

Walnut propagation: India

ABSTRACT

The state of Jammu and Kashmir in the northwest of India is the country's main walnut-producing zone: all the walnuts exported by India are produced in the state. Persian walnut (*Juglans regia*), covering about 63 000 ha of the region, is the most commercially important species, with an annual production of approximately 60 000 tonnes and a farm value of about 25 million Indian rupees.

Since the entire walnut plantation is of seedling origin, however, there is considerable variation in nut crop production. The development of walnut cultivation has in addition faced a number of constraints, including:

- non-availability of plant material of known pedigree and characteristics produced by vegetative propagation;
- an absence of proper classification of local varieties;
- a long gestation period and low tree density per hectare, resulting in low productivity.

In order to reduce the gestation period, increase productivity and ensure uniform product quality, a two-phase project of the Food and Agriculture Organization of the United Nations (FAO) – TCP/IND/4554/8221 (1996-98) – tested different methods of vegetative propagation of walnut under local agroclimatic conditions. The introduction and transfer of this propagation technology to the state represents a major contribution to the future development of walnut production in India as a whole.

The objective of the first phase of the project was to establish the capacity of the Department of Horticulture of Jammu and Kashmir to produce high-quality yield, healthy walnut planting material for commercial distribution to producers. The second phase aimed to further strengthen and improve the results of outstanding walnut varieties and grafting techniques and train national technical staff and nursery workers. National and international personnel from Iran, Italy and Spain were involved.

Activities started in February 1996, with the first visit of the international consultant/team leader, a specialist in walnut propagation and nursery management. An assessment of different walnut-growing areas of the state was conducted

²⁸ At the time of writing, US\$1=42.5 rupees.

and a detailed two-year work plan prepared. Locally selected genotypes were chosen as scion material, the prerequisite for any propagation programme, to train counterpart staff on the importance of specific pruning of walnuts to stimulate production of graft sticks for future multiplication and planting. A preliminary grafting trial was conducted, using a sample hot callusing cable unit. During the same year, land was designated by the state government for establishing a walnut nursery and mother plant and progeny orchard at Zainpora farm in Shopian to produce the required number of graft sticks for future propagation.

Three grafting techniques were introduced under the project at different points in time: hot callusing, chip budding and hypocotyl grafting. Hot callusing was demonstrated on three project sites and more than 50 persons were trained. A 65-70 percent success rate in vegetative propagation of walnuts was achieved by using hot callusing cable on the graft union. Chip budding achieved a 10 percent success rate; although the initial bud take was 70 percent, frost injury seems to have reduced the survival percentage. The hypocotyl grafting technique averaged around 50 percent in terms of final survival of the graft-take, despite certain limitations of a climatic and human nature. The hypocotyl technique is now being used to establish trials under the agroclimatic conditions of Jammu and Kashmir.

To date, some 1 200 grafted walnut plants have been planted in the progeny and mother orchard of Zainpora farm. Of the 2 312 plants produced during the 1996-98 period, 661 have been planted in the progeny and mother plant orchard. In addition, 540 grafted plants of nine exotic varieties received under the project from FAO have been planted in these two orchards. The establishment of the progeny orchard to obtain a greater number of graft sticks is expected to create conditions for mass production of grafted seedlings for large-scale nursery production.

Training for technology transfer was an important component of project activities. For example, a nine-week study tour for three people was organized in Bulgaria, Italy and Spain to provide knowledge about the latest developments in the walnut industry through visits to advanced nurseries, walnut farms, walnut manufacturers and government research institutions involved in walnut study programmes. The project organized 38 weeks of fellowships for training local researchers in European research institutes, where they learned the fundamental principles of propagation techniques, nut evaluation and computer skills. Several training sessions were arranged at Jammu, Ramban, Shalimar and Zainpora by the team leader.

²⁹ Shoot of a plant, especially one cut for grafting or planting

Information on project activities was disseminated during a one-day seminar in Srinagar, attended by more than 700 farmers. The preliminary results of this innovative project have been presented and discussed in various national and international meetings and workshops, with a final international workshop held at Srinagar in June 1998. During this latter event, everyone involved in the field project discussed their work and the results achieved and made recommendations. The national project director's membership of the International Plant Propagators Society provided an ideal opportunity to broadcast project results to a global audience and offers the potential for increased cooperation among scientists, nurserymen and farmers in future walnut production in Jammu and Kashmir.

