

## Cultivation of Black Goji Berry (*Lycium Ruthenicum* Murr.) in the Trans-Himalayan Region Ladakh: Agro-Technique Harvest, Yield and Cost-Benefit Analysis

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### ABSTRACT

The present study discusses the agro technique, harvesting, yield, and economics of less explored highly medicinal plant black goji berry (*Lycium ruthenicum*). It was observed that black goji berries can be easily cultivated through seed, pencil-thickness hardwood stem cuttings, and rootstock. Black goji berry harvesting is a very difficult and tedious task for goji growing farmers as the berries get easily ruptured during harvesting and lose their content. To address these obstacles, DIHAR-DRDO, Leh conducted several goji berry harvesting trials deploying various techniques. Collecting fruits/berries to their full potential requires careful planning and tactics, which involves the use of an appropriate harvesting method that minimizes damage. After performing various method of harvesting, the best outcome was reported in cutting the fruit-bearing branch method as its less expensive with minimum fruit damage (5 %), time-saving, and retain the quality of fruit as compared to the other harvesting methods. An approximate cost production and net profit calculation were performed for 1011.71 square meters (02 Kanal) plantations of *L. ruthenicum* to their average yield of fruit production per plant. The average yield of three-year-old hardwood stem cutting and uprooted plant is 500-600 gm of fresh berry per plant on average. The economic relation to the cost production of *L. ruthenicum* is highly beneficial and it has all the capabilities of enhancing the socio-economy of the fragile ecosystem.

**Keywords:** *Lycium ruthenicum*; Agro technique; Black goji berry; Harvesting; Economics; Yield

### 1. INTRODUCTION

Black goji berry (*Lycium ruthenicum* Murr.) is a hardy deciduous shrub with purple-blackberry, belonging to the nightshade family (Solanaceae) and regionally known by various traditional names all over the world in China it's called "Hei Gou Qi" and in Ladakh "Tsekar or Khitser". It has been used for centuries in Europe and Asia (especially China) for its ecological, nutritional, and medicinal values.<sup>1,2</sup> *L. ruthenicum* is one of the few potential but lesser-known multipurpose temperate plant species native to higher altitudes of China (Nei Mongol, Ningxia, Qinghai, Shaanxi, and Xinjiang) Afghanistan, Kazakhstan, Turkmenistan, Tajikistan, Iran, Pakistan, Russia, and India.<sup>3,6</sup>

Goji berry can be used for many purposes and thus, has considerable economic potential<sup>7</sup>. Recently, it has attracted considerable attention from researchers around the world, especially in China, mainly for its nutritional and medicinal values. In China,

*L. ruthenicum* has been consumed since 2000 years back as traditional food and medicine.<sup>8</sup> With increasing research on goji berry, it has been shown that the fruit of goji berry contains proteins, vitamins (vitamin C, vitamin b12, vitamin B2, vitamin B1, vitamin D) minerals, dietary fibers, fats, polysaccharides, phenolic compounds, flavonoids and anthocyanin.<sup>9,12</sup> As a result of its diversity of bioactive compounds, it's used to develop drugs, dietary supplements, and functional foods and exhibits great potential pharmacological and therapeutic properties such as antioxidant, immunomodulatory, anti-fatigue, anti-aging, anti-cancerous, nourishes liver and kidney, cardio-protective, and wound healing.<sup>13,16</sup>

Additionally, the ecological value of the goji berry is enormous since it has wide adaptation, rapid growth, and sucking habits, coupled with strong deep penetrating and horizontally running roots. Due to these peculiar characteristics, goji berry is an ideal pioneer plant for soil and water conservation, desertification control, and reforestation of fragile ecosystems.<sup>17-18</sup> As a result, this thorny shrub in Ladakh can be easily used to prevent soil erosion as the region is prone to soil erosion and it

can convert the wasteland into greenery, thereby making Ladakh greener.

*L. ruthenicum* is a bisexual flowering plant and the dispersal of pollen is performed by bees and wind.<sup>3</sup> The berry can be consumed in both fresh and dehydrated form by soaking in liquor or water to make *Lycium* Juice or tea and can be chewed directly. Berries are small globose, on an average 8.5 mm in diameter (ranging from 7.5 mm to 11.45 mm), and have 8.1 mm width (ranging from 6.95 to 11.21 mm).

