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AGRICULTURAL DEVELOPMENT AND ADVISORY SERVICE

HORTICULTURAL DEVELOPMENT COUNCIL

REPORT ON THE 8TH INTERNATIONAL ASPARAGUS SYMPOSIUM MASSEY UNIVERSITY PALMERSTON NORTH, NEW ZEALAND, AND PRE AND POST SYMPOSIUM TECHNICAL TOURS NOVEMBER 1993

WILSON J DYER

ADAS, BURY ST EDMUNDS

ADAS

1.0 OBJECTIVE OF THE VISIT

1.1 To attend the 8th International Asparagus Symposium at Massey University, Palmerston North, New Zealand, 21-26 November 1993 and pre and post Symposium technical tours.

1.2 To broaden contacts with researchers, consultants and growers from different parts of the world, present at the Symposium.

1.3 To visit some of the best and most influential growers' holdings within the Symposium arrangements and outside the formal visits.

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ADAS

2.0 SUMMARY OF FINDINGS - WITH POTENTIAL TO THE UK ASPARAGUS INDUSTRY, FROM THE SYMPOSIUM ABSTRACTS AND TECHNICAL VISITS

2.1 Symposium Abstracts

2.1.1 The Symposium covered all the major topics connected with the development of the asparagus crop including breeding, cloning, tissue culture, plant physiology, environmental aspects, nutrition, irrigation, weed control, diseases and post harvest handling including cooling and cool chaining.

Presentations were made by researchers from over 20 countries with some specific papers on production in particular countries, including The Philippines, Mexico, China and Peru.

2.1.2 Cultivar evaluations have been carried out in all asparagus producing countries. Some are capable of being successfully grown over a wide geographical area whereas others have a relatively restricted area in which they produce satisfactory results.

2.1.3 The international cultivar trial planted in 1986 on over 40 sites throughout the world will be reported on in a final report prepared by Dr Mike Nichols at Massey University, Palmerston North, New Zealand, by the end of March 1994. It is anticipated that full results will be available for inclusion from nearly 20 sites. Reports will be sent to all the collaborating researchers.

A meeting held to discuss progress with this trial also discussed initiation of a new trial to be planted on a worldwide basis in 1995. It is envisaged that trials will be laid down with core cultivars selected for a range of climatical zones, eg tropical, temperate.

2.1.4 A cultivar trial in Germany produced very similar results to the UK trial planted in 1986 with poor performance from varieties such as UC157 and Del Monte and good performance from Dutch all male cultivars.

2.1.5 Cultivation of green asparagus in Denmark is limited due to low yields, variability in spear diameter and quality. The Danish Institute of Plant and Soil Science has bred a cultivar that is suitable for Denmark's cool climate.

2.1.6 New micropropagation systems and anther culture systems have been developed in a number of countries including Japan, Italy, Germany, Canada.

2.1.16 Trials carried out at Hamilton, New Zealand, on re-using old asparagus land have indicated that the reduced yield syndrome associated with the carry over of fungal disease, plant toxins and/or herbicides in old production beds, may be shorter lived than anticipated, and limited to plant losses during establishment.

2.1.17 Cool chaining guidelines have been developed by researchers at Levin Research Centre in New Zealand to minimise heat unit accumulation along the cool chain.

2.2 Technical Visits

2.2.1 The New Zealand asparagus industry is centred around six major production areas, each with its own Asparagus Growers Association. These are all very active and work under the umbrella of the Asparagus Growers Council. Each has representatives on the Council who have inputs into R & D and promotional activities.

2.2.2 The main objective of the New Zealand industry is to produce high quality produce for export, mainly to Japan. Growers make full use of the most up to date technology for crop production techniques, cultivar selection and post harvest and cooling systems.

2.2.3 All harvesting is carried out by hand with spears being cut and placed in containers slung around the operator's waist. No field grading is carried out other than to eliminate the very small or bent spears which are unmarketable.

All grading is carried out in the packing shed. Straight line conveyor lines incorporating washing and trimming equipment are used in every packhouse. Automated/computerised graders are also quite common.

2.2.4 All of the export and home market crop is packed in 5 or 10 kg wooden pyramid packs. This is a very efficient method of packing. Very little bundling is carried out. Produce supplied to processors is packed loose in 15 kg boxes.

2.2.5 Much emphasis is placed on cooling. Most packhouses have hydrocooling facilities and all have cold stores.

2.2.6 Centralised packing is a common feature in New Zealand with a grower/packer frequently packing for up to 20 other growers within a 20 mile radius. Each grower's production is assessed daily as it enters the packhouse and paid according to grade out.

3.0 SUGGESTED POINTS OF ACTION BY ADAS

3.1 Maintain links with the New Zealand asparagus industry. ADAS has very good liaison with research organisations, consultants, growers and packhouse operators in New Zealand and an excellent two way flow of information is in operation.

Because the UK asparagus industry is following the New Zealand industry in terms of production and handling techniques, it is important that links are maintained and periodic technical tours are made.

3.2 Encourage the industry to invest in asparagus research and development.

3.3 Evaluate along with leading growers and marketing organisations alternative packing and marketing methods. The UK system of handling and packing the crop into bundles is expensive. Packing into larger units should be examined as a means of reducing costs.

3.4 Examine the possibilities of carrying out a cloning programme in the UK with the aim of establishing high yielding crops of quality spears.

3.5 Continue to evaluate new cultivars, especially those being developed in Europe.

3.6 Compare a range of fern growing and harvesting periods to develop viable and economic cropping performance outside of the traditional UK season.

3.7 Carry out a study to determine the presence of asparagus viruses on UK crops.

3.8 Develop new cooling and other shelf life work, not carried out in the UK since the 1980s and extend the work to cool chaining of the crop from packhouse to consumer.

4.1 PRE-SYMPOSIUM TECHNICAL TOUR VISITS

19 November

Background to asparagus industry in New Zealand

The main asparagus growing regions are the Waikato, Hawkes Bay, Manawaku and Canterbury. In 1992 8,000 tonnes were produced nationwide from 2,500 hectares. Of this total 1,750 tonnes were exported fresh, 650 tonnes exported frozen, 3,100 tonnes canned and 2,500 tonnes sold to local markets. Japan and the USA are the main importers of New Zealand fresh product. All exported fresh production is air freighted. Most of the canned product is exported to Australia.

At present there are 16 exporters and 5 canneries of asparagus operating in the country. Asparagus production has been static over the last few years. Harvesting is done manually and takes place from mid September to late December.

The Waikato

The Waikato region is the largest asparagus growing area in New Zealand, producing about 30% of the national crop. The region is a large river basin with the Waikato river running northwards through it. The area planted is 650 hectares with much of this on free draining sandy loams.

Visit to: Alex Boyd's Asparagus Packhouse, Cambridge, Hamilton

This operator grows 15 hectares of asparagus on free draining Horotui sandy loam soil. The cultivars Jersey Giant, N.Z. Beacon, Limbras 10 and 22, UC157 and Taramea are planted. Row spacings range from 1.5 m and 0.30 m in row to 1.4 m with 2 row beds all ridged.

Shelter belts were planted around each field.

The export packhouse employs 30 people over the production season and consists of two non automated sorting lines and one automatic grader. Fifteen local growers (on 70 hectares) supply the packhouse.

The packhouse also housed a cold store which stored all the packed crop prior to distribution.

The 1992 throughput was:

230 tonnes - export - packed in 5 kg wooden pyramid packs

41 tonnes - processing

28 tonnes - local market

Further details were presented at the Symposium and is provided in the abstract numbers:

39 Crop environment interaction controlling the quality of asparagus green spear production.

41 Succession of weed flora in some New Zealand asparagus crops.

52 The fertiliser requirements of asparagus on allophanic clay based volcanic ash soil.

62 Re-using old asparagus land.

The research programme at Bland Research Station includes work on Kiwifruit, Persimmon, Grapes, Nashi, Blueberries, Chestnuts and Novel Crops/Herbs.

