

# White Asparagus Production

**For the Gourmet Market**

A report for



By Richard Weston,

2012 Nuffield Scholar

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# Executive Summary

Current demand for white asparagus exists within the high end Australian restaurant market. The restaurant industry is reliant on fine quality, seasonal fresh produce that can be sourced locally and value added, ensuring customer satisfaction and return visitation.

There is currently no white asparagus industry within Australia. No findings on volumes, growth and consumption statistics have been recorded. However, 98 per cent of asparagus consumed in the Netherlands is white, with 750 growers and with a market value of 50 million Euros (as at 2012). In comparison, 99 per cent of asparagus consumed within Australia is green, with 73 per cent exported overseas to Japan.

Much of the information provided in this report is based on research, advice and significant learnings gained from the author working alongside world leading white asparagus breeders, producers and companies. The report outlines the framework for the future trials of white asparagus production in Tasmania and focuses on varieties and soil conditions, as these are the two main elements for the industry's success in Europe.

White asparagus requires specific climatic conditions. Tasmania's temperate maritime climate, abundant water and rich soils would provide a perfect location for trialling a fledgling industry. In addition, soil types within Tasmania have many characteristics in common with the Netherlands and Germany. In the Netherlands, white asparagus is predominately grown in sandy loams and in Germany in clay loams. Tasmania has a combination of both soil profiles.

To establish an industry, appropriate trialling and evaluation under Tasmania's particular growing conditions will be critical for the potential emergence of the white asparagus industry.

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All Photos supplied by Richard Weston

# Foreword

Weston Farm was established by my wife, Belinda, and I in 1993 in the semi-rural outskirts of Brighton, an outer city suburb north of Hobart. Up until 2010, the farm concentrated on growing award winning olive oil and specialising in growing and exporting herbaceous Peony Roses as cut flowers.

In late 2009, we started growing a range of vegetables such as burdock, kohlrabi, and salsify, aiming for the local high-end restaurant trade. Within a relatively short timeframe we were supplying five restaurants. One restaurant in particular, Garagistes – co-owned and operated by Luke Burgess (voted best up and coming chef in Australia 2011-2012 by Gourmet Traveller 2012) – has been important in this expansion. Luke previously worked extensively throughout the world, including time at Noma, which has won the *Restaurant* magazine award for Best Restaurant in the World three years in a row, dating back from 2010. It was during one of our many conversations about potential vegetable crops for the high-end restaurant market that we identified white asparagus as a promising option, noting its lack of availability in Australia and the strong potential for growing it in Tasmania.

With some initial background research into the white asparagus industry within Australia and then during a two month practical study trip in a number of key European locations, it became very clear to me that there was an opening for a niche market to be established in Tasmania, and possibly elsewhere in Australia.

I am extremely fortunate to be working closely with and supplying some of Tasmania's leading and talented chefs, who are passionate about ensuring that each dish celebrates fresh, local produce. My discussions with them both prior to and following my research trip indicate that white asparagus would significantly add to this partnership. The product presents well, has a great flavour and can be served in many different ways. If it can be successfully grown in Tasmania, white asparagus could become an exciting new addition to the state's high end restaurant and specialist agricultural industries.

My studies of white asparagus, including my research tour of key growing areas in Europe, was supported by Bayer International's vegetable seed research facility, Nunhems, in the Netherlands. Nunhems is headed by Dr. Ben Silvertand, a world leader in white asparagus breeding and production. I also worked on a daily basis with Leo Winkelmolen, an assistant plant breeder and white asparagus farmer, travelling with him to Spain and Germany

assessing new trials of white asparagus. Will Teeuwen, the general manager of Teboza, which is a family business that is well versed in growing and marketing asparagus for generations, also assisted in my studies. I would like to express my sincere thanks and gratitude to these gentlemen, whose advice and support made my study trip a most productive – albeit extremely busy and, at times, exhausting – experience.

My journey into the world of white asparagus would not have been possible without the incredible organisation that is Nuffield Australia and the financial support of my sponsors, and the ongoing support of my family.



# Acknowledgments

My family have been a source of boundless support throughout my Nuffield experience. Without their constant encouragement and belief it would not have been possible for me to fulfil my obligations as a 2012 Nuffield Scholar. Also I would like to thank my extended family and friends for assisting my wife Belinda and my children Lloyd and Campbell, during my two month absence from the Weston Farm and family life.

Thank you to Nuffield Australia for their courage and vision in selecting me as a scholar, along with my supportive financial sponsors Impact Fertilisers and the Tasmanian Government.

Thank you for the friendship of my fellow Nuffield Scholars, who have shared the experience and have helped see me through the Nuffield journey, along with their supportive partners who kept in regular contact with my wife and family.

A special thank you to Dr Ben Silvertand and the white asparagus team at Nunhems Bayer, as this report would not have been possible without their assistance, time and knowledge.



*Figure 1: Photo of the author with the white asparagus trialling team at the Nunhems Research facility Nunhems.Netherlands (4/5/2013)*

# Abbreviations

TSV – Tobacco Streak Virus

AV-1 - Asparagus Virus 1

AV-2 – Asparagus Virus 2

EAA – European Asparagus Aphid

TPB – Tarnished Plant Bugs

APB – Alfalfa Plant Bugs

N – Nitrogen

CaCO<sub>3</sub> – Limestone

P<sub>2</sub>O<sub>5</sub> - Phosphate

K<sub>2</sub>O – Potash

Dioecious plants produce a male plant and a female plant, and not usually a single plant with both male and female, eg, *Ginkgo bilobas*

# Objectives

The main aim objective of this report is to fully describe all aspects of the international white asparagus industry, including:

- Climatic conditions
- Soil agronomy
- Varieties
- Production and harvesting methods and issues
- Post-harvest production and storage
- Field establishment
- Production methods applicable to the Tasmanian and Australian context.

# Chapter 1 – Introduction

Asparagus has been a valued vegetable since its early domestication, not only for human consumption, but also for its medicinal properties. Nowadays its cultivation occurs in all continents, with steady incremental growth of the planted area, due to an increased consumer demand for fresh, canned and frozen asparagus. Over the past ten years, the largest increases in asparagus production have occurred in countries such as Peru and China, which have low labour rates and therefore the possibility of marketing their production when prices are high in other countries or hemisphere (Benson, 2002).

Some seed companies have taken advantage of this expansion and have responded to expanding demand and production by developing hybrids that are adapted to new production areas and cultivation strategies. However, the development of new varieties – which are highly productive and tolerant of the most frequent diseases, and also have high market quality – will be the major challenge for breeders in the coming years.

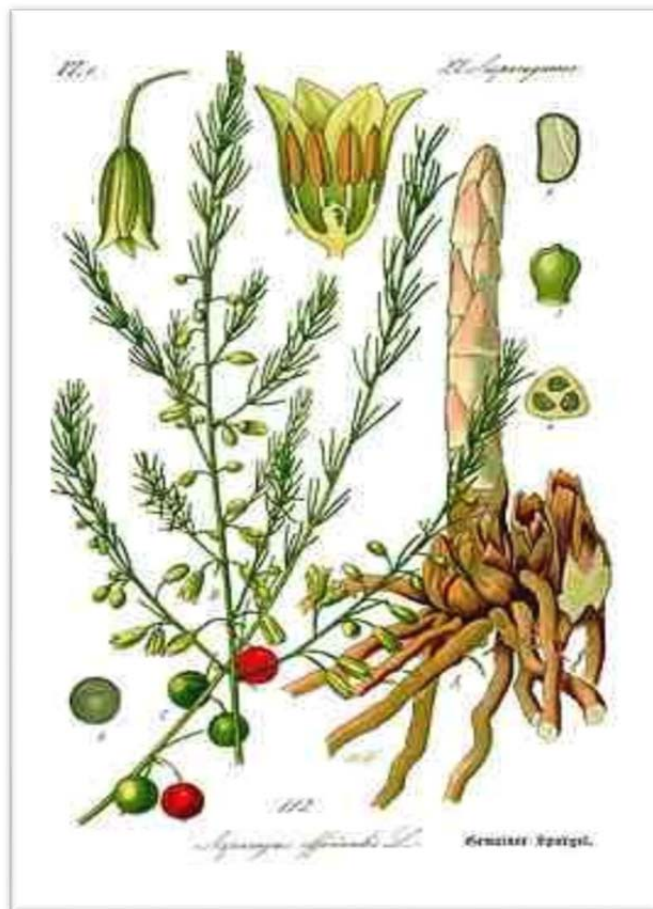


Figure 2: German botanical illustrations of asparagus (Wikipedia, November 2009)

## The History of Asparagus

Asparagus is a large genus comprising about 150 species of herbaceous perennials, tender woody shrubs and vines. While some species are grown for their ornamental value and foliage, only one (*A. officinalis* L.) is grown for food purposes (Bailey, 1942). Three subgenera, *Asparagus*, *Protoasparagus* and *Mysiphyllum* can be recognized (Clifford and Conran, 1987). The species of the first subgenus are dioecious<sup>1</sup>, while those of the other subgenera are hermaphrodite. Asparagus species are naturally distributed in Asia, Africa and Europe. Many of them have economic value as ornamentals (*Asparagus plumosus*, *A. densiflorus*, *A. virgatus*) or for their medicinal properties (*A. racemosus*, *A. verticillatus*, *A. adscenens*) (Stajner et al., 2002). The search for young, tender shoots as a tasty vegetable of the wild species *A. acutifolius* has cultural roots in Spain and Greece (Ellison, 1986). However, the only worldwide cultivated species for tender shoots of either blanched (white) or light exposed (green) is *A. officinalis* (hereafter referred to as ‘asparagus’ or ‘cultivated asparagus’).

