labor time of the crop. With mechanical harvesting, first fruits to fall tended to be those fruits with a greater mass and diameter, these fruits had more soluble solids and were less firm. Selective harvesting of apricots according to maturity was difficult to implement with vibratory systems. Mechanical harvesting of apricots resulted in reduction of crop costs as well as minimized the need for temporary labor in the peak harvesting period/season. Also, there is urgency of upscaling of the specially designed machines suitable to local topography and crop structure in consideration with social and environmental factors. Harvesting season for the apricot fruit crop hardly lasts for a month. Vibrator/ shaker is petrol run and consumes one litre of fuel per hour on an average. Two persons are

required to operate the harvesting machine. The total operational cost works out to be INR 215 per hour for the mechanized harvest of apricots.

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