Visit to: Trevor Syng, Arapuni Asparagus, Cambridge, Hamilton

This operator grows 53 hectares of asparagus on a free draining sandy loam.

The cultivar grown is exclusively NZ Beacon.

Five growers supply the packhouse which employs 50 packers during the production season. About 45 pickers are employed.

The 1992 production figures were:

50 tonnes - export
180 tonnes - canning
90 tonnes - frozen
28 tonnes - local market
12 tonnes - gate sales

The crops on the farm are produced on 1.50 m wide rows with an in row spacing of 0.30 m. The crops are grown on the flat. Shelter belts are planted around each field.

Harvesting rigs are used on this farm. Essentially up to 4 or 5 people sit on a rig attached to a tractor 3 point linkage. Each harvested one row of asparagus. Piece work rates are paid.

The packhouse consisted of two non automated sorting lines and one automatic grader. A hydro-cooler was installed. Packing was into 5 kg wooden pyramid packs for export and packed loose into 15 kg boxes for the processing markets.

Cold storage facilities are available for storing the packed product prior to dispatch.

4.2 VISITS MADE DURING THE SYMPOSIUM

23 November

Visit to: Crop and Food Research Ltd, Levin Research Centre, Levin

This Centre has been working on asparagus for over 25 years.

The Centre has carried out important work on cultivar evaluation, with the prime objective of assessing cultivars suitable for fresh export. It has also investigated the effect of cutting spears at two heights, on the percentage saleable yield, evaluation of yield performance after only two years harvests where results have shown that the performance can be closely correlated with yield data collected over four to six years.

Soil suitability for asparagus production has been assessed along with fertiliser requirements.

Spacings, plant populations, irrigation and establishment methods, times and methods of establishment have been investigated at the Station.

The Centre has assessed the tolerance of hybrids to fusarium species.

Comparison of harvesting daily and every two days has been evaluated with a range of cultivars, and comparisons have been made between sledge and hand harvesting.

A full report on the above investigations is included in my Study Tour Report of 1988.

More recently the work at Levin has concentrated on post harvest research under the guidance of Dr Ross Lill. His group is developing controlled atmosphere and cool chain technology to ensure better quality produce for export markets.

They are also making significant progress with the use of carbon dioxide and temperature control for disinfestation in preference to methyl bromide.

During our visit we were shown the post harvest research work which is further detailed in the abstract numbers:

11. Improving the New Zealand Asparagus Cool Chain.

12. Quarantine issues in the international trade in asparagus.

47. Changes in glutamine synthetase in harvested asparagus.

48. Respiration and soluble carbohydrates in tips of harvested asparagus spears.

than the traditional cans, at a price competitive with cans. Most of Clarus's asparagus is marketed in Australia, through the national supermarket chains.

Grocorp Asparagus Packhouse, Napier

Essentially this operation packs squashes as its major commitment, and asparagus in the early summer months.

Full hydrocooling and cold storage facilities are available.

An automated Mike Schwarz asparagus grader forms the central feature of the asparagus packing operation, which takes in asparagus from the Hawkes Bay area. As for other packhouses, the major objective is to export asparagus mainly to Japan.

Mission Vineyards, Hawkes Bay

A guided tour around the processing and bottling plant of this major wine producer.

Grower Canneries Ltd, Hawkes Bay

Grower Canneries principally processes peas, tomatoes and asparagus. Approximately 1,200 tonnes of asparagus are canned and 600 tonnes frozen. The major markets for asparagus are Australia, Japan and the home market.

26 November

Visit to Alastair Hogg, Rangitiki Asparagus, Halcombe, Manawata

Alastair and Judy Hogg and brother Richard run an asparagus operation on a mixed 320 hectare (800 acre) farm.

Both Alastair and Richard have visited the UK and visited me to discuss asparagus production techniques and HRI Kirton to discuss brassica plant production in modules.

Until recently the operation packed for 24 other growers in the area, but now only pack their own produce from about 8 hectares (20 acres) grown on 1.80 m (6 ft) wide rows with an in row spacing of 0.30 m (12 ins).

A range of cultivars are grown including Jersey Giant and some Dutch all male and French cultivars. Jersey Giant tended to be very purple when cold which was not acceptable to the Japanese market. Buds of the French cultivar tended to open up when warm.

4.3 POST SYMPOSIUM TECHNICAL TOUR VISITS

28 November

Visit to: Dominion Salt Ltd, Lake Grassmere, Marlborough

Construction of the Salt Works at Lake Grassmere commenced in 1943.

Lake Grassmere has features necessary for a Solar Salt Works:

a. A large area of flat land with impervious soils, located on the coast.

b. A readily available area unsuitable for any other use.

c. The lowest rainfall area in New Zealand.

d. The area is noted for long sunshine hours and frequently experiences strong north-westerly winds during the summer months.

The total area for solar salt production on the site is approximately 1,400 hectares, consisting of a main lake of 700 hectares, 10 concentrating ponds of 480 hectares, 5 final concentrating ponds of 80 hectares, 4 days storage ponds of 20 hectares, 22 crystallising ponds of 90 hectares and 40 hectares of re-concentrating ponds and 8 hectares of wash brine ponds.

The salt making season is of six months, commencing in early October. Salt is deposited in the form of a hard crust underneath the brine in the bottom of the crystallising ponds. Harvesting usually begins by early March and lasts for 4 to 6 weeks.

Salt harvested since 1953 on a commercial basis now exceeds 1.4 million tonnes.

Up to 100,000 tonnes are harvested in a good year.

The salt is processed by combination of re-washing, crushing, drying and screening before being packed in small bags containing 25 or 50 kg or large bulk bags containing 1-2 tonnes of salt.

The biggest part of the production is used by the New Zealand freezing industry for treatment of hides and skins. Domestic salt is also produced.

The company has produced a new hybrid called JWCI and demand for seed is currently outstripping supply.

Aspara Pacific maintains a close working relationship with other research organisations in the area including Crop and Food Research Ltd, Lincoln University and the Ministry of Agriculture and Fisheries.

Further details of Dr Peter Falloon's work can be found in the abstract numbers:

43. Effect of thiabendazole (Tecto 20S) and metalaxyl (Ridomil MZ72) on asparagus establishment in replant soil.

45. Survey of asparagus crops in New Zealand for asparagus virus 2.

63. Pacifica - All green clone.

64. JCWI - Asparagus hybrid.

65. Development of new varieties with resistance to Phytophthora rot.

Lincoln University, Lincoln, Christchurch, and Crop and Food Research Ltd

Because of appalling weather conditions the programme to visit each of these centres was hastily re-arranged at one venue.

Dr Marlene Jasper from Lincoln University discussed the work she was carrying out on Asparagus Virus 2. Details are provided in Abstract:

45. Survey of Asparagus crops in New Zealand for Asparagus Virus 2.

59. Effect of Asparagus Virus 2 on yield of asparagus officinalis.

Dr Tony Connor of Crop and Food Research Ltd discussed his work on Genetic Engineering which is reported in the Abstract 7 - Genetic engineering of asparagus - assessment of methods, field testing and food safety considerations.

Dr Derek Wilson of the Physiology and Agronomy Section at Crop and Food Research Ltd discussed the results of an irrigation trial to determine optimum irrigation management for the cultivars UC157 and Jersey Giant. This is also reported on in Abstract 50.

The trial concluded that:

: Asparagus is very resilient to SMD.

: Irrigation aided establishment.

UC157 has been very disappointing and has failed to produce a viable yield in its second harvest season.