The postulated regions of asparagus origin are Eastern Europe, Caucasus, and Siberia where supposedly it was domesticated (Sturtevant, 1890). Greeks and then Romans took the culture of growing asparagus from eastern nations, from which they also took the old-Iranian word ‘sparega’ (which means shoot, rod, spray), becoming ‘asparagos’ and ‘asparagus’ in Greek and Latin respectively. One of the first detailed guides on how to raise asparagus is traced back to about 65 A.D. by the Roman, Columella (Luzny, 1979). Romans spread the culture of growing asparagus, along with the Empire, throughout Europe. There is also evidence that crusading troops brought asparagus seeds from Arabian countries to the Rhine valley around 1212 (Reuther, 1984). Throughout Europe, with the exception of Spain (Knaflewski, 1996), the decline of the Roman Empire brought a decline in its cultivation, which was then confined to some feudal lords and monastery gardens as a medicinal plant until the Renaissance, when it was rediscovered as an appreciated vegetable (Luzny, 1979).

The perennial part of the plant is the rhizome (crown), which is composed of clusters of buds with primary fleshy (storage) and secondary fibrous (absorbent) attached roots. The buds sprout rendering the edible organ, a tender growing shoot (spear) between 18-25 cm long. Once harvests are discontinued, shoots continue to grow becoming the aerial part of the plant (fern), which is responsible for the replenishment of carbohydrates and accumulation until the next harvest season. The full expanded stems, between a few to 50 or more per plant

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<sup>1</sup> Dioecious plants produce a male plant and a female plant, and not usually a single plant with both male and female, eg, *Ginkgo bilobas*

depending on age, sex and cultivar, have long internodes and can vary in height between 30 and 200 cm. Each stem contains primary and secondary branches where flexuous cladodes (10-25mm) are disposed in whorls (see Figure 2 above).

In normal temperate field conditions, flowering starts in the second year from seed germination, however, some plants can flower at the end of the first year. Flowering occurs in flushes, with up to three flushes per year. Anthesis in each stem begins once it is almost expanded, following an apical direction in the main stem and in primary and secondary branches. Depending on air temperatures, blossom in each stem can last up to two weeks.

Normal sex ratio, in out-bred populations and cultivars is 1:1 staminate (male) to pistillate (female) plants; however, some hybrid cultivars are composed of entirely male plants. Natural pollination is conducted by bees and bumblebees, and normally makes plants flower earlier and produce many more flowers than females. Fruits, which are reddish berries when mature, bear up to ten (normally 6-8) round black seeds. A three year old or older female plant produces more than 2,000 flowers and has the potential to produce more than 10,000 seeds (Machon et al.,1995).

## **White Asparagus Production within Australia**

In the course of this study, Joe Vizzarri, one of Australia's largest asparagus producers and a member of the Australian Asparagus Council, was interviewed about his knowledge and views regarding the production of white asparagus in Australia. Mr Vizzarri oversees 24 properties totalling 566 hectares of asparagus. His production runs for seven months of the year, resulting in 4,000 tonnes of asparagus exported per year.

Mr Vizzarri (February 2013) advised that, at present, there is very limited white asparagus grown in Australia due to the low demand for the product. However, he also acknowledged that he has continual requests for white asparagus produce from high end restaurants and went on to say that there is an opportunity to fill the void in this niche market.

Mr Vizzarri went on to express his interest in purchasing white asparagus if there was any surplus production available.

# Chapter 2 – White Asparagus planning for open field production

Based on the author's research, observations, and advice from producers on tour it is concluded that the planning of white asparagus is, largely, similar to that for green asparagus. However, there are some notable differences. The common aspects and white asparagus-specific considerations in open field production planning are explained below.

## Climate

Asparagus has adapted to a diverse range of climates, from temperate to subtropical zones. It requires a vegetative growth period of sufficient length to renew the carbohydrate reserves in the crown, which is the source of new spears. Sprouting of the buds in the crown, which produce the new spears, begins at the temperatures of 10°C or above. The optimal temperature for growth is between 18°C–29°C. However, the drier the site – especially during the harvest season – the better will be the spear quality. Also, rust and other diseases will be less severe (ADC, 2001). White asparagus is a water-stress tolerant plant and will take extremes of hot and cold conditions. The climate in Tasmania – with an average summer temperature of 25°C and a winter average temperature of 12°C, and an average rainfall of 625 ml per year (with the wettest period between June and October) – provides ideal conditions for white asparagus production (Australian Bureau of Meteorology website).

## Field Selection

The criteria used in the selection of the field to be used for white asparagus production should include soil type and fertility, slope and drainage, presence of perennial weeds, and location with respect to the packing shed and cooling facilities.

Deep, well-drained soils with a sandy loam to loamy texture are best suited for white asparagus production. A small clay fraction and high organic matter content improves the cation exchange capacity of the soil and provides conditions for good soil tilth. Liberal amounts of organic matter and animal manure should be incorporated into the soil before transplanting and on an annual basis thereafter. This will improve soil tilth and lower the need for commercial fertilizers. At least 10 tonnes of manure/organic matter should be applied to an area beneath the planting furrow before transplanting. An additional five tonnes per hectare of manure/organic matter should be annually applied, about 10 cm deep and five cm wide on

both sides of the row. The bands should be 35 to 45 cm away from the bed centre. Optimal soil pH is between 6.0 to 7.0 (ADC, 2001).

Compared to other vegetables, asparagus is fairly tolerant of salts. Electrical conductivity of the saturation extract of soil can be as high as 10m/mhos with no reduction in yield, depending on irrigation management. Maintenance of 3 to 6 per cent organic matter in the soil improves soil tilth and the utilization of pre-emergent herbicides. A soil that will not form a hard crust after rainfall and can be cultivated into a loose, friable condition is best for asparagus growing. Stones and severe crusting can cause abrasions to the spear sides and cause crooked spears (ADC, 2001).

The subsurface soil characteristics are also very important as asparagus can be a very deep-rooted crop (up to 1.5 metres in root depth). Deep soils that lack impermeable hardpans allow excess soil moisture to move out of the root zone thus reducing the severity of damage caused by pathogens and anaerobic conditions. Since most of the storage root system on asparagus is found below the 60 to 90 cm soil depth, the pH and fertility of this soil should be evaluated prior to planting. Ripping and deep ploughing of soil and incorporation of soil ameliorants should be considered for less than optimal soil types. The installation of drainage tiles to remove excess water and salts is of definite value in this crop since a well aerated subsurface profile allows maximum root growth (ADC 2001).

The author's observations and research indicate that the different cultivation and harvesting aspects of white and green asparagus require the selection of a specific soil type for each. White spear production requires that the soil be very light or well aggregated so that the physical impedance to the cutting knife is low. The organic matter, tilth and aggregation of the soil covering the crown will affect the quality of the white spear by influencing the spear diameter and colour of the tip. A finely aggregated soil will allow the white spear tip to stay completely covered from light while a coarsely aggregated soil would allow light penetration and subsequent pigmentation of the spear (ADC, 2001).

Field slope and drainage of surface waters should be sufficient to provide for acceptable means of irrigation and to remove excess water during rainy periods and following irrigations. Water drainage is important in reducing the water saturation of the soil profile, as prolonged saturation predisposes the asparagus plant to stress and provides a medium for the fungal plant pathogen *Phytophthora megasperma* sporulation and infection.

Mr Leo Winkelmolen, Assistant Asparagus Breeder at Nunhems (March 2013) advised that white asparagus should always be grown on raised beds, about 40 cm above the soil level. Fields with perennial weeds present should be avoided. If fields are selected for asparagus



production that contain perennial weeds, measures should be taken to eradicate the weed problem prior to planting.

Asparagus should not be planted in fields that were cultivated with asparagus within the previous eight years. Planting asparagus into an old asparagus field may cause an allelopathic response or suppression of growth of the new plants by substances that are released from old root pieces in the soil.

## **Field Establishment**

There are three ways of establishing white asparagus fields: through direct seeding, transplanting one year old crowns and transplanting seedlings. Each method has advantages and disadvantages. The most practical method of establishing white asparagus plantation is by purchasing seed and producing seedling transplants.

### **Direct Seeding**

Direct seeding requires considerable expertise. Seed beds must be thoroughly prepared, and irrigation may be needed if dry weather persists. Weeds can also be problem for cultivation.