The goji berries are under-utilised wild edible shrubs that have the potential to contribute to improving the economy, health, food security, and nutritional quality of the hilly people. Apart from health care, medicinal plants are primarily the alternative income-generating source for underprivileged communities.<sup>19,20</sup> Insufficient research and developmental activities have resulted in the under-exploitation of goji berry's potential value to human well-being. Medicinal and aromatic plants are receiving attention globally as sources of herbal drugs.<sup>21</sup> There is no published record available on the agro technique of goji berry after so, therefore an attempt has been made to standardize the cultivation method of goji berry. Production through cultivation can reduce the pressure on wild medicinal plants and maintain uniformity in production. Cultivation of plants will prevent environmental degradation and also the loss of genetic diversity of the species from the wild.

DIHAR-DRDO Leh is an Indian frontier research organization that is working on goji berry before this study local considered goji berry as fodder and because of their pointed thorn it was used as bio-fencing to prevent the invasion of wild animals and human beings in their cultivated fields and lawns. After putting enormous efforts by DIHAR-DRDO to explore goji berries in Trans Himalayan Ladakh, goji plantations are becoming distinctly encouraged by farmers.

The goji berry market is also expected to grow in India because it exercises the food and beverage industry, pharmaceutical industry, and cosmetics industry. Accounting for these peculiarities, it sounds to enunciate that investing in a goji plantation might be a decision worth considering for farmers of the study region. Having immense ecological and economic advantages of this thorny plant goji berry growers need yield, production,

marketing, and financial information to make sound decisions concerning the establishment of a goji berry orchard at the commercial level. Therefore, the objective of this article is to deliver basic knowledge regarding the yield, cost, and return of growing, harvesting, and marketing of goji berries. The data raised in the study is deliberately presented as a guide to a helping hand to an individual who is eyeing to enter the goji berry business and also those who are currently growing goji berry to make more informed business management decisions (Fig. 1).

## 2. METHODOLOGY

This study was carried out during 2018-2021 at the Defence Institute of High-Altitude Research (DIHAR), Leh Trans Himalayan Ladakh India, to evaluate the cultivation practices, yield, economics, and suitable approach of goji berry harvesting.

### 2.1 Propagation Technique

#### 2.1.1 Propagation Through Seed

Fresh fruits of *L. ruthenicum* was collected from the wild and brought to DIHAR DRDO Lab, Leh Ladakh. Seeds were separated from the pulp and washed with distilled water. For performing the seed germination test, seeds were placed in a glass of water, and selected only settled down seeds and rejected the floating seed. The selected seeds were disinfected with 1 % Sodium hypochlorite and washed with distilled water. The seed was sown in pots containing the media (coco-peat) in a greenhouse Water was sprinkled daily to maintain the moisture and monitored regularly for initiation and progress of germination until no more germination was observed for more than a week.

#### 2.1.2 Propagation Through Pencil-Thickness Hardwood Stems Cuttings

Pencil-thickness hardwood stem cuttings were collected from the wild (Nubra Valley) in early spring. The cuttings were trimmed to their original size of 20-22 cm and planted in black poly-bags using sand as rooting media in Fiber reinforced greenhouse. The base of the cuttings was treated with IBA. The planted cuttings were kept moist during root formation by misting water regularly.



Fig 1. (a) *L. ruthenicum* shrub



(b) Leaves and flower



(c) Fully ripe goji berries

After 100 days, the sprouted cuttings were transplanted to their permanent location.

## 2.2 Harvesting

Harvesting of black goji berries is a tedious and cumbersome operation and there are no harvesting tools and methods in the Trans Himalayas of India. The harvesting of goji berry yield is very low due to the thorny nature of the plant. Three different harvesting methods were evaluated; beating the bush with the stick, cutting the fruit-bearing branch, and handpicking. The following materials are required pruner, plastic sheet, gloves, stick, forceps, and tray.

### 2.2.1 Beating the Fruit-Bearing Branch

In this method, a sheet of cloth or polythene is spread under the plant canopy. The tip of the fruit-bearing branch is held with one hand and gently beaten with a stick the berries and leaves both will fall on the spreading sheet.

