Australian Government
Rural Industries Research and Development Corporation

Walnut Industry

Research & Best Practice Implementation

A report for the Rural Industries Research and Development Corporation

by H. Adem & Peter H. Jerie

May 2004

RIRDC Publication No 04/032
RIRDC Project No DAV-164A

ISBN0642 58742 6
ISSN 1440-6845

Walnut Industry Research and Best Practice Implementation
Publication No. 04/032
Project No.Dav-164A.

Researcher Contact Details
Harold H. Adem
Institute of Sustainable Irrigated Agriculture
Mailbag 1 Ferguson Rd. Tatura, Vic. 3616

Phone: 03 5833 5231
Fax: 03 58335218
Email: harold.adem@nre.vic.gov.au

In submitting this report, the researcher has agreed to RIRDC publishing this material in its edited form.

RIRDC Contact Details
Rural Industries Research and Development Corporation
Level 1, AMA House
42 Macquarie Street
BARTON ACT 2600
PO Box 4776
KINGSTON ACT 2604

Phone: 02 6272 4819
Fax: 02 6272 5877
Email: rirdc@rirdc.gov.au.
Website: http://www.rirdc.gov.au

Published in May 2004
Printed on environmentally friendly paper by Canprint

Foreword

The aims of the project were to assist the Australian walnut growers to capitalise on the present period of rapid expansion in the industry and allow growers to compete successfully with imports and create a new export industry.

Walnut production from the previous project demonstrated that commercial yields of 0.3t ha^{-1} are attainable four years after planting grafted trees. In years five and six walnut yields were 1.3t ha^{-1} and 1.9t ha^{-1} respectively. With less than 5% of domestic market supplied by Australian walnuts, considerable opportunity exists for import replacement and for the development of exports into the Northern Hemisphere.

Barriers which limited the expansion of the industry were the lack of planting stock, and lack of knowledge on tree management by the grower as well as a limited understanding of irrigation, fertilisers and canopy management. A Business Plan was developed to deliver an extension program to the walnut industry, through a series of meetings held over a six month period in order to develop the appropriate model.

On-farm demonstrations included demonstrations on new propagation techniques to both growers and nursery managers. Seminars were presented on the measurement of the available water in the soil and a demonstration on the installation and reading of tensiometers was held and followed up at subsequent meetings. Seminars were presented on the management of nutrition in the walnut orchard. Sessions included the identification of fertilisers, the availability of nutrients to the plant, interpretation of plant and soil analysis and fertigation techniques. Demonstrations of tree training were conducted in group sessions as well as with individual growers.

Over the last three years, approximately 500ha of new plantings have commenced in Australia with approximately 2000ha planned for Victoria alone in the coming years. A new 1000ha planting in northern Victoria, the biggest walnut orchard in Australia, is a measure of the success of the project.

This project was funded from RIRDC Core Funds which are provided by the Australian Government.

This report, a new addition to RIRDCs diverse range of over 1000 research publications, forms part of our Prospective new industries- New Plant Products Program, which aims to facilitate the development of new industries based on plants or plant products that have commercial potential for Australia.

Most of our publications are available for viewing, downloading or purchasing online through our website:

- downloads at www.rirdc.gov.au/fullreports/index.htm
- purchases at www.rirdc.gov.au/eshop

Simon Hearn
Managing Director
Rural Industries Research and Development Corporation

Acknowledgments

The researchers gratefully acknowledge the support for this project from the Rural Industries Research and Development Corporation and the Australian Walnut Industry Association. The Department of Natural Resources and Environment supported this project with funds from the key project *Fruit and Nuts: Best Practice and Export Development*.

Contents

List of plates

List of figures

List of tables

Executive Summary

The Australian walnut industry needs to expand if it is to survive. It is small by comparison with most other nut industries producing an estimated 150 tonnes in 2002, whilst we imported around 2,500 tonnes of walnuts worth close to $13 million. In many parts of Australia, the Mediterranean climate and, compared with other competing countries, clean air and water as well as fewer pests and diseases are important factors which favour walnut production. The aim of the project is to assist the Australian walnut industry capitalise on the present period of rapid expansion in the walnut industry to allow growers to compete successfully with imports and create a new export industry.

Walnut production from the previous project (DAV-73A) demonstrated that commercial yields of 0.3t ha^{-1} are attainable four years after planting grafted trees. In years five and six, walnut yields were 1.3t ha^{-1} and 1.9t ha^{-1} respectively. With less than 5% of the domestic market supplied by Australian walnuts, considerable opportunity exists for import replacement and for the development of exports into the Northern Hemisphere.

Exciting new advances in R&D made in the last two years has created a new generation of walnut investors with plantations of 12,000 to 500,000 trees, in contrast to the traditional growers with 100 to 1,000 trees. New plantings are of high yielding, early-bearing cultivars planted in hedgerows which quadruple tree numbers for the same area of land.

Many walnut growers came from a background in business but had little horticultural experience prior to establishing a walnut orchard. Clearly there was a need for continued education and training in developing their skills in horticultural practice. The project leader, in collaboration with AWIA, has proposed a formal course of study for walnut growers conducted jointly by staff from DNRE and the TAFE system of education. Most participants in the project were owners of new plantings or investors keen to establish a new planting. Others accepted the latest research developments but needed support and training to fully implement the results.

Barriers which limited the expansion of the industry were the lack of planting stock, and lack of knowledge on orchard management by growers that included a limited understanding of irrigation, fertilisers and canopy management. A Business Plan was developed through a series of meetings held over a six month period in order to develop an appropriate model. The present project was a joint venture between RIRDC, DNRE and AWIA implemented through the industry's business plan.

Many leading researchers from around the globe have visited Tatura and in turn the project leader has visited international centres of excellence. Networks established by the author enabled a number of people in the industry to visit centres of excellence in the USA and France, Italy and Spain to learn Best Management Practice.

On-farm activities included demonstrations on new propagation techniques to both growers and nursery managers. A discussion on the measurement of the available water in the soil and a demonstration of the installation and reading of tensiometers was held and followed up at subsequent meetings. Seminars were also presented on the management of nutrition in the walnut orchard. Sessions included the identification of fertilisers, the availability of nutrients to the plant, interpretation of plant and soil analysis and fertigation techniques. Demonstrations of tree training were conducted in group sessions as well as with individual growers. In winter, pruning exercises were conducted on selected orchards and these were followed up in summer with a review of the effects of pruning had on the walnut trees.

The success of the project was measured in the number of participants entering the program plus the level of competency reached by the participating walnut growers. Tree management theory was provided through seminars and written material including publications in the Australian Nutgrower and handouts. Theory was followed up by practical classes where growers were instructed in propagation, fertiliser management, irrigation management, soil water monitoring and pruning. Participants in the classes were then assessed for competency, on their own orchard, as they demonstrated each of the skills learnt. The program of training proved to be highly successful in taking the growers from a position of little or no experience in horticulture to a point where they could independently manage their orchards to a high standard.

Since the project began, approximately 500ha of new plantings have been established in Australia with approximately 2000ha planned for Victoria in the coming years. Other states are expanding their walnut industry and Tasmania alone has 600ha of new plantings with another 200ha in progress. The AWIA Consultancy Service has provided an effective vehicle to assist the walnut industry reach a critical mass thereby enabling it to replace imports and create export markets. A new 1000ha planting in northern Victoria, the biggest walnut orchard in Australia, is testimony to the success of the project.

1. SETTING THE SCENE

1.1 Introduction

The Australian walnut industry needs to expand if it is to survive as it is small by comparison with most other nut industries. Production was estimated (exact figures not available) at 150 tonnes in 2002, whilst we imported around 2,500 tonnes of walnuts worth close to $13 million. In many parts of Australia, the Mediterranean climate and, compared with other competing countries, clean air and water as well as fewer pests and diseases are important factors which favour walnut production.

Up until the last 15 years, Australian walnut production was based on cultivars that were introduced in the early 1900's or seedling trees, planted on a wide (15m x 15m) spacing, that were not irrigated but relied on rainfall. Production and the quality of nuts were generally low especially in years of drought and fluctuated from year to year depending on the annual rainfall. Harvesting and processing were done entirely by hand and marketing was largely by selling directly from the farm to the consumer. The early cultivars often took 8-10 years to produce a commercial crop, and when the orchard reached maturity at 15 years of age, the yields were often low (<1.5t ha^{-1}).

The previous walnut project (RIRDC, DAV-73A) demonstrated that walnut trees can be grown on shallow, poorly-structured surface soils provided the soils are first modified so that water, oxygen, mechanical resistance and nutrients are at levels that are not limiting to root growth. The project capitalised on over 60 years of research on fruit trees at ISIA, Tatura by extending current knowledge to a management system for walnuts. Under the Tatura system of soil management, the volume of soil available was increased by moving the topsoil from the traffic line onto the treeline to create a bank in the area where tree root activity is highest. A soft, stable soil was created by changing the sodic sub-soil to calcic by the addition of gypsum ($Ca\ So_4.2H_2O$). Biological activity was kept high and the soil on the treelines stabilised to keep it soft and porous by growing ryegrass and by using straw mulch. Tensiometers were used to determine the best time to irrigate to keep the soil soft for continued root growth and to supply the water required for tree growth.

Walnut production from the previous project also demonstrated that commercial yields of 0.3t ha^{-1} are attainable four years after planting grafted trees. In years five and six walnut yields were 1.3t ha^{-1} and 1.9t ha^{-1} respectively. The walnut yield of 1.9t ha^{-1} in year 6 exceeded the district mean of 1.5t ha^{-1} for mature trees and demonstrated the suitability of the new high yielding cultivar Chandler, in south-eastern Australia. These figures compared well with yields from the major production areas of the USA, France and South Africa. The prospects are high for reaching the target yield of 4t ha^{-1} in 10 to12 years when the orchard reaches maturity. These early findings pointed the way for an expanded, profitable walnut industry for Australia.

To address the need for expansion of the walnut industry, extensive consultation took place between the AWIA and DNRE in order to develop a project that could be self-funding in the absence of a research levy on walnut growers. Clearly, in an industry where the total production of walnuts was only 100 tonnes, a research levy on production would not be enough to attract adequate matching funds from RIRDC. The outcome of the meetings was a structured approach to the task of assisting the walnut industry move forward in the face of the increased interest shown by existing growers wishing to improve production and new investors wishing to enter the industry. The plan involved the development of a Business Plan to identify the strengths, weaknesses and opportunities in the Australian walnut industry. The plan was to use the proceeds from fee-for-service consultancies to provide the industry contribution towards a research grant from RIRDC. The reaction from the walnut

industry was that there was a need for a consultancy service and that growers were prepared to pay for the service.

A Business Plan provided the blueprint on how a consultancy service would meet the needs of the industry for those growers wanting specific and confidential information. General information was provided free of charge through the traditional channels of communications including seminars, farm walks, conferences, publications and phone calls. To assess the effectiveness of the project a Bennett's Hierarchy was used to test the overall performance.

2. CURRENT PRACTICES

2.1 Knowledge, Attitude, Skills, Aspirations

With less than 5% of the domestic market supplied by Australian walnuts, considerable opportunity exists for import replacement and for the development of exports into the Northern Hemisphere. Exciting new advances in R&D made in the last two years have created a new generation of walnut investors with plantations of 12,000 to 500,000 trees in contrast to the traditional growers with 100 to 1,000 trees. New plantings are of high yielding, early-bearing cultivars planted in hedgerows which quadruple tree numbers for the same area of land.

The current Project (DAV-164A) commenced in July 1999 with the compilation of a database of new orchards under development. Details on location, land area, soils, water resources, irrigation method and walnut varieties were documented. To maintain confidentiality, the names and specific details on the locations and property sizes have been withheld from this report. Best Management Practice guidelines were provided to new growers and plots to monitor soils, irrigation, rootstocks, fertilisers and tree training.

Barriers which limited the expansion of the industry were the lack of planting stock, and lack of knowledge on tree management by the grower as well as a limited understanding of irrigation, fertilisers and canopy management.

Many walnut growers had a background in business but little horticultural experience prior to establishing a walnut orchard. Clearly there was a need for continued education and training in developing their skills in horticultural practice. Most growers aspired to produce high quality nuts with minimal inputs and without degrading the environment, but they often lacked an understanding of the complex linkages that occur between the ecosystem and the crop.

2.2 Reactions

Enthusiasm for investment in walnut growing in Australia is at an all-time high with growers keen to improve performance of the walnut business. Publication by the project leader of the Final Report on Project DAV-73A plus a chapter on walnuts in The New Rural Industries Handbook on the RIRDC website has created considerable public interest in walnut production. Further publicity has been generated by the Guide to Establishing a Walnut Orchard produced by the Australian Walnut Industry Association (AWIA) and reports in the Australian Nutgrower contributed by the project leader.

2.3 Participation

Most participants in the project were owners of new plantings or investors keen to establish a new planting. Owners of established plantings adopted the latest research developments but needed support and training to fully implement the results. Service industries ranging from soil surveyers, nursery managers, machinery companies and chemical suppliers also took part.

2.4 Activities

In the early stages of the project it became clear that a back-to-basics approach was needed to help people enter the walnut industry for the first time. The information collated from the client database suggested that most participants had a limited knowledge of horticulture. A small number had experience in mixed farming enterprises. Almost none were orchardists diversifying from stone and pome fruit or other nuts into walnut production.