Direct seeded asparagus fields are usually planted in pre-formed, flat bottomed furrows. In direct seed furrow planting, the beds are 1.5 m apart with the furrow bottoms 20 cm below the prepared soil surface. One single row furrow, spaced 1.5-1.8 m cm between rows, is usually used. Once plant growth has developed enough to permit cultivation without covering the young plants, the furrows are gradually closed with cultivators or hoes until the soil surface is level. This should be completed by autumn. Finally, the row spacing will be about 15 cm between plants. Plant density will be about 44,500 plants per hectare. This will require approximately two kilograms of seed per hectare. Seed is slow to germinate and seedling emergence may require many days, depending upon soil moisture and temperature. At a soil temperature of 20°C, emergence occurs in about 15 days, but at 15°C about 24 days are required (ADC, 2001).

Research and advice provided to the author confirm that the advantages of direct seeding include more spear numbers and total production per acre, as well as earlier completion in many cases. The disadvantages include small spear sizes, possible shorter bed life, potential weed competition problems, and higher seed cost.

### **Crown Planting**

One year old crowns grown the previous year in a nursery bed are used to plant the field. To grow the crowns select a level, fertile, well-drained, weed free field that has no previous

history of asparagus production. Light-textured soils are best for ease of digging. Soil pH should be 6.0-7.0. After ploughing, apply fertilizer in accordance with soil test and incorporate into the soil surface. Manure at the rate of 10-15 tonnes per hectare can be substituted for part of the chemical fertilizer if it is free of weed seeds.



*Figure 3: Photo of crown planting taken at Roermond, Netherlands (16/4/2013)*

In the nursery, seed is drilled 2.5 to 4.0 cm deep in rows about 30 cm apart on twin-rows, 100 cm beds or on single-row, 75 cm beds, at the rate of 2.3 to 6.5 kg /hectare. To make digging and separating the final stand easy, and to avoid crown damage, plants should be about 7.5 cm apart. If planting is sufficiently early, the nursery should yield 200,000 to 250,000 usable crowns per hectare. Proper spacing of seed should be done to avoid having to thin out the plants in the nursery (ADC, 2001).

White asparagus needs a good supply of moisture available at all times for uniform growth. Keeping the soil moist is especially necessary near the surface, before the seeds sprout, and when the plants are small. The author supervised the grading of white asparagus crowns by approximately 50 contracted workers at the Teboza Asparagus production facility at Helden in the Netherlands. At the end of the first growing season, the tops are cut, raked up and burned. After digging, the crowns are separated and graded.



*Figure 4: Photo of crown lifting taken at Teboza Farm at Helden, Netherlands (28/3/2013)*

Dr Ben Silvertand of Nunhems (March 2013) advised that there are three specific grades of crowns:

- A grade – which weigh between 45-70 grams;
- B grade – which weighs between 25-45 grams; and
- C grade – which weigh up to 25 grams.

Crowns that are severely injured should be discarded. It is normally recommended to divide the crowns; a larger one can be separated into five or six parts for planting as separate crowns, unless the individual sections are too small. Crowns should be planted immediately into the production field if possible. Where inclement weather may prevent planting, they should be dug and held in cold storage, loosely packed in well ventilated cool store at 2°C and 90 per cent relative humidity. This approach was observed at Teboza's and Nunhems' facilities. Drying and freezing of crowns should be avoided. Dip crowns in a recommended fungicide solution before planting (ADC, 2001).

Prior to planting the crowns, the fields should be furrowed out in late winter when conditions are right. Fertilizer is generally applied at this time. The crowns are placed in the bottom of 20-25 cm deep trenches spaced 15-20 cm apart down the row, depending on variety. The trenches (eventual beds) are spaced 1.5-1.8 m apart. The crown should be place by hand in an

upright position with the roots spread out or alternatively, by a planting machine (ADC, 2001).

The operation of the planting machine, a highly efficient and precise way of planting large hectares, was observed at Teboza's and Nunhems' facilities. The machine is attached to the back of the tractor and two people sit either side placing the crowns onto a wheel that rotates and holds the crowns in place. As the crowns make contact with the soil, it places them into position at the base of the prepared furrow and covers the entire crown over. Depending on the speed of the crown placers, it is possible for two people to plant between 120 – 150 crowns per minute. Subsequent irrigations should be made as needed to sustain normal growth. The crowns are then allowed to grow all year without cutting. Furrows are gradually filled in, without completely covering the growing spears, until the land is level or slightly ridged over the plant row. Plant population is 18,750 to 25,000 plants per hectare. It must be noted that crowns are not permitted to enter into Australia due to strict quarantine regulations. However, seed is permitted as long as it is certified and has all the appropriate sanitised certificates.



*Figure 5: Photo of crown planting activity taken at Roermond Netherlands (16/4/2013)*

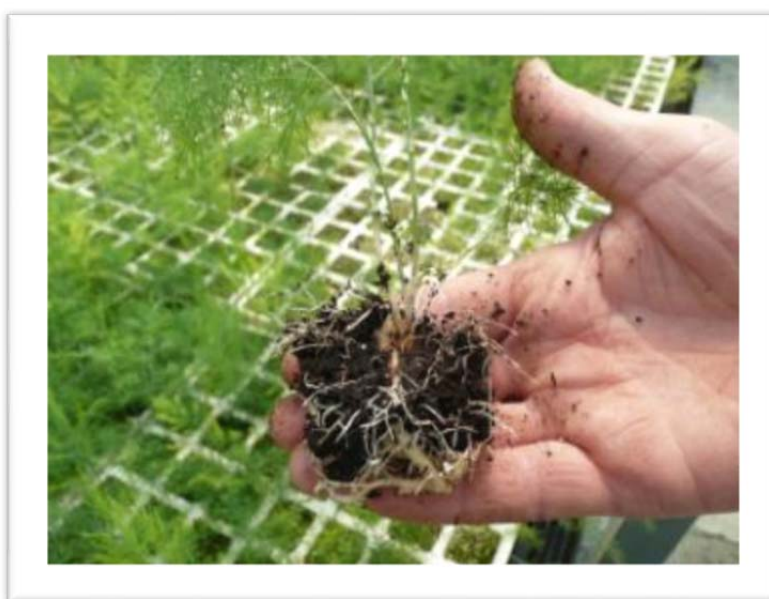
The advantages of crown planting include greater efficiency, good spear size and production and long bed life potential. Some disadvantages include less than perfect stands and more disease problems. Commercially, asparagus crowns often are dug in the autumn in temperate growing areas after the tops are completely killed by frosts. The crowns are separated and then stored at temperatures a few degrees below freezing and at 85% - 90% relative humidity. Crowns may be advertised as one or two years old. It is questionable practice to plant two

year old crowns, and never plant three year old crowns. The older the crowns, the greater the injury when they are dug up.

### **Seedling Transplanting**

Whilst working with Mr Leo Winkelmolen (April 2013) at the Nunhemsresearch facilities, the author observed the practice of growing and producing seedlings for transplanting.

The author observed that seedlings are usually produced in greenhouses and transplanted into commercial fields when they are 10 to 12 weeks old. Mr Winkelmolen (April 2013) confirmed that a survival rate of 92-98 per cent can be expected in the field.



*Figure 6: Photo of asparagus seedling taken at Nunhems Research Facilities (19/4/14)*

An advantage of using transplants is that the grower can transplant anytime, weather conditions permitting. Transplants can be grown in preformed trays with a plant density of one plant per every 10-16 square cms.

A greenhouse temperature range of 18°C (night) minimum to 29°C (day) maximum provides good germination and plant growth. Irrigation and fertilization needs vary with the existing climatic conditions, soil mix, and the age of the seedling. Initial nutrient requirements can be met by incorporating a complete fertilizer containing micronutrients into the soil mix.

The frequency of irrigation and fertilization is dependent on the size of the plant growing cells and the original fertility of the soil mix. Irrigation is generally required every two or three weeks with a complete nutrient solution containing the minor elements. High temperatures and too much nitrogen result in large tips and poor root development. If plants begin to get too



large, growth can be slowed by reducing the temperature to 10°C-15°C, but do not over-harden.

As observed at a farm near Seville in Spain the field is prepared by furrowing out 15-20cm deep for beds 1.5-1.8 m apart. Fertilizer is then applied prior to planting or will be mixed in the transplant water at planting. The young seedlings are transplanted with down the row spacing at 15-20 cm between plants, depending on variety. About 0.25 litres of water is applied with each plant at transplanting and the rows are wheel pressed on each side of the planted row to ensure good soil moisture contact with the transplants.



*Figure 7: Photo of asparagus trial plantings taken at Seville, Spain (23/4/2013)*

The advantages of seedling transplanting include:

- excellent stand survival and uniformity,
- earlier return on investment, earlier production, and
- possibly higher production per hectare.

Some of the disadvantages are that initial stand establishment costs are higher and there is potential for weed competition problems.

In all three methods of planting (except direct seeding) where furrows are used, light cultivation is practised so that soil is thrown into the furrows during the course of the first growing season, keeping weed competition to a minimum but allowing the young asparagus fern and crowns to develop. By season's end, the furrow or trench will be filled in to field level with the developing crowns buried 20 cm deep and the resultant fern growth 0.6-1.0 m

tall above the soil surface. Post emergence herbicide treatments are also used during the initial establishment season along with cultivation, once the fern has reached appropriate height. The tops should be cut to the ground at the end of the first growing season (in winter). Prior to the start of the first cutting season, soil will be mounded into planting rows creating a raised bed 40 cm above the field level (ADC, 2001).



