

**TECHNOLOGY FOR WALNUT PRODUCTION IN BHUTAN**  
**Horticulture Sector**  
**Renewable Natural Resources Research Centre Bajo, Wangdue Phodrang**

**PRE-PRODUCTION STAGE**

**A. Growing Conditions**

1. Altitude

- Between 1,300-2,500 metres above sea level (masl).
- Beyond 2,500 masl (like in Bumthang), commercial walnut production is not recommended as it results in erratic and even total crop loss in some years when there is late spring frost.

2. Temperature

- Adapted to cold temperate zone, requiring cool period in autumn to promote leaf fall and the physiological process of plant hardening and induction of dormancy.
- Not recommended in areas where late spring or early fall frost is common as freezing temperature kills the growing point of walnut trees and severely affects production.
- Temperature of 38°C or more results in sunburning of hulls and shriveled kernels, with severe damage occurring at temperature over 40°C.

3. Irrigation

- Requires 800 mm rainfall or irrigation equivalent. To obtain high yield, avoid planting walnut in drought-prone areas.
- Spring rainfall is associated with increased problems from walnut blight.

4. Soil pH • Requires slightly acidic soils between pH 5.5-6.5.

- Prone to zinc and boron deficiencies, hence select a site wherein recent soil analysis shows reasonable levels of zinc and a slightly acidic pH.

5. Soil texture

- Grows best on deep, friable loamy soil where roots can develop to 3-4 m depth. Besides good top-soil, the subsoil should be free of impermeable layers like clay and rock gravel and anaerobic conditions (clayey soil coupled with high rainfall).
- Walnut can not tolerate wet soils for any extended period. A few hours of water-logging can cause severe damage.

6. Topography

- Gentle slopes are more easily managed. As walnut plantation is likely to be on steep slopes in Bhutan, there are two important factors to consider:
  1. Choose a site with southerly and south-westerly facing slopes. This warms up faster in spring and cools down more slowly in the autumn, thus extending the growing season at higher altitude. Northerly and easterly aspects tend to be colder and more prone to frost damage at higher altitudes, but may allow walnut production at lower altitude.

2. Choose a site with good frost drainage. Unimpeded down slope drainage of cold air is important particularly in spring where a build-up of cold air in pocket behind a line of trees or in a fold in the ground can cause crop loss due to late frosts.

### **B. Choice of cultivars**

The newly-released cultivars by the Ministry of Agriculture for general cultivation in Bhutan are indicated below:

#### Kanthe Selection

- Big and long trapezoid nuts, semi-erect, and vigorous
- Regular bearer
- Thin-shelled
- Leafing out in 1st week of April
- Flowering habit: Female flower first
- Disease: Tip die back
- Nut size index: 4.27 mm
- Nut in-shell average weight: 26.11 g
- Kernel average weight: 9.32 g
- Harvesting in end-September under Yusipang condition.



(Photo courtesy of RNR RC-Yusipang)-

#### Yusipang 2

- Big and long ovate nuts, semi-erect, and vigorous
- Regular bearer
- Thin shelled
- Leafing out in 1st week of April
- Flowering habit: Female flower first
- Disease: Some tip die back
- Nut size index: 4.00 mm

- Nut in-shell average weight: 20.75 g
- Kernel average weight: 8.3 g
- Harvesting in end-September under Yusipang condition



## II. PRODUCTION STAGE

### 1. Plant propagation

#### a. Preparing the seeds

- Use the local walnut seedlings as rootstocks.
- Collect the walnut in September to October from the forest. Hull the seeds and air-dry in the open shed.
- Stratify walnut seeds either by early fall planting (planting in December where natural stratification occurs) or by moist cold stratification for spring planting (end of February).
- At lower elevation, stratify the seeds in moist sand or peat moss for about two months. At higher elevation, there is no need to stratify as they are naturally stratified by exposure to outside winter temperatures in a cold room or shady open area.
- Dip the seeds for one minute in hot water (that is, almost boiling condition) before fall planting or stratification.

#### b) Preparing the nursery

- For fall or spring planting, prepare the nursery carefully.
- Plant the seed in about 10 cm deep and 15 cm apart in rows and 50 cm between the rows. It takes more than two months for the seed to germinate in the nursery for fall planting without stratification while for spring planting (after cold stratification), the seeds germinate within 1-2 weeks after planting.

- Undercut the seedlings when it is about 30 cm tall. Irrigate the seedlings thereafter.
- Thin the seedlings, if required, a few days after undercutting.
- Make sure that the nursery is free of weeds. Irrigate frequently and fertilize the seedlings to correct soil deficiencies.
- If nursery is properly managed, seedlings attain grafting size within a year's time

### c) Grafting operation

The most suitable time to graft walnut under ambient condition is towards the end of dormancy or early spring season (mid-March) especially in an altitude of 700-2,100 masl. If the nursery is located at higher altitude, use grafting cable or hot callusing technique to maintain suitable temperature for walnut grafting (20°-30°C).