2.5 Extension

Workshops that incorporated seminars and farm walks over a two-day period were held annually at Tatura. Field days and workshops were open to the general public as well as AWIA members. The research findings were presented at the Australian Nut Industry Council annual (now biennial) conferences and published in the Australian Nutgrower industry journal. DNRE, as the only public agency conducting walnut R&D in this country, has a high-profile reputation both nationally and internationally. This project capitalised on the success of previous work and provided an important impetus to the industry. Using networks established through the previous project, considerable expertise from international sources was utilised in the development of technical information to benefit the Australian industry (including 39 international scientists).

2.6 Conferences.

In 1999 the project leader presented an oral paper on the Tatura system of walnut production at the Fourth International Walnut Symposium at Bordeaux, France. In April 2001 the project leader presented a paper on tree establishment at the Australasian Conference on Tree and Nut Crops held at the University of Western Australia in Perth.

2.7 Business plan

A Business Plan was developed in collaboration with the AWIA through a series of meetings held over a six month period in order to develop the appropriate model. Integra Pty. Ltd. was engaged by the project leader to facilitate the activities at these meetings and assist in the development of the plan that was subsequently endorsed both by the AWIA and DNRE. The present project was a joint venture between RIRDC, DNRE and AWIA implemented through the business plan.

2.8 Visiting scientists and networks

The project leader has established an extensive network of international scientists who specialise in walnut research. These collaborative links provided the project leader with access to the latest information on walnuts and the opportunity to learn from others who have the knowledge and experience from a longer association with walnut research. Many leading researchers from around the globe have visited Tatura and in turn the project leader has visited international centres of excellence. A free exchange of information via fax and email communication has continued throughout the term of the project.

2.9 On-farm demonstrations

On-farm demonstrations included propagation techniques for both growers and nursery managers. The sessions on propagation included an outline of the theory drawn from the available literature, discussions on the selection of suitable rootstocks and varieties plus visits to selected properties where the procedure was demonstrated.

A discussion on the measurement of the available water in the soil and a demonstration of the installation and reading of tensiometers was held at a special meeting of the Loddon group and followed up at subsequent meetings.

Seminars were presented on the management of nutrition in a walnut orchard. Sessions included the identification of fertilisers, the availability of nutrients to the plant, interpretation of plant and soil analysis and fertigation techniques.

Demonstrations of tree training were conducted in group sessions as well as with individual growers. In winter, pruning exercises were conducted on selected orchards. These were followed up in summer with a review of the effect that the pruning had on the walnut trees.

2.10 Resources

The present period of rapid expansion of the industry, the staffing arrangement (0.5 FTE for project leader) together with the geographically diverse industry meant that budget resources were stretched to the limit.

3. PERFORMANCE

3.1 Resources

The initial concern in the project was one of building the client base to a level that was large enough to meet the project aims. In June 1999, there were approximately 80 members in AWIA and, at this time, the number was considered too small to support the full time services of a consultant. To address this shortfall in numbers, some consultancies were conducted outside the walnut industry in other nuts or stone and pome fruit. The experience proved invaluable not only in terms of revenue, but it also provided a wealth of knowledge particularly on the generic issues of land selection, irrigation, nutrition and canopy management etc. Other useful experiences were in the areas of mechanical harvesting, marketing and product promotion. The insights gained by working in a related industry (eg. the larger and more advanced almond industry) provided a valuable model that could be adapted for walnuts.

Additional funds were sought from RIRDC in a collaborative proposal between the project leader and the AWIA for the production of a quality management guide. A separate, one-off grant from RIRDC provided the necessary funding to assemble the guide as a first step towards a comprehensive quality assurance program for the walnut industry.

3.2 Business plan

A business consultant was engaged to assist the Australian Walnut Industry Association (AWIA) develop a business plan for specialist extension managed on a fee-for-service basis. This approach was worked out and agreed to by the AWIA. The business plan was followed throughout the course of the project. No revisions were deemed to be necessary as considerable discussion preceded the drafting of a document that provided a useful set of guidelines for the running of the consultancy process. Overall, the business plan provided a framework that greatly assisted the walnut industry in coming to terms with the idea of a fee-for-service provider.

3.3 Visiting scientists and collaboration

The project leader has developed collaborative links with key researchers from around the world. Walnut researchers Dr W.H. Olson, Dr W.W. Barnett, DR L.C. Hendricks, Dr D. Ramos, Dr S. Sibbet, Dr B.W. Wood and Mr J. Edstrom from the University of California have visited Tatura and are continuing to collaborate in the walnut project. In 1999, the project leader met with leading researchers at the Fourth International Walnut Symposium at Bordeaux. At the symposium, the project leader presented an oral paper on the Tatura system of walnut production. The symposium provided an excellent opportunity for discussions with some of the key people in walnut research including Dr G. McGranahan, Dr W. Reil (USA), Dr J.C. Navatel, Dr E. Germain and Dr J.P. Prunet (France) and Dr N. Aleta, Dr J.M. Lopez (Spain). During the conference proceedings, the project leader was invited to present a bid to host the next symposium in Australia. Although Australia's bid was narrowly beaten by Italy, it was strongly supported by delegations from the USA and France. A good opportunity exists for Australia to host the Sixth International Walnut Symposium in 2007.

3.4 Tree establishment

The tree establishment trial involved six grower members of the Loddon Walnut Discussion Group from the Pyramid Hill, Durham Ox and Serpentine areas in Victoria (Plate 1). At the time of planting, walnut trees from traditional nursery stock were in short supply, costly and tree failure after transplanting was experienced. In many parts of the world, the practice of direct seeding walnuts and grafting or budding in situ has been carried out for centuries. Planting grafted nursery stock is the traditional method for establishing a walnut orchard where tree uniformity and timeliness are prime considerations. Direct seeding may be considered cheaper because the cost of the grower's time in caring for the trees is not always considered and the practice of field budding, unless performed skilfully, can result in uneven trees.

A popular method used for direct seeding of walnuts is to collect Black Walnut fruit when the outer flesh (hull) is ripe and appears black. The fruit is tumbled with water in a concrete mixer to remove the flesh, thereby separating the seed. The seed is then stratified, a process of storing the moist seed at below 10^0C. This is usually achieved by placing the washed seed in a plastic bag which is then stored in a refrigerator. An alternative method is to store the seed in damp, coarse sand outside and away from direct sunlight (Plate 2). The stratification period takes around one to two months and serves to induce dormancy in the seed preparing it for germination. Proper stratification of walnut seed will promote and a higher and uniformity of germination.

Plate 1. Members of the Loddon walnut Group.

Plate 2. Walnut seed stratified in boxes of sand.

Direct-seeding has had several other advantages in that it allows the seedling tree to develop an undisturbed taproot in situ and avoids the transplant shock often associated with nursery stock. It was faster and cheaper to sow seed, but the lead-time until nut production took longer when compared with transplanted trees. Seedling survival was highest and the uniformity and vigour of the orchard improved when two to three seeds were sown at each tree site and the best seedling retained whilst the others were removed (Plate 3).

In the study group during the first summer, seedling emergence figures between orchards varied depending on the soil type and whether one or two seeds were placed at each tree site. Generally, seedling emergence was highest (up to 90%) on sandy loam soils where two seeds were planted at each tree site. In most cases, seedling growth (trunk diameter <10mm) was less than optimum in the first growing season. Patch-budding of the rootstock was only attempted when the rootstocks were large enough (>20mm diameter)(Plate 4). Weeds were perceived as the biggest problem in this approach, followed by inadequate levels of water and nutrients plus the lack of proper staking and tree guards.

Plate 3. Direct-seeding a black walnut rootstock into the orchard

Plate 4. A walnut rootstock patch-budded in the field

To address some of the problems associated with direct seeding of the rootstock, a new system of tree establishment was tested. Instead of sowing it directly into the orchard, the seed was sown into coarse sand in plastic sleeves that measured 500mm in length by 100mm in diameter (Plate 5). A metal staple in the bottom of the sleeve allowed drainage but prevented the sand from falling out. The sleeves were placed together in a nursery area until the walnut seedlings emerged. The seedlings were then sorted for health and vigour and the best ones selected for planting. A hole, 100mm in diameter and 100mm deep, was dug at each tree site and, after removing the staple, the seedling was planted with the sleeve in place. A spring-steel stake (2.5m long and 8mm diameter) was placed inside the sleeve to provide support to the tree. The sleeve thus became an effective guard against wind, herbicide drift, and animal pests plus it provided a warm, moist microclimate to assist seedling early growth. The new system gave almost 100% success in emergence and in some cases doubled the growth rate of rootstock when compared with the traditional system. When the rootstock attained a trunk diameter of >20mm, patch-budding to the desired walnut cultivar was carried out.

Plate 5. A walnut rootstock seedling propagated in a plastic sleeve.

The new technique, developed by the project leader, of growing seedlings in a protected environment by using a plastic sleeve that then becomes a tree guard was successful with walnuts. The technique provided a useful microclimate within the transparent, polyethylene, plastic sleeve that encouraged early seed germination and improved seedling emergence. The system was more reliable than the direct seeding method, minimised the labour input and reduced tree losses. Other benefits included the

ability to transplant a small, delicate seedling from the nursery into the field and control weeds using herbicides whilst the tree seedling was safely protected inside the tree guard. A good opportunity exists for extending the method to other fruit and nut species.

In the second summer on some properties, tree growth was improved (trunk diameter >20mm) through soil-water monitoring using tensiometers, greater use of fertilisers including fertigation (soluble fertilisers injected into the irrigation water) and the use of tree guards and stakes. On properties where the trees had reached a trunk diameter of >20mm, patch-budding was attempted in January and February. Where budding was attempted on trees with a trunk diameter of 10-20mm, the success rate was low (< 20%). Best results (80%) were achieved on large stocks (>20mm diameter) and where the day and night temperatures exceeded 30^0C and 15^0C respectively.

3.5 Irrigation

In the Loddon Walnut Group, soil types varied from sandy loams to heavy clays between properties and where variation occured within the same property, irrigation scheduling was made difficult. Irrigation was by microjet (fixed jet) with an output of <50l/hr on all but one property where microsprinklers (rotating jet) were used. The growers were introduced to the use of tensiometers (instruments to measure soil wetness) and trained in their use to allow them to accurately monitor soil-water (Plate 6). Guidelines were established so that growers could determine the optimum available water for walnut trees. The aim was to keep the soil wetted to between 10-50kPa (matric suction), representing the range on the tensiometer where water is readily available to the tree. This gave the growers a simple tool for deciding when and for how long to irrigate. The water-holding capacity of the soil in two orchards was described by measuring both the matric suction and the soil-water content. The results were plotted on a graph and matric suction was converted to a log value to reduce the scale on the vertical axis (Figs 1&2). The optimum range of 10-50kPa matric suction therefore translated to a range of approximately 2-4log kPa. In orchard No.1, matric suction of 2-4log kPa represents a soil water content of 15-20% compared with orchard No. 2, where the water content range is 22-29%. The differences in the water holding capacity, a reflection of the differences in soil texture (proportions of silt, sand and clay), were taken into account when irrigation scheduling was calculated for each orchard.

The study group monitored the availability of water by the use of tensiometers placed at between 200mm and 600mm depth in the soil, and they used the information to determine irrigation scheduling (Fig 3). The soil was kept wetted to a matric suction of between 10 and 50kPa as prescribed by the project leader. The tensiometers proved to be sensitive to changes in soil water, and showed the changes in matric suction over the one or two days after irrigation was applied. The optimum water content was at 10kPa matric suction or Field Capacity ie. when the soil had drained under the effects of gravity and contained optimum levels of stored water and oxygen. The dry end of the scale was chosen as 50kPa matric suction at a point where the tree reacted to water stress, and where if irrigation or rainfall did not occur, a reduction in tree growth was experienced. The results show that the irrigation scheduling kept the soil slightly wetter than the desired 10Kpa of matric suction for most of the growing season. In early summer the soil at 0-200mm depth dried out to above 50kPa suction and placed the walnut trees under a period of water stress. In another part of the orchard, a more intensive monitoring of the water in the soil at 0-200mm depth showed the soil was kept wetted in the 10-50kPa matric suction range for most of the summer (Fig 4). The amplitude of fluctuations in the tensiometer readings illustrated the dynamics of the soil-water system when wetted up by irrigation (or rain) and then dried out by the walnut tree roots. The rapid change in available water in the soil also shows the sensitivity of the system and how quickly water stress in young trees can occur. Careful management of the irrigation scheduling is particularly important in seedling trees where the root system is shallow and not fully developed.

Plate 6. A tensiometer and digital readout used to measure soil water (matric suction).