The operation packs for about 10 other growers who grow locally. Approximately 90% of the grade out makes export quality. It is packed in 5 kg wooden pyramid cases.

This company has a very efficient packing line operated by 20 staff, with a throughput of 400 kg/ha.

The packed produce is put through a hydro cooler, prior to cool storing before being taken to the airport for export.

Peter and Sarah Williams, Ashberton

Peter and Sarah Williams have just become involved in asparagus production and have planted 16 ha on an open, wind swept site on the Canterbury Plain. The soil is a shallow sandy loam over stones. The main cultivar grown is UC157.

Aspara Pacific Ltd, Templeton, Christchurch

Please see notes on pages 15-16.

5.0 INTERNATIONAL ASPARAGUS CULTIVAR TRIAL

A meeting was held during the Symposium to discuss progress with this trial. Dr Mike Nichols of Massey University organised this trial to be planted on approximately 40 sites around the world in 1986. The UK site was at Luddington EHS. Annual reports have been sent to Dr Nichols.

It was agreed at this meeting that a deadline should be set for presentation of a full report of comparable results from each site. It is anticipated that results from about 20 sites will be available for inclusion. Dr Nichols agreed to present the report to all the collaborators by the end of March 1994.

On receipt of the report each site will be able to compare its results with other sites in the world. The objective ultimately is to key in with "similar site records" for other data, especially cultivar performance, in future years.

At this meeting we also discussed opportunities for developing a further cultivar trial. A protocol was agreed.

6.0 ABSTRACTS

Nos. 1-53 Presented as Papers

Nos. 54-85 Presented as Posters

1. IMPORTING FRESH ASPARAGUS - A PERSONAL VIEWPOINT

M R A Paske
Marketing Director
Exotic Farm Produce Limited,
Kirton,
Boston,
Lincolnshire
England.

The annual consumption of green asparagus in Europe has steadily increased over the twenty eight years that I have been involved in growing and importing the crop. No longer can it be regarded as an exotic vegetable. Instead it is now available fresh for 52 weeks of the year. High quality supplies are available in their seasons from many countries throughout the World. Farmers and growers in developing nations see it as a crop with a future and are planting large areas. The relatively high selling prices make it a natural choice to pay a reasonable return and to cover the post harvest handling costs and air freight. But are they right? With increased tonnages from new higher yielding varieties, longer harvest seasons and the increase of production is the market available to absorb all the supplies or will the prices drop to uneconomical levels, as with so many other horticultural and agricultural crops. In my paper I hope to answer some of these questions and provide an insight into the expansion ofthe market for asparagus in Europe.

2. COMMERCIAL ASPARAGUS OPERATION IN THE PHILIPPINES

P D Jensen and D J Lesnick
Dole TropiFresh
14th Floor, BA-Lepanto Building
8767 Paseo de Roxas, 1226 Makati, MM
PO Box 1541 MCPO
1255 Makati, MM, Philippines

Dole TropiFresh began field trials with asparagus in the Philippines in 1986. Commercial operations began in 1990. Today 600 hectares are harvesting asparagus. The planted area will increase to 1,000 hectares by 1994. The primary market is Japan. The peak supply period is August thru February. TropiFresh supplies the market on a year-round basis.

TropiFresh manages a contract grower programme. Each grower has about 2.3 hectares. Growers are organized into cutting groups and associations for the purpose of efficient operations and financing. Productivity in the fields has been high. This has been due to the good operation of the grower program and the agricultural practices that have been implemented. The major practices that TropiFresh has modified are the mother fern concept, installing effective drains and irrigation systems, and setting the proper fertilization rates. TropiFresh buys asparagus from the growers and packs it at a company-run packing house. It is boxed, chilled, stored and loaded on company vessels to Japan. A wide range of sizes and grades are packed and shipped.

Ongoing problems to be addressed are irrigation, sizing, grade deterioration, spear colour and unstable freshness in the market.

5. ASPARAGUS CULTIVATION IN CHINA

Xu Heling, Peng Mingsheng & Feng Xiaotang
Vegetable Crop Institute
Jiangsu Academy of Agriculture Science
Nanjing
China 210014

Asparagus cultivars were first introduced into China at the end of Qing Dynasty about 100 years ago. At first, asparagus was only cultivated occasionally in the suburbs of large cities such as Shanghai, Tianjing and Peking. Because chinese people weren't accustomed to eating asparagus, it was underdeveloped. In 1974, asparagus was planted commercially and rapidly expanded in area. Today there are about 600,000 hectares planted with asparagus in some 20 provinces.

6. INFLUENCE OF LOW TEMPERATURE EXPOSURE DURING HARVEST ON ASPARAGUS YIELD

P C Keulder & C A H Riedel
Botany Department
University of the North (Qwaqwa Campus)
Private Bag X13
9866 Phuthaditjhaba
South Africa

Asparagus cultivation in Qwaqwa, South Africa is subject to considerable variations in temperature during the harvest period in spring (September - November). In a seven year survey (1986 - 1992) the daily yield of asparagus was monitored together with the daily minimum and maximum air temperatures. Minimum air temperatures ranged from 0,4 to 15,5°C, while maximum air temperatures varied between 6,9 and 32,0°C. The majority of the 165 ha was established with UC72 and male cultivars were progressively introduced in expanded areas. Boonlim was harvested since 1991 on an area of 12,1 ha.
The intensity of yield reduction with low temperature regimes was evaluated in respect to the following aspects:
- cultivar responses to low temperatures
- soil conditions (pH, nutrient levels)
- response time for yield reduction and subsequent recovery

8. THREE NEW GREEN ASPARAGUS CULTIVARS; APOLLO, ATLAS AND GRANDE AND ONE PURPLE CULTIVAR, PURPLE PASSION

B L Benson
California Asparagus Seed and Transplants, Inc
2815 Anza Ave
Davis
California 95616
USA

In 1984 the initial crosses resulting in the cultivars Apollo, Atlas and Grande were made in a breeding program to widen the pools of new cultivars. Parental selections were based on the horticultural, morphological and genetic background of the plants. The female parents were selected from previously adapted cultivars in California with high yields and superior spear quality. The common male parent was selected due to its genetic background (eastern U.S.A.) and its apparent adaptability to the Central California asparagus production area. The cloned parent plants are free of Asparagus Latent Virus 2 as are the cultivars.
Apollo, Atlas and Grande produce spears with very tight heads with little anthocyanin pigmentation. Spear yields range from 25 to 50 percent higher in California over UC 157 and in Washington equal to or better than most of the New Jersey cultivars. Test plantings in many of the productions areas around the world have shown these cultivars to be superior.
Purple Passion was bred from two generations of single plant selections from Violet de Albinga from Italy. This tetraploid cultivar produces large diameter, tight headed, purple coloured spears. The sweet tasting spears with mild asparagus taste have a 6° to 6.5° Brix reading. Purple Passion is adapted to warm, mediterranean climate.

9. ASPARAGUS BREEDING IN THE NETHERLANDS

C T J Scholten & P H G Boonen
Regional Research Station Noord-Limburg
P.O.B. 6077
5960 AB Horst
The Netherlands

One of the main problems in asparagus breeding is the evaluation of new hybrids. Screening on yield, quality of the harvested spears, spear thickness and earliness of the new hybrids takes a lot off time, space and labour. According to our earlier results an new experiment was started in 1988 to investigate how many years of harvesting is necessary to select the most promising new hybrids and to define the genetic capacity of the new in-bred lines. This experiment was harvested till 1992 and during this period the most promising hybrids were selected. From the 79 experimental hybrids, the twenty most hopeful were selected after two years and after three years harvesting an extra five were selected. These last five were added because they reached there production potential at a later stage. In 1992 the same 25 earlier selected hybrids, seemed again to be the most promising. In 1992 a new field trial with 200 experimental hybrids was planted and the evaluation will also be based on three years of harvesting.

