Research article

Prospects of *Prunus armeniaca* L. in Economic Upliftment of Hill Communities of Uttarakhand, India

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Curr. Appl. Sci. Technol. 2024, Vol. 24 (No. 6), e0257865; https://doi.org/10.55003/cast.2024.257865

Received: 27 February 2023, Revised: 12 December 2023, Accepted: 25 April 2024 Published: 2 August 2024

Keywords

Prunus armeniaca;
potential areas;
kernel;
oil yield;
livelihood

Abstract

In Uttarakhand, there are several trees' species that produce seeds of high oil content known as tree borne oilseeds (TBOs). However, there is very little information on TBOs and their relationship with the livelihoods of the people in local communities. The present study focused on *Prunus armeniaca* L. (Wild Apricot), the seeds of which yield oil. Phytosociological analysis was carried out at 8 potential areas between the altitudes of 1642 and 2630 m by placing 20 quadrats of 10×10m size. The physical parameters of the fruits and seeds were studied. Oil was extracted from seed kernels using Soxhlet apparatus. Personal interviews were done to assess the relationship of the plant oil to the livelihood issues of local communities. The research indicates that the species was failing to regenerate naturally in the region and there was a lack of awareness about its potential uses. The density of *P. armeniaca* ranged between 50 and 120 indi/ha across all the sites. The seed kernel oil content across all the sites ranged between 38.75±2.4 to 57.27±2.4% (on kernel dry weight basis). One hectare of plantation with 400 trees of *P. armeniaca* can generate about 1.24-2.34 tha^{-1} kernel, 0.61-1.15 tha^{-1} oil yield, and can give rise to an average net income between Rs.71,000/- and 217,000/- ha^{-1} $year^{-1}$. The study reveals that *P. armeniaca* can play a vital role in providing opportunities for livelihood generation and economic upliftment for the local hill communities in the region.

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1. Introduction

The vegetation of Himalayan region varies due to different demographic conditions having an altitudinal range associated with different climatic and biotic features [1-3]. There are several multipurpose tree species growing in Uttarakhand which have the potential to yield edible/non edible oil from seeds and kernels. *Prunus armeniaca* L. is an important multipurpose tree species commonly known as "Chullu" or "Wild Apricot" and found in the dry temperate regions of North-Western Himalayas, particularly in the valleys of Jammu and Kashmir (specially Ladakh), Himachal Pradesh and Garhwal, and in the Kumaun hills of Uttarakhand states of India along an altitudinal range between 1600 and 3000 masl. *Prunus armeniaca* belongs to the family Rosaceae and sub-family Prunoidea. The seeds of the species are a principal source of oil in the remote areas of Himalayan region. The oil has medicinal properties and is used as a substitute for edible oil and massage oil in some remote areas/villages of the Kumaun and Garhwal Himalayan regions [4]. About 51 million population of the Indian Himalayan region (IHR) (6% of India's population) lives in rural areas where their employment to a certain extent depends on resources available in the accessible close-by forests [5]. Agriculture and related activities provide livelihood to extensive segments of the Himalayan peoples [6, 7]. Replacement of traditional subsistence agriculture by cash crop-based horticulture has been increasing and several conventional crops have now completely disappeared while others are on the edge of eradication [7-9].

The complicated connection of poverty, unemployment and other circumstance embody the most difficult challenge of sustainable agriculture advancement in hilly regions. In Uttarakhand, traditional communities evolved subsistence-oriented but stable agriculture, and a diversified, livelihood strategy that combined crop, the keeping of livestock, and forestry along with resource recycling and collective sharing. In recent years, this equilibrium has been seriously disrupted and the virtually self-sufficient system has broken down. With increasing climatic stress caused by factors such as erratic rainfall and with global food price volatility affecting even remote mountain communities, mountain agriculture has increasingly become a less reliable livelihood strategy. All of these factors have increased the need for local people to migrate. The specific characteristics of hilly areas such as poor accessibility and income marginality have contributed to the impact of the changes. There is an urgent need to explore viable livelihood opportunity for improving the income of these poor and marginal farmers. Under these conditions, oil seeds producing tree species plantations can be an excellent source of employment for the local dwellers. The oils from this tree are frequently used as raw materials in industrial and chemical processes [4]. These species have an enormous potential to provide broad scale business/employment opportunity in the remote regions of the Himalaya. *Prunus armeniaca* is an important multipurpose oilseed producing tree species of the region. The oil of the species has huge potential in improving the economic status of the people. It has medicinal properties and can be used for cooking, body massages, and other purposes. The leftover after oil extraction is also used as animal feed in some areas. The dried fruits of *P. armeniaca* are also sold in the Ladakh, J & K and some other regions [10]. Due to the high demand and economic importance of the species, the present study was focused on identifying the potential areas for the cultivation of *P. armeniaca* and the assessment of regeneration status, oil yield and potential role in improving the livelihood of folks in some major regions of its occurrence in Uttarakhand.