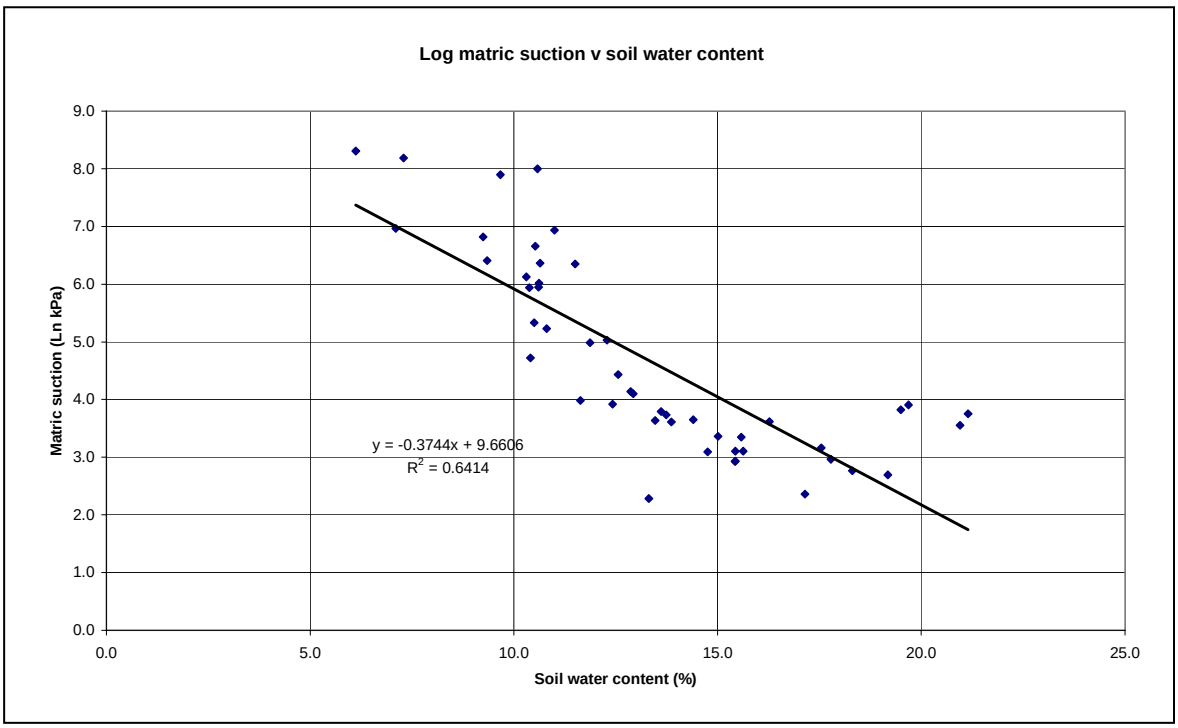

Figure 1. Relationship between soil water content and the log matric suction in orchard No. 1.

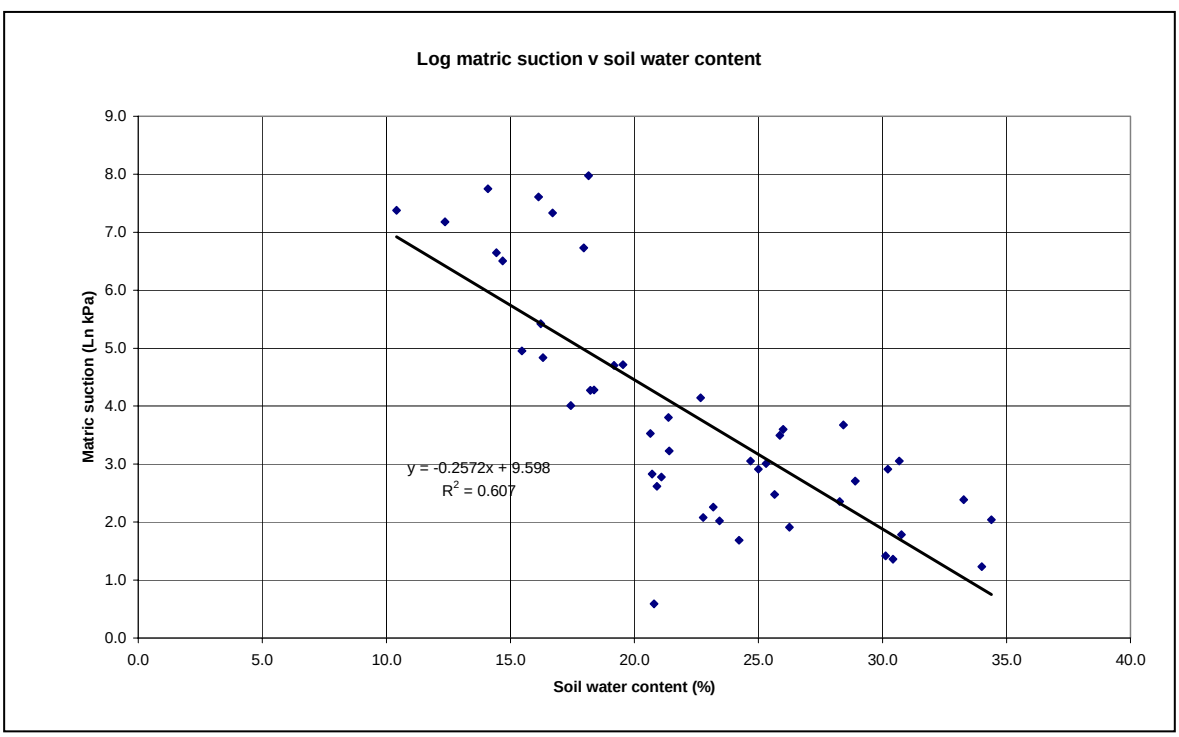

Figure 2. Relationship between soil water content and the log matric suction in orchard No. 2.

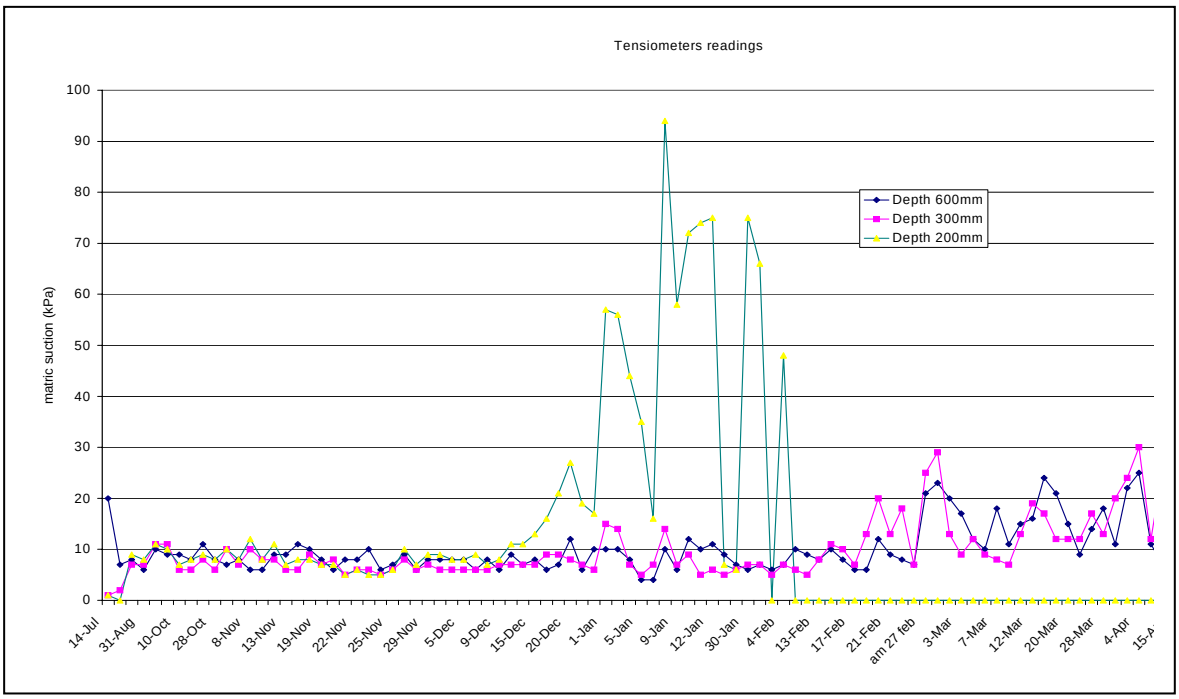

Figure 3. Tensiometer readings at 600mm, 400mm and 200mm depth in the soil

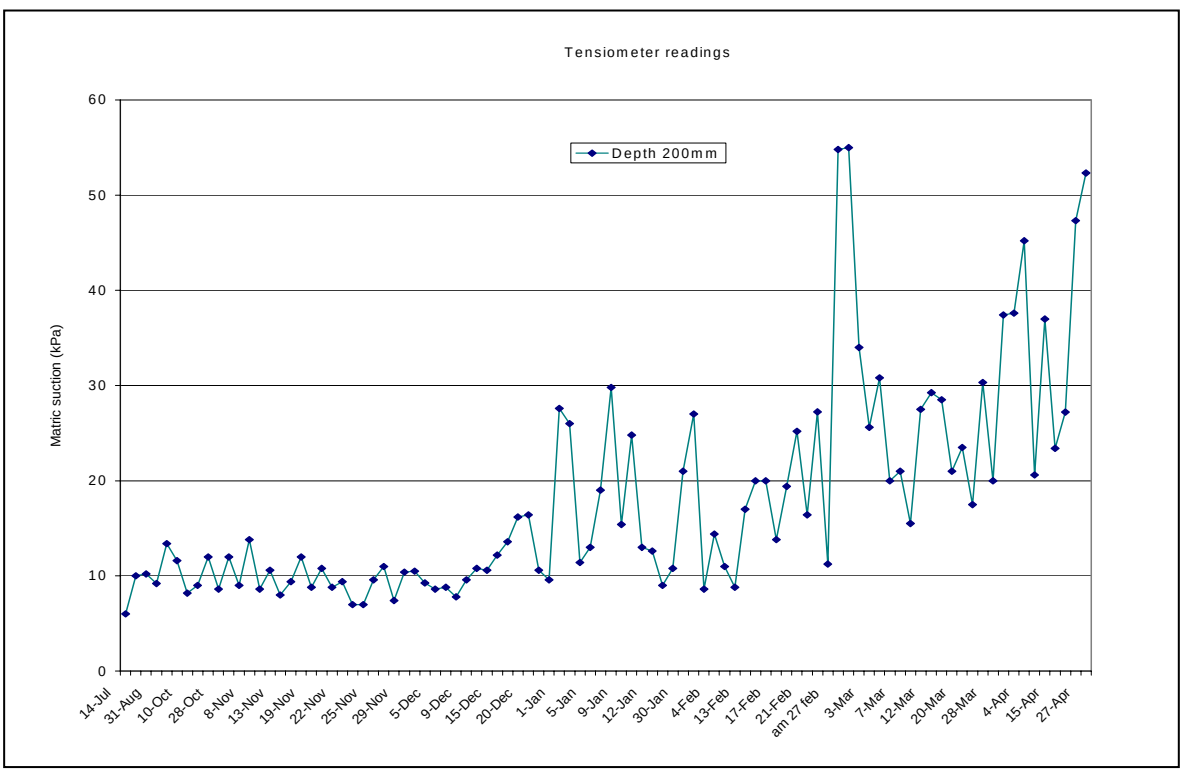

Figure 4. Tensiometer readings at 200mm depth in the soil

3.6 Tree training

The large increase in new plantings has created an urgent need to make walnut growers more aware of the close relationship between tree shape, light interception and improved walnut yields. Traditionally, walnut trees in Australia are not pruned or are pruned incorrectly, resulting in a longer lead-time to the first crop and low yields compared with world standards.

In July 2001, to illustrate the benefits of pruning trees correctly, a demonstration trial on canopy management was initiated on a commercial orchard located in the Ovens Valley, Victoria. A Central Leader style (Christmas tree shape) was chosen as it is recognised internationally as one of the most efficient of canopy shapes for walnut production. An evaluation of the Central Leader system of pruning was conducted during a farm walk as part of the annual seminar/farm walk weekend organised by the project leader in February 2002. Demonstrations were also conducted on a number of other orchards where growers requested private tuition. The benefits of improved tree training will take some years to be expressed in terms of improved yield and are therefore outside the timeframe of the present project. Demonstration trials and practical workshops will need to be continued for several years, through new sources of funds, in order to encourage growers to adopt improved methods of training trees.

3.7 Nutrition

Walnut growers were introduced to the subject of nutrition in walnut trees through lectures on soil and plant analysis plus the theory behind classes of fertiliser and their availability to walnut trees. Discussions were held on the critical levels of nutrients determined by leaf analysis and how deficiencies in particular elements may be addressed.

Plate 7. Fertigation system (left of frame) and irrigation filters.

The project leader introduced the topic of fertigation (fertilisers injected into irrigation water) and assisted growers in the selection and operation of the equipment (Plate 7). The project leader provided advice on the interpretation of soil and plant analysis to help the growers choose the correct fertilisers, timing and application rates. A paper on nutrition that described a system of Fertigation was presented at three seminars including the Flourieu Irrigation Expo in October 2000 in South Australia, the Loddon Walnut Group meeting in November 2000 and at the Annual Workshop held at Tatura in February 2002.

3.8 Extension

Presentations to the walnut industry included over 20 topics as listed below:

- Soil management
- Rootstock selection
- Budding and grafting
- In-vitro propagation
- Disease management
- Soil-water monitoring
- Irrigation scheduling
- Weed control
- Fertigation
- Nutrition
- Tree staking
- Seed stratification
- Planting
- Tree training
- Orchard spraying
- Scion wood selection
- Harvesting
- Grading and sorting of nuts
- Cultivar selection etc.