### 2.2.2 Cutting the Fruit-Bearing Branches

Cutting the fruit-bearing branch is a selective method in which the fruit-bearing branch is cut down with the aid of a pruner. During this method, only highly fruit-bearing branches are selected. After cutting the branches allow them to dry in a shaded area. After a gentle shake, the dried berries were neatly separated from the branch. The dry leaves also fall along with dry fruit so therefore the fruit and leaves were separated by sieving.

### 2.2.3 Using Forceps or Handpicking

In this method with the aid of forceps, all fully matured fruits are plucked and collected in a tray.

## 2.3 Yield Assessment and Cost-Benefit Analysis

The production costs, yield, and profitability evaluation were determined approximately by small-scale cultivation of goji berries on 1011.71 square meters (02 Kanal) land. The standard practices for field preparation; planting, irrigation, weeding, harvesting, and post-harvesting were followed. In 2018, 2-3-year-old hardwood stem-cutting and uprooted plants were brought from the wild. The uprooted plant was planted in a permanent location and the cuttings were grown in black poly-bags treated with rooting hormone for rooting. After the formation of the roots in three months, the cuttings were transplanted to a permanent location without disturbing the roots. The watering was done via surface irrigation.

The FYM fertilizer (2 tonnes) at the rate of 1200/ton was applied to the field before and after planting. The data were collected from 2018-2021. The data of yield and economics were recorded for 3 years of goji berry plants raised by hardwood stem cuttings and uprooted plants. The cost-benefit analysis of cultivated goji berry was calculated in Indian rupees /1011.71 Square meter (02 Kanal)/ Year.

## 3. RESULTS AND DISCUSSION

### 3.1 Propagation Techniques Through Seeds

The seed germination of *L.ruthenicum* is quick and fairly good as after three weeks seeds start to germinate. The propagation of goji berries can be performed through seeds with ease and an ample amount of seedlings produced. The seed germination percentage is observed more than 90 %. The germination may delay if the temperature dips down. Growing seedlings indoors for outdoor growing may enable the propagator to obtain higher germination a percentage.

The seeds of *L. ruthenicum* can be directly sown in a permanent field (outdoor) by making seed beds during the month of May-June but it requires plenty of seeds. Observations found that in this method the germination percentage is drastically reduced. So to overcome this low germination percentage, increase the rate of sowing which is only feasible if the seed amount is not a limiting factor. Transplanting the seedling requires a minimum of 15 days of hardening for a better survival percentage. Hardened seedlings are planted into holes of 2-3 inches in dimension and watered regularly through flood mode to keep them moist and help in re-establishment. After establishment watering can be reduced to twice a month. The success of transplantation is mainly dependent on the size of the seedling and hardening. Early transplanting of seedlings reduces the survival rate but letting the plants grow in the greenhouse during the first winter increase the success of transplantation.

### 3.2 Propagation Through Pencil-Thickness Hardwood Stems Cuttings

So, in this experiment, it was observed pencil thickness hardwood stem cutting gives the best sprouting and rooting percentage (90 %) in sand media treated with 1500-2000 ppm of IBA. Extensive studies have been conducted at MAP Division (DIHAR) on rapid propagation through stem cuttings and therefore it was concluded that pencil-thickness hardwood stem cutting (20-22 cm length) is highly recommended for vegetative propagation. The polarity of the cutting must be marked at the site of sampling.

To avoid transpiration from the exposed region of the cutting, it must be wrapped in wet cloth till it reaches the workplace also don't trim the cutting into its final size at the sampling site because trimming of actual size can also increase transpiration. During root formation, moisture must be maintained in the poly bags.

Following rooting, before transplanting to the permanent field, hardening is required (15 days) for all healthy sprouted cuttings. During transplantation, tear the poly-bags without disturbing the newly formed adventitious roots and transplant the cutting along with their sand media into the permanent field. The survival % of the cutting will gain 90 % by following this method. Disturbing the roots causes decreases in the survival percentage of the

transplanted cuttings. During transplanting, cuttings are planted at a spacing of 3 ft gap between cutting to cutting (plant to plant) and 6ft between row to row. At the initial stage of transplantation, watering is required regularly to avoid dryness and after the plant is established watering can be reduced to twice a month. The hardwood stem cuttings bear flowers and fruits in the second year of transplantation but take more than 4 years from seed. Besides seeds and hardwood stem cuttings, goji berries can also be cultivated through rootstock. Cultivation of medicinal and aromatic plants in the mountainous region will improve the socio-economic condition of peasants and also support the conservation of medicinal plant diversity in their natural habitat<sup>22</sup>. Unemployment in the Indian Himalayan region is a serious issue and the government and public sector can't provide jobs for all educated youth.<sup>23</sup> Therefore, the cultivation of such medicinal plant species on barren and marginal land by educated, uneducated, and unemployed youth can increase the self-employment of the region (Fig. 2).