12. QUARANTINE ISSUES IN THE INTERNATIONAL TRADE IN ASPARAGUS

A Carpenter
Levin Research Centre Crop & Food Research
Private Bag 4005
Levin
New Zealand

Asparagus is characterised by a range of both specialist and generalist pests. It is essential that asparagus traded across international borders be free of pests and diseases. There are 3 problems - a lack of effective detection systems, the complexity of the plants structure, and of quarantine treatments effective against a narrow range of problems.

13. ASPARAGUS PRODUCTION IN PERU

F D de la Flor B. & E van Oordt P[1]
Horticultural Research Programme,
Universidad Nacional Agraria La Molina
Lima
Peru.

Peruvian asparagus production has developed in the last 4 years to become the country's third agricultural export after Coffee and Cacao. In 1992, Peru exported some 31,000 tonnes of canned, fresh and frozen asparagus for a total value of $ US 50.0 Million, mostly to European and US markets and recently to other Latin American countries and Japan.

The Peruvian coastal area, west of the Andes mountains and near the Pacific Ocean, is a long strip of desert-like land about 50 km, wide and 2500 km long with average temperatures of 16.6°C in winter and 22°C in summer, and temperature variations between day and night of 6-8°C, high luminosity and little or no rainfall the year round. In this area all Peruvian asparagus is grown.

There present area is 17,800ha, of which 55% (mostly old plantations), is Mary Washington, and 41% is 'UC 157' (both F_1 and F_2). The most recent plantings are with, "Ida Lea', 'Cipres' and 'UC 72'. About 73% of the area produce white asparagus and the rest green asparagus.

All the fields are artificially irrigated, either by gravity on the sporadic coastal valleys or by drip irrigation from subsoil water on adjacent deserts. The combination of mild winters and summers and water control enables growers to regulate harvests, and thus Peru is able to produce and export asparagus the year round.

Yields are very variable, They may reach as high as 22,000kg/ha per year on 4 or 5 year old high quality plantings on Lima and Ioa departments, but the national average is 5,600kg/ha per year due to about 50% of the area being low-quality old plantings on the north. Many growers regulate their crops to harvest twice a year. Research is under way to establish the best long term cultural practises for Peru's special conditions.

[1] E van Oordt P., V.O. Consultores y Promotores S.A.,
Lima, Peru

16. EARLY EVALUATION OF YIELD AND SPEAR WEIGHT IN ASPARAGUS CULTIVAR TRIALS

A Uragami, M Nagai & H Yoshikawa[1]
Hokkaido National Agricultural Experiment Station
Sapporo 062
Japan

An international asparagus cultivar trial (IACT) and a line selection trial were conducted in Hokkaido from 1985 to 1992. In IACT, 13 cultivars, including two Japanese cultivars were individually evaluated in four replicate experiments, each with 30 plants. In the line selection trial, 15 lines and cultivars were individually evaluated with 25 plants. In November 1988, stem diameters of all stalks of ten plants per plot were measured and the squares of their diameters were summed. Young spears were harvested every year from early May for two to eight weeks, from 1989 to 1992. Sums of the square diameters in 1988 and accumulated yields for the four years were significantly correlated in the line selection trial but not in IACT. In IACT, the correlation coefficient between the yield in 1989 and the accumulated yield during the four years was significant at 5% level. The correlation coefficient between the average spear weight in 1989 and the average spear weight during the four-year harvest was also significant in IACT.

[1] National Research Institute of Vegetables, Ornamental Plants and Tea, Ano 514-23, Japan.

17. EVALUATION OF TWENTY-EIGHT ASPARAGUS GENOTYPES ON THEIR THIRD YEAR OF HARVEST AT VALDIVIA, CHILE

A Krarup
Instituto de Produccion y Sanidad Vegetal
Facultad de Ciencias Agrarias
Universidad Austral de Chile
Casilla 567
Valdivia
Chile

Twenty-eight asparagus genotypes were planted on August 1988, at Valdivia, Chile, in order to evaluate their behaviour for green spear production under local conditions. Total accumulated yield, for the first three harvests, ranged from 5,737 to, 16,927 kg/ha, being closer to the top of the range Junon, Cito, Aneto, Larac, Jersey Giant, UC 157, Schwetzinger Meisterschuss, and Gynlim, not differing, from Lucullus 235, Franklim and others, which were significantly better than Brock's Imperial, D'Argenteuil, Lucullus 235 and Del Monte 361. Annual yields together with a distribution in calibers of the third yield is presented. Junon appears having a higher yield of the largest size, both in weight as in percentage of its production; Lucullus 310, Cito, Sch. Meisterschuss and Lucullus 234 gave higher number of spears, being together with others superior to Brock's Imperial, and D'Argenteuil.
Within the third year of harvest, at a given period, the daily spear elongation was 5.58 cm, as an average, with a mean daily temperature of 15.5C; at the same period and through a regression between height of spears and a scale of head opening score, the height at which the different spears would start to open was calculated, according to this, D'Argenteuil and Aneto would open at a lower height and UC 157, Brock's Imperial, and Mary Washington at a higher, the rest being intermediate.

20. DEVELOPMENT OF GENETIC MARKERS TO IDENTIFY TWO ASPARAGUS CULTIVARS

M L Roose & N K Stone
Department of Botany and Plant Sciences
University of California
Riverside, CA 92521
USA

Asparagus cultivars are difficult to identify because many differ only in performance characters that are influenced by climate and soil type. We have been particularly concerned with methods for identification of 'UC157' and 'Ida Lea', clonal-hybrid cultivars developed and patented by the University of California. In order to distinguish Fl seed of these two cultivars from F2 or open-pollinated seed of these or other cultivars, we wish to identify molecular markers that are homozygous for different alleles in the parental clones of each cultivar. Initial studies with isozymes and RFLPs detected with random genomic probes did not reveal any suitable markers and indicated that the parental genotypes were highly homozygous and genetically very similar. We then screened for RAPD (random amplified polymorphic DNA) variation among the parental clones using 60 random decamer primers. Repeatable polymorphisms were amplified with 9 primers in one or both families. Initial results are consistent with dominant inheritance for 8 of these polymorphisms. One primer amplified two polymorphic products that may represent codominant alleles, but formal inheritance tests are still in progress. Eleven amplified segments, including those showing polymorphism, were excised from the gels and used as probes on Southern blots of parental and Fl hybrid DNA. Ten amplified segments hybridized to one or a few genomic DNA fragments, and four of these probes detected polymorphisms. For two of these polymorphisms, the parents of 'UC157' had different restriction fragments that were both present in the Fl. No suitable markers for 'Ida Lea' were identified. The formal inheritance of these polymorphisms is being studied in F2 populations and the amplified segments are being sequenced to develop specific PCR primers for cultivar identification.

21. ADVANCES IN ASPARAGUS BREEDING FOLLOWING *in vitro* ANTHER CULTURE

A Falavigna, P E Casali & M G Tacconi
Research Institute for Vegetable Crops
Montanaso L.
Italy

In vitro another culture technique was applied during the last 17 years in a long-term breeding program of asparagus. Respect to the results described at last Symposium in Ferrara, the advancement of the research on doubled-haploid clones is concerning the *in vitro* propagation of selected 26 females and 16 males, and their subsequent plantation in a soil naturally infected by Fusaria (replanted with asparagus crop). At the third year of evaluation it was possible to confirm the good performancies of the clones; besides 4 females and 5 males showed a good level of resistance to *Fusaria* as the percentage of surviving plants was near to 100%, while for the remaining clones this percentage ranged from 20 to 50%. Selected doubled haploid males were crossed with doubled or heterozygous females to obtain "two ways" and "three ways" all-male hybrids respectively. Results from multi-location field trials evidenced that the best "two ways" and "three ways" hybrids possessed a yield stability along the years, higher than that of commercial controls, indicating that the absence of genetic stability does not precludes a good level of phenopitic stability. On the basis of these results, four all-male hybrids named Eros (AM771), Ringo (H106), Golia (H412) and Argo (AM723) were released and the commercial seed production starts in 1993; besides a wide collection of doubled haploid selected clones are available for further breeding.