2. Materials and Methods

2.1 Site description and identification of potential areas

A total of 102 areas were visited across the nine districts of Uttarakhand where *P. armeniaca* was abundantly found and 84 areas were recorded as potential areas in Nainital, Almora, Pithoragarh, Bageshwar, Pauri, Uttarkashi, Tehri, Rudraprayag and Chamoli districts. The density of the species ranged between 25 and 120 indi/ha (Figure 1).

However, the present study was focused in three districts of Uttarakhand; Nainital, Almora and Uttarkashi, between the elevations of 1642 and 2630 masl. The 8 sites that offered the most potential, i.e. 4 in Nainital, 2 in Almora and 2 in Uttarkashi district, were selected for the study (Table 1).

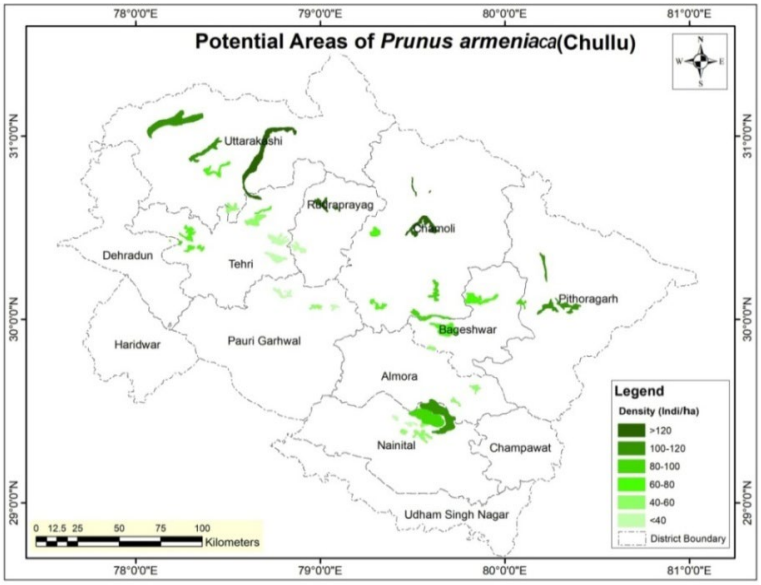

Figure 1. Map of Uttarakhand showing potential areas of *P. armeniaca*

Table 1. Details of the selected study areas of *P. armeniaca*

S. No.	Districts	Areas	Elevation (masl)	Coordinates
1.	Nainital	Site-1 Chiyori Dhura	1687	N 29°30′16.99″ E 79°31′51.13″
		Site-2 Talla Ramgarh	1642	N 29°26′26.38″ E 79°33′44.06″
		Site-3 Budibana	1858	N 29°26′45.44″ E 79°37′28.47″
		Site-4 Satbunga	2167	N 29°26′35.39″ E 79°36′51.76″
2.	Almora	Site-5 Toli	1937	N 29°33′00.52″ E 79°43′48.61″
		Site-6 Near Lamgara	1840	N 29°31′55.88″ E 79°45′15.28″
3.	Uttarkashi	Site-7 Sukhitop	2595	N 31°00′07.11″ E 78°42′04.83″
		Site-8 Harsil	2630	N 31°02′08.89″ E 78°44′13.87″

2.2 Climate of the study areas

The selected study sites, which were located in mid to high elevation areas (1500-3000 masl), had a cool temperature in the areas of high elevations. Generally, three seasons were recognized for the studied areas, viz. summer (April-June), rainy (July-September) and winter (November-March) while a short period for autumn and spring was observed. The annual rainfall ranged between 170 and 190 cm. The mean monthly minimum temperature ranged between 8.8°C in January and 21.2°C in June and the mean maximum temperature between 12.3°C during winters and 29.9°C in summer [11].