### 3.3 Harvesting

A perusal of the data in table 1 indicates that the percentage of damage was higher in beating the branches method (65 %) followed by cutting the fruit-bearing

branch. There is no major difference between cutting the fruit-bearing branch and handpicking in terms of fruit damage. This is natural as by cutting the fruit-bearing branch and handpicking most of the berries are not disturbed or touched or ruptured. The delicate nature of the skin does not resist pressure to rupture. The cost of labor was higher in hand picking, and lowest in beating the branches but the sorting of leaves and fruit becomes the major issue in this method. This difference is understandable as picking up tiny berries from thorny plants manually takes time. Beating the branch requires fewer man-hours as compared to cutting the fruit-bearing branch. Therefore, per-person harvest was best by beating the branch (Table 1)

The flowering bud develops in May in the goji berry, and the fruits begin to ripe in late August, therefore, farmers have the opportunity to harvest the goji berry fruit from August till the end of October. The harvesting of goji berries is very challenging both manually and mechanically the major problems faced in harvesting because of certain reasons like the plant being highly thorny, fruits being soft and highly perishable and the peduncle being strongly attached to the plant causing severe adversities at the time of harvesting. During harvesting, a person may get injured

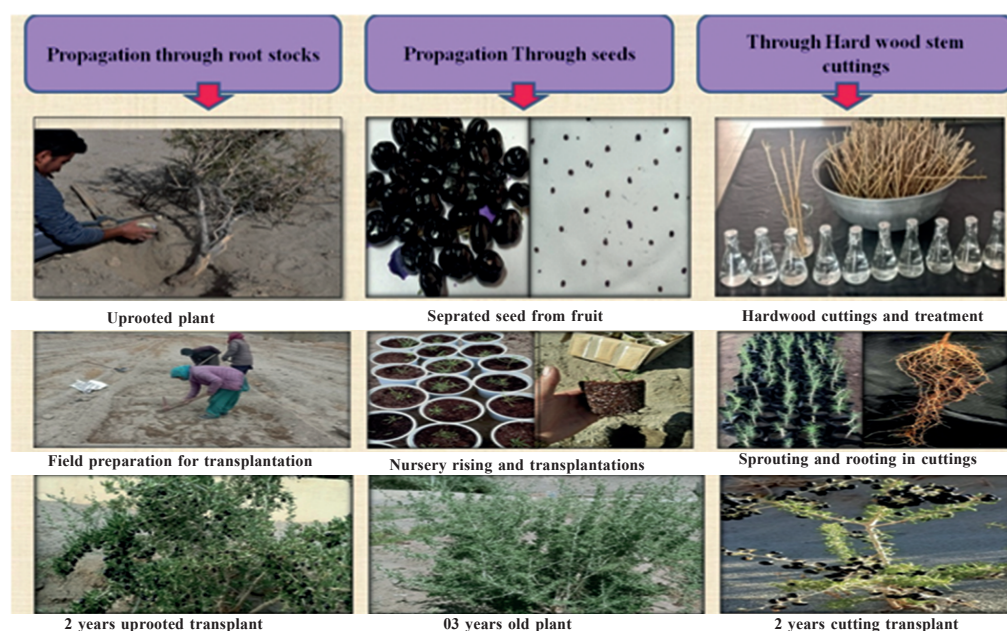


Figure 2. Various propagation techniques.