Extension activities serviced both the traditional grower (highly diverse) and the new grower (emerging). Specific assistance was provided through specialist extension managed on a fee-for-service basis. Field days and workshops were open to the general public as well as AWIA members. The project was a successful, joint venture between RIRDC, DNRE and AWIA implemented through a business plan.

The project leader held meetings with members of the Loddon Walnut Group on a monthly basis on each of their properties in turn, and conducted a combined discussion group/farm walk session. The topics discussed were selected by the group to coincide with seasonal activities plus potential problem areas were identified to allow for management planning. Tree establishment was identified as a key issue for new growers entering the walnut industry for the first time. The strong relationship between tree growth and efficient irrigation focussed the group's attention on monitoring tree growth and soil-water. Up to 50 growers from around Victoria that were not organised into groups were assisted with a similar range of issues, on a one-to-one basis.

Communication of the project activities and new developments continued through the Australian Walnut Industry Association, media reports and seminars. The annual seminar and farm walk conducted at the Tatura Institute on 31 March and 1 April 2001 attracted 50 Victorian and interstate

participants and was reported as highly successful by the walnut industry. Walnut orchards at Toolamba and Myrtleford in Victoria and at Barooga in NSW were visited as part of the seminar program. The last workshop held in February 2002, attracted over 35 participants. Orchard walks were conducted on properties at Gapsted in the Ovens Valley and Myrrhee in the King Valley, Victoria. The farm walks were followed by a seminar day at Tatura where the project leader presented two papers titled 'Walnut Tree Establishment' and 'Fertigation' respectively. A paper on tree establishment was presented by the project leader at the Australasian Conference on Tree and Nut Crops held at the University of Western Australia in Perth, in April 2001. The conference attracted a large number of both national and international delegates, many of whom showed considerable interest in the Tatura walnut project.

Extension advice delivered by the project leader through farm visits has enhanced linkages with the grass roots members of the industry. The visits also served as a vehicle for forming a collective overview of industry problems and concerns as well as provided a communication network with the walnut industry. Prior to the commencement of the research on walnuts at Tatura, few Australian growers had ever visited another country to see walnut production in other parts of the world. Networks established by the author have facilitated visits by a number of people in the Australian industry to centres of excellence in the USA and France, Italy and Spain to learn Best Management Practice. The project leader has visited these centres and brought back literature, photos, research findings and notes from interviews as well as visual experiences to share with the Australian walnut industry members. Contacts established during and after the visits have been maintained through regular email, letter and fax communication. A direct benefit of these study tours has been a number of visits by some of the most highly acclaimed researchers in walnuts from around the world. Visiting scientists to Australia were encouraged to speak to local walnut growers and give advice on walnut production, processing and marketing thus reinforcing local extension messages.

The publicity given to the progress of walnut research and the expansion of the walnut industry has attracted considerable public attention. Radio interviews and press releases have stirred the public interest and dispelled many of the misconceptions about growing walnuts. Many people who firmly believed that walnuts take a long time to bear and only grew in the mountains are surprised to hear that walnuts will bear nuts in three years and will flourish in many parts of Australia. The number of enquiries from the public has continued to grow steadily and many of these people have gone on to become involved in the walnut industry. Since the project began, approximately 500ha of new plantings have commenced in Australia and a further 2000ha are planned for Victoria in the coming years. Other states are also expanding their walnut industry and Tasmania alone has 600ha of new plantings with another 200ha planned for the future.

As further evidence of his long-term commitment and confidence in the walnut industry, the project leader, in collaboration with AWIA, has proposed a formal course of study for walnut growers, to be conducted jointly by staff from DNRE and the TAFE system of education. In response to this proposal, a formal request was made from researchers in the Kingdom of Bhutan expressing the wish to receive training in walnut production at Tatura under this scheme.

3.9 Consultancies

The revenue generated from consultancies between July 1999 and June 2002 has exceeded $70,000. Best Management Practice delivered through a fee-for-service consultancy service continues to grow from strength to strength. The number of clients serviced is now over 100 with the largest property

sizes now at 650ha. In the last 12 months there have been over 260 requests by phone and a similar number of email messages and mobile phone calls for assistance (Table 1).

Table 1. A description of the consultancy task and the number of times requested (Jul 99-Jun02)

Description of the consultancy	Number of requests
Inspect land and discuss walnut establishment	46
Discuss proposed project	23
Conduct demonstration	10
Prepare reports	10
Visit client in a follow up meeting	6
Discussions with client	6
Hold panel discussion	4
Present seminar	3
Review project	3
Prepare letters	3
Total	118

3.10 Participation

A database has been set up to contain information on each property, including its size, soil type, irrigation, planting densities and rootstocks. In response to requests for advice, the project leader has visited many properties in all states of Australia (except Northern Territory) including George Town (Tasmania), Brisbane (Queensland), Orange (New South Wales), Clare (South Australia) and Nannup (Western Australia) (Table 2).

Table 2. Numbers of growers participating from each state

State	Number of growers
Victoria	98
New South Wales	19
Western Australia	5
South Australia	4
Queensland	2
Tasmania	2
Australian Capital Territory	2
Northern Territory	-

Walnut orchards surveyed ranged in size from one hectare at the hobby farm level to 650 hectares (spread over several locations) at the corporate farm level. In northern Victoria, a new investor has engaged the services of the project manager to assist in the development of 1000 hectares of walnuts on the one property. Presently it represents the largest walnut development undertaken in Australia.

3.11 Reactions

Feedback from the walnut industry has indicated that with large increases in planting over the last 10 years, tree establishment is a key issue for new growers entering the industry. Investors seeking a

return in the shortest possible time have also created an urgent need for better understanding of relationships between irrigation, nutrition, tree growth and early yields.

Consultation with industry is ongoing with seminars, conferences, farm walks and meetings held 5 to 6 times each year. Weekly contact via telephone and email is made with growers who are engaged in establishing new orchards or in need of management advice on traditional plantings. Support for the AWIA Consultancy Service from the walnut industry was extremely high.

3.12 Knowledge, Attitude, Skills, Aspirations

Presently, AWIA has approximately 120 Members with at least 15 others who are involved in walnut production but are not members of the association. Interest in planting walnuts is at an all time high, a fact demonstrated in the last 5 years by the membership in AWIA increasing by 10% each year. All members were able to access the advice offered by the consultancy service either by requests for specific information (fee-for-service) or through the provision of general information (seminars, publications and farm walks).

The Project has provided the Australian walnut industry with a unique opportunity to access the most up-to-date information from within the resources of DNRE plus access to information from international researchers from around the globe. The demand for consultancy services was high with a substantial number of new investors entering the walnut industry. Some topics relating to walnut production were outside the scope and resources of the project but the important ones, by popular demand, relating to orchard establishment were identified and addressed successfully. The skill level attained by growers participating in the program was considerable. Many of these growers are now able to propagate their own trees, schedule their own irrigation, manage fertigation and train their trees.

Excellent opportunities now exist for a rapid expansion of the walnut industry in Australia. Public interest in walnut production in this country is presently at an all time high with considerable investment being directed into the industry. With improved techniques, the establishment of new orchards is becoming more attractive, easier and faster than before. Walnuts are under-produced in Australia, have wide appeal to consumers, provide good return on investment, have few pests and diseases, are easily harvested mechanically, and offer distinct advantages over many other fruit and nut crops.

The expansion of the walnut industry will have a low impact on the environment. Management of the orchard is based on non-tillage, biological recycling of organic matter and careful inputs of water and nutrient. In Australia, walnut orchards have few pests and diseases making the crop well-placed for the popular ‘clean and green’ image and suitable for organic production.

4. DISCUSSION

An analysis of the nature of enquires made to the AWIA Consultancy Service revealed that most of the information sought came from new investors to the walnut industry and centred on tree establishment. The major inputs into the successful establishment of trees were identified as propagation, nutrition, irrigation and tree training. The establishment of guidelines and sound scientific principles gave the walnut growers some simple but powerful tools to manage their orchards to a high standard. The introduction of benchmarks (specifications) in each of the inputs provided a useful reference for the grower to work to.

The farm walks and demonstrations of techniques in field budding, fertigation, soil water measurement and tree training, were supported by material that provided the underpinning theory. The information provided was specific and quantified, removing much of the mystery and folk law that can overwhelm new investors in horticultural enterprises. The formation of Loddon Walnut Group was successful and group activities helped to maintain enthusiasm, by providing comparisons between properties. Resources were shared and lively discussion was assured at each meeting.

Within the space of three years, the level of competency in tree management reached by the participating growers was impressive. At the beginning of the project, none of the participating growers had propagated walnuts, used fertigation, managed orchard irrigation, soil monitoring equipment nor had any experience in tree training. Guidance provided by lectures and written material on each of the above skill areas provided a solid background in the theory. The practical demonstrations, in the field on the growers respective properties, provided training that put the theory into practice. The growers that took part in the program are now managing their properties independently, using techniques that are currently being used by experienced horticulturalists and researchers.

From the commencement of the project to the present time the number of investors in walnuts has grown exponentially. The AWIA Consultancy Service has provided an effective vehicle to assist the walnut industry in reaching a critical mass to enable it to replace imports and open up export markets. A 1000ha planting in northern Victoria, the biggest walnut orchard in Australia, is testimony to the success of the project. Other walnut projects are planned whilst many of the existing growers are embracing the guidelines for orchard management discussed in this report. The successful collaboration between the walnut investors, RIRDC, AWIA, DNRE and overseas researchers through this project has provided a strong base for the walnut industry to build on as it moves on to a bright future.

5 APPENDICES

5.1 The business plan

Australian Walnut Industry Association

"AWIA Consultancy Service"

Business Plan

1999 - 2002

Prepared by
Michael Young & Associates
(Myfora Pty Ltd)
GPO Box 2811
Canberra ACT 2601

17 August 1999

Contents - The AWIA Consultancy Service Business Plan

1. Business Overview

The **AWIA Consultancy Service (AWIACS)** is a service wing of the **Australian Walnut Industry Association (AWIA).**

The **AWIA Consultancy Service**, through a fee-for-service advisory service to members of AWIA and other interested parties, will generate the Walnut Industry cost-share component of the Rural Industries Research and Development Corporation (RIRDC)-funded Walnut Research and Development Project at Agriculture Victoria's (AV's) Institute for Sustainable Irrigated Agriculture (ISIA), Tatura, Victoria. It will also generate additional R&D funds for the Walnut industry.

This Business Plan has been developed through a series of intensive workshops, involving representatives of AWIA and ISIA's Horticultural (specifically Walnuts) Research and Development Program.

Mr Harold Adem, from ISIA, Tatura, is the Principal Researcher in the RIRDC Walnut Project and is at the forefront of those capable of providing reliable advice relating to the implementation of best practice in the Walnut Industry. He is sought after to provide technical advice on many issues such as initial site selection, orchard establishment and basic crop husbandry procedures. He will be the Principal Consultant in the AWIA Consultancy Service and provide the extension component of the RIRDC Project.

The RIRDC Walnut Project provides an innovative opportunity to support the Walnut R&D program by charging a fee-for-service to those in the Walnut Industry who require specific advice and will therefore benefit most from an enhanced R&D program - rather than imposing a general R&D Levy across all participants in the industry. The funds raised are returned to the RIRDC Walnut Project.

The Planning Workshops resulted in the following:

Vision

To provide a profitable, quality service that helps the Walnut Industry and funds its Research and Development

Mission

The AWIA Consultancy Service is in the business of ….
Providing professional, state-of-the-art advice on the financial, horticultural, processing and marketing aspects of walnut production.

Values

- **To respect confidentiality**
- **That as much information that can be shared, should be shared**
- **To be a user pays, fee for service business**
- **To be improvement focused**
- **To deliver a responsive, relevant and timely service**
- **To put members first, using business common sense**
- **To use commercial business judgement in delivering services**

What are the unique features of the AWIA Consultancy Service?

The Australian Walnut Industry Association, as sponsors of the AWIACS, have demonstrated a willingness to be innovative in the way their industry supports research and development.

The AWIA Consultancy Service provides a direct link between industry research and information and technology transfer which will result in accelerated adoption of best management practices at all levels within the industry.

As the AWIACS grows, so will the capacity of the Walnut industry, to conduct supporting research and development, grow.

The fees generated by the AWIACS will offset the industry research costs and, potentially, add to the scale of research activity.

The AWIACS represents an important partnership between the Walnut Industry, Agriculture Victoria and the Rural Industry Research and Development Corporation that focuses on meeting the needs of a growing rural industry.

The AWIACS provides a means for delivering high quality information and support, to the existing industry and future investors, in an organised way.

Whilst not unique in horticulture, the Walnut Industry's small size provides an excellent opportunity to use the AWIACS to deliver a highly integrated advisory service that works with and builds on the successes of individual clients through involvement of them in participatory research and development and demonstrations of success.

What is the projected minimum revenue for the next three years?

	Year 1 1999/2000	**Year 2** 2000/2001	**Year 3** 2001/2002
Revenue	**$15000**	**$15225**	**$15453**

The revenue estimates indicated here, are the minimum amounts required to meet the Walnut Industry share of the Walnut Research and Development Project, in partnership with RIRDC and Agriculture Victoria.

This income will be achieved by the Service providing a minimum of 30 days charged out at $500 per day (Year 1). Principal Adviser is Harold Adem from Agriculture Victoria. He is able to commit 70 days per annum to this service, from which the 30 chargeable days per annum must be achieved to meet the RIRDC Project commitment.