2.3 Identification of potential areas

Information regarding availability of species was generated from available literature, field visits, personal interviews and PRA exercises. For identification of potential areas, a thorough survey of the Kumaun and Garhwal region of Uttarakhand was conducted over two consecutive years, thereafter probable potential areas were identified. However, only those areas that had a species density above 40 indi/ha for trees and a spread of 4-5 hectares were selected [12]. To identify the potential areas for the studied species in Uttarakhand, maps were prepared by the GIS experts using GIS software (Arc-GIS and Google Earth). The coordinates were recorded with help of GPS. The collected GPS data were plotted in a LULC (Land Use Land Cover) map and imported to GIS platform. GIS processing and analysis was done for the final output of the map.

2.4 Phytosociological analysis

The phytosociological analysis was carried out across all the selected areas in various districts of Kumaun and Garhwal regions of Uttarakhand. Vegetation analysis was made by placing 20 quadrates of 10×10 m [13]. Density, frequency, abundance, A/F ratio, basal, mean basal and, total basal area, relative values and IVI (important value index) were calculated [14]. Regeneration potential was studied at each selected site [15]. To study the regeneration potential, population structures were made of the studied species at all sites [16, 17]. Identification of superior individuals was done by studying various tree physical characteristics such as tree height, collar diameter, number of flowers and density. Tree height was measured using Ravi multimeter and circumference was measured by meter tape. At each site, 20 physically superior trees were selected after a thorough survey of the stand [12].

2.5 Fruit and seed yield estimation

The fruit and seed yield estimation were made by counting the number of branches, twigs/sub branches, numbers of twigs per branches and number of fruit per bunch. The average fruit production per tree was calculated by multiplying the total fruit number by the average weight of 1 fruit (average weight of fruit/seed = randomly selected and weighed 20 fruits/seeds). This gave an approximate value of fruits/seeds per kg per tree and seeds per kg per tree [12, 17, 18].

$$\text{Fruit/seed weight (kg/tree)} = \frac{\text{No. fruits/seed on tree} \times \text{Weight of 1 fruit/seed (g)}}{1000\ \text{(g)}} \quad (1)$$

The continuous extraction process was used for oil extracting using a Soxhlet apparatus and hexane as the solvent. The process is generally applied to the removal of natural products from dried tissue originating from plant parts. Non- steam volatile compounds present can be removed by solvent extraction using a continuous process [19].

2.6 Assessing role in livelihood generation

To assess the economic impact of studied species in the Uttarakhand, a thorough survey was made through available literature, field visits, personal interviews and PRA exercises [20-22]. Plantations in different areas were visited to gathering information regarding crop yield and basic economics (investments). After the selection of the potential areas, a complete inventory of the studied species was done. Fruit yields, seed yields, kernel yields and oil yield per hectare from the study areas were estimated by multiplying the minimum and maximum values for each parameter/tree to get the range and range of income per hectare through the sale of oil, calculated by multiplying the minimum and maximum market rates [20, 21, 23].

3. Results and Discussion

3.1 Vegetative analysis and regeneration status

The highest density (120 indi/ha) was found at site-7 having a total basal area of 8.94 m^2 ha^{-1} and the lowest (50 indi/ha) was at site- 5 having a total basal area of 2.41 m^2 ha^{-1} (Table 2). The sapling density ranged from 30 to 40 indi/ha and seedling density of 15 to 30 indi/ha. Seedlings were present in all the selected sites, except for sites- 2 and 4. Saplings were present in all the studied areas and most of them had been planted. Young trees were present but old trees were completely absent. The low representation of seedlings, saplings, and the absence of old trees reveals that *P. armeniaca* was failing to properly regenerate in the studied areas (Figure 2).