Table 1. Comparison of each harvesting technique in black goji berry

Type of harvesting	Damage %	Cost of labor/ 02 kanal	Harvesting capacity/ person	Sorting/cleaning difficulties
Beating the fruit-bearing branch	65%	13000 rupees/2 Kanal	4-6kg/hr	Very high
Cut the fruit-bearing branch	5%	18000 rupees/2 Kanal	3-4kg/hr	Low
Handpicking or using forceps	3%	60000 rupees/2 Kanal	0.5-1kg/hr	Very low

due to the thorny nature of the plants. Bringing fruits to the market requires special handling to preserve their quality, shape, and size. A different harvesting method gives a different quality of fruits. Therefore, cutting the fruit-bearing branch method is the most convenient method to harvest the goji berry in terms of reducing fruit injury and retaining fruit shape. It's also less time-consuming and less labor-intensive. One person can harvest around 3-4 kg of fresh ripe fruit per hour by cutting the fruit-bearing branch and it's comparatively slightly less efficient in terms of harvesting capacity per person than beating the thorn methods (4-6 kg). In the case of beating the thorn method fruit injury is high (65 %) because it's very soft and delicate, the fruit will rupture as they strike or collide during falling from the twig. Through this method, one person can harvest about 4-6 kg of ripe fruit per hour. The major drawback of this method is it causes severe injury to the mother plant and also the physical appearance of the berry has deteriorated which is considered to be an important factor in the marketing of goji berries. Separation of fruit and leaves is also a major issue in this method.

However, the handpicking method is laborious and time-consuming. But using this method we can get well-conditioned healthy goji fruits. Unlike sea buckthorn, the height of the goji shrub is accessible and can be harvested by this method. Through this method, hardly a single person can harvest around 1 or 0.5 kg of fruit per hour. So, therefore, this method is only applicable to small orchards *Lycium* but can't be applicable at a larger scale. Therefore, for commercial purposes cutting the fruit-bearing branch is the suitable method of harvesting as compared to other harvesting methods.

In this study, we found all the harvesting method is not completely perfect but the degree of perfection becomes vary according to the types of harvesting methods. Cutting the fruit-bearing branch is somehow

more suitable than the other two methods in various aspects but it requires certain precaution and cares while cutting the branches. Cutting the fruit-bearing branch in the active season may lead to a weaker plant as it has no stored carbohydrates in its lower parts. In the case of cutting the fruit-bearing branches, it reduces the next year's yields as the flowering is set on the 2<sup>nd</sup> year and 1<sup>st</sup> year branches. But in 2<sup>nd</sup> year branches, flowering and fruiting appear quickly as compared to the 1<sup>st</sup> year branches. So therefore we observed uneven ripening in the goji berry plant. Delayed harvesting of goji berries can get rid of uneven ripening. Therefore, the ideal harvesting time for goji berries is late Sep-Oct for this method. Unnecessary cutting of branches should be avoided during harvesting. Still, a better technique of harvesting method is required at the global level to harvest goji berries manually without harming the quality of the fruit and the mother plant.

### 3.4 Yield Assessment and Cost-Benefit Analysis

The small-scale cultivation of goji berries was established 2018 in April in an area of 1011.71 square meters (02 Kanal). The first fertile year of the plantation was the 2<sup>nd</sup> year after planting uprooted plants and hardwood stem cuttings. The approximately monitored costs and production indicators were reported for three years. The average fresh goji berry yield ranged from 500-600 g/plant under review in the first three years and the production of goji will increase every other year as the plant is completely established. During the study, it was reported that in the wild a well-established goji plant bears 2-2.5 kg of fruits per plant. The investment period of the goji berry plantation covers 3 years, which involves planting and the subsequent 3 years of nursing. The total capital investment for the establishment of the goji field till the fruit harvesting were shown in Table 2. As the total cost of production of *L. ruthenicum*

**Table 2. Cost of cultivation and production of black goji berry (Rs/2 Kanal)**

Items	Details	Rate (Rs)	Amount
Land preparation	Two times ploughing in 1st year (March-April)	Rs 1000/ploughing	2000
Cost of planting material	1500 plant	Rs 10/ Cutting	15000
Manure FYM	2 ton	Rs 1200/ ton	2400
Planting	08 man-days	Rs. 700/man-days	5600
Irrigation	60 times	Rs. 300/irrigation	18000
Weeding	30 man-days	Rs. 700/ma days	21000
Harvesting of Fruit/Berries	19 man-days	Rs.700/man-days	13300
Sorting/cleaning/ drying	8 man-days	Rs. 700/man-days	5600
Land cost for three years		Rs. 30000/year	90000
Miscellaneous (Growth hormone, pruner, etc)			5000
<b>Total Cost of Production</b>			<b>172,900.00</b>