*Figure 8: Photo of soil mounding at Teboza farm taken at Horst, Netherlands (3/4/2013)*

Originally, the beds were raised by manual labour, but these days it is undertaken with a tractor with a cultivator mounted on the front. This in turn works the soil and passes beneath the tractor where it is cultivated a second time. It is then fed through a bed former. This preparation is undertaken in late winter so that no damage can occur to the asparagus crowns. The author observed bed raising at various locations, including Teboza's farm at Horst (see above photo).

Typically, deeper planting of the crowns results in fewer spears of increased diameter and weight. Also, increased planting density results in more spears of reduced diameter and weight.

After a one year establishment period, it is possible to harvest in the second year for a period of 10 days. After the asparagus harvest period is over the tops are allowed to grow to replenish the carbohydrates in the crown. During the third year, asparagus can be harvested for a period of six weeks and in the fourth year they will be harvested for a period of eight weeks. At end of each harvest season the spears are allowed to grow vegetatively for a least 4-6 months before cutting the growth back to soil level. Avoid leaving any plant stubble above ground as this may serve as a source of inoculum for rust and other diseases. The asparagus

vegetation removed from the field should be burned or used as organic matter on non-asparagus fields. Old asparagus vegetation exerts an allelopathic effect which will suppress new spear growth. After the tops have been disposed of, the field is disced or roto-tilled lightly, and a low ridge of soil is left over the rows to hasten decomposition of the stubble (ADC, 2001).

## **Plant Depths and Spacing**

The bottom of the furrow should be 20 cm below the level soil surface for roots, transplants, or direct seeding. Do not plant into subsoil.

Spacing between and within rows for white asparagus are the same for both crowns and transplants. Recommendations for between row distances are 1.5 to 1.8 metres. Consultant at the Dutch firm, New Standard Asparagus, Mr Michel Neefs (May 2013), advised the author that recommendations for within row spacing are determined by the variety being planted, for example Magnus F1 is suited to 20cm spacing, ensuring high quality thick spears, whereas Grolim F1 is suited to high density plantings 15 cm between crowns. In the earlier years of harvest, yields are likely to be higher from closer spaced plants, whether within or between rows. Eventually these differences will decrease. Spears may be smaller from crowded plants during the early life of the asparagus field.

## **Varieties and the Development of new varieties**

There are numerous asparagus cultivars grown worldwide. It takes several years of testing to determine which are the most suitable cultivars for a particular region. Some varieties that yield well in the early years may have a short life span. Results often are variable (ADC, 2001).

The author has considered trialling in Tasmanian climatic conditions, specifically, and is of the view that the following cultivars have good commercial potential:

- Vitalim F1 – A male hybrid, very early production, high yield potential, long profitable lifetime, uniform quality and grade.
- Gijnlim F1 – Suitable for white and green production, very early production, exceptionally high production potential, extremely suitable for forced production.



- Avalim F1 – Suitable for white and green, very early production, good spear thickness and of excellent quality, ideal for extra early forcing, strong foliage, and little susceptibility to foliage disease.
- Cumulus F1 – 100 percent male. Very white asparagus, a very early variety giving high yields. High quality thick and very smooth skinned spears. Good tip closure, strong against hollow spears and rust.
- Thielim F1 – High production potential, uniform quality and grades, straight smooth stems with good thickness. Highly suitable for peeled processing. Strong foliage. Little susceptibility to foliage diseases.
- Grolim F1 – The ideal variety for bumper harvest. Early production. Exceptionally high production potential. Uniform diameter and quality grades. Ideal for high planting densities.
- Magnus F1 – A 100 percent male variety, very white asparagus. Mid-early variety with a high yield. High quality thick and very smooth skinned spears. Good tip closure and strong against hollowing spears.
- Herkolim F1 – The variety for the highest yield. Highly uniform quality and grades. Exceptionally high production potential. A good choice for replanting. Ideal for high planting densities<sup>2</sup>.

## **The Development of New Varieties**

Nunhems Bayer, Limseeds and Bejo Seeds all have extensive varietal trials ongoing. While at Bayer Research Institute, Nunhems, the author worked intensively with Senior White Asparagus Breeder, Dr Ben Silvertand. Discussions with Dr Silvertand (April 2013) and others confirmed that the trialling of new asparagus is constantly challenging and highly complex.

This section of the report attempts to describe some of the key elements of white asparagus trialling without going into the scientific and other technical complexities, based on the author's observations and information from Dr Silvertand and Mr Leo Winkelmolen in particular, while working at Nunhems research facility.

Trialling starts with the selection of parent plants, usually one male and one female. The idea of crossing the two parent plants is to hopefully incorporate the best genetic traits. An

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<sup>2</sup> It should be noted that while the varieties listed have been selected by the author as having the greatest commercial potential in Tasmanian conditions, the descriptors of each variety have been sourced from material produced by asparagus breeding company Limseeds.

example of such a cross could aim to combine rust resistance from the female and the uniformity of spear size from the male.

To guarantee that there is no cross pollination from other asparagus plants, male or female, the selected parents are grown in large tubs placed into specially constructed polyethylene covered greenhouses. In late spring, the selected parents are placed inside; one male to six females is the normal ratio. Once the male and female parents are in full flower a secondary cover is then placed over, to ensure no chance of cross pollination.



*Figure 9: Photo of bee boxes waiting for collection at Mertens Warehouse at Horst.Netherlands (4/4/2013)*

At this point, a box of bees is placed inside the secondary tent for a duration of four weeks. Once pollination has occurred the bees are then removed and the plants are left to grow throughout the summer and into the autumn. In late autumn the asparagus produces bright red berries, which contain 6-8 black fertile seeds. The seeds are then collected, processed and stored for the following spring sowing. Six female asparagus plants can produce up to 1,000 seeds in the first year and every year after up to 4,000 seeds.

### **New variety assessment**

The trialling and selection of new varieties is a four year process and is generally consistent across the industry. The selected 400 seedlings are planted in late winter early spring, and they are carefully tended for the next 12 months. In the following spring the spears are harvested for 10 days, and the following recording is undertaken using the criteria:

- Number of spears per crown
- Uniformity and diameter of spears

- The number of hollow spears
- The number of spears with rust
- The weight of the spears
- The number of open heads.

The recording is undertaken in the field and the data is collected electronically. Potential new varieties are laid out in lots of 10, with specific numbers for identification. This coincides with the electronic data collector. At the end of the first season, all the information collated from each potential variety is assessed. This job is undertaken by the senior plant breeder and any new varieties that show poor characteristics from the assessment criteria are eliminated.



*Figure 10: Photo of author assessing asparagus trial beds taken at Seville, Spain (18/4/2013)*

In the first year 400 asparagus plants are assessed and 300 are deleted. In the second year 100 asparagus plants are assessed and 92 are deleted. In the third year eight asparagus plants are assessed and four deleted and in the fourth year the chosen varieties will undergo commercial production trials. If the trials are successful they will be marketed for sale to asparagus farmers.

# **Chapter 3 – White Asparagus alternative production methods**

## **Open Field Production**

Traditionally white asparagus was grown in the open field, and the seasons were determined by weather in any given year. The mounding of beds was all performed by manual labour, as was the removal of the old ferns in the autumn. It was the varieties grown and the knowledge of the farmer that, to a great extent, determined the quality of the spears. These days, however, there are many different methods of growing white asparagus.

During the 2013 spring white asparagus harvest in Europe, the best price obtained per bunch (500 grams) was €20. Farmers that can produce and harvest white asparagus the earliest are able to command the highest price. This being the case, the Netherlands white asparagus industry has developed many different ways to manipulate the seasonality, for early and late production.

For white asparagus farmers the longer the season the better for farm profits. Three months is usually considered a good season. This is achieved by selecting varieties that can be early, mid or late producers.

Traditionally white asparagus crowns are planted 20cm deep into the furrows and are mounded 40cm above the crown, however, farmers wishing to force early production will plant the crowns as shallow as 15cm. Planting the crowns at 15cm enables the farmer to produce white asparagus five days earlier than the crowns placed at 20cm in depth. One centimetre of depth equals one day later in harvest; this is a rule of thumb used for white asparagus production in Europe.

## **Plastics/Black & White**

In the past 20 years, the use of plastics has become the industry norm and the preferred growing method in Europe.

Traditionally without plastics, the quality of the white asparagus was largely due to the skill of the harvester. It was the harvester's ability to identify the spears below the soil surface, before penetration. This was essential in maintaining the purity of the white asparagus.

There are four main reasons for using plastics:

- To prevent any light reaching the growing spear
- To increase soil temperatures
- To manipulate the harvest date
- To reduce weed competition.

The plastic that is used throughout Europe in the white asparagus growing regions is a two-sided black and white coated plastic with a thickness of 300 microns and a width of 1.5 metres. The plastic is placed on top of the rows and depending on the market and the farmer's timeframe gives him the ability to speed up or slow down production. Quite simply, the plastic increases the soil temperature by as much as 15°C. When the black coated side is upright facing the sun it absorbs heat which is transferred to the soil and the growing crown, keeping in mind that white asparagus starts to grow above 10°C. When the plastic is turned to show the white coated side, it reflects the sun's light and reduces the soil temperature to slow down the asparagus spear production.