The impact of the project is considerable and its achievements are expected to play a significant role in sustaining a large population living in the walnut-producing foothills of the state. The establishment of the mother and progeny orchard, the setting up of 35 hot callusing cable units and the introduction of advanced propagation technology hold great promise for improved walnut production.

INTRODUCTION

Walnut, *Juglans regia*, is called by different names in different parts of India. The most commonly used name is akhroot, while in Kashmir it is called *dun*. In India, walnut grows in the northwestern Himalayan belt, expanding up to Darjeeling and Sikkim. It flourishes in temperate belts, however, at altitudes of 900-3 500 m. The tree normally grows well in cool climates that are free from frost during spring but does not thrive in areas with hot summers. The production of a good quality walnut crop is, however, dependent on altitude, temperature fluctuations and humidity/moisture during the main fruit development stage. Frost or snow during flowering destroys young flowers and new shoots, thereby affecting crop production. Normally, an evenly distributed annual rainfall of 760 mm is considered the optimum for a good quality crop.

Well drained, fairly deep silt-loam or friable clay-loam, well supplemented with lime and rich in humus, are considered best for successful walnut cultivation. The accumulation of water is harmful for the development of trees and also affects the quality of nuts. Trees grown on shallow soils with scant moisture content remain stunted and are very often affected by sunburn.

Walnut trees can be raised either from seeds or through budding or grafting methods. Planting using vegetative propagation is almost non-existent. Young walnut plants raised from seedlings come to fruit at the age of 10-15 years but optimum production is not expected until the plant reaches the age of 20-25

years. In Kashmir, these trees may continue to flower until the age of 100 years.

Walnut trees are susceptible to pests and disease such as walnut weevil (*Alcidodes porrectirostris* Marsha), walnut blue beetle (*Monolepta erythrocephala*), Sanjose-scale (*Quadraspidiotus perniciosus* Comst), and walnut green aphid (*Chromaphis juglandicola* Kalt). Among the different pests prevalent in the walnut-producing areas, walnut weevil is considered serious in some places. Defoliation due to *Chaetopractus odata* has occasionally been observed in some areas. Among the common diseases, leaf spot, powdery mildew and gall-canker are of some significance.

Walnut plants in Jammu and Kashmir start flowering in February and may continue until April. In areas at lower elevations, flowering occurs early, whereas at higher altitudes it occurs late. The walnut shell in most varieties begins to harden in the middle of June, after which there is little or no increase in size. The most rapid growth of nuts takes place during the 5-6 weeks after flowering.

PRE-INNOVATION

The state of Jammu and Kashmir is the major producer of walnuts in India; indeed, the entire quantity of walnuts the country exports is produced in the state. In this northwestern area of the country, walnuts are grown all over the Kashmir valley and the hill regions of Jammu. The most important districts for walnut cultivation are Anantnag, Pulwana, Kupwara, Budgam, Baramulla and Srinagar. In Jammu, the largest areas under walnut cultivation are Doda district, followed by Poonch and Udhampur, with minor quantities grown in Rajouri and Kathua districts. The walnuts produced at altitudes of 1 500 m and above are considered of superior quality, with a light-coloured kernel and a characteristic thin shell. At lower elevations, the kernel usually turns brown because of high temperatures at the time of ripening.

Since the entire walnut plantation is of seedling origin, this causes great variability in nut crop production. Unlike other crops, no well-defined classification has been established for walnuts in Jammu and Kashmir. The classification in use is based on trade practices. Broadly speaking, the walnuts in these areas are divided into three categories: thin, medium and hard shell. The walnuts produced in Jammu usually have a thicker shell and are sold in local markets under the name *pahari*. On the basis of packaging, the walnuts are divided into two categories, bag and box quality. Thin-shelled *kagzi* walnuts are usually brought to market in wooden boxes and baskets. Nuts with thicker shells are usually transported in bags. In terms of taste, Kashmir walnuts are considered superior but the variations in the colour and size of the crop are not favourable attributes.