24. RELATIONSHIP BETWEEN SOIL TEMPERATURE AND SPRING SPEAR EMERGENCE AND QUALITY IN COASTAL SOUTH CAROLINA

Robert J Dufault
Horticulture Dept
Clemson University
Charleston, SC 29414
USA

The soil temperature threshold modulating first spring spear emergence (FSE) is unknown. The objective of this 5 year study was to document the relationships between min/max soil temperatures (mMst) at a 15 cm depth with emergence, quality, yield, and peaks of production. 'UC 157 Fl' seedlings were transplanted in 1986 and harvested and graded from 1988 to 1992. The date of FSE varied as much as 49 days among the five years and averaged Feb 15. Average mMst for 1988-1992 for 14 days before FSE and the day before FSE were 11.0 + 3.0 / 15.7 + 2.7C and 14.4/18.0C, respectively. Mean mMst during the harvest season (51 days long) were 14.3 + 3.5 / 19.7 + 3.6C, respectively. Linear increases in spear emergence with mMst were weakly correlated (R2 = .30 and .21, respectively). The major peak of emergence occurred 22 to 25 days after FSE at mMst of 15/21C, respectively. It required 11, 22, and 39 days after FSE to complete 25, 50 and 75% of the harvest season, respectively. Individual spear weight and spear diameter did not correlate with mMst. Linear increases in marketable weight (kg/plot) weakly correlated weakly (R2 = .26) with min, but not max soil temperature. Although the initiation of first spear emergence increases with soil temperatures, sustained high emergence rates after the first major peak of emergence did not occur with increasing soil temperatures. Other physiological factors not considered in this study affected spear emergence.

25. GROWTH OF ASPARAGUS SPEARS AND FERN AT HIGH TEMPERATURES

Yung-fu Yen, M A Nichols & D J Woolley
Department of Plant Science
Massey University
Palmerston North
New Zealand

One-year old crowns of cvs. Brocks, Larac, Tainan No.1, and UC157 were grown in growth cabinets to examine spear yield and fern development at high temperatures (28C, 33C and 36C). In one study, spears were harvested for 2 months and measurement of spear weight, spear yield, spear diameter and spear number were taken. In another study the spears were not harvested, but were left to develop into fern, and the height during development from spear to fern was measured. These results showed that not only did high temperature depress spear yield, but also depressed the total fern weight of the whole plant and individual fern height.

When fern height was fitted to the Richard's Growth Equation, the Gompertz function was preferred to the monomolecular or the logistic function. The patterns of the developing fern hight changes with temperature, the higher the temperature the faster the growth, but fern height did the reverse. The spear growth (up to 70 cm high) was exponential, but spear growth appeared faster at 33C than at 28C and 36C. The criterion of fern or spear heat adaption with the parameters of Richard's Equation and relative spear growth rates was in order of Tainan No. 1 > Brocks > UC157 > Larac.

28. CHANGES IN CARBOHYDRATES IN STORAGE ROOTS OF YOUNG ASPARAGUS PLANTS

W B Dean & Elzbieta Skrzeczkowska
Department of Horticulture and Landscape Architecture
Washington State University
Prosser, Washington USA

Asparagus roots contain complex fructopolysaccharides that are hydrolyzed and transported to shoot buds for growth. The nature of these polysaccharides has been recently documented (Shiomi, 1993). Pressman (1993) reported a decrease in the degree of polymerization of oligosaccharides found in asparagus storage roots during the harvest period but did not provide details of individual changes in oligosaccharides.

Jersey Giant asparagus plants were grown in a greenhouse from seed for four months. The mature fern was removed, and weekly harvest of shoots and roots was made for carbohydrate analyses. Specific changes in storage root carbohydrates of young asparagus plants were measured during spear growth. There was no change in root oligosaccharide amount one week after removal of mature fern even though new spear growth had begun. The amount of oligosaccharides (DP3-DP17) decreased significantly after the first week and then levelled off. Fructose and sucrose increased after cutting the mature fern, decreased during a moisture stress, and then returned to previous levels. Glucose decreased throughout the harvest period and became near zero by week 4.

The oligosaccharides in storage roots of asparagus appear to be hydrolyzed at similar rates judged by their disappearance. An exception to this was DP4, which did not decrease during the harvest period until the final harvest.

29. STUDIES OF THE GROWTH AND DEVELOPMENT OF SUCCESSIONAL FIELD PLANTINGS OF ASPARAGUS SEEDLINGS

S Sudjatmiko, K J Fisher, M A Nichols & D J Woolley
Department of Plant Science
Massey University
Palmerston North
New Zealand

Seven successional plantings were made at 4 weekly intervals from September with the varieties UC157 and Jersey Giant. From 4 weeks after the first planting successional destructive harvests were made at 4 weekly intervals until autumn. Plant growth fitted a logistic growth model with a heat unit time scale. The shoot root ratio increased until the February harvest when it started to decrease. This pattern was followed by all plantings and was described using an allometric relationship. The earlier the planting the greater the plant dry weight at the final harvest (April). There were no differences between the two cultivars in total plant dry weight or shoot dry weight at the final harvest for the 7 planting dates, although Jersey Giant did have the higher crown dry weight. At the final harvest, shoot number per plant increased with earliness of planting, while bud and root numbers were not different with the early and then decreased with the later plantings. For each of the 7 planting dates, UC157 had more shoots and in most instances more buds and roots at the final harvest than Jersey Giant.

32. AERIAL CROWN-LIKE BODY FORMATION THROUGH NODAL SEGMENT CULTURE

H Araki, S Watanabe[1], T Harada[2] & T Yakuwa[2]
University Farm
Niigata University
Muramatsu
Niigata 959-17
Japan

An aerial crown-like body was often formed at the node. It was similar to the underground crown forming at the basal portion of the seedling in histological observation, because of the numerous crown buds and vascular bundle with unfixed direction. Aerial crown-like bodies were induced by culturing the nodal shoot segments of asparagus young seedlings in modified MS medium supplemented with 0.5-2 mg/l ancymidol and 0.1-0.3 M sucrose. Especially, in the medium supplemented with 2 mg/l ancymidol and 0.1 M sucrose, aerial crown-like body formation and many crown bud induction were very frequently recognized. Aerial crown-like body formation was completely suppressed in the presence of 1-10 mg/l gibberellin (GA_3), and GA_3 made the lateral buds develop into lateral shoots. Vigorous rooting was accelerated by transferring the nodal segments with aerial crown-like body to the basal medium. The obtained plantlets were successfully transplanted to soil. The resulting aerial crown-like body was induced by inhibiting GA activity, and its formation was effective for propagation through tissue culture.

[1] Hokuriku Natl. Agr. Exp. Stn., Johetsu, Niigata 943-01, Japan.

[2] Department of Horticulture, Faculty of Agriculture, Hokkaido University, Sapporo 060, Japan.