The regeneration of most wild edible species/multipurpose species is generally poor in natural habitats and it is mainly due to intensive biotic pressure on them [24]. From the present study, it was evident that *P. armeniaca* was failing to regenerate, had scattered type of the distribution, and had a low density per hectare (50 to 120 indi/ha). Seedlings were present but saplings were lower in number than the seedlings, which indicate that the conversion rate of seedlings to saplings was low. Tewari and Tewari [25] reported poor regeneration in natural habitat for *Prunus cerasoides* in Kumaun. Similarly poor regeneration was reported for *Baccaurea sapida* [24] and *Myrica esculenta* [26] in their natural habitats. Some researchers worked on the natural regeneration of certain NTFP's in India and reported that the regeneration of 30% NTFP yielding trees was under threat [27]. Furthermore, it was observed that the regeneration of species that were in commercial use had declined significantly and this decline in regeneration was probably due to biotic pressure from both human activities and grazing.

Table 2. Vegetational parameters of *P. armeniaca* across all the sites

S. No.	Districts	Areas	Density (indi/ha)	Total Basal Area (m^2 ha^{-1})	IVI
1.	Nainital	Site-1 Chiyori Dhura	70.00	2.41	60.49
		Site-2 Talla Ramgarh	65.00	2.21	68.84
		Site-3 Budibana	50.00	2.24	59.09
		Site-4 Satbunga	95.00	3.10	74.30
2.	Almora	Site-5 Toli	60.00	2.41	65.68
		Site-6 Near Lamgara	65.00	3.08	59.71
3.	Uttarkashi	Site-7 Sukhitop	120.00	8.94	91.97
		Site-8 Harsil	105.00	6.86	82.53

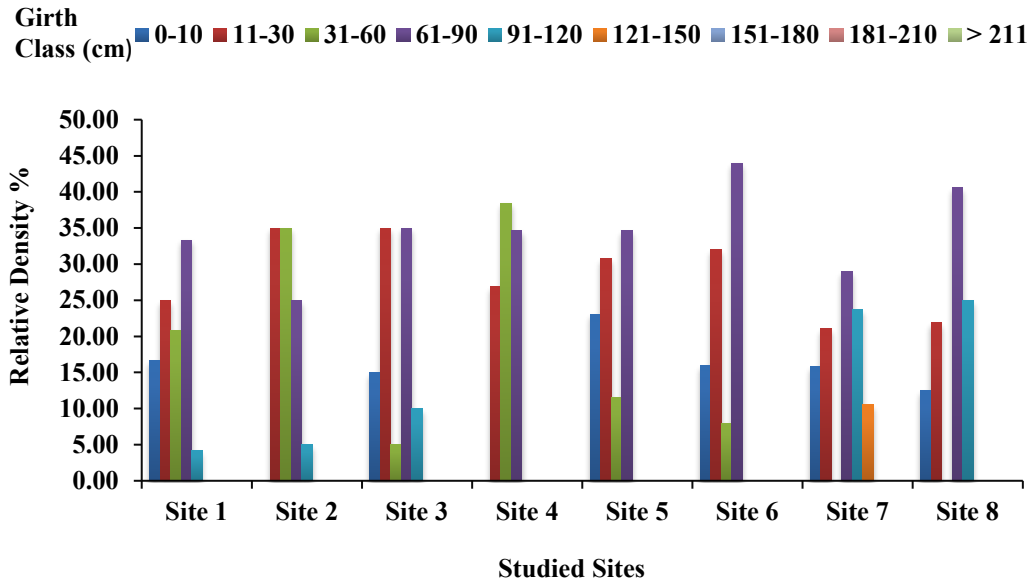

Figure 2. Population structure of *P. armeniaca* across all the selected sites

3.2 Fruit and seed parameters

Flowering of *P. armeniaca* occurred during Feb-March and fruiting was initiated during the 3rd week of May. Fruits matured over the period of June-July. During the collection period, fruits changed in color from green to yellow and seed color changed from light brown to dark brown. The fruit color was the main visible character used for identifying fruits maturity and harvest time. The mean fruit size of *P. armeniaca* ranged from 440.30 to 1295.09 mm^2 and seed size ranged from 223.19 1 mm^2 to 465.66 mm^2.