The use of plastics has become incredibly valuable to the farmer for now the farmer can clearly identify the spear growing beneath the plastic, as it protrudes from the soil it indents the plastic but still is deprived of sunlight, not jeopardising the spear quality.

## **Mini Tunnels**

The use of plastic is taken one step further with the use of mini tunnels which were observed in the Netherlands. In late winter, the black plastic is placed over the asparagus rows; this is then followed by the mini tunnels. The tunnels are a series of steel hoops set at 1.5 metres apart and sitting 30 cm above the black plastic. Clear plastic is then stretched over the hoops and folded down either side down into the ground. This increases the soil temperature by trapping two layers of warm air, one below the black plastic layer and one above. The advantages are that the heat is trapped for longer periods, due to the double plastic skin. This once again can increase temperatures by as much as 10°C-12°C.

## Blow Tunnels

Blow tunnels are becoming more widely used due to the high prices and demand for early white asparagus production. The author observed the use of blow tunnels in the Netherlands but understands that they are also widely used in Germany.

In late winter, the blow tunnels are placed over the asparagus fields. The dimensions of tunnels are generally 100 m x 40 m x 1.8 m high. The blow tunnels are laid out over the asparagus beds and a trench is dug around the outer edge. The soil is back-filled over the outer edge of the tunnel to secure the plastic sides. A door is then attached at one end of the tunnel. To inflate the blow tunnel a pipe is placed under the soil and is fed into the tunnel alongside the opening door. Hot air is generated by a diesel compressor to inflate the blow tunnel. The ideal air temperature is 27°C. Due to the consistent high temperature, the white asparagus is able to be harvested at least four weeks earlier than that of the mini tunnels.



*Figure 11: Photo of author examining blow tunnels at Horst, Netherlands (5/5/2013)*

The only one downside of the blow tunnel system is during daylight hours temperature can exceed 35°C due to the sun increasing the internal temperature; this restricts the time to harvest, as heat is detrimental to the harvested white asparagus spears. Harvesters, therefore, can only work between the hours of 3am and 11am in the morning.

## **Hot Water Pipes**

On the Teboza Farm, in Helden in the Netherlands, heating was in the form of hot water pipes. Copper pipes are placed throughout the asparagus field prior to crown planting. They are placed at a depth of 45cm which is 25 cm deeper than the crown. The pipes have a diameter of 25 mm and are heated by hot water or gas. The water is heated to a temperature of 24°C.

In addition to the hot water pipe system, mini tunnels are installed with the black plastic combination to ensure harvesting is up to four weeks in advance of normal open field production.

## **Glass House**

The use of glass houses in the white asparagus industry is relatively new. The glass houses are not typical of how white asparagus has been grown but due to changing economic climates within the Netherlands horticulture sector, there is an excess of unused glass houses. This has provided an opportunity for companies like Teboza to initiate large scale production within these glasshouse structures. The process is the same, using the black plastics, but the glass houses have very sophisticated heating systems, usually heated by gas or oil. The temperature is usually around 25°C; this enables harvesting up to four weeks earlier.

# Chapter 4 – Cultural Practices

## Water Requirements

White asparagus needs a consistent supply of moisture and should be irrigated routinely during the growing season. An average of 2.5 cm of rain or irrigation water per week is optimal. Either furrow or drip irrigation is recommended. Sprinkler (overhead) irrigation is useful to establish the plants but it is not advisable after the row canopy thickens, since it will render the foliage more susceptible to fungal diseases, especially rust (ADC, 2001).

If tensiometers are used to schedule irrigation, they should be placed at a depth of 15 cm, measured from bottom of the planting furrow. New beds will benefit from irrigation when the tensiometer gauge indicates a reading of 50.

After harvest is complete, all beds should be split open close to the crowns to allow soil aeration and good fern growth. In most production areas irrigation takes place during the fern season and not during the cutting season. Irrigation is applied at regular intervals as needed by plants. Soil moisture affects the amount of both fibrous and storage root system growth in asparagus. Moist, well-drained soils will have a greater abundance of fibrous roots than soils that are allowed to dry and then are irrigated profusely.

## Fertilizer Requirements

Precise recommendations for fertilization of asparagus are difficult to make because this perennial crop often is more subject to differences in environmental conditions and the cultural practices of different growers than to fertilizer.

A soil test before planting will determine the need for lime and availability of phosphorus and potassium. Most soils in Tasmania are acidic or alkaline. Asparagus grows best at a soil pH between 6.0 and 7.0. The need for minor fertilizer elements is not likely to occur unless the pH is greater than 7.5. If large amounts of lime is required to raise the pH to the desired level, lay down half of it and incorporate the remainder after ploughing. If possible, apply the lime several months before planting. It is recommended to incorporate about four tonnes per hectare of finely pulverised limestone ( $\text{CaCO}_3$ ) on soils with a pH between 5.0 to 5.5. Annual applications of limestone may be necessary to maintain the desired pH of 6.5 to 7.0 (ADC, 2001).



Phosphorous and potassium should be provided so that the soil contains 250 kg of available phosphorous and 300 kg of available potassium per hectare. Also apply 70 to 100 kg of actual nitrogen per hectare. Broadcast the fertilizer and plough it under when preparing the land for the planting furrows.

Before spear emergence after pruning, a general recommendation is to apply nitrogen (N), phosphate ( $P_2O_5$ ) and potash ( $K_2O$ ), each at the rate of 50 kg/ha and lightly incorporate them into the soil. Soils high in available phosphorus and potassium may require  $P_2O_5$  and  $K_2O$  applications every other year, but apply nitrogen every year. Annual applications of high quality manure at the rate of 12 to 25 tonnes per hectare may eliminate or greatly diminish the need for any application of mineral fertilizers. It is highly recommended to incorporate liberal amounts of animal manure/organic matter into the soil after each harvest cycle. Bury the manure/organic matter about 10 to 15 cm deep in two bands on each side of the row. The bands should be at least 30 cm away from the centre of the row in order to avoid crown damage (ADC, 2001).

## **Disease and Pest Management**

This section describes the most commonly confronted asparagus pest and diseases in Europe and, to the author's knowledge, in any area that asparagus is grown. Each type of pest and disease is described briefly, with a potential control method suggested. This information was obtained from the *Manual of Plant Diseases and Pests of Asparagus Crops* (2011) and translated into English especially for the author, courtesy of Mr Leo Winkelmolen, at Nunhems.

### **Asparagus Rust**

Asparagus Rust (*Puccinia asparagi*) can be a serious disease in high rainfall areas. High humidity and moderately warm temperatures favour disease development. Planting asparagus beds in areas with poor air drainage, or where dew frequently occurs, should be avoided since moisture on plant foliage favours rust development. Well-timed irrigations, wide row spacing and orienting the rows with the prevailing wind direction help to reduce the incidence of rust.

When the infestation is heavy, a premature defoliation of the fern occurs. The net effect is to reduce carbohydrate storage in the crown and weaken it for the next production season.

Severe rust infection reduces both the weight and number of spears produced by cultivars susceptible to rust.



Figure 12: Photo of asparagus rust taken at Teboza Asparagus Factory (1/5/13)

Rust produces three different types of pustule during the growing season. The first pustules appear on plant foliage, *aecia*, are oval in shape and light orange in colour. The blisters are raised at first; later the centre of the pustule sinks in stages. The most commonly noticed pustules are the *uredia* that appear on spores. These wind born spores infect healthy plants. Pustules with black spore masses, called *telia*, affect the fern foliage from early to late summer.

Summer stage pustules arise as blisters, and rupture the outer layer to expose brownish red powdery spores which replace the spore spreading summer stage pustules in early autumn. Spores over winter form pustules and give rise to a new disease cycle in the spring.

Growers can control rust by preventing growth of volunteer plants during the cutting season and by isolating seedling beds from commercial fields. Resistant and moderately resistant varieties retard rust development, even though they may become infected.

### ***Fusarium* wilt and *Fusarium* crown rot**

*Fusarium* wilt and *Fusarium* crown rot are caused by *Fusarium oxysporum* sp. *Asparagi* and *Fusarium moniliforme*. *Fusarium* is probably the most prevalent soil-born fungus disease that affects asparagus. Infected seedlings may fall over on the ground due to the destruction of seedling tissue near the soil line. On infected crowns, needles near the tip of primary shoots turn yellow and the growing point dies. The entire stem will eventually turn yellow and die.