33. SOMATIC EMBRYOGENESIS IN ASPARAGUS SUSPENSION CULTURE

G Reuther
Department of Botany
Forschungsanstalt Geisenheim
65366 Geisenheim
Germany

Asparagus callus cultures of supermale, male and female cultivars have been established in Erlenmeyer flasks and in bioreactor. In order to transform shoot regenerating callus into embryogenic callus the hormone combination 1 mg/l IAA, 0,1 mg/l BA and O,l g/l 2iP in mod. Linsmaier/Skoog basal medium was replaced by 1 mg/l kinetin and 1 mg/l 2,4-D. In all cultivars under control 2,4-D inhibited shoot regeneration and promoted the formation of globular callus clumps. The clumps consisted of a smooth surface and attained a torpedo-shaped structure. Two differentiation pathways were recorded:

a) increase of callus clumps to multi-nodular structures with root and shoot initials;
b) torpedo-stage of smaller units with defined bipolar character.

By histochemical and histological studies the proembryonal and embryonal differentiation patterns could be discriminated from incompetent material. The total protein content of callus grown in 2,4-D/Kin supplemented medium was distinctly higher than in the shoot regeneration medium. The growth rate of the callus mass in bioreactor corresponded with the decomposition of sucrose and the decrease of the conductivity.

36. EFFECT OF GENOTYPE AND AUXIN ON DIRECT SOMATIC EMBRYOGENESIS FROM PROTOPLASTS DERIVED FROM EMBRYOGENIC SUSPENSION CULTURES OF *ASPARAGUS OFFICINALIS* L.

R A May & K C Sink
Department of Horticulture
Michigan State University
East Lansing
MI 48824
USA

Embryogenic callus from four asparagus genotypes (Jersey Giant 8, MD10, Rutgers 22, and 86SOMI) was initiated from micropropagated spears placed on semisolid LS medium containing 5 μM 2,4-D or 50 μM NAA, concomitantly. After three subcultures, such callus tissue was used to initiate cell suspensions in liquid medium of the same composition. The eight sets of suspensions were used as sources of protoplasts at two months of age and again at five months. Protoplasts were immobilized at 10^5/ml density in MS medium with 0.6% agarose and overlaid with liquid KM medium containing the same concentration of auxin as the corresponding donor suspension or no plant growth regulators (PGR's). There was a significant interaction between genotype, suspension PGR, and inclusion or exclusion of PGR's in the protoplast culture medium. First divisions were observed as soon as 3 days depending on the culture and plating efficiencies recorded at 14 days ranged from 0 - 40%. Globular somatic embryos developed directly from protoplasts at 10 - 14 days and bipolar embryos could be subcultured 3 - 4 weeks after initial culture. All four genotypes were capable of regenerating plants via protoplast-derived embryos; however, protoplasts cultured without PGR's derived from NAA suspensions of Rutgers 22 was the best treatment with over 40% of the protoplast-derived embryos germinating into plants.

37. THE ESTABLISHMENT OF ASPARAGUS CLONES OUT OF TISSUE CULTURE

K J Fisher, B R MacKay & M A Nichols
Department of Plant Science
Massey University
Palmerston North
New Zealand

A nutritioual study with an asparagus clone found that a growth rate maximum was not attained when the plants were fed daily with a 100 mgl^{-1} N, 34 mgl^{-1} P, 100 mgl^{-1} K nutrient feed. Clones were grown for 4 weeks at 14°C, 21°C, 28°C in growth cabinets. At 14°C clones did not grow, while growth increased over the temperature range to 28°C. As temperature increased so did partitioning of planting both seedlings and clones through black polythene mulch increased plant dry weight at the end of the growing season. The seedlings partitioned 40% of their dry matter to the shoots whereas the clones only 26%. Experience has shown that after transfer out of tissue culture the growth of asparagus clones does not compare with that of seedlings. Possible reasons for this are discussed.

40. MAGNETIC RESONANCE IMAGE ANALYSIS OF FIBRE IN ASPARAGUS

D E Marshall, J M Halloin[1], T G Cooper Sr[2] & G A deZoeten[3]
Department of Agricultural Engineering
Michigan State University
East Lansing, MI 48824
USA

Development of stem vascular tissue presents a major problem in marketing of asparagus, *Asparagus officinalis* L. Non-destructive means for assessing this development are needed. We investigated use of magnetic resonance imaging as a tool for evaluating fibre development in asparagus stems, and compared this with the more conventional analysis by shear press. Spin-spin (T2) and spin lattice (T1) proton relaxation times, and moisture content were not consistently distinguishable between tender and woody (=high fibre) stems. Signal intensity of magnetic resonance images were greatest at vascular bundles, apparently due to free water within them, but differentiation between woody and tender was highly subjective. Analysis of tenderness with conventional shear press methods provided more reliable differentiation of tenderness groups than did magnetic resonance imaging.

[1] Department of Botany Plant Pathology, Michigan State University, East Lansing, MI 48824, USA
[2] Department of Radiology, Michigan State University, East Lansing, MI 48824, USA
[3] Department of Food Science and Human Nutrition, Michigan State University, East Lansing, MI 48824, USA

41. SUCCESSION OF WEED FLORA IN SOME NEW ZEALAND ASPARAGUS CROPS

A Rahman & P Sanders
AgResearch
Ruakura Agricultural Centre
Hamilton
New Zealand

The weed flora of most New Zealand asparagus crops has changed rapidly due in part to cultural practices but largely due to repeated use of herbicides. The weed composition in early establishment phase of crops consisted of many annual broadleaf and grass weed species, of which only five or six broadleaf and two or three grass weeds dominated. The spectrum of weeds varied with both climatic and soil (mainly texture) differences and the numbers reached to several million seedlings/ha at some sites. As these common weeds were removed by cultivation or more often by herbicides, the composition shifted to warm-zone perennial grasses e.g. *Paspalum* spp., *Cynodon dactylon.* Broadleaf weeds that emerged as specific problems were *Gnaphalium luteo-album* in fields where uracil or triazine herbicides were used repeatedly, and triazine-resistant *Chenopodium album* and *Polygonum persicaria* as a result of relying on triazine herbicides. Other particularly troublesome weeds to appear in many fields included *Cirsium arvense, Calystegia silvatica, Convolvulus arvensis,* as their growth habits are somewhat similar to asparagus and herbicides do not provide adequate long term control. *Ranunculus repens,* a weed of pastures and orchards, has also encroached into some fields, and recently *Cyperus rotundus* has also appeared in some crops which may prove a difficult problem in future. Research has kept pace in developing control strategies, which are discussed in the paper. It is strongly recommended to rotate herbicides (belonging to different chemical families) in the weed control programme to slow down the shift in weed composition and limit development of herbicide resistance.

44. CONTROL OF ASPARAGUS RUST IN THE SACRAMENTO-SAN JOAQIN DELTA REGION OF CALIFORNIA

R J Mullen & T C Viss
University of California Cooperative Extension
Stockton
California
United States of America

Asparagus Rust (*Puccinia asparagi*) is a recurring disease problem on some asparagus fields in the Sacramento-San Joaquin Delta Region of California, as well as on the Central California coast. Severe infection can defoliate asparagus fern during late summer and early fall resulting in reduced carbohydrate storage in the crown for the following harvest season. Foliar fungicide sprays of currently registered materials in California have been somewhat ineffective, or erratic in their performance on this pathogen. Evaluation of new candidate chemical materials, well as standard compounds for control of asparagus rust was begun in 1991. Thirteen individual or combination treatments will have been studied for disease control efficiency over the three year study period. Thus far the most effective compound has been Sandoz 619F, sprayed alone, on a 14 repeated day schedule once pustule and urediospore development begins to occur, followed by Bayleton (triademefon) alone, and a standard combination treatment of Funginex (triforine) plus Dithane (mancozeb). Two additional materials - Rally (myclobutanil) and fluazinam show promise. Cultural practices such as long interval furrow irrigation, wide-row spacings, and mechanical soil incorporation of fern at the end of the season can greatly reduce disease incidence.