In-shell walnuts for export are graded and sold under marketing rules set in 1966. Those of a minimum size of 32 mm, a good cracking rate of over 90 per cent and the fewest internal defects are assigned the grade designation of India Super-special. Nuts with a minimum size of 30 mm are designated India-Special and nuts of 24-26 mm are graded India I and India B-grade. The kernels of the *Juglans regia* produced in India are assigned the grade designation of India light half; they have a light creamy and light golden colour. The other designations used for the halves that have cotyledons of fully developed kernels are known as:

- India-Special light half
 - Indian Light broken
 - Indian Light pieces
 - Indian Light crumbs
 - Indian Light-my-fire
 - Indian Light Amber halves
 - Indian Light Amber broken
 - Indian Light Amber pieces
- depending on the colour of the kernel.

Production of walnuts has increased over the years. In 1974-75, an area of 13 246 hectares under walnuts yielded about 10 000 tonnes of nut crop. Harvesting starts from the middle of August and continues until 15 October. In cooler areas, at higher elevations, however, the maturity of nuts and kernels may be delayed and thereby prolong the harvest period. Fruits are harvested from the trees when the splitting of the hull and the natural drop of some nuts occur. The common harvesting practice is to beat the bearing branches with long poles. The fallen crop is usually collected by women. The harvested crop with hulls is heaped and left until separation of the hull is made easier. The hulling process is followed by thorough washing in fast-flowing streams. In some areas, the bleaching of nuts is also practised to some extent. The nut crop is dried in the open air and sun and depending on weather conditions it may take from 5-8 days to dry. Mechanical devices for dehydration are beyond the means of individual small-scale producers. The main markets for the walnuts are Jammu and New Delhi. Processing of the entire walnut crop earmarked for export is carried out in Jammu. Walnut cultivation is mostly restricted to the foothills of rainfed areas and is practised by small farmers who are mostly tribal dwellers on marginal land.

Walnut cultivation has not developed very rapidly because of a number of

³⁰ An embryonic leaf in seed-bearing plants.

constraints, including:

- non-availability of plant material of known pedigree and characteristics produced through vegetative propagation;
- an absence of proper classification of local varieties;
- a long gestation period and low productivity;
- low tree density per hectare;
- low productivity.

INTRODUCING INNOVATION

Realizing that these constraints were the main factors limiting walnut cultivation, the Government of Jammu and Kashmir sought assistance from **FAO** through the Ministry of Agriculture. A project for the transfer of technology on vegetative propagation of walnuts was agreed for a period of two years from January 1996 to December 1998, later extended to June 1998 (Phase II). The project has made substantial contributions to the promotion of walnut cultivation on a scientific basis in India.

The first phase of the project was implemented between February 1996 and December 1997. However, due to unforeseen logistic problems, the equipment necessary for the initial phase of the project could not be delivered according to the planned time schedule. Project implementation was therefore delayed for one season, which was crucial with regard to meeting the initial project goals. The Government of India and the project counterpart staff, while appreciating and encouraged by the achievements of the project, requested an extension of an additional six months, which was granted. The second phase – TCP/IND/8221 – was carried out from 1 January to 30 June 1998.

The objective of the first phase of the project was to establish the capacity of the Department of Horticulture of the state of Jammu and Kashmir to produce high-quality yield, healthy walnut planting material for commercial distribution to producers. The second phase aimed to further strengthen and improve the results of outstanding walnut varieties and grafting techniques and train national technical staff and nursery workers. National and international personnel from Iran, Italy and Spain were involved.

Activities started in February 1996 with the first visit of the international consultant/team leader, a specialist in walnut propagation and nursery management. Assessment of different walnut-growing areas of the state was conducted and a detailed two-year work plan prepared. A preliminary grafting trial was then conducted by the consultant, using a sample hot callusing cable unit. In the same year, land was designated by the government for establishing a walnut nursery and mother plant and progeny orchard at Zainpora (Shopian).

Project activities became fully operational in January 1997, when machinery, equipment and plant material were delivered.

Problems

Since availability of scion material, the prerequisite for any propagation programme, was limited in the state, locally selected genotypes from Skuast in Shalimar were chosen to train the counterpart staff on the importance of specific pruning of walnuts to stimulate the production of graft sticks for future multiplication and planting. In February 1996, the technique was applied to several walnut selections from which, one year later, 600 graft sticks were collected and used for the hot callusing grafting programme. In 1998, graft-stick production reached about 4 000. In order to obtain the required number of graft sticks for future propagation, a progeny orchard of walnut was established at Zainpora farm.