On mature plants, a distinct wilt occurs that is most noticeable in heat. Infected stalks turn yellow and die. One or two shoots of a crown may show symptoms while the others appear normal, or the entire hill may yellow and die. Usually scattered throughout the field, affected plants may be more numerous in low areas or on sandy slopes. A reddish brown discoloration is evident in the vascular tissue of the crown and roots. Large, fleshy storage roots may become hollow and limp; crowns rot or eventually die. Studies have indicated that older crowns tend to be more tolerant to the disease and that harvesting for too long a period weakens the crowns, disposing the plants to infestation. Plant stress, virus infection, high soil temperature, and light soils increase the disease problem. Common causes of plant stress are over-cutting, drought, over watering, insect injury, inadequate weed control, disease, and soil compaction. *Fusarium oxysporum* or *F. moniliforme* cause a slow rotting in the asparagus crown primarily by destruction of the vascular system. The reduction in the spear size and spear production is due to the separation of the bud (spear) from its source of energy, which is an intact root system.

Because *Fusarium* species are present in most agricultural soils, the diseases are almost impossible to avoid. Control, therefore, is directed at minimizing infection early in the life of the crowns, and at maintaining a vigorous, long-lived asparagus stand by careful management. Suggested management practices include:

1. Avoid replanting in land which previously grew asparagus or select fields that have been out of asparagus for at least eight years. *Fusarium* builds up to extremely high levels during the long period of asparagus culture in the field and survives many years in the soil even after the crop is removed.
2. Soil fumigation with a suitable material will reduce infection in crown nurseries or direct seeded asparagus.
3. Use treated seed. Untreated seed should be disinfected with one part sodium hypochlorite bleach in five parts water for 40 minutes. Rinse seed in fresh water and dry before planting.
4. Use only vigorous, one year old crowns and encourage proper handling procedures for transplanting. Weak crowns are highly susceptible to infection.
5. Treat seed and crowns with a fungicide (Benlate™).
6. Be as careful as possible during tillage practices to avoid wounding fleshy roots and crowns.

### **Botrytis blight**

The disease, caused by the fungus *Botrytis cinerea*, occurs during summer causing browning of the lower fern canopy. Botrytis progresses most rapidly during hot, moist weather when the fern does not dry adequately. The disease begins on senescing (dying) flowers or injured fern. *Botrytis* spores are spread by wind and rain within the dense fern canopy. Individual lesions are tan with dark brown borders, often surrounded by a yellow halo. When wet weather persists, newly emerged spears may be completely blighted, turning brown or black and often covered with grey, fuzzy spore-bearing fungal growth. Zineb and Dithane M-45 will partially control *Botrytis* when used regularly.

### **Stemphylium purple spot**

The fungus, *Stemphylium vesicarium*, causes small, slightly sunken, purple spots on asparagus spears just before harvest. Asparagus ferns also become infected, showing tan to brown lesions from three to 15 mm in length with dark purple margins. The fungus needs moist conditions from dew or rain to infect plants. The fungus enters asparagus through wounds and stomata. More severe purple spot occurs on spears following wet weather and cool temperatures. When rainfall ceases and temperatures warm, purple spot infections fail to develop.

Applying a fungicide to spears is not a satisfactory method of controlling purple spot. Because new spears emerge daily, it would be impractical to cover and protect all plant tissue surfaces. Destroying overwintering sources of inoculum such as old, infected ferns and plant debris will reduce disease incidence on spears. Completely burying infected ferns by cultivation will reduce inoculum levels and subsequent infections. Infections readily occur through wounds. Planting cover crops that reduce wind-blown sand may aid in disease control.

### **Virus – induced stand decline**

Three different viruses cause stand decline. These are tobacco streak virus (TSV), asparagus virus 1 (AV-1), and asparagus virus 2 (AV-2).

Each virus reduces plant vigour and productivity. Plants infected by TSV are stunted and produce small spears. Growth of plants infected by either AV-1 or AV-2 alone may be

reduced by as much as 20 per cent. Plants infected with both AV-1 and AV-2 decline and die, usually within two to three years after double infection. Symptoms of virus-induced decline resemble decline caused by many other factors, especially fusarium wilt. Asparagus plants infected with AV-2 become much more susceptible to Fusarium wilt than non-infected plants.

AV-1 is spread by many common aphid species that feed on spears. These include the green peach and potato aphids. AV-1 is not transmitted by the asparagus aphid. AV-2 is seed born and appears to be transmitted through pollen. Because virus infected seedlings usually survive, many young plants will be infected when planted if the incidence of AV-2 is high in a given seed lot. As AV-1 is spread into the field over the succeeding years, plants that become infected with both viruses begin to decline and die.

AV-1 is easily spread by a variety of aphids that visit asparagus only briefly. It is virtually impossible to control. Although pollinating insects are suspected of spreading AV-2, no effective control practices are known. However, virus induced stand decline can be reduced substantially, perhaps eliminated, in isolated fields by the use of virus-free seed.

### ***Phytophthora* spear slime and crown rot**

This disease is caused by *Phytophthora megasperma* var. *sojae*. On soils susceptible to poor drainage, *Phytophthora* spear slime and crown rot can be a serious problem. The characteristic symptom is an odourless decay accompanied by white mould growth. Rotting is usually predominately at the base of the spear. Infection occurs after heavy or prolonged rain. No commercial cultivar is resistant to *Phytophthora*. Control is mainly achieved by using the fungicide metalaxyl (Ridomil) as a soil drench. Growers should cultivate asparagus on raised beds to facilitate drainage during periods of high rainfall.

### **European asparagus aphid**

Called *Brachycolus asparagi*., aphids are about one to two mm long, and are powdery grey green to green. Eggs are green to black and are laid on asparagus ferns. Eggs hatch into winged and wingless aphids throughout the year. There are many generations per year. Aphids feed in the axils of the ferns where the leaves join the stem. Heavily infested plants have a large number of severely stunted, blue grey shoots around the base of the plant, and an abundance of aphid honeydew is present. The European asparagus aphid (EAA) feeds exclusively on asparagus, injecting toxic saliva as it feeds on plant juices. When numbers are

high, enough toxin is injected to cause growth abnormalities, stunting, and a bush resetting of fern. Dormant buds on the crown, which would produce next year's crop, may begin to grow prematurely, resulting in crown decline. Damage is usually spotty throughout affected fields.

It is important to sample fern growth for EAA before populations may become excessive. The fern should be bent over white trays and beaten, and the aphids will be visible on the white surface. Insecticides such as mevinphos or malathion control EAA. Carbaryl is toxic to biological control agents, and not effective against EAA. Sampling for EAA should be carried out when plants are in the fern stage. Sampling involves collecting one secondary branch from each of 200 plants. Treat the field if any aphids are found. Destruction of dormant foliage in the autumn and shallow roto-tilling of the field in the spring greatly reduces aphid populations. Malathion at two kg active ingredient per hectare controls asparagus aphid but Di-Syston at one kg active ingredient per hectare, probably provides the best chemical control.

### **Garden centipede or symphylan**

This caterpillar belongs to the species *Scutigerebella immaculata*. The garden centipede is a major pest on white asparagus. During periods of extended wet weather or on water saturated soils, it can become a serious problem. These small, 0.6 cm long, white insects cause injury in the form of large numbers of small, round holes in storage roots, crowns, and on the below-ground portions of spears. They also predispose the asparagus plants to additional damage from disease organisms that invade the wounds. Winter flooding of fields for at least two weeks and soil fumigation of the beds before planting has helped reduce damage in affected areas.

### **Thrips (Franklinilla sp.)**

Thrips infestations can cause considerable damage in asparagus. The insects remove moisture from the fern, weaken its vigour, and can even kill the tops of small seedlings. They are very minute insects of one to two mm long. They migrate or are blown into asparagus fields during the cutting season from neighbouring grasses, weeds or forage crops. Maintaining weed-free headlands and fields is the only practical control measure available. Malathion sprays also will reduce the incidence of thrips.

### **Asparagus beetle (*Crioceris* sp.)**

Asparagus can be attacked by two species of beetles, the common asparagus beetle *Crioceris asparagi* and the twelve-spotted asparagus beetle *C. duodecimpunctata*. Common asparagus beetles are brightly coloured, with dark blue wing covers rimmed in red, and with three variously shaped, cream coloured markings on each wing cover. Their heads, legs, and antennae are black, while the thorax is dark red. The twelve-spotted asparagus beetle is reddish orange with six black spots on each wing cover. Both beetles are about six mm long. They are found wherever asparagus is grown. The pest injures the plant by gnawing the epidermis of the stems of the tender young shoots.

Larvae are dull blue grey with black head capsules. Beetles over-winter as adults, and the females begin laying eggs on asparagus spears in spring. Within a few days after feeding, common asparagus beetles begin to lay small 1.5 mm, oval, dark brown eggs attached on end to spears, either singly or in rows of two to seven eggs. Spotted asparagus beetles do not begin egg-laying until shortly before seed pods begin forming, attach their eggs sideways onto the fern. After three to 14 days of incubation, eggs hatch into small, dull grey to olive green larvae with black legs and heads. Larvae feed on the tender, green tissue for 10 to 21 days, growing to 10 to 15 mm long. Mature larvae drop to the ground, forming pupal cells just beneath the soil surface. After five to 14 days, adults emerge, completing the entire life cycle in three to seven weeks, depending upon climatic conditions.

Adults and larvae feed on green fern and spear tissue throughout the season. As well as producing feeding scars and spear malformation, beetles contaminate asparagus with eggs and excrement, rendering the spears unmarketable. Beetle feeding causes a distorted spear growth with a distinct “shepherds crook” shape. Yellow- orange larvae of the spotted beetle initially feed on leaves, eventually moving into developing seed pods.