45. SURVEY OF ASPARAGUS CROPS IN NEW ZEALAND FOR ASPARAGUS VIRUS 2

M V Jaspers & P G Falloon[1]
Department of Plant Science
Lincoln University
Lincoln
New Zealand

From 67 commercial crops of asparagus *(Asparagus officinalis L)* in New Zealand two spears were collected from each of 10 randomly selected plants. Sap extracted from spears was mechanically inoculated into *Chenopodium quinoa* and *Nicotiana tabacum.* Indicator plants showing typical Asparagus Virus 2 (AV2) symptoms (systemic mottle and/or chlorosis on *C.quinoa* and systemic necrotic spots on *N.tabacum*) were recorded as positive. Indirect ELISA was also used to test the same samples for AV2 and the methods compared. ELISA gave the highest level of agreement with the results from one or both of the indicators.
AV2 was detected in 62 of 67 crops with an average 44% of the sampled plants infected, the range being 10-100%. Cultivar analysis showed no difference in levels of AV2 infection between cultivars. Age analysis of crops indicated a higher incidence of AV2 infection in older crops. These results suggest that AV2 may be mechanically transmitted on cutting knives during harvesting of spears.

[1] Aspara Pacific Ltd, P O Box 36, Lincoln, New Zealand

48. RESPIRATION AND SOLUBLE CARBOHYDRATES IN TIPS OF HARVESTED ASPARAGUS SPEARS

D E Irving & P L Hurst
New Zealand Institute for Crop & Food Research Limited
Levin Research Centre
Private Bag 4005
Levin
New Zealand

Asparagus *(Asparagus officinalis* L.) spears were held at 20°C for up to 5 days after harvest and examined for changes in respiration rate and concentrations of soluble carbohydrates. The respiration rate and the gas exchange (respiratory) quotient (CO_2/O_2) declined in parallel during the first day. There was a rapid loss of sucrose from spear tips over the first 6 h, and a more gradual loss thereafter. Glucose concentration declined gradually throughout, but fructose concentration hardly changed during 3 days. We conclude that the metabolism of asparagus spear tips is characterised by a switch from sucrose-derived hexose phosphate to another primary respiratory substrate, probably derived from protein and/or lipid, immediately after harvest.

49. USING INSULATION AND COOLING TO IMPROVE THE ASPARAGUS COOLCHAIN

B L Bycroft, D W Brash & F Bollen
Crop and Food Research
Levin Research Centre
Levin
New Zealand

The success of the New Zealand asparagus industry depends on the delivery of high quality fresh asparagus by air to distant markets. Lack of temperature control on aircraft and during off-loading can cause rapid quality loss in asparagus.

In simulated transport experiments in 1991 and 1992, we tested the effect of various covers and passive cooling treatments on the temperatures within pallets of fresh export asparagus. After cooling the pallets to 0-2°C, the treatments were applied and the room temperature raised to 20°C. Temperature changes during this time were monitored at probes positioned throughout each pallet.

Foil/polybubble laminate and builder's foil provided effective air exchange barriers between the cooled asparagus and the warm room. The addition of an ice blanket or dry ice lowered the mean pallet temperature even further. Ice reduced the vertical temperature gradient within the pallet.

Insulation plus ice or dry ice has the potential for commercial use during the export of fresh asparagus, provided the asparagus is cooled adequately prior to treatment.

52. THE FERTILISER REQUIREMENTS OF ASPARAGUS ON AN ALLOPHANIC CLAY BASED VOLCANIC ASH SOIL

J A Douglas & J M Follett
NZ Institute for Crop & Food Research Ltd
Ruakura Agricultural Centre
Private Bag
Hamilton
New Zealand

Two fertiliser trials were conducted on newly established asparagus on a typic vitrandept (Horotiu sandy loam) soil in the Waikato, New Zealand which had been unfertilised for 6 years. Asparagus seedlings (Jersey Giant Syn 4) were planted in November 1987 with fertiliser treatments applied in 1988 and reapplied in 1990. A 2^5 factorial experiment with 4 rates of potassium and 2 rates of magnesium, nitrogen and boron was laid down on 3 blocks pre-treated with different rates of phosphatic fertiliser before planting the asparagus. A second experiment examined the effect of 4 rates of boron.

Asparagus spears were harvested in 1990 and 1991. Yield increases were only recorded to potassium application. Fern samples collected in 1989,1990,1991 and 1992 showed increased potassium concentrations but little or no change in other nutrients except for phosphorus concentration in 1989. Soil test values for phosphorous, potassium, magnesium and boron were all increased by the fertiliser application.

The experimental results will be presented and discussed in relation to the fertiliser requirements of asparagus on volcanic ash soils.

53. RESPONSE OF ASPARAGUS TO 3 N AND 5 K LEVELS AFTER 10 YEARS.

D C Sanders, R A Bailey, P David, C Prince & O Bandele
Horticultural Science Department
North Carolina State University
Raleigh, NC
USA 27695-7609

'Mary Washington' was grown at all possible combinations of 0, 56, 168 kg N/ha and 0, 56, 168, 336, 504 kg K/ha for 10 year. Accumulated yield increased with N rate, but did not increase in yearly yields at more than the 56 kg N/ha except in early years. The 504 kg K/ha suppressed yield in most years and the accumulated yield. The yield decreases in the high level of K was reduced at the high N rate.

56. PROSPECTS AND PERFORMANCE OF ASPARAGUS (ASPARAGUS OFFICINALIS LINN) CULTIVARS IN KULLU VALLEY HIMACHEL PRADESH

D K Sharma
University of Horticulture and Forestry
Regional Horticultural Research Station
Bajaura
Kullu (H.P.) -175 125
India

Asparagus (*Asparagus officinalis* Linn) was introduced in Kullu Valley of Himachal Pradesh long time back but became popular recently. The agroclimatic conditions of Himachal Pradesh are highly suitable for asparagus cultivation and high quality asparagus can be produced from March to July after third years of the transplanting.

Five cultivars viz Perfection, Brock Imperial-814, Local, UC-72 and, Conovers Colossal were planted during November, 1990. It was found that cultivar Brock Imperial-84 resulted in the maximum spear yield (494.67 g/plant) and the lowest spear yield (188.33 g/ plant) was observed from local collection. The maximum spear weight (39.7 g) and spear diameter (2.3cm.) were also recorded from Brock Imperial-84 cultivar during third year cropping.

57. ECONOMIC PROBLEMS OF DECLINING ASPARAGUS FIELDS

H P Hartmann
Geisenheim
Federal Republic of Germany

Declining of asparagus fields results in a changing proportion of different spear sizes on the total yield and the total number per hectare. The poster presents the influence of these changes on economic datas.

1. In white asparagus declining starts after the third year of harvest. The percentage of asparagus spears with a diameter of 16-26 mm decreases, the percentage with a spear diameter of 10-12 mm increases.
2. The average spear weight decrease.
3. The number of spears per 100 kg increases.
4. The labour input for yielding increases.
5. The average price for spears of a growing old field decreases per 100 kg compared with a younger one in the same season.
6. The average income per season decreases.

The input of all basic datas to calculate the marginal income indicates that after the maximum in the third year these figures are declining in the following one. Computing the correlation by setting the contribution margins of different experiments for 100% the coefficient of variations of the b-values so obtained was 17.4%. The average correlation of six field trials at Ingelheim asparagus experimental field was calculated as:

$$y - 124.6 - 9.07 x$$

This result means that the marginal income every year is reduced by nearly 10%.

The intention is to develop a model for white asparagus that allows to describe the effects of declining on economy.