Identified Roles for the AWIA Consultancy Service

- Extension service to growers and prospective growers
- Provide technical advice tailored for individual
- Problem solving, especially for local conditions
- Create opportunity to increase production and profitability
- Training in best practice - to provide what AWIACS market research identifies as needed
- Industry marketing support services - market development
- Ensure more efficient use of personal and financial resources for development, production, and marketing of walnuts
- Dissemination of information to assist industry to achieve mission and objectives
- Provide practical advice to growers and help growers to secure funding from government for walnut research
- Research, including identification of useful areas for new research
- Helping growers to produce quality walnuts at a competitive price
- Provide a focal point for industry development
- Provide research and advice to enable growers to manage their walnut enterprise.

2. Market & Competitive Profile

How big is the total market for the Consultancy Service? Is the market growing or declining?

There are approximately 80 AWIA members, as well as other growers, at various stages of development and with varying scales of production, from small lifestyle farms with only a few hundred trees to some large commercial operators with several hundred hectares planted.

There is a growing interest in the Walnut industry from **existing farmers** who wish to diversify their farming operations as well as **new investors** who are seeking some long-term rural investment opportunities to complement enterprises such as wine grapes, olives and a range of traditional crops.

Exciting new advances in R&D made in the last two years has created a new generation of walnut investors with plantations of 12,000 to 50,000 trees, in contrast to the traditional growers with 100 to 1,000 trees. New plantings are of high yielding, early bearing cultivars planted in hedgerows which quadruple tree numbers for the same land area. The RIRDC Walnut R&D project at Tatura is evaluating a soil and water management system which allows walnuts to grow as hedgerows on shallow clay-pan soils, producing yields of 1.2 t/ha on 5 year old trees and demonstrated the capability of new, high yielding cultivars eg. Chandler, in south-eastern Australia.

The inquiry for information on Walnuts has been growing rapidly, following some industry publicity and the Walnut Industry Forum held at ISIA, Tatura in early 1999. These inquiries have focused on Mr Harold Adem, Principal Walnut Researcher at DNRE's ISIA, Tatura, as well as experienced members of the Australian Walnut Industry Association - in particular, the executive members.

Whilst this is a relatively small industry, there is a considerable hunger for information that will assist investors to achieve cost-effective and early returns from their investment. ISIA Tatura is recognised as a leading Walnut Research facility, with the capacity to provide an integrated management information service, based on "best practice" for the industry. The opportunity to link research and extension through the AWIA Consultancy Service was endorsed by the last AGM of the Walnut Industry Association. This indicates strong industry support for the Service and scope for considerable growth in the demand for services. Membership of the AWIA has been increasing at 10% per annum over the last five years.

The continuing demand for the services will arise from the varying stages of development that the individual investors have reached. There will be on-going demand for advice in the areas of initial site selection and investment feasibility, right through to harvesting, processing and marketing of the walnuts.

There is a considerable opportunity for the Australian Walnut Industry to make significant in-roads in to the current import trade for walnuts, provided they are cost efficient and are capable of producing high quality walnut products. The AWIA Consultancy Service will provide the technical support to enable the industry to compete effectively against imports (Australia presently imports 4,500 to 5000 tonnes of walnuts - in-shell equivalent) and may enable an export market to develop. An export market intelligence service could be developed through an alliance with the DNRE Agribusiness Unit (P. Hansford).

3. Strategic Direction

The target market for the Consultancy Service

1. **Existing members of the Australian Walnut Industry Association (AWIA)** are the prime targets for the services. AWIA members have endorsed the Service and have recognised the benefits of a fee for service advisory service, based on best practice that is supported by the RIRDC Walnut Research Project. The members have recognised that the proposed service will enable those in most need of technical support services to benefit most from their indirect investment in the on-going research program.

2. **Non-Members of AWIA and new investors in the Walnut Industry -** AWIA will promote membership of AWIA to all newcomers in the industry, thus giving them access to member rates for the consultancy service. This client group will initially be seeking basic investment and feasibility information, followed by a progression through all phases of development, production and marketing of walnuts. Non-members of AWIA will pay a higher daily fee for services from the AWIACS and, in general, members of AWIA will receive preferential treatment from the AWIACS, all else being equal

What are the long term Goals/Objectives of the AWIA Consultancy Service?

1. **Research Commitment** - demonstrate to RIRDC that the Service will generate the minimum annual Industry R&D contribution of $15,000 (in 1999 $), with $2-3000 due by the end of August, 1999.

2. **Financially successful** - the Service will be run using standard commercial practices, including fee for service and will set financial priorities based on application of business common sense. The Service will work towards being independent of Government funding for research and development.

3. **Relevance to industry needs** - the Service will develop an understanding of client needs and deliver information and training that is relevant to the specific needs of the Industry sectors, at a time that is relevant to the industry.

4. **Provide benefit to clients** - Individual clients will have access to specific advice regarding the implementation of best practice in their situation (location and stage of development).

5. **Information dissemination** - The role of the service is to provide advice to the Walnut industry on the basis of the R&D program at Tatura and elsewhere and to assist in providing opportunities for information gathering, dissemination and exchange of ideas through field days, forums and publications.

What are the major things that you will need to achieve in order to meet these

Goals/Objectives?

Objective No: 1

"Research Commitment - demonstrate to RIRDC that the Service will generate the minimum annual Industry R&D contribution of $15,000, with $2-3000 due by the end of August, 1999."

Steps:

- Form a Steering Committee to manage the Consultancy Service
- Create awareness of service by AWIA members through an initial heavy advertising campaign using verbal contacts, seminars, industry notices and high profile PR events.
- Clarify range of services to walnut industry association members: property feasibility assessments (pre-purchase) for new members; diversification options to provide cash flow on existing properties; generic services that can apply across a range of similar horticultural industries; training - TAFE etc short courses.
- Develop clearly stated scale of fees for service and expenses recovery policy (travel costs, administrative services etc).
- Must achieve a minimum of 30 days per annum, at $500 per day, to achieve $15,000 industry R&D input per annum.
- Need 6 days by end of August ie. nearly 1 day per week to deliver $2-3000 initially - underwritten by AWIA with a fully recoupable advance, if required.
- Consult an average of 2.5 days per month, minimum, for next 12 months to deliver $15,000 annually (minimum target).
- Requires a strategy for capturing existing demand for services.
- Requires a strategy for capturing new and ongoing demand for services.
- Finalise arrangements and approvals with RIRDC, AV Services and all key administrative procedures, pre-start-up.

Objective No: 2

" ***Financially successful - the Service will be run using standard commercial practices, including fee for service and will set financial priorities based on application of business common sense. The Service will work towards being independent of Government funding for R&D***."
Steps:

Establish transparent accounting/business management systems with clear audit trail, including:

- Invoicing for work done
- Collection of funds
- Payment of accounts relevant to service
- Separation of consultancy service funds/accounts from general AWIA funds
- AWIA R&D sub-committee will be responsible for funds received - if funds in excess of $15,000 are raised then put in R&D reserve to enable additional R&D work and/or cover future shortfalls.
- Clear process for transfer of funds generated from the consultancy service to the RIRDC project.
- Clear record of work done by the consultant:
- Client contact records
- Service provided
- Record time spent on a job - both **chargeable and non-chargeable hours**
- Advice given
- Fees charged
- Expenses relating to the provision of the service
- When billed to client
- Policy for when client charging applies - initial consultation, up to ten (10) minutes, is free. Thereafter, hourly/daily rate applies - say, $80 per hour (or part there of) up to 4 hours, then $500 per day for members of AWIA. - $120 per hour, up to 4 hours, then $750/day for non-members.
- Consultant requires provision of phone, fax, mobile and Email to enable client access to the consultant at his home (for evening and weekend access).
- Secretarial services should be accessed on an as-needed basis - out-sourced at $30/hour and charged to the client.
- The priorities for the delivery of services will be set in reference to the commercial impact ie. impact on the service's financial bottom line eg. if possible, for distant clients, aim to visit more than one at a given location - either singularly or in groups, depending on the service being

provided.

- A brochure, outlining conditions of use of the service or **Terms of Business**, will be produced.

Objective No: 3

" Relevance to industry needs - the Service will develop an understanding of client needs and deliver information and training that is relevant to the specific needs of the Industry sectors, at a time that is relevant to the industry."

Steps - The following services have been identified to be supplied:

- Identification of suitable land for efficient walnut production - site selection - for new and existing growers, this could be the most critical success factor.
- Identification of most appropriate establishment systems - soil modification, irrigation layout specifications, varieties etc
- Modification of existing systems to enable adoption of best management practices
- Sourcing of raw materials - rootstocks, trees, scions - and tying up a supply for continuity for members - develop contracts with accredited suppliers
- Designs/specification of irrigation systems that are cost efficient for individual situations.
- Advice on operational management - tasks, timing and specific recommendations
- Assessment or design of and recommendations for specialist equipment
- Harvest technology, including drying - to currently available best practice
- Storage and processing of produce
- Identifying additional supporting technical services (marketing, water quality experts etc)
- Facilitate marketing links to walnut product buyers - through association with DNRE Agribusiness - to provide market information feedback into management practices that impact on quality standards and marketability of product - vis seminars and newsletters.
- Packaging of integrated services - eg. Co-ordination of soil testing, earthworks/soil modification, irrigation system installation, tree planting, fertiliser application, irrigation scheduling, pruning and other crop maintenance needs.
- Training of support service providers to ensure standards are adhered to.
- Any one of the above services may be required by individual clients at different times in their investment/crop growing cycle.
- **The advertising for these services must be done with care, ensuring that the AWIACS has**

the capacity to deliver the services that it is claiming expertise in.

Objective No: 4

"Provide benefit to clients - Individual clients will have access to specific advice regarding the implementation of best practice in their situation (location and stage of development)."

Steps/Benefits:

- Access to individualised specialist services, as a priority
- Cost advantage and priority access to service by members of AWIA - $500 per day or $80 per hour vs $750 per day or $120 per hour for non members - the preference is to encourage membership of AWIA.
- Networking with other clients and access to the consultant's network
- Access to overseas experts - through visiting scientist programs and group travel to overseas areas which demonstrate best practice in walnut production
- Access to group processing/marketing arrangements to achieve critical mass and efficiencies of scale
- Sharing of specialised equipment and access to skilled, accredited contractors
- Establish systems for continuous improvement of the industry in a learning environment.

Objective No: 5

"The role of the AWIACS is to provide advice and feedback to AWIA and the R&D program at Tatura and elsewhere and to assist in providing opportunities for information gathering, dissemination and exchange of ideas through field days, forums and publications."

Steps/Actions:

- Development/promotion of a Walnut Industry prospectus/facts sheet based on Australian benchmarking studies.
- Provision of updated key investment data for existing and prospective growers.
- Advise on the development of an annual program of co-operative activities - field days, farm walks, technical forums and Industry PR events.
- Provision of short courses, covering wide range of crop management issues - TAFE.
- ISIA, Tatura is a centre for walnut research - it is a place where visiting scientists could be located to carry out Walnut projects.

- AWIA and the AWIACS will benefit from its association with ISIA through their ability to identify opportunities for collaborative research with visiting scientists.

- ISIA, Tatura is a key resource centre, being the consultant's base, with a library containing comprehensive information on soils, irrigation management, crop nutrition, crop management, farm management economics and natural resource management (salinity, water quality, land and water conservation).

- Creates a learning environment through active involvement of clients in research and extension activities - the Service will promote participatory research and demonstration opportunities that involve growers and others in a total experiential learning environment.

- Promotion of membership participation in on-farm trials of best management practice
    - for demonstration at industry events
    - for on-going management and monitoring

- Potential to develop a "Crop Check" system for growers that enable individuals to compare themselves with industry benchmarks - relating to cost efficiency, water-use efficiency and effectiveness of practices under a range of locations and conditions as demonstrated in current R&D programs.

4. Operational Policies, Strategies and Actions Personnel Management and Resourcing

An AWIA Consultancy Service (AWIACS) **Steering Committee** will be formed.

The Steering Committee will comprise a minimum of four (4) persons:
- 2 AWIA members to be nominated by the Executive of AWIA
- 1 Agriculture Victoria representative, nominated by ISIA, Tatura, if required
- the principal consultant/Harold Adem (ex-officio)
- the AWIA President (ex-officio)

The **role** of the Steering Committee is:
- to advise the Principal Consultant on matters relating to the running of the AWIACS.
- to support the Principal Consultant in relation to all activities
- to form a project management team with the Principal Consultant.

The Steering Committee can co-opt expertise, as required.

AWIA will provide publicity for the AWIACS and will support and direct the AWIACS, through the Steering Committee. AWIA are information providers with respect to the availability of the AWIACS and will direct technical inquiries to the AWIACS.

The **role** of the Consultant is to provide the consultancy service and keep the Steering Committee briefed on progress. The Consultant/Harold Adem is accountable to the AWIA Executive, through the Steering Committee.

The operational performance of consultancy tasks by Harold Adem will be at his professional discretion - he will be accountable to the Steering Committee through his ability to generate fees and meet operational costs

The Steering Committee reports to the Executive of AWIA, re: progress, on a six (6) monthly basis.

Harold Adem's employment conditions, including salary and on-costs, are the responsibility of AV and will follow AgVic guidelines.