Whip grafting is the best method to graft walnut if the size of rootstock and scion are same. For the large size rootstock, use modified whip grafting. Scion is a short piece of shoot containing dormant buds that is united to the rootstock on the upper portion of the graft and form the shoot system of the composite plant. The procedure is as follows:



**Modified whip grafting**  
(Photo courtesy of RNR RC Bajo)

- Prepare the materials required for grafting such as sharp knife, grafting tape, wax and aluminum vessel, burner (to melt wax), and plant materials (scion and rootstock).
- Use 1-2 year old healthy rootstocks of *Juglans regia* and freshly collected scions of known cultivars for grafting. Use only dormant scion and active rootstock for grafting.

- Make a slanting cut (about 5 cm) with a sharp knife at the base of the scion and at the top of rootstock. For the rootstock, make the cut in the bark portion or lesser cut on wood portion depending on scion size. Modified whip grafting
- Fit the cut sections of rootstock and scion together making sure that the cambial layers of both rootstock and scion fit perfectly.
  - Tie the fitting (graft union) with a grafting tape.
  - Dip the scion portion of the grafted plant into the hot wax to prevent scion desiccation.
  - Grow the grafted walnut in the nursery or in pots with a growing medium prepared as 1:1:1 ratio of sand, Farm Yard Manure (FYM), and soil. Add basal fertilizers.
    - Remove the suckers or shoots growth from the rootstock as and when it appears.
    - Irrigate the nursery 1-3 times a week depending upon the weather condition and soil types.
    - Take note if bleeding occurs during grafting, that is, sap flow due to root pressure, as it kills the grafts. Control the bleeding by either cutting off the rootstock 5-8 cm above the grafting site about two weeks beforehand or make few slanting cuts in the rootstock through the bark into the wood as low as possible below the grafting point. If any later bleeding happens, it occurs through these cuts. Also, stop irrigation for about two weeks prior to grafting.

## 2. Layout and tree density

- Layout the orchard in square or Quincunx (diamond) design in gentle slope and flat valley. Use contour planting for hilly and steep slope.
- Consider the number of trees to plant per unit area in terms of both short- and long-term productivity of an orchard. The short-term objective is to have maximum numbers of trees to obtain the earliest economic production potential per unit area. If the initial tree density is too high, remove specific number of trees 8-10 years after planting.
  - Space the plants depending on the tree type and vigour. For small and compact tree, use initial spacing of 5 m x 5 m and adjust this to 10 m x 10 m at maturity (high density planting).
  - For highly fruitful lateral-bearing but vigorous cultivars and terminal- bearing vigorous cultivars, maintain an initial spacing of 6 m x 6 m and finally adjust to 12 m x 12 m.
  - As a general guide, use the following spacing:
 

Seedling trees	12 m x 12 m
Grafted on <i>Juglans regia</i>	10 m x 10 m
Grafted <i>Juglans nigra</i>	8 m x 8 m

- When pollenizers are required, place them in permanent position to avoid their elimination during the temporary tree removal. Every eight row, plant a pollenizer variety that is perpendicular to the usual direction of the wind.

### 3. Pit digging and filling

- On clayey or not very fertile soil, dig a pit 1 m deep and 1 m in diameter. For loamy soil, dig a pit 0.3 m deep and 0.3 m in diameter.
- Break the hard layer on any side of the pit.
- Keep the top surface soil but separate this from the subsoil.
- Fill the pit with mixture of rotten FYM and top surface soil at a ratio of 1:2.

### 4. Planting

- Order the planting materials in advance before planting.
- If planting is delayed, lay the seedlings in a trench. Cover the root portion with moist soil. Do not allow the seedlings to dry.
- Prepare a hole just enough to accommodate the entire root system. Spread the roots around in all sides and cover with soil. Make sure that the graft union is above the soil zone.
- Plant the seedlings in late dormant/early spring season. Irrigate immediately.
- In the first year, prune the young tree by cutting the top above the graft union but leaving 5-6 buds.
- Paint the trunk with whitewash.
- Stake the young tree in the windy area.
- As the tree leaf out and growth occurs, pinch the growing tip from the shoots other than the one selected as a main trunk.

### 5. Applying manures and fertilizer

- Use the following guide below as a indicative amount of NPK for the walnut in the absent of plant and soil nutrients analysis information:

Year	N Dose (g/tree)	Location: circle around the tree (m)
1	100	0.5
2	200	1.0
3	300	1.5
4	400	2.0
5-7	500	2.5
7-9	600	3.0

10 to full production 900 3.0

- In the first five years, place small amounts (about 100 g) of P and K per tree. From fifth year up to full production, apply 40-80 kg/ha of P and 60-100 kg/ha of K based on soil fertility and plant vigour.