3.3 Oil yield of *P. armeniaca*

Across all the studied sites, the mean kernel oil content% of *P. armeniaca* ranged between 38.75±2.4% and 57.27±2.4%. The mean kernel oil content % of *P. armeniaca* in year-1 ranged from 38.75±2.4% to 55.15±2.0% and in year-2 from 40.63±2.1% to 57.27±2.4%. When we compared the mean kernel oil content % of year-1 and year-2 across all the sites, it was found that the highest mean kernel oil content % (57.27±2.4%) was in year-2 at site-8 and the lowest (38.75±2.4%) was in year-1 at site-5 (Figure 3). When we compared the tree wise variation in mean kernel oil yield, all the trees of site-8 had the highest average oil yield, which was above 52%. Across all the trees at site-8, the highest (61.80±0.7%) oil yield was for T6 and the lowest (49.63±1.3%) oil yield was for T3. The lowest oil yield below 45% was from site-5 (Figure 3). ANOVA showed that the kernel oil content percent of *P. armeniaca* varied significantly across the sites, trees and years. The interactions between the years × sites, years × trees, sites × trees and years × sites × trees were significant ($P<0.05$) (Table 3).

Oils from seeds of tree can be categorized as both edible and non edible. These oils are put to various uses, e.g., edible oil for human consumption, chemicals and industrial application. Tree borne oilseeds (TBOs), also known as minor oilseeds, are a potential source of edible oil. Several

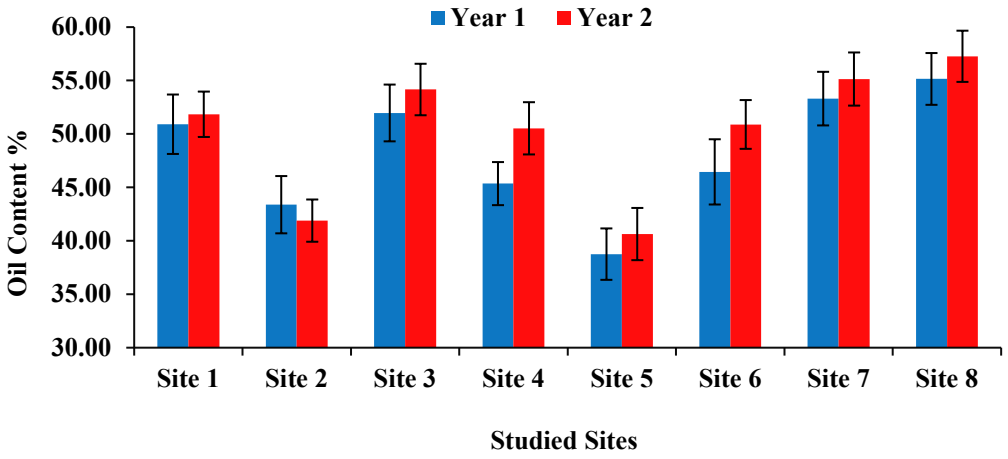

Figure 3. Mean kernel oil content % of *P. armeniaca* across all the sites

Table 3. Analysis of variance (ANOVA) for oil content percentage across different trees, sites and years of *P. armeniaca*

Dependent Variable: Oil Content %				
Source	**Type III Sum of Square**	**df**	**Mean Square**	**F-Value**
Year	1258.973	1	1258.973	56.27 **
Site	27147.108	7	3878.158	173.34 **
Tree	2499.536	19	131.555	5.88 **
Year × Site	823.644	7	117.663	5.25 **
Year × Tree	1254.905	19	66.048	2.95 **
Site × Tree	10305.752	133	77.487	3.46 **
Year × Site × Tree	11041.936	133	83.022	3.71 **