The RIRDC/AV project will provide resources for the consultancy, subject to reimbursement of agreed costs - eg airfares, major reports and other major consultancy client-specific costs - see list below.

Home office communications capability for Harold Adem will be funded from within the RIRDC/AV project. Outsourcing of direct support to the consultancy (secretarial support for major reports, printing etc) at discretion of Harold Adem - and charged to the client.

If Harold Adem departs from the project, the whole project will need to be re-negotiated ie. no DNRE guarantee for immediate replacement of Harold Adem with the same level of service.

AWIA, in consultation with Agriculture Victoria, should develop **options** for training additional walnut extension specialists who can compliment Harold Adem's services and develop a succession plan for the continuity of those services.

Marketing of the services

The AWIA Consultancy Service (AWIACS) is aimed at helping the industry to become more efficient and market competitive.

The AWIACS is an innovative **extension program** for the walnut industry.

An important marketing action is for AWIA Executive and ordinary members to be proactive in informing inquirers of the existence of the service - at initial contact.

Provide information to current AWIA members through the Industry Newsletter.

Prepare a market information publication/brochure for prospective clients.

Advertise "The AWIA Guide Book" in popular rural press - Weekly Times, The Land, National Market News, Good Fruit and Vegetables and Farm Magazine.

Provide an article in "Nutgrower" with photos.

Prepare Press Release at launch.

Have an "Official" launch - Ag Minister

Take opportunities to talk on walnuts at service clubs, conferences etc

Target the Wine and Olive Industries with walnuts as an opportunity for diversification.

Devise a marketing strategy for post-initiation stage - based on success stories to date.

Managing Finances and Business Operations

Underwriting - AWIA has agreed to underwrite the AWIACS by providing RIRDC with $2-3000 (as required) by August, 1999, to be fully recouped from project earnings, by the end of the first financial year (30 June, 2000).

Business Address - AWIA/AV need to agree on a **Registered Office** and **Business Address** for all correspondence to the AWIACS and initiate necessary action without delay.

Legal Structure - AWIACS requires the creation of a legal entity (company) so that it can enter into agreements, contracts, have banking facilities and minimise legal liability of AWIA - take advice from AV Services. Printing of all stationery requires the business entity to be in place.

Contracts with Clients - a standard letter of offer for services, the quoted cost of the service (consideration) and a form of acceptance will be prepared as the basis for a short contract for services offered.

Invoicing - The Consultant will prepare and provide invoice to client - The cheques will be payable to a new **AWIA Consultancy Services** account. - AWIA is to create this account.

Expenses - The RIRDC/AV project will approve for payment and pay **all** AWIACS expenses.
The project recoups all agreed expenses from AWIA through reimbursements from clients, including

- airfares
- accommodation
- vehicle hire

Third Party Costs - the AWIACS will facilitate, specify, make arrangements but **will not handle $$** eg soil tests, contract work, supply of irrigation equipment, planting material etc.

AWIACS **will require documentation** that the client accepts responsibility for all 3rd Party Costs.

Risk - AWIA will seek legal advice (AV Services) re: professional insurances and wording of disclaimers relating to the provision of advice - essential documentation **must** be identified and enforced.

Review risk issues on a regular basis (6 months) and document any critical incident responses (actual or potential insurance claims).

The Consultant will operate within AV's Occupational Health and Safety Guidelines.

5. Implementing the Service

Implementing the Service - Timing And Responsibilities

1. Complete the Business Plan - seek official acceptance by AV Services and RIRDC - late August, 1999. - AWIA/AV/P.Jerie

2. Establish recommended business structure, business address to required standards - late August, 1999. - AWIA to consult with AV Services.

3. Establish the Steering Committee - August, 1999 - 2 X AWIA members + 1 AV representative (ISIA, Tatura) + Consultant (ex-officio) + AWIA President (ex-officio).

4. AWIA to provide underwriting funds ($3,000) to RIRDC before end of August, 1999.

5. Harold Adem to establish accounting/business record system - times, client details, requests, advice given, costs - back-up data and invoicing system. - August, 1999. Ensure that Harold Adem is fully costed and that the risk of "overservicing" is managed.

6. Document accounting procedures - August, 1999. - HA

7. Develop a AWIACS **"Terms of Business",** for attachment to the sample short form contract, that covers intellectual property, confidentiality, payment terms, third party costs etc. as identified.

8. Print letterheads and business cards - showing affiliation with AWIA - as soon as possible.

9. Establish preliminary client list - August, 1999. Harold Adem to commence operating as soon as AV and RIRDC have approved commencement.

10. AWIA and Harold Adem to plan AWIACS Launch by Ag Minister.

11. Develop, print brochures, newsletters and news releases - initial July, 1999 and on-going - AWIA Executive and HA

12. Finalise arrangements for using AWIA logo. AWIACS to seek written authority to use AWIA logo, once the AWIACS legal entity is constituted - HA and Charles Chiba

13. Define accountabilities - see personnel management above - August 1999. Steering Committee

14. Develop Review framework - 1st Review of the Business Plan is due 1st November, 1999 - the Review Summary becomes the RIRDC Milestone Report - end August, 1999. Steering Committee and HA.

15. The Business Plan is to be a living document that responds to the Review outcomes.

6. Other Information

This Business Plan must be read in conjunction with the RIRDC Funding Application for the Walnut Industry Research and Best Practice Implementation project (Ref: NPP99-32), originating from ISIA, Tatura. The budgets applicable to that project are also applicable to this Business Plan.

Source of funds	1999/2000	2000/2001	2001/2002	TOTAL
RIRDC:				
Salaries	$35,200	$35,728	$36,263	
Travel	4,500	4,567	4,635	
Operating	5,300	5,380	5,461	
Capital	Nil	Nil	Nil	
TOTAL	45,000	$45,675	46,359	$137,034
Research Organisation (AV)	12,000	12,179	12,362	$36,541
Industry ## (AWIACS)	15,000	15,225	15,453	$45,678
Total Funding	$72,000	$73,079	$74,174	$219,253

These funds are the fees for service, generated by the AWIA Consultancy Service, based on a minimum of 30 days professional fees, charged out at $500 per day to members of AWIA. It should be noted that non-AWIA members seeking advice from the AWIACS will be charged at $750 per day. All expenses, relating to client business will be charged directly to the individual clients.

Amounts raised in excess of the $15,000 per annum (indexed at 1.5% annually) will increase the industry contribution to the R&D project and, hence, increase the scale of R&D capable of being undertaken by this project.

A sample Invoice, a sample Letter of Offer and the Australian Walnut Industry Association Strategic Plan, 1997-2002, follows.

AWIA Consultancy Service Address:… Phone:…...

Sample Invoice

INVOICE

AWIA

LOGO

Date	Invoice No
	00/1001A1

Bill to
Mr Big Walnutgrower Orchard Lane Treesville Vic 390X

te	Description		$
Date of job	For the professional services of *(insert name/s of consultant/s)* for *(Description of job)* …….		**$1000.00**
	In due course 10% GST will be added onto the professional fee component for contracts extending beyond 30th June, 2000.		
	(Here set out expenses)		
	• Accommodation	$100.00	
	• Air fare	$438.00	
	• Taxi	$27.00	
	• Travel	$120.00	**$685.00**
		Total	**$1685.00**

Please pay within **7** days

Signed: HA Consultant……

AWIA
Consultancy
Service
Address…

AWIA

LOGO

Sample letter for offer of services - short form contract

3 May 2004

Apple and Pear Tree
RSD 2065
Treesville 369y

Re: Walnut project advice

Dear Apple and Pear,

This letter confirms our agreement for the provision of the type of service requested. Please find below the summary terms of our agreement, as discussed by (phone……etc) on the (Date of the contact).

- **Delivery date**: Visit on XYth September, 1999, with completion of report by XY+5th September, 1999
- **Total estimated price: $1685 -** including 2 days professional time @ $500 per day plus reimbursement for travel and accommodation, as agreed... ie. The estimated price is a basic price and is subject to variations encountered and reported to client for acceptance prior to proceeding.
- **Payment terms:** Net 7 days from the receipt of the invoice following completion of the task, as requested. ## **Comment… Credit worthiness to be established prior to submitting this Letter of Offer**

I am looking forward to undertaking this work. If you have any questions, please do not hesitate to call me at anytime.

Please acknowledge your agreement to the above terms and conditions and those attached, by signing and dating the space below and returning a signed copy of this letter to me prior to the commencement of the work.

Sincerely,

Harold Adem
Consultant

_____ Acknowledged by

_____ Date

Australian Walnut Industry Association Strategic Plan
For the five years ending in 2002

AIM:

To facilitate the development of **strong** and profitable Walnut industry in Australia.

To increase production, improve yield and quality.

OBJECTIVES:

To select walnut varieties suited to Australian climate and soils with proven productivity for industry development.

To promote sound orchard management practices, including the adoption of QMS to walnut production in Australia.

To develop an efficient**,** cost effective harvesting and processing technology.

To facilitate observance of quality standard of produce to be marketed.

To develop domestic and export markets.

STRATEGIES:

For walnut varieties:
In collaboration with growers, survey existing planting stock**,** to identify vigorous, disease resistant trees that produce quality walnuts.

Assess varieties, including new and overseas varies suited for specific climatic and soil conditions.

Implement variety selection through grower trials.

Encourage and support research on walnut variety selection suited for industry development.

Promote research into propagation techniques, including those based on tissue culture.

Collect and disseminate information on selection trials. Hold meetings, workshops, etc. on the subject, to increase growers' awareness of walnut varieties sited to specific climatic and soil conditions.

Collaborate with the International Walnut Research Network for exchange of research information.

For Orchard Management:
Improve present techniques of orchard management, develop and facilitate research trials and organise the funding of these.

Revise and continually update the AWIA Guide Book for the growing of walnuts in Australia.

Develop a Quality Management System (QMS), for all aspects of walnut production and marketing of Australian walnuts**.** Produce the Walnut Quality Guide to provide explanation of the system**.**

Encourage growers to use only chemicals registered for use on walnuts at rates and at timing according to established Maximum Residue Limits.

For Harvesting and Processing:
Hold seminars, training courses and technical workshops to encourage adoption of quality management in orchard practices and the harvesting and handling of the crop.

Liaise with Government, research organisations and other bodies to encourage research and to collect and distribute information to AWIA membership.

Facilitate observance of the accepted industry standards in packaging and presentation for marketing.

For Product Quality:
Make the AWIA Trade Mark (consisting of the logo with the approved inscription) available to members for the marketing of Australian prime quality walnuts.

Actively encourage adoption of AWIA quality standards by growers and distributors.

Review adoption of standards by the Australian walnut industry.

For Marketing:
Identify and describe domestic and export market opportunities for the benefit of AWIA members.

Develop marketing strategies and techniques to replace imported walnuts and export Australian walnuts.

Advise members on market opportunities and suitable strategies for market development.

TARGETS:

Increase productivity:

- through varietal selection and facilitating quality management through education and training to encourage the use of the Walnut Quality Guide, in all aspects of production, harvesting and handling of walnuts.

Increase production:

- achieve import replacement in excess of 10% by the end of 2002.

Improve profitability:

- through adoption of cost-effective production and optimal marketing by the year 2000.

Develop marketing strategy:

- by the year 2002 for the replacement of imported walnuts and the export of Australian walnuts**.**

Increase local consumption:

- through disseminating information to consumers on aspects of health, nut quality and use of processed products;
- through increasing consumer awareness by establishing a presence of nuts in the media, at agricultural shows, food fairs and harvest festivals.

5.2 Fertigation

FERTIGATION

Introduction

Fertigation is a technique for using irrigation water as a carrier of fertiliser in solution in a piped irrigation system to deliver a known concentration of nutrients to crops. Fertigation has the advantage of delivering nutrients from a point source to wherever irrigation is applied to the crop. The operation is simple because it uses the irrigation infrastructure already present without the costs associated with conventional spreading of fertilisers with tractor equipment. Nutrients in solution are in a form readily taken up by plant roots and there are fewer losses due to volatility of some compounds. Fertigation is a flexible method because small amounts of nutrients can be introduced at frequent intervals rather than in fewer large doses.

Soil management and soil texture

Soil management in the orchard has an important bearing on nutrient availability, water infiltration and aeration. In many orchards, 75% of roots, responsible for most of the uptake of water and nutrients, develop within the top 1 metre of soil and within approximately a 2 metre strip along the tree line. To create the best environment for tree roots, the soil in the tree line should not be trafficked, be kept moist by irrigation and supplied with organic matter from grass roots and straw mulch. Grass roots create pores in the soil in the process of extending through soil and when the roots die a channel is left behind. Earthworm and other microbial activity create tunnels in the soil for the passage of nutrients water and air to the tree roots. Pores created by plants and animals in the soil are called biopores and become useful agents in improving the structure and drainage of the soil. Straw mulch increases levels of organic matter, decreases evaporation from the soil surface and encourages tree roots to grow right to the soil surface underneath the straw. Organic matter plays an important part in controlling the availability of nutrients, especially nitrogen, phosphorous and sulfur.

The proportion of silt, sand and clay in a soil, referred to as texture, has a strong bearing on the buffering (storage of nutrients) capacity and the loss of nutrients due to leaching. Sandy soils have less buffering capacity and are readily leached of nutrients. Clay soils have a strong buffering capacity and because they tend to drain slowly, nutrients are not leached readily but denitrification (loss of nitrogen) can occur under waterlogged conditions.