Because beetles are present throughout the season, constant vigilance is necessary for control before economic injury is sustained. Special attention should be given to seedlings and young plantings. Activities which reduce levels of infestation are as follows:

- Reduce weeds.
- Clean cut all asparagus spears during harvest to reduce food sources
- Destroy nearby wild asparagus which could harbour beetles

- Several effective insecticides are available (permethrin, carbaryl, malathion methoxychlor). Begin spraying before egg-laying as soon as beetles are observed in spring. Monitor the beetle population carefully and continue treatment throughout the season as necessary.

Take samples in fields when plants are in the fern stage. Count the number of beetles found on 200 plants per field. If there are more than five beetles, the field should be treated with an insecticide.

### **Cutworms**

Two cutworm species are found in asparagus fields. Spotted cutworm, *Amathes c-nigrum*, larvae are found feeding usually near the spear tips. The brownish larvae have a pair of dark hash marks on the rear end. Redback cutworm, *Euxoa ochro-gaster*, larvae usually feed on the side of spears, at or below the ground line. Larvae are pale yellow to dark red and up to five cm long when full grown. Adults are heavy bodied, dull coloured, nocturnal moths. Eggs are laid in grassy and weedy areas within the crop or in headlands.

Affected spears and fern are malformed, usually curving towards the injured side, or have areas of tissue chewed or cut off. Cutworms are active above ground at night, hiding during daylight in debris or soil. Careful soil excavation around the base of injured spears may reveal the larvae. Damage is sporadic and difficult to predict.

Because larvae are more easily controlled when young, early detection of injury is important. Monitor fields for cutworm damage to spears during the cutting season and look for poor producing crowns. If plants are not producing adequate new growth, examine the soil around crowns for cutworms. Permethrin (Pounce, Ambush) at 0.1 kg active ingredient per hectare provides excellent control. Methomyl, Sevin and Sevin bait are also labelled for cutworm control on asparagus. Weeds and cutworms are associated, since female moths prefer to lay their eggs on weeds. Good weed control will reduce cutworm populations in asparagus fields.

### **Plant Bugs**

Tarnished plant bugs (TPB), *Lygus lineolaris*, and alfalfa plant bugs (APB), *Adelphocoris lineolatus*, will feed on asparagus spears and fern. TPB adults are six mm long, oval, straw green to dark brown insects with yellow, brown and black markings. APB adults are eight mm



long, having a more elongated oval shape than the TPB, and green with cream coloured markings. Nymphs (young) of both species are light green or yellow-green, smaller than adults, and lack fully developed wings.

TPB adults over-winter in fence rows, crop refuse, and weedy, sheltered areas, emerging in spring to feed on weeds and plant bugs. Eggs are laid in stems and petioles of weeds and other vegetables and hatch within 10 days. After three to four weeks nymphs become adults. Thus, there are one or two overlapping generations per year, depending upon the climate. APB has a life cycle similar to TPB, other than overwintering as eggs in alfalfa.

Plant bugs possess piercing and sucking mouthparts, inject toxic saliva into the plant and extract plant sap. Such feeding causes distortion, wilting, and or dieback of fern and spears. When bugs feed on newly emergent spears, the spears become malformed, wither and turn brown. Puncture marks from plant bug mouth parts are often visible at or below the area of distortion. When terminal buds during fern growth are killed, auxiliary buds proliferate, causing a “witches broom”.

To control plant bugs, control weeds adequately and avoid growing another susceptible host crop near asparagus (such as beans, potatoes or strawberries). Malathion, methoxychlor, or mevinphos may provide control.

### **Asparagus Miner**

The asparagus miner fly is small, three mm long, and metallic black, with two clear wings. Flies lay eggs beneath the epidermis of the asparagus stalks. Pale white, legless larvae tunnel beneath the epidermis both above and below ground. After growing to about three to five mm long, larvae change into pupae with a brown, oval case of about 3.5 to five mm long. Egg, larval and pupal stage each requires two to three weeks to complete, allowing two generations per year. Second generation pupae overwinter under the stem epidermis below the ground.

Damage at the base of the spear may occur in young asparagus fields but is not considered significant. However, the miner is capable of transmitting *Fusarium*. No effective control measures have developed. Insecticides aimed at beetle control may also be effective against miner if applied before eggs are laid.

## **White Grubs, Wireworms**

Because these larvae normally feed on grass roots, injury to asparagus may occur if planted in land previously growing pasture, forages or sod, or in old weedy fields. Either avoid such land or treat the soil with a recommended insecticide (Diazinon, Mocap) before planting asparagus.

## **Weed Control**

Weeds are one of the most common problems asparagus growers face worldwide. They compete with asparagus plants for light, moisture, nutrients and interfere with harvesting, thus reducing yields. Asparagus is a poor competitor against weeds. All types of weeds infest asparagus, including annual and perennial grasses and annual, biennial and perennial broadleaves. The information in this section was obtained from *ADC Commercialisation Bulletin #10: Asparagus* (2001) and the *Aceera Manual of Plant Diseases and Pests of Asparagus Crops* cited above.

Perennial weeds should be destroyed as thoroughly as possible during the soil preparation period or many months before planting in the case of heavy perennial weed pressure. After spears emerge, soil should be moved into the furrow in small quantities. Slowly filling in the furrow as the season progresses helps to control small weeds by smothering them. Frequent weed control is necessary by hoeing, cultivating, and or using herbicides. Mechanical removal of weeds by hoeing or cultivation is only temporary and usually has to be repeated several times per year. Herbicides provide more lasting control but also may have to be reapplied several times per year, depending on the weed pressure and environmental conditions.

Determine your herbicide needs based on the weed species and whether they will be emerged and growing at the time of application. There is no effective chemical control for weeds in asparagus once the spears are emerged. In fact, application of certain chemicals just prior to spear emergence can be dangerous.

Generally, the best approach to weed control in asparagus is to use several different materials and split applications. However, due to lack of seedling selectivity of most weedicides, there are some weeds that get through most control programs.

# Chapter 5 – Post-harvest handling and product specifications

## The Harvesting of White Asparagus

Regardless of which production method is used, the harvesting approach is the same. It is essential that the white asparagus spears are kept completely covered by soil and plastic, this is under taken by mounding the soil 40 cm over the tops of the crowns in late winter. At this point the plastic covering is placed across the top of the mounds to restrict sunlight.

Traditionally the harvest would commence in the second to third week in April in the Northern Hemisphere. The spears commence to grow and as they penetrate the top of the soil, small raised indentations can be observed along the plastic covered bed, which indicates their locations ready for harvest.



*Figure 13: Photo of indent in plastic sheeting and asparagus cutting knife prior to harvesting, taken at Nunhems Research Facility at Nunhems, Netherlands (27/4/13)*

At this point the harvester removes the plastic sheeting and commences the harvest. The technique required to harvest the white asparagus spear is by placing a middle and index finger down beside the emerging spear, removing around 7-10cm of soil, giving a clear view of the spear. An asparagus cutting knife is then directed down 24 cm at a slight angle and the

spear is then cut. The spear is carefully removed and placed into a cutting frame. It is critical to back-fill the exposed hole with the disturbed soil otherwise the remaining spear quality is compromised.



*Figure 14: Photo of exposed hole created during harvesting taken at Horst, Netherlands (27/4/13)*

If it is not placed back over the remaining emerging spears, a pink or purplish hue will be imparted to the tips and upper part of the spears exposed to the sunlight. This is due to anthocyanin pigment formation. Care must also be taken not to injure the other buried spears growing from the crown. In order to harvest asparagus spears with a compact tip, they should be harvested on a daily basis.



*Figure 15: Photo of author participating in harvesting activity at Horst, Netherlands (27/4/13)*

Spear harvesting is undertaken early in the day; individual spear weight is at its greatest in the pre-dawn hours, and then decreases as the day goes on. The spear weight in the morning is at its highest due to cell turgor due to more water in the spear. Air temperatures are lowest in the pre-dawn hours as is the pulp temperature of the spear. Since the spears are cooler in the morning the post-harvest changes will occur more slowly, also the energy required to cool an already cool spear will be less than the energy to cool a warm spear.

Collection of the spears is undertaken by the harvester, as the harvester cuts the individual spears to a standard length of 24 cm, it is then placed into a collection box; all spears are orientated in the same direction. When the box is full they are cut with an asparagus saw, which removes 2 cm from the ends of the spear. This leaves a spear length of 22 cm, which is a European standard for white asparagus.



*Figure 16 : Photo of freshly harvested white asparagus spears in a collection box at Seville, Spain (20/4/2013)*

## **Yield**

There is a wide range of average yields of white asparagus depending on numerous environmental, soil types and genetic factors. Typical average yields in the Netherlands are between 8,000-14,000 kg/hectare.

## **Post- harvest handling**

Asparagus is a highly perishable vegetable crop that needs to be cooled as soon as possible after harvest for maximum preservation of shelf life.