**Table 3. Total production value and net return in case of average yield (2 Kanal)**

<b>Total Avg. yield of fresh fruit/ plant</b>	<b>600 g *1000 plants = 600 kg approx.</b>
Total Avg. yield of dry fruit	60kg/1000plant
Cost of goji berry in rupees (5000.00/kg)	60kg @ Rs. 5000.00 = 3.00 Lakh approx.
Total cost of production	1.95 Lakh/2 Kanal approx.
Gross return through the sale of goji berry	3.00 Lakh/2 Kanal approx
Net return=(Gross return-Total cost of production)	1. 00 Lakh/2 Kanal approx

is approximately 2 Lakh/ 1011.71 square meters (2 Kanal) of land. After subtracting the cost of production from revenues generated just passing three years the net cash flow or net income emerges. Farmers establishing new goji berry plantations will experience convincing profit (Table 2 and 3).

The net profitability is directly proportional to the yield while the yield is expected to increase in the future as the plant grows and produces a higher number of fruit-bearing branches therefore the net income will be high after each passing year. In small-scale cultivation, the share of the cost of land and labor cost is the major cost factor. A rental rate of 30000 rupees per 1011.71 square meters was estimated as the average rental rate for barren land in villages of Ladakh. But the land values may differ in every region and also the rental cost. For calculating the yield, the fruits were harvested and allowed to dry in a shade and dry place to avoid fungal growth.

It takes about 1 month to completely dry under natural conditions as berries contain 90 % moisture i.e. 1 kg of fresh berries remain 100 gm after drying. After drying collected berries should be cleaned (removal of impurities) and kept with due care to avoid damage and stored in a cool and dry place. Wooden boxes or airtight polythene/gunny bags are used for storage and keep away from strong, direct light to avoid degradation of anthocyanin a chemical compound that is light sensitive. The average yield is around 500-600 grams of fresh goji berries per plant under a cultivated state. The author also found that in the wild availability of water around the plant gives a higher yield and bigger berries than in drought areas even in drought areas there was no fruiting.

Research performed by Papp and porpaczy found that irrigation may double the yield of sea buckthorn berries.<sup>24</sup> However, it can be summarized that the presence of water shows that plants developed twice as big berries on irrigated land than on non-irrigated sites.<sup>25</sup> The yield of the goji berry can improve by taking care and planting the best variety found in the wild and needs to protect the fruit from birds as birds damage the fruit by eating it. The bird can reduce the yield as it has a great affinity to goji berries. Goji berry has been cultivated for commercial purposes in many countries like the USA, Japan, Korea, China, and other Asian countries.<sup>8</sup>

Currently, the black goji berry price is very expensive than the red goji berry due to the scarcity of wild black goji berries in the market and their higher functional value.<sup>26</sup> The selling cost of dried goji berries is assumed around 5000 rupees per kg of dry weight in Ladakh India. After the successful cultivation of goji berries on a large scale, Ladakh may become the only goji berry exporter of India, and the economy of the region will be boosted very efficiently.

#### 4. CONCLUSION

From this study, it's concluded that goji berries can be cultivated through seed and pencil-thickness hardwood stem cuttings. Hardwood stem cutting is the most suitable planting material to cultivate goji berries because it yields fruits within a short time. The plant takes 4-5 years to bear fruits from seeds whereas stem cuttings begin bearing fruit in the second year. The manual harvesting of goji berries on a large scale is not ideal as there are several disadvantages, so the introduction of a mechanical harvesting device to enhance capacity and efficiency without damaging the fruit and mother plant is imperative. The results of the profitability of cultivation in the present study confirm that goji berry cultivation for commercial purposes is profitable. There is a great deal of ecological and economic fragility in regions like the cold desert of Ladakh and elsewhere in similar regions. Folklore tells us that medicinal and aromatic plant represents a vital source of livelihood for poor rural communities. Therefore, such medicinal plants are means of generating employment and income for many poor families. The local Government, LAHDC needs to provide incentives to the farmers for the cultivation of goji berries on a larger scale and financial assistance to create infrastructure facilities to make value-added products of goji berries to uplift the socio-economy of the region.

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