oilseeds are edible and are used as food in different regions [28]. *Prunus armeniaca* grows extensively in Indian Himalayan states, i.e. Himachal Pradesh, Jammu and Kashmir, Uttarakhand and some parts of north eastern states. The seeds of *P. armeniaca* are a good source of edible oil containing large amount of unsaturated fatty acids. Due to the availability of this fruit in large quantities, there is a huge scope for the extraction of oil from the seeds of the species. In the present study, we estimated the kernel oil yield of *P. armeniaca* and the yield ranged between 38.75±2.4 to 57.27±2.4% across the 8 studied sites and the maximum oil yield was recorded from site-8 in Uttarkashi district. In another study on the oil yield of *P. armeniaca*, the oil yield ranged between 45.6 to 46.3 % across different locations in Himachal Pradesh [29]. Similarly, a 44.35% oil yield was reported from the seeds of *P. armeniaca* collected from the Garhwal region of Uttarakhand [30] and a 43.5% oil yield was found from the improved technology which was higher when compared to oil yield (32.54%) recovered by traditional method [31]. In different regions of Jammu and Kashmir, kernel oil yields of 25.52 to 54.64% were reported [32].

3.4 High oil yielding individuals

Out of 160 individuals, 34 individuals were identified as high oil yielding individuals with oil yields above 55% and 19 individuals were identified as low oil yielding individuals, with oil yield below 40% across all the studied sites. The remaining 107 individuals were average oil yielding individuals which had oil yields between 40% and 55% across all the studied sites. Figure 4 shows the high and low oil yielding individuals of the species across all the studied sites.

Our results are within the range reported by other researchers for *P. armeniaca.* According to Singh [28], the oil content percentages of *P. armeniaca* and *Juglens regia* ranged from 47.30 to 48.96% and 55.25 to 57.08%, respectively. When we compared the oil yield of the other oil yielding trees species with our present studied species, it was found that *P. armeniaca* in our studies produced high oil yields ranging between 38.75±2.4 to 57.27±2.4%.

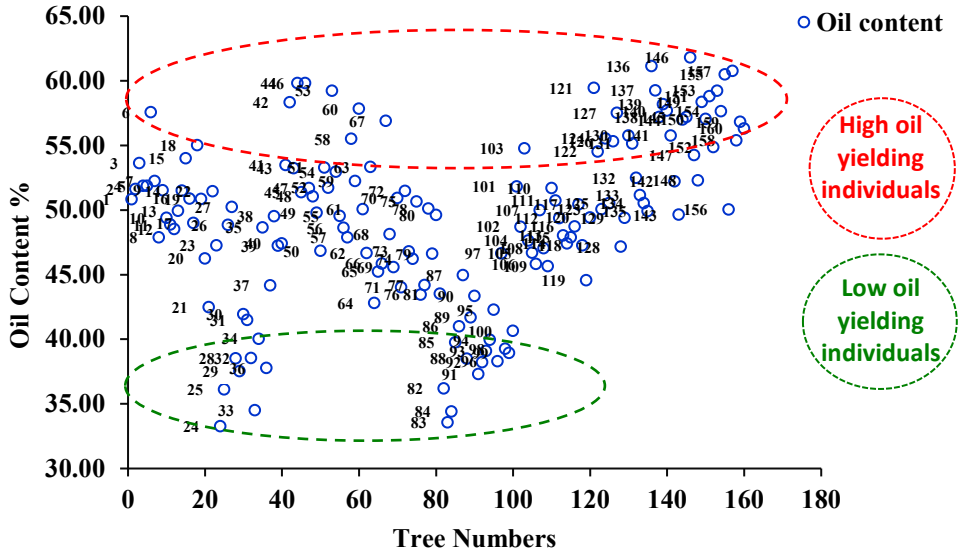

Figure 4. Oil yielding individuals of *P. armeniaca* across all the studied sites

3.5 Average production from a hectare plantation of *P. armeniaca* and role in livelihood generation

Fruits of *P. armeniaca* are collected by the communities for self-consumption (eating) and selling purpose. This knowledge on the utilization has been transmitted by ancestors from generation to generation both orally and practically. Communities residing in the remote hilly areas of the Uttarkashi district extract the oil from the kernels of the *P. armeniaca* seed, and the oil is mostly used for cooking, as medicine, and for body massage. The waste generated after oil extraction (Khal) is used as animal feed. The oil of *P. armeniaca* is usually sold at Rs. 200-250/- per liter. The market price of *P. armeniaca* oil is very high and ranges between Rs. 1500/- and 2500/- per liter. At present, oil expellers have been established in some of the areas so extraction of oil is done by mostly through the machines and the cost of oil extraction is Rs. 2-3 per kg.