The respiration rate of asparagus is among the highest of all horticultural crops. The natural metabolic process of respiration continues in the asparagus spear after harvest, consuming sugars and releasing CO<sub>2</sub> and heat. Also, the tip of the spear keeps elongating and the fibre content increases as a consequence of the lignin that is produced in the vascular bundles over time, especially at temperatures above 2° C. Spear elongation will occur more rapidly with increasing temperature. Spears held at 1°C for eight days will have about 3.5 mm elongation, while spears held at 13°C will elongate 25.4 mm. Higher storage temperatures will cause more rapid elongation. It has been shown that as much shelf life and quality is lost in one hour at 20°C as is lost in 19 hours at 1°C. Lowering the pulp temperature of asparagus to 1°C reduces the rate of respiration low enough to allow the spear to be stored for two to three weeks without significant deterioration of quality.

For maximum quality preservation and shelf life, asparagus should be placed into a hydro-cooler at 2°C for the first 24 hours; this prevents anthocyanin pigment formation. White asparagus should be maintained at this temperature during the entire transportation, distribution, and marketing periods. Relative humidity should be maintained at 95 to 98% in order to prevent spear shrivelling, and fibre formation. Moisture should be abundant at the spear butt to prevent dehydration. Lack of moisture causes a physiological stress resulting in ethylene production and senescence of the tissue. Increased ethylene also stimulates the production of lignin in the vascular bundles, which in turn causes fibrous spears. It is essential not to break the cold chain during transport and distribution. Re-warming of previously cooled asparagus will result in moisture condensation on the surface of the spears, followed by increased incidence of microbial decay.

## **Cooling**

Asparagus should be cooled immediately after grading and packing. The length of time between harvest and hydro-cooling should be no more than two hours, preferably less. During this period, the spear loses water due to its severance from the crown and it loses sugars due to respiration. Hydro-cooling is the most efficient method of lowering the pulp temperature of asparagus. Hydro-cooling is a process in which the commodity is passed through or immersed

in cooled water for a given period of time. During immersion heat from the commodity is transferred to the water which is then recirculated.

A submersion type of hydro-cooler involves putting the packed boxes in cold water for a long enough time to reduce the pulp temperature to 2°C. The packaging container should be constructed with ventilation openings in such a manner to allow free movement of cold water into and out away from the spears during hydro-cooling. The water in the chiller should be changed regularly, at least every second day, or sooner if the water looks dirty. Also, the water should be kept chlorinated at a level near 150 ppm chlorine. Chlorine is used to help prevent spread of disease organisms. Organic matter and dirt in the hydro-cooling water will de-activate the chlorine.

The ideal method of handling cut asparagus is to first hydro-cool the cut spears then store them in a cold room at 2°C until they can be packed. Also air temperatures below 0°C during cool storage should be avoided, since white asparagus begins to freeze at -0.8°C. Frozen spears completely lose their market value.

## **Post-Harvest Problems**

Asparagus is susceptible to a number of post-harvest problems, all contributing to quality reduction and market loss. The more common problems include:

- Loss of spear turgidity. This is due to improper cooling and poor temperature/humidity management.
- Wilting, which occurs rapidly at temperatures above 5°C and relative humidity below 75 per cent.
- Spear discoloration is due to exposure to high temperatures, light and ethylene.
- Toughness of asparagus is due to the development of cells with thick walls containing a material called lignin. Most rapid fibre formation occurs during the first 24 hours after harvest and this fibre formation can be slowed down dramatically by cooling the asparagus as soon as possible after harvest. There is a slow increase in fibre with time in storage. Water loss after harvest tends to increase fibre development. Decreasing water loss by raising the relative humidity, using film wraps, or placing the butt ends on a moisture-containing pad will decrease fibre development.



- Broken tips and spears are the most common damage during hand harvest. Careful handling can eliminate this problem.

## **Grading/Grade Standards/ European Standards for the Fresh Market**

White asparagus is a high-value but very perishable product; consequently the quality requirements are very stringent. The purpose of the European standards for the fresh market is to define the quality requirements for white asparagus at the dispatching and sale point.



*Figure 17: Photo of grading activity at Teboza grading shed at Zandberg, Netherlands (1/5/2013)*

Grading of white asparagus is divided in five distinct classes:

1. AAA1 White – is the highest grade of white asparagus. To obtain this grading, the spears must not have any of the following flaws or defects:
  - Pure white, with no signs of rust.
  - Spear must be straight with no bends or curves.
  - Head of the spear must be closed and tight.
  - Heads must not be hollow.
  - Heads must have a diameter between 28-38 mm and a length of 19-22 cm.
  - The cut at the spear base must be clean and square.



2. AAA1 – this is the second best grade, due to its slight variation of colour, being a creamy white not a pure white but has all the above characteristic of the AAA1 white
3. AA1 – this third grade of white asparagus; a diameter of 20-28 mm and length of 19-22 cm places it in this grade
4. A1 – has a diameter of 16-20 mm, with a length of 19-22 cm
5. B1 – is the lowest grade, this has a diameter of 14-16 mm and a length of 17-22 cm.

All white asparagus, once graded, is then peeled and packaged for market. White asparagus that is damaged is not graded and is sold as seconds in bags for soup production, as are the remaining peelings.

## **Packaging and Marketing**

The contents of each package or each bundle in the same package must be uniform, and consist of spears of the same quality, the same colour and the same size as it was graded. The packaging must be sufficient to ensure adequate protection for the asparagus. Where printed matter is used, the printing must be on the outside and not come in contact with the asparagus. Spears may be packed in bundles or in bulk packages.

Each white asparagus package must rate the following, legibly marked on the outside:

1. Identification – Packer, Dispatcher, name and address and code mark
2. Nature of produce – white asparagus
3. Origin of produce – country or origin, national, regional or local trade name
4. Commercial specifications – quality class, size and (for asparagus packed in bundles), the number of bundles and the unit weight per bundle.

It is very important to use a well-designed container with good top and bottom venting that allows for efficient hydro-cooling and storage. The wholesale/retail package external appearance should attract the attention of the buyers and motivate them to purchase it.

Normal corrugated cardboard loses its stability if it becomes moist. For this reason, special water –resistant packaging material should be used, for example cardboard coated with polyethylene.

For the European market, the typical final package is a five kg polyethylene-reinforced carton approximately 40 x 30 cm. Ten 500 grams bundles are put in the carton, usually wrapped in a perforated plastic sleeve. The bundles should be placed upright in a vertical position, one beside the other. In addition to the typical 500 gram bundles, another type of retail package in Europe is the 250 gram bunched bag.



*Figure 18: Photo of graded white asparagus product taken at Zandberg, Netherlands (1/5/2013)*

# Conclusion

There is a potential opportunity to establish a white asparagus industry within Tasmania. It will require careful planning, research and ingenuity. At this point the white asparagus industry within Australia is insignificant, but this in itself is a great opportunity.

In Europe, chefs eagerly await the commencement of the white asparagus season, as it is highly sort after. If the same consistent quality is produced in Tasmania and partnerships continue between producer and the chef, this will build the foundations of a niche industry. The trialling of varieties, evaluating and establishing commercial volumes of white asparagus would be a long-term goal.

As previously stated, the industry will require further research and development. It would be presumptuous, at this point to delve into delivery, marketing and how many producers would be required. As far as paying for research, Weston Farm will undertake the importation of seed and set up a two hectare trial site which will be assessed using the same procedures and criteria as observed at Bayer's Research Centre, Roermond, Netherlands.

Australia is ready and waiting for the arrival of locally grown, high quality white asparagus – but only time will tell.

# Recommendations

Recommended steps to establish a white asparagus industry in Tasmania:

- Undertake extensive trials on varieties suitable to Tasmanian conditions.
- Research growing methods applicable to Tasmanian climatic conditions.
- Establish a strong partnership with Nunhems Bayer.
- Continue to nurture partnerships with existing and potential restaurant clients.
- Search for Federal and State agricultural grants to assist with the commencement of a white asparagus industry.

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# Plain English Compendium Summary

Project Title: White Asparagus Production for the gourmet market	
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<b>Objectives</b>	The main aim of this report is to fully describe all aspects of the white asparagus industry and provide a technical approach, so that the possibility of a white asparagus industry may emerge within Australia.
<b>Background</b>	White asparagus is consumed predominately in the Netherlands, Germany, France, Austria and Switzerland. White is preferred over green asparagus. In the Netherlands 98% of all asparagus consumed is white. In Germany the average person consumes 1.7 kg of white asparagus per year. The Australian white asparagus industry is insignificant in global terms. 98% of asparagus consumed in Australia is green. To educate the Australian consumer to white asparagus will be a long term process.
<b>Research</b>	The Netherlands is a big consumer and producer of white asparagus so it was obvious that my studies would begin in Roermond, Netherlands, with one of the biggest research and development companies (Nunhems Bayer), for over two months. Being fortunate to travel as part of the white asparagus breeding team to Germany and Spain to further my research. My time was also spent at Teboza, one of the largest white asparagus growers in Europe, undertaking harvesting, grading, and packaging, which provided me with most of the information required for this report.
<b>Outcomes</b>	To prepare the technical background for the launch of a new industry within Tasmania
<b>Implications Publications</b>	