Experiences

Three grafting techniques were introduced at different periods of time.

Hot callusing. This technique was introduced by the team leader in Jammu and by national counterparts in Kashmir in the winter of 1996. It showed encouraging results, with significant differences in growth behaviour. In Jammu, the grafted plants were vigorous in growth, whereas growth was very slow in Kashmir. The winter trials performed in 1997 and 1998 confirmed the initial findings. Climatic conditions, particularly low winter temperatures, were found to adversely affect the functioning of the cable in Kashmir. Results showed that the grafting conducted in March and April fared better. Average success for the three seasons was 30-60 percent. Besides temperature, there were many other factors that influenced the success of grafting, particularly human error.

Hot callusing was demonstrated at the three project sites and more than 50 persons have been trained. However, only a few workers were found to perform the technique with notable success.

Chip-budding. This technique was demonstrated during the third mission of the team leader at Shalimar. The bud-take was about 70 percent, but in the ensuing spring season the bud sprouting was less than 10 percent. This was most possibly due to frost injuries. Towards the end of the project, the patch budding technique was also demonstrated at Shalimar and is still under trial.

Hypocotyl grafting. This technique was introduced with the aim of extending the grafting season from winter, by hot callusing, to summer, by hypocotyl grafting, patch-budding and chip-budding.

Two national counterparts were trained, one in Italy and one in Spain and a consultant provided direct technical assistance to the project. The hypocotyl

TABLE 1
Selected list of the genotypes propagated in Jammu and Kashmir during the project period

Genotype	Number
Chenovo	378
Drianovskv	269
Shalimar 10	229
Wussan 8	205
Ooex Ducholieria	175
Wussan 2	175
McKinster	170
Wussan 1	168
McKinster	139
Wussan 3	100
Shalimar 2	70
Wussan 7	56
Wussan 4	51
Tuttle 31	45
Rajouri selection	33
Budaam 1	20
L44	18
Lake English	3
Total	2 312

technique is now being used in trials under the agroclimatic conditions of Jammu and Kashmir. Considering the encouraging results obtained by both trained researchers, it is expected that positive results under climatic conditions of the state will be obtained.

POST-INNOVATION

The hot callusing technique has produced varying grafting/take results with a maximum success of 65-70 percent, using the expertise of trained personnel. Grafting conducted by untrained budders was found to produce success of no more than 10-20 percent. Such a trend was observed at Jammu, Ramban and in Srinagar. Both national counterparts conducted grafting themselves, demonstrating that by avoiding human error the rate of success recorded with hot callusing can be considerably higher.

The effect of climatic conditions in three different zones of the state is confirmed by the results of three years. Plants hot callused in Jammu showed vigorous growth in terms of height and trunk thickness. Plant height was more than the minimum nursery standard size of 1.2 m. At Ramban, the growth was less than at Jammu. In Srinagar it was the lowest: in the same planting season, plants did not achieve standard size.

Chip-budded plants that survived injury from low temperatures grew to the standard size after one year of budding.

Propagation of selected genotypes could not be undertaken because of the non-availability of a sufficient quantity of suitable scion. This deficiency at the start of the project resulted from lack of a proper pruning technique for the mother plants.

Introduction of the budding and grafting technique after local staff training resulted in the multiplication of several selected genotypes, for which only one tree was available at the start of the project. At the end of the project, 2 312 grafted plants of selected genotypes had been produced (Table 1).

Update of mother plant orchard, progeny orchard and seedling production at Zainpora

To date, 1 201 grafted walnut plants have been planted in the progeny and mother plant orchard of Zainpora farm.

From the 2 312 plants produced during the last two years, 661 plants have been planted in the progeny and mother plant orchard. Moreover, 540 grafted plants of nine exotic varieties received under the project from FAO have been planted in these two orchards.

The establishment of the progeny orchard to obtain a greater number of graft sticks is expected to create conditions for mass production of grafted seedlings. During the 1997-98 season, seedling production started and more than 500 000 graftable seedlings of one and two years old were available for the programme. Study tour and fellowships. A total of 11 weeks of study tour and 38 weeks of fellowship training have been provided through the project.