Nutrition

For function and growth, plants obtain most of the mineral nutrients from the soil water solution. Soil minerals and organic matter, that make up the bulk of the soil mass, act as a buffer or store of nutrients available to plant roots. Nutrients may be classified into three classes according to the relative quantities needed by the plant and the different forms the nutrient is available in (Table 1.).

Table 1. Forms of nutrient elements found in soil solutions

Class of nutrient	Element	Cationic form	Symbol	Anionic form	Symbol
Primary	Nitrogen	Ammonium	NH_4^+	Nitrate	NH_3^-
				Nitrite	NO_2^-
	Phosphorous		P	Hydrogen phosphate	$HPO_4^=$
				Dihydrogen	$H_2PO_4^-$
	Potassium	Potassium ion	K^+		
Secondary	Calcium	Calcium ion	Ca^{++}		
	Magnesium	Magnesium ion	Mg^{++}		
	Sulfur		S	Sulphate	$SO_4^=$
Micro nutrients	Iron	Ferrous ion	Fe^{++}		
		Ferric ion	Fe^{+++}		
	Manganese	Manganous ion	Mn^{++}		
	Zinc	Zinc ion	Zn^{++}		
	Copper	Cupric ion	Cu^{++}		
	Boron		B	Borate	$H_2BO_3^-$
				Neutral boric acid	H_2BO_3
	Molybdenum		Mo	Molybdate	$MoO_4^=$
	Chlorine		Cl	Chloride	Cl^-

Soil pH

Soil pH affects both the availability and absorption of mineral nutrients. Measurements of soil pH can be a good guide to the diagnosis of nutrient deficiencies and should be corrected before nutrients are applied. Low pH (<5.5) may result in deficiencies of Ca, Mg, P, or Mo and perhaps excesses of Mn, Fe, or Al. High pH (>7.5) may result in deficiencies in Mn, Zn, Fe, or Cu.

Fertilisers

Many fertilisers are available in soluble form making them suitable for fertigation. This paper will mainly discuss nitrogen fertiliser because of its dominance in plant performance and its potential negative effects on the soil environment. Other nutrients are acknowledged as important but will not be dealt with separately. Plants are major users of nitrogen and most horticultural crops become nitrogen deficient if N is withheld. Fertilisers containing N are widely used in orchards and vineyards and, being a moderate expense in the overall production costs incurred in the business, can be applied too heavily or inappropriately. Inefficient application techniques will reduce the proportion of applied fertiliser taken up by the tree. Using more fertiliser than needed by the crop can not only waste money but can lead to soil acidification and contamination of groundwater. Nitrogen fertilisers can contain N in different forms that move through the soil at different rates giving rise to the term nutrient ‘mobility’ in the soil (Table 2).

Table 2. Mobility of fertilisers in soil

Mobile component	Less mobile component
Urea	Ammonium
Nitrate	Potassium

The ability of a fertiliser to dissolve in water is not always a good indicator of the mobility of the nutrient. Urea, a N source often used in fertigation, is easily dissolved, is very mobile and is easily leached past the rootzone of trees and vines. Ammonium also dissolves in water, but is much less mobile because it sticks to clay particles. Ammonium fertilisers such as MAP and ammonium sulphate are less likely to be leached past the rootzone. Ammonium nitrate breaks down to a nitrate component which is mobile and easily lost by leaching whilst the ammonium component binds strongly to clay particles. Calcium nitrate and potassium nitrate are both mobile and subject to leaching but may slowly increase soil pH (Table 3).

Table 3. Effect of different sources of nitrogen on soil pH

Fertiliser	**No leaching**	**100% leaching**
Most acidifying	Lowers pH	Lowers pH rapidly
Ammonium sulphate		
MAP		
Moderate	Lowers pH	Lowers pH
DAP		
Low/neutral	No effect	No effect
C.A.N.		
Urea		
Ammonium nitrate		
N.P.K. (Urea based)		
Organic manures		
Alkaline	Raises pH	
Calcium nitrate		
Potassium nitrate		

Fertigation using drippers, microjets and sprinklers

Fertigation coupled with treeline irrigation gives the operator good control over the timing and dosage. However, if poorly managed, fertigation can lead to severe acidification of the soil profile. Where drippers or microjets are employed to wet the treeline only, tree roots are concentrated in this narrow strip and fertiliser uptake by the tree or vine is both efficient and rapid. Care is needed because most of the fertiliser needs of the tree or vine are met in a small volume of soil. Fertigation should be done a day or two after a rainfall event or irrigation so that the fertiliser is applied whist the soil is still wet. When using fertigation the irrigation run should be shorter than usual and the fertiliser applied in the last 30 to 60 minutes of the run.

Sprinkler irrigation

In orchards managed under sprinklers, the whole orchard floor is wetted but most of the active roots important for the uptake of water and nutrients are encouraged to grow on the treeline where there is less compaction and better drainage of the soil. Employing fertigation techniques with sprinkler irrigation may not be efficient. In the traffic line of the orchard, the density of tree roots is low, so much of the fertiliser will be leached past the rootzone and the rest will be picked up too slowly. This can lead to a waste of nutrients, an increase in soil pH, contamination of groundwater and a slow response in the crop. A delay in the response to added fertiliser makes it difficult to target nutrients at specific growth stages of the crop.

Soil and leaf analysis

Soil tests are a useful way to establish base levels of nutrients in the soil and are particularly import when the orchard is being established. A new planting also presents the best opportunity for correcting low pH in the soil by the incorporation of lime. Continued soil tests can be carried each year before the start of the growing season. Fertiliser suppliers can advise on the application rates for fertilisers based on the performance of crops in a given area. Nutrient levels can also be determined by leaf analysis and then compared with standards that are recognised to be non-limiting to plant growth (Table 4). Leaf analysis is best undertaken in mid to late January by sampling eg. 50-100 terminal leaflets of the last fully-expanded leaf. Leaflets should be from shoots of average vigour from trees of the same cultivar, selected at random.

Table 4. Critical nutrient levels of walnut leaves sampled in January

Nutrient	Symbol	Desired level
Nitrogen	N	2.2-3.2%
Phosphorous	P	0.1-0.3%
Potassium	K	1.2-3.0%
Calcium	Ca	>1.0%
Magnesium	Mg	>0.3%
Sodium	Na	<0.1%
Chloride	Cl	<0.3%
Copper	Cu	4-20ppm
Zinc	Zn	20-200ppm
Manganese	Mn	30-350ppm
Boron	B	35-200ppm

Fertigation equipment

Fertigation relies on introducing a known volume of nutrient solution into an irrigation pump or mainline. A simple way to accomplish this is to connect a fertiliser tank via a hose to the inlet pipe of the irrigation pump. A small tap in the hose will allow the flow to be adjusted to meter out the nutrient solution accordingly. Alternatively, a venturi may be installed in a bypass loop connected in parallel with the irrigation main. The negative pressure created by the venturi will draw the solution into the irrigation water. A hydraulic pump driven by the water pressure may also be used to operate a diaphragm pump to inject the nutrient solution into the irrigation line at a pressure above line pressure. In large systems, centrifugal pumps, operating on mains power can supply nutrient solution at pressures above that of the irrigation main. Battery operated pumps have the advantage of portability and allow the nutrient solution to be injected into any part of the irrigation system so that fertilisers can be targeted at specific areas or avoid the problem of dilution when injecting into large capacity mains. Time clocks and computer controls may be employed to automate the fertigation system.

Conclusions

Fertigation, the complimentary adjunct to microirrigation, has introduced many changes to the traditional practice of broadcasting solid fertilisers. The ability of these new systems to spoon-feed

nutrients to the crop gives the horticulturalist a powerful tool to promote higher yields and better quality produce. Although absolute amounts for each nutrient for a given crop are not always available, the guidelines that do exist provide a baseline from which to build on. By comparing the nutrition of high and low yielding crops, and with good record keeping, the grower can establish his own guidelines for nutrition. Fertigation has the flexibility to not only correct major nutritional imbalances but also to fine tune minor deficiencies. When teamed up with microirrigation, fertigation allows good management of vegetative vigour as well as fruit and nut quality by applying calculated amounts of specific nutrients introduced at strategic times during the growing season.

5.3 Canopy management

BACKGROUND

Through the process of evolution, walnut trees are genetically programmed to extend quickly upwards and outwards to out-compete neighbouring plants in a bid to capture sunlight and survive. In doing so the tree effectively shades out competition and then reproduces itself by flowering and spreading seed for a new generation to emerge. This blueprint, although effective in ensuring the survival of the species, is far from the ideal package we would want for a nut orchard. Instead we would prefer compact trees that come into nut production early, and produce high yields without shading each other in the process.

Low margins and high establishment costs have forced nut growers to seek a return on their investment in the shortest possible time. High yields, early in the life of a walnut orchard, are directly proportional to the number of trees per hectare. However, with higher tree densities more skill is needed in training, irrigation, nutrition, harvesting as well as in pest and disease control.

THE THEORY

Light interception and tree shape

A positive correlation exists between the interception of sunlight in the orchard and walnut production per hectare. Sunlight has a profound effect on not only shoot growth but flower formation, nut set, nut development and nut quality. In an umbrella-shaped walnut tree, unpruned and separated from neighbouring trees, production is limited by the shadow it casts upon itself. At a distance of more than say 1.5m in from the edge of the canopy, light levels can fall to less than 30% resulting in little or no nut production. The shape of the tree also has an effect on the canopy volume to surface area ratio. Ideally, a well-planned orchard should intercept 70-80% of sunlight falling on the land. Traffic lanes for machinery make up the rest of the land area. Sunlight interception is also influenced by tree height and therefore the maximum tree height in summer should not exceed 80% of the row width.

Umbrella-shaped trees severely shade both the interior and the lower parts of the tree as the tree gets older. Central leader or pyramid-shaped trees have better light interception even with age. Central leader trees allow sunlight to penetrate to the base of the canopy and cause less shading of neighbouring trees in the orchard.

Plant structure and hormones

The cambium layer under the bark separates the phloem or food conducting tissue from the Xylem or water and nutrient conducting tissue. Meristems (tip buds) are the areas in the tree where there is active cell division to produce growth. Meristems are present in buds and root tips as well as in the cambium layer and when active, we get shoot and root elongation as well as an increase in the diameter of stems and roots.

Hormones are chemicals that occur naturally in very small quantities in plants. Two important ones controlling the growth of trees are auxins and gibberellins. In spring, when the apical meristem on a shoot begins to elongate an auxin known as indole-acetic-acid (I.A.) produced in the apical bud moves downward in the phloem and prevents any side shoots from developing and competing. The inhibiting effect declines within a distance of around 40 to 50cm from the apical bud. Other hormones such as cytokinins and gibberellins are also important in plant function. By leaving the

apical meristem on the tip of the shoot uncut (ie. not heading the shoot) we can achieve optimum shoot growth and stem thickening. Auxins produced at the tip of the main leader of the tree restrict competition from side shoots and so the tree grows faster and stronger. Gibberellins are mostly produced in the roots and move upward in the tree. Within the tree at a point where auxins and gibberellins meet, the hormonal balance established has an influence on the angle of branches that develop from the main stem. A broad angle tends to produce a stronger union between the branch and the main stem compared with a narrow angle.

Apical or basal dominance and limb angle

Apical or basal dominance refers to the whether the tree exhibits a natural tendency to tend to grow upwards or sideways respectively. Some walnut cultivars tend to grow upwards to become tall and narrow whilst others tend to grow sideways to become shorter and wider. A tree that is normally apically dominant may lose this dominance if allowed to crop nuts too early in its life and results in a stunted tree. Apical dominance is greatest when a shoot is held vertical and dominance declines proportionally when the shoot is angled away from the vertical.

Shoot orientation close to the vertical will produce very vigorous growth whereas shoot orientation that is close to horizontal tends to set more nuts. In the latter case the tree may respond by sending up vertical shoots emanating from the horizontal shoot. A branch angle of between 45^0 and 60^0 from the vertical is believed to be the best angle for nut set. However a balance between shoot vigour and nut set is needed.

Pruning cuts

Pruning is a dwarfing process and the apparent vigour induced by hard cutting of shoots is simply the tree attempting to grow back what has been cut off. The quickest way to grow a tree is to avoid heading cuts (shoots cut by 25-50%) and to leave the leaders alone. Shoots removed from a tree by pruning should be viewed as a loss of energy that the tree has expended. Skilled training of the tree canopy involves directing tree growth into a canopy to provide a strong framework, optimises light interception and maximises nut production. The best way to do this is to remove unwanted growth by pinching out or pruning shoot tips before the tree has committed a lot of energy and resources into unwanted growth. If the shoot placement is correct but the angle is wrong, bracing or tying of the shoot at the correct angle is an efficient way to train the tree without wasting growth.

Shoot growth and nut set

The precocity, or ease with which a young walnut tree begins to set nuts early in its life, has a large impact on the growth of the tree. If the tree is growing slowly and has not filled its allotted space in the tree row before commercial cropping begins, the tree can remain stunted. Although walnut growers may welcome early production it can lead to a ceiling on yields caused by the reduced size of the orchard canopy. This dwarfing effect is caused by competition between shoots and nuts for energy sources within the tree. Removing nuts (thinning) in years one to three after planting, particularly from apical buds on leading shoots, will reduce the competition and maintain vigour in the remaining shoot. Heading back shoots to remove nuts developing from the apical bud results in a loss of wood and a loss of apical dominance. Heading shoots is the accepted practice in many commercial orchards where thinning of nuts is considered too labour intensive and expensive.