## **6. Training**

- Train the walnut after the first year using the Modified Central leader System (delayed open centre).
- After the 1st years' growth, head back to 2 m of its height. Remove all the lateral shoots on the leader, leaving one or two shoots at lower level on the trunk to provide shade on trunk's south and west sides.
- To avoid narrow crotches, remove all primary buds above 1.5 m from the ground to force secondary buds to grow.
- Select main scaffold limb 1.6 m above ground. Choose primary scaffold limbs in all directions on the trunk. Ensure that limbs have wider angles, more than 30 cm apart vertically on the main trunk.
- Remove the rest of the vigorous branches leaving small branches undisturbed for fruiting.
- Head back all the selected limbs on terminal fruiting cultivars but not for lateral fruiting ones.
- After 2-3 years, allow the secondary scaffold limbs on primary scaffolds to grow by removing the extra vigorous branches.
- Head back all scaffold limbs every year in terminal fruiting cultivars.
- For cultivars that are highly fruitful on lateral buds, head back a large number of new shoots on the periphery to reduce fruiting and increase vigorous shoot growth throughout the trees' periphery.
- On terminal bearing cultivars, head back selected branches and thin out limbs completely.

## **7. Pruning**

- Carry-out pruning operation in the dormant season but early spring is preferable. Further delay causes excess bleeding.
- For young (16-17 year-old) and middle aged trees (34-35 year-old), cut back 3-year old shoots. For mature trees (40 year-old), cut back 4-5 year-old shoots.
- Initiate selective thinning out of limbs in the top and sides of the tree before overcrowding becomes serious. Do not remove more than 25% of the branch structure at any time.
- Treat all the cut surfaces with a tree wound dressing such Copper oxychloride or Bordeaux paste.

## **8. Tree thinning**

- Practice tree thinning in closely-planted orchards (high density planting). Remove the tree before it begins to crowd.
- Remove the one-third temporary tree or alternate tree at one time as the tree gets crowded leaving trees on the edges of the plantation.

X	X	X	X	X
X	R	X	R	X
X	X	R	X	X
X	R	X	R	X
X	X	R	X	X
X	R	X	R	X
X	X	X	X	X

Alternate tree removal (R) leaving edge trees in place

### 9. Mulching

- Mulch the tree with plastic or organic materials like straw or grasses

### 10. Intercropping

- Intercrop walnut trees with legume fodders in areas traditionally under pasture farming system. For other farming systems, use low growing and noncompetitive vegetables such as non-climbing beans and other legumes, tomato, and onion and more competitive vegetables such as chili and asparagus.
- Intercrop during the first 4-6 years after planting only.
- If sustained intercropping is planned from the establishment of the orchard, modify the spacing, that is, much wider between rows of mature trees.

### 11. Irrigation scheduling

- Do supplemental irrigation in dry spring and early summer before the start of monsoon period, that is, provide irrigation from April to June
- No irrigation is needed from June onwards until harvest since this is the monsoon season.

### 12. Top-working

- For walnut orchard establishment, plant the walnut seedlings directly in the production field without nursery grafting and top-worked two years later. This is the best method of orchard development in Bhutan.





Two-year old walnut seedling plantation (Photo courtesy of RNR RC Bajo)



Top-worked walnut fruited two years after operation at 2,300 masl (Photo courtesy of RNR RC Bajo)

- To avoid sap bleeding, either head back the stock two weeks before actual operation or make few slanting cuts on the stock through the bark into the wood just bellow the grafting point so that if any bleeding occur later, it occurs though these cuts.
- Select disease-free young trees for top-working.
- Cut the dormant scion wood from the parent tree in advance. Wax the scion, pack properly, and store in the refrigerator at 4o C.
- Do bark grafting for top-working in late spring (end of March to April) or when new growth has taken place.
- Wrap the graft union with thick plastic sheet. • Paint the stem portion with white wash.
- Remove the shoots other than the scion growing on the plant.

### **13. Harvesting and post-harvest operation**

- Walnut trees from seedling bear nuts in 10-12 years and full commercial production 18-20 years from planting. On the other hand, grafted walnut starts

production earlier, that is, in 4-5 years after planting and full commercial production in 8-10 years only.

- A fully-grown, big size tree produces as high as 100-150 kg nuts but the average yield is 40 kg per tree.
- Crop maturity and harvest in Bhutan starts from August-October depending on the elevation and cultivars. Do not delay harvesting to avoid deteriorating the nut quality kernel (brown colour kernel). The lightest kernel colour commands higher price in the international market.
- To determine maturity, observe the following:
  - a) The nuts are mature when the nut dehisce and fall. In higher altitude, kernel matures earlier to hull dehiscence while in the lower altitude, hull dehiscence take place prior to kernel maturity.
  - b) The walnut kernels are mature when the packing tissue between and around the kernel halves has just turned brown and crop can be harvested if 80% of the nut can be removed with 95% of them hullable. Harvest the remaining nuts few days after the first harvest.
- Collect the nuts from the ground. Clean, wash, and spread the nuts on a sheet or floor to dry them up to 8% moisture level.
- Grade the nuts according to size, colour, and variety.
- Store the nuts in gunny bags inside small well-ventilated rooms free from excessive humidity. Nuts have long shelf-life and it can be sold in extended marketing season.

#### References:

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