As state earlier, the average kernel oil content of *P. armeniaca* ranged from 38-57%. Approximately 400 individuals can be planted in 1.0 ha area in 5 × 5m spacing. The trees start bearing fruits at the age of 5-6 years and continues to bear well for a period of 50-60 years. Full bearing occurs after 8-10 years of plantation. The average fruit yield from 1.0 ha plantation ranges

from 23.14-43.75 tha^{-1}, seed yield 3.97-7.50 tha^{-1}, kernel yield 1.24-2.34 tha^{-1} and oil yield 0.61-1.15 tha^{-1}. The oil is generally sold at Rs. 200-250 per liter locally. The average income from a 1.0 ha plantation can range between Rs. 71.000/- and 217,000/- ha^{-1} year^{-1} (Table 4). However, the cost of plantation and maintenance may vary depending upon various factors including agro-climatic conditions, wage rates, input costs, and so on. In the other study, researchers estimated that 121.6 Kg of oil can be extracted from 320 Kg of *P. armeniaca* kernels and also revealed that a cottage scale unit to process apricot seeds with profit margins of 20-25% can generate employment for at least one person per unit [29].

In the Uttarakhand region, local hilly communities often depend on forests sources because income from agriculture is marginal and seasonal. Multipurpose oilseed yielding tree species can be promising sources of income generation in the Himalayan region. The present study suggests that a hectare of plantation of *P. armeniaca* (wild apricot) can generate excellent yield and income.

Table 4. Average fruit yield, seed yield, kernel yield, oil yield t ha^{-1} from *P. armeniaca* plantation and income ha^{-1} from sale of oil

Age of Plantation (About 6-8 Years)	
Spacing of Plantation	5 × 5m
No of Individual	400 ha^{-1}
Fruit Yield	23.14 - 43.75 tha^{-1} year^{-1}
Seed Yield	3.97 - 7.50 tha^{-1} year^{-1}
Kernel Yield	1.24 - 2.34 tha^{-1} year^{-1}
Oil Yield	0.61 - 1.15 tha^{-1} year^{-1}
Income through sale of oil (@ Rs. 200/- to 250/- liter^{-1})	Rs. 122,000/- to 287,000/- ha^{-1} year^{-1}
Recurring Cost	Rs. 51,000/- to 70,000/- ha^{-1} year^{-1}
Net Income	Rs. 71,000/- to 217,000/- ha^{-1} year^{-1}

Initial cost of plantation development varies between Rs. 5500/- and 6000/- per hectare which should be subtracted from 1st year income generated from sale of oil.

4. Conclusions

Considering all the above perspectives, there is a tremendous potential to plant oilseeds producing trees like *P. armeniaca* in degraded and waste lands if appropriate planting materials and practices are developed. The production of such oilseeds producing species can play an important role in providing the opportunities of employment and incomes to the local communities of the region. The results of present study indicate that the species *P. armeniaca* can be a vital option for providing livelihood opportunities for the local marginalized hill communities of Uttarakhand. As per present study, a good yield from a 1.0-hectare plantation with 400 trees can generate excellent income and play an imperative role in building the self-sufficiency of the local people. This study provides a unique science-based perspective on some realistic options for generating livelihoods and economic conditions for the local hill communities in the region. In order to design a work plan for the development of livelihood possibilities in the region, the study recommend that government and nongovernmental organizations should fully employ their resources at the grassroots level.

5. Acknowledgements

The authors are thankful to the Department of Forestry and Environmental Science, D. S. B. Campus, Kumaun University, Nainital for providing all the necessary facilities to carry out the present study. The authors are also thankful to the people who directly or indirectly helped during present study.

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