The central leader tree

Many species of fruit and nut trees have an apically dominant structure and grow naturally into a central leader tree (pyramid shape). This tree shape is one of the most efficient for light interception and crop production. Proponents of central leader trees claim that less feeder leaves are needed per fruit or nut for its development and more fruit or nuts can be produced per unit stem diameter. On the negative side are claims that central leader trees are harder to prune, more mistakes are made and the risk of sunburn may be higher. In a hedgerow orchard, walnut trees trained to a central leader shape have the potential to yield higher and for longer than either a vase-shaped or an umbrella-shaped tree.

The three-to-one rule

If we consider the framework of the tree as a system of branched pipes carrying water from the roots to the tips of each shoot. Our aim is to conduct the bulk of the water to the tip of central pipe (stem) to maintain apical dominance. Branch pipes that have a diameter close to that of the main pipe, or where we have too many pipes originating from the one point, draw too much water from the main pipe. By keeping branch pipes less than one-third (ie. 3-to-1) the diameter of the main and only one branch at each point, we maintain apical dominance of the flow of water. In a central leader tree, failure to remove branches greater than one-third the diameter of the main stem and multiple branching at one point will result in reduced apical dominance and a weak or stunted central axis in the tree.

THE PRACTICE

Pruning at planting

When planting a new orchard, trees should be cut back to four to six buds above the graft union to compensate for root loss during transplanting. This applies to both field-grown stock where major root loss may occur in cutting of the taproot and potted trees where fine roots may be lost through drying. Cutting of the scion restores the top-to-root ratio of the tree and forces strong vertical growth from one or more of the buds. In spring and early summer, a single shoot is allowed to develop and competing shoots are removed (by thinning cuts) or restricted by pinching out the growing tips. The remaining shoot develops into a single rod to form the central leader (axis) of the tree.

Pruning the first year's growth

The leader produced during the first summer may be two to three metres in height and some branching may have developed at the base. In the following winter, where trees have not grown to a metre in height it may be necessary to cut the shoot back to four to six buds again to stimulate strong growth in the following summer. Where growth of the leader is satisfactory, any branches larger than one third the diameter of the main stem should be removed. Branches less than one meter from the ground should be removed to allow for trunk shaking in the future. The remaining branches that will make up the primary scaffold should not be opposite each other but be spaced in a spiral pattern at least 30cm apart vertically and 120^0 apart horizontally. Three to four primary scaffolds are selected at this time. Where not enough branches exist, a cut (notch) made 180^0 horizontally in the bark above a well-placed bud will stimulate a shoot to grow from that point. Scaffolds should be angled at 45^0 from the vertical with the aid of string ties or spreaders cut from narrow pieces of timber or pruning sticks. Necked buds should be removed as they produce a narrow crotch angle that can lead to limb breakage.

Pruning in subsequent years

Selection of primary scaffolds should continue as described in the previous paragraph. Heading cuts can be used on primary scaffolds to remove 25-50% of the shoot length and stimulate secondary scaffolds (branching) to develop. Heading cuts stimulate the tree into producing shoot growth at the expense of nuts at the terminal ends of shoots. Pinching back shoot tips can also remove nuts with a minimum loss of wood in the tree. Heading of scaffolds is also unnecessary in terminal-bearing cultivars unless the shoot is growing in the wrong direction. Heading of the leader can upset the apical dominance and is unnecessary when the tree is growing vigorously. When the leader is headed back, a new leader must be selected and competing shoots thinned out.

Conclusion

Tree training for an intensive hedgerow planting requires a careful study of the growth habit of the walnut tree. Each tree is an individual and must be managed according to the available framework of the tree. Thinning and heading cuts, tying, spreading, pinching and notching are the main techniques involved in tree training. The methods described here are meant as a general guide only and specific advice and a demonstration of tree training can be arranged by contacting the author.

5.4 Training course

<table>
<tr>
<td><u>Weekend 1</u>
Introduction to the Walnut Industry

Origins of the walnut tree
History of the walnut industry in Australia
Economic fundamentals – profitability, productivity
Current production
Consumers – local/export
Projections for the future</td>
<td>Physiology of a Walnut Tree
Plant structure
Root structure
Trunk structure
Canopy structure
Leaf structure / function
Seasonal growing physiology
Flower structure
Pollination
Nut growth and development</td>
<td colspan="2"><u>Weekend 4</u>
Irrigation
Water source
Design options
Application methods
Water quality
Filtration
Pumping
Frost management
Water requirements for walnuts
Automatic control
Soil water relationships
Measuring soil moisture
Field trip</td>
</tr>
<tr>
<td><u>Weekend 2</u>
Soils
Soil classification
Texture
Soil properties
Soil testing
Depth
Structure
Infiltration
Aeration
Drainage
pH
Salinity
Management</td>
<td>Site Selection
Soil
Water
Aspect
Slope
Temperature
Wind
Frost
Nutrients</td>
<td><u>Weekend 5</u>
Orchard Management
Planting
Nutrition
Fertiliser/fertigation
Training
Pruning
Recognition of pests and diseases
Pest and disease management
Application of chemicals
Spray programs
Canopy management
Weed control
Spray machinery</td>
<td>Propagation
Seed treatment
Germination
Budding
Grafting
In vitro culture</td>
</tr>
<tr>
<td><u>Weekend 3</u>
Walnut Selection
Varieties
Source of plant material
Cultivar selection/breeding
Market requirements
Field trip</td>
<td>Site Preparation
Soil testing
Ripping
Marking out
Pollination
Irrigation
Nutrition
Soil modification
Field trip</td>
<td><u>Weekend 6</u>
Harvesting
Crop estimation
Nut development
Optimal picking time
Options for harvesting
Labour management
Post harvest handling
Dehydration
Sorting and grading
Handling and packaging
O.H.& S.</td>
<td>Marketing
Quality assurance
Industry standards
Marketing options
Domestic opportunities
Export opportunities
Processing
Value adding
Overseas experience
Field trip</td>
</tr>
</table>

5.5 Setting up the orchard trial according to the Tatura method

The following series of steps were used in setting up a walnut orchard

1. In autumn, the orchard treelines were pegged out accurately and the irrigation mains installed, running across the treelines.
2. Lime when necessary (determined by a soil test to achieve a target pH of 6.5) was spread over the whole area and incorporated with a rotary-hoe.
3. A Road Grader was used to move the topsoil from the centre of the traffic line to the treeline to create a bank approximately 0.5m high.
4. Irrigation laterals and microjet sprinklers (output 5-10mm hr^{-1}) were installed and the plot irrigated for 3 hours.
5. When the soil had drained to around Field Capacity (10kPa matric suction), the entire orchard was cultivated with a power harrow and the soil surface smoothed.
6. Gypsum when necessary was applied in a 2m wide strip along the treeline.
7. The orchard was sown to perennial ryegrass and irrigated for 2 hours.
8. In late winter, the ryegrass sward was mown close to the ground.
9. The 2m wide strip was cultivated (0.2m depth) with a power harrow and the soil surface smoothed.
10. The trees were planted and the soil around the tree was not compacted but watered lightly to prevent slumping of the soil.
11. A mulch of straw (0.1m thick) was applied in a 2 m wide strip on the treeline.
12. In spring/summer, herbicides were used to control weeds in a 2m wide strip on the treeline.
13. In spring/summer, the orchard was slashed and the clippings delivered onto the treeline to supplement the straw mulch.

6. REFERENCES

Adem, H.H. (1993a). Soil management in orchards. 3rd Annual Conference, Australian Nut Industry Council. Mt. Evelyn, July.

Adem, H.H. (1993b). Farm mechanisation. 3rd Annual Conference, Australian Nut Industry Council. Mt Evelyn, July.

Adem, H.H. (1994a). Propagation and management for vigour of walnut trees. Aust. Walnut Ind. Ass. Seminar. Tatura, March.

Adem, H.H. (1994b). The Tatura soil management system for orchards and vineyards. Hortplan,Soil Management Workshop. Griffith, May.

Adem, H.H. and Aumann, C.D. (1994). Soil management for maximum production and early bearing from nut trees. 4th Annual Conference, Australian Nut Industry Council. Mildura, August.

Adem, H.H. (1994c). Hedgerow planting for high yields of walnuts. 4th Annual Conference, Australian Nut Industry Council. Mildura, August.

Adem, H.H. (1994d). The walnut industry in California. Australian Walnut Industry Association workshop. Tatura, December.
Adem, H.H. (1994). Tatura Permanent Beds. Department of Soil and Environmental Science, University of California, Riverside, USA, September.

Adem, H.H. (1995). Growing walnuts in Australia and California. La Trobe University seminar program. Bundoora, May.

Adem, H.H. and Aumann, C.D. (1995). Walnut production on a shallow clay-pan soil in southern Australia. III International Walnut Congress. Alcobaca, Portugal, June.

Adem, H.H. and Aumann, C.D. (1995). Soil and water management for nut trees. 5th Annual Conference, Australian Nut Industry Council. Orange, August.

Adem, H.H. (1996). Sustainable production in nut trees. 6th Annual Conference, Australian Nut Industry Council. Albury, August.

Adem, H.H. (1997). A simple, low-cost harvester for nut crops. 7th Annual Conference, Australian Nut Industry Council. Mildura, July.

Adem, H.H. (1998). Walnuts. In: The New Rural Industries – A Handbook for Farmers and Investors. Ed: K. Hyde. RIRDC.

Adem, H.H. (1998). The walnut research program in Australia. Institut de Recerca I Tecnologia Agroalimentaries, Reus, Spain, October.

Adem, H.H. and Aumann, C.D. (1998). An approach to sustainable management of soils under irrigated crops. Australian Society of Soil Science Incorporated, National Soils Conference, Brisbane, April.

Adem, H.H. (1999). A report to industry on the walnut industries in France and Spain. Aust. Walnut Ind. Ass., Seminar. Tatura, March.

Adem, H.H., Jerie, P.H., Aumann, C.D. and Borchardt, N. (1999). High yields and early bearing for walnuts. RIRDC.

Begg, E.L, Huntington, G.L and Wildman, W.E. (1998). Evaluation and Modification of Soils. **In:** Walnut Production Manual. (Ed. D.E. Ramos). **6**. 39-53. University of California, Division of Agriculture and Natural Resources. (Communication Services-Publications).

Bean, R., 1992. Nut imports into Australia. *Australian Nutgrower*, 31.

Catlin, P.B and Schreader, W.R (1985) Root Physiology and Rootstock Characteristics, **In:** *Walnut Orchard Management*, (Eds.Ramos D.E.) **15**, 75-81. Division of Agriculture and Natural Resources, California.

Burt, C., O'Connor, K. and Ruehr, T. 1995. *Fertigation.* Irrigation Training and Research Centre, California Polytechnic State University (Pubs).

Catlin, P.B (1998) Root Physiology and Rootstock Characteristics, **In:** *Walnut Production Manual..,*

(Ed. Ramos D.E.) **15**, 119-126. Division of Agriculture and Natural Resources, California.

Chiba, M.V (1993) Walnut growing in Australia: an industry perspective. *Acta Horticulturae,* **311**, 234-239.

Germain, E., Lespinasse, J.M., Reynet, P. and Bayol, M. (1977) Orchard training of lateral fruit-bearing walnut varieties. Assessment of trials carried out in France. Proc. III Int. Walnut Congress. Ed. J.A. Gomes Pereira. Acta Hort. 442. ISHS.

Hassall and Associates (1999) Walnut production **In.:** *The new rural industries, financial indicators*. (Ed. Hyde, K.W.) 41.

McNabb, S., Schneider, H. and Jerie, P. 1995. *Efficient Fertiliser Application in Orchards.* Agriculture Notes, Natural Resources and Environment. AGO240, ISSN 1329-8062.

Mapelli, S., Lombardi, L., Brambilla, A., Iulini, A. and Bertani, A. (1997) Walnut plant selection to hypoxic soil resistance. *Acta Horticulturea,* **442,** 129-132.

Nelson-Parker, N., (1992). Walnuts as a crop. *Australian Nutgrower*, 47-48.

Ramos, D.E. (1998). (Ed.) Walnut production manual. University of California, Davis.

Reil, W. (1998) Seed-seedling-grafted tree comparison trials. *Walnut Research Reports*. Walnut Marketing Board. 129-133.

Ross, N.W., Rizzi, A.D., Aldrich, T.M., Ramos, D.E., (1982). Training young walnut trees by the modified central leader system. Cooperative Extension, University of California.

Sibbett, G.S., Coates, W.W. and Edstrom, J. Orchard planning, design and planting. **In:** Walnut Production Manual. (Ed. D.E. Ramos). **6**. 39-53. University of California, Division of Agriculture and Natural Resources. (Communication Services-Publications).

Somerville, W. (1996). Pruning and training fruit trees. Inkata Press

Van den Ende, B. (1997) Turn wood into profit, Proceedings of a one-day workshop. NVFA and Goulburn Ovens Institute of TAFE publication.