A nine-week study tour for three people was organized in June 1997 in Bulgaria, Italy and Spain to provide information about the latest developments in the walnut industry through visits to advanced nurseries, walnut farms, walnut manufacturers and government research institutions involved in walnut study programmes. One early and positive result of this study tour was the participation of the president of the Italian Walnut Cooperative Society at the International Walnut Workshop held at the end of the project in Srinagar. The Italian society has shown interest in promoting the walnut trade and industry.

A week-long study tour was organized in August 1997 for the national project director to participate in the Congress of the International Plant Propagator's Society at Arundel, United Kingdom, to present and discuss the preliminary results of vegetative propagation of walnut in Jammu and Kashmir.

An additional week's study tour took place in Italy in January 1998 for the grower who won the first prize in the walnut exhibition held in September 1997 at Srinagar, in which more than 700 growers participated.

The project has provided a total of 38 weeks of fellowships for training local researchers in research institutes in Europe. The fellows have contributed positively to the project after learning the fundamental principles of propagation, nut evaluation and computer skills by applying the technology in Jammu and Kashmir. Each fellow has produced specific reports and training papers, which were discussed during the workshop held at Srinagar.

Several training sessions on grafting technique were arranged at Jammu, Ramban, Shalimar and Zainpora by the team leader during each consultancy mission.

Dissemination of project activities

On the eve of FAO's World Food Day in 1997, a one-day seminar on walnuts was held in Srinagar, in which more than 700 farmers participated. Cash prizes and certificates were awarded to those involved. The first-prize winner was sent on a one-week study tour to Italy.

Paper presentation and participation in Congress

The preliminary results have been recorded and discussed in various national and international seminars and workshops, with a final international workshop held at Srinagar from 15 to 17 June 1998. All those involved in the field project presented their work and results and put forward recommendations.

The national project director's membership of the International Plant Propagators' Society was a good opportunity for dissemination of results, since the society has global outreach with wide potential for further cooperation among scientists, nurserymen and farmers in Jammu and Kashmir.

LESSONS LEARNED

The aim of the project was to introduce modern propagation techniques for adoption under the agroclimatic conditions of Jammu and Kashmir. This helped create the necessary knowledge to establish modern walnut orchards and support local efforts to produce walnuts of uniform quality and compete on the international market. In this way, growers are in a better position to earn maximum benefit.

The executive phase of the project has been completed within the stipulated time frame and the results have been reasonably encouraging, even though the initial working period was unfavourable and troublesome. These results have been achieved thanks to the active involvement of the teams from the Horticulture Department and central and state governments, with a key role played by FAO staff and consultants in New Delhi, Rome and Bangkok.

The results achieved through the use of hot callus grafting are quite encouraging. Good results are also expected through the modified hypocotyl MHO and

hypocotyl HG techniques. While conducting the trial on the use of hot callus cable for grafting, certain limitations of a climatic and human nature were observed, even though the success of this technique averaged around 50 percent in terms of the final survival of the graft-take. The plants produced by this technique showed interesting results under the agroclimatic conditions prevalent in the state. Plant growth in Jammu was quite vigorous and achieved nursery standard height in the same grafting season. At Ramban, the plants were less vigorous but achieved marketable size in the same season. Plants grafted in Srinagar required two years in which to reach the standard height. The possibility of producing plants of standard height in one growth season could be used to produce plants in Jammu and transfer them in winter to Kashmir for plantation in orchards.

With the available technology and organized effort, the state could be able to produce plants of international standards to reach an export market. This prognosis is based on the fact that Jammu and Kashmir has the best selections of walnut germplasm of exotic and local genotypes, which cannot be found in any other country. A good foundation for future development of walnut propagation has been made by the project in that a mother and progeny orchard has been established at Zainpora, using local germplasm as scion material. This genetic material is now available for use in large-scale nursery production.

With existing facilities of 35 hot callusing units provided by the project, it is possible to plan the production of about **14 000** grafted plants per year, taking into consideration an average 50 percent success rate. With improvement of the training skills of field workers, the efficiency of this system can be increased to at least 70 percent, based on results obtained earlier and the estimated target. The hypocotyl grafting technique and the modified hypocotyl in which local workers have been trained abroad can prove a useful tool to increase production of grafted plants.