60. THE IMPACTS OF ANCYMIDOL, ABA, PACLOBUTRAZOL AND UNICONAZOL ON SOMATIC EMBRYOGENESIS OF ASPARAGUS

B C Li and D J Wolyn
Department of Horticultural Sciences
University of Guelph
Guelph
Ontario
NlG 2Wl Canada

The impacts of anti-gibberellins (ancymidol, ABA, paclobutrazol and uniconazol) on somatic embryogenesis were evaluated. Callus induced from seedlings of asparagus genotype G447 were transferred to embryo induction medium (MS+3g/L sucrose+0.1mg/L NAA+0.5mg /L kinetin), with different concentrations of anti-gibberellins (ancymidol, 0.25, 0.50, 0.75mg/L; ABA and paclobutrazol, 0.05, 0.1, 0.15mg/L; uniconazol, 0.025, 0.05, 0.075mg/L). After 8 weeks, the recovered bipolar or globular embryos were incubated in MS medium plus 60g/L sucrose, 0.75mg/L ancymidol, 40mg/L adenine sulphate dihydrate and 0.17mg/L sodium phosphate monobasic for germination. All four anti-gibberellins increased the ratio of bipolar versus globular embryos, by enhancing the induction of bipolar embryos 100-1000% and decreasing the production of globular embryos 10-50%, relative to the control with no anti-gibberellins. There was no difference in the total (bipolar+globular) number of embryos produced from all treatments. The germination rate of bipolar embryos produced with four anti-gibberellins increased by 100-1200%, compared with the control. None of globular embryos germinated. Two-ten times more plants were recovered from the embryos produced from four anti-gibberellins than the control. Ancymidol (0.75mg/L) and ABA (0.O5mg/L) produced the best results; 59 (±4) and 46 (±8) bipolar embryos/g callus were produced, 38% and 37% of them germinated, and 23 and 16 plants/g callus were recovered, respectively.

61. GENETIC TRANSFORMATION OF ASPARAGUS THROUGH THE BOMBARDMENT OF ASPARAGUS CELLS

B C Li and D J Wolyn
Department of Horticultural Sciences
University of Guelph
Guelph
Ontario, NlG 2Wl
Canada

Suspension cells from both anther and somatic tissue-derived calli of asparagus genotype G203 were used as the targets of particle gun bombardment for transformation. Tungsten particles were coated with pKGUS plasmid containing β-glucuronidase (GUS) and NPTII genes, and accelerated by the helium to bombard the cells. After 48 hours, the bombarded cells were incubated with the X-Glu substrate to determine GUS expression. Sixty-five haploid and 80 somatic cells or cell clumps per plate (10^4-10^5 cells) showed positive GUS expression. After 7-10 days, the bombarded haploid cells were transferred to embryo induction medium (MS+0.75mg/L ancymidol+0.lmg/L NAA+0.5mg/L kinetin) with 25mg/L kanamycin to induce resistant calli. The bombarded somatic cells were incubated in two media:l) MS+0.lmg/L 2,4-D+25mg/L kanamycin and 2) MS+0.2mg/L NAA+ 0.02mg/L kinetin+25mg/L kanamycin. Five (±3) and 10 (±5) resistant calli per plate were recovered from bombarded haploid and somatic cells, respectively, and transferred to the embryo induction medium with 25mg/L kanamycin to induce embryos and plantlets. Plants have been regenerated from bombarded haploid and somatic cells. GUS activity was detected in resistant calli, embryos and plants.

64. JWC1 - ASPARAGUS HYBRID

P G Falloon, B L Mackintosh[1] & A M Andersen
Aspara Pacific Ltd
P O Box 36
Lincoln
New Zealand

JWC1 is a new clonal hybrid that has out-yielded all other asparagus hybrids in New Zealand. It's long, all-green spears makes it suitable for export, process or local market.
JWC1 is the result of a cross between a single male (3M) and a single female (91F) plant both of which were selected from the open pollinated variety Mary Washington. The first seed of this new dioecious hybrid was planted in field trials in 1977.

JWC1 has been evaluated in the main asparagus production areas of New Zealand. At every site it produced higher yields than UC 157 and Jersey Giant. Trials in the North Island showed that JWC1 had 18% more export spears than Jersey Giant in the Waikato. In the Manawatu JWC1 out-yielded Jersey Giant by 42% and Taramea by 16%. Field trials in Hawkes Bay showed that JWC1 produced more than twice the cannery yield of UC 157 over a seven-year evaluation period.

Spear quality of JWC1 is better than Jersey Giant. JWC1 produces a thinner spear than Jersey Giant with more spears meeting export diameter specifications. The tighter head of JWC1 when left to grow to 25 cm long means that it can safely be harvested at a longer length than Jersey Giant. The purple blush that often develops at the base of spears of Jersey Giant is almost absent in JWC1.

[1] Wattie Frozen Foods Ltd, P O Box 502, Feilding, New Zealand

65. DEVELOPMENT OF NEW VARIETIES WITH RESISTANCE TO PHYTOPHTHORA ROT.

P G Falloon, A M Andersen & D Abernethy
Aspara Pacific Ltd
PO Box 36
Lincoln
New Zealand

Phytophthora rot affects asparagus production in Europe, North America, South America and Australasia. At present disease control is achieved with the use of fungicides. There are no varieties of asparagus that are resistant to Phytophthora rot.

At Lincoln we have developed techniques that can effectively identify Phytophthora-resistant lines of asparagus and are using these in our breeding programme to develop varieties that are resistant to this important disease of the crop.

A field disease nursery is used to determine the field resistance of asparagus breeding lines and clones to several highly virulent isolates of Phytophthora. Plants were selected from lines that showed improved levels of resistance in the field disease nursery and planted in a polycross block. Seed from several parents had approximately twice the number of resistant plants when compared to UC 157 and Jersey Giant-Syn 4 in the disease nursery.
The aim of our breeding programme is to incorporate this resistance into hybrids that also have superior quality and improved yield.

68. RESULTS OF THE INTERNATIONAL ASPARAGUS CULTIVAR TRIAL IN POLAND

M Knaflewski
Department of Vegetable Crops
Agricultural University of Poznan
Dabrowskiego 159
60-594 Poznan
Poland

A trial with eleven cultivars originating from different countries was established in western part of Poland in the summer of 1987. Blanched spears were harvested in the years 1990 - 1993. The mean temperature in the harvest period in these years ranged from 11.3C to 17.3C. The highest accumulated yield for the four years of harvest was obtained witth Jersey Giant, Geynlim, Vulkan (Lucullus 234), Jupiter (Lucullus 310) and the lowest with UC 157, Larac, Tainan No 1, Del Monte 361. In 1993 high yield was also obtained with the cultivar Franklim which shows significant yield increases in successive years. The strongest reaction to low temperatures during the harvest period as expressed by lower yield occurred with cultivars: UC 157, Larac, and Largo. In contrast, the highest yielding cultivars showed no such temperature-dependent reaction. The differences between yields of the lowest and highest yielding cultivars amounted to ca. 250% in average years and to ca. 450% in the second year of harvest when the lowest mean temperature occurred. The best-quality white spears were produced by Jersey Giant, Geynlin, and Vulkan (Lucullus 234) and the lowest quality with cultivars: UC 157, Del Monte 361, Franklim, and Tainan No.1. The highest yielding cultivars also showed the highest level of tolerance to Botrytis.

69. IN VITRO COLD STORAGE OF ASPARAGUS

P J Fletcher
New Zealand Institute for Crop & Food Research Ltd
Private Bag 4704
Christchurch
New Zealand

To assist with commercial production of asparagus clones, a system for in vitro storage of high health asparagus germplasm has been devised. In vitro mini-crowns, preferably with storage roots, are stored on a medium consisting of Murashige and Skoog salts with the addition of 3% sucrose, 4% sorbitol, 0.4 mg/l thiamine, 200 mg/l glutamine, 100 mg/l inositol, 1.0 mg/l ancymidol, 0.8% Agar. The cultures are stored in an incubator at 6 C with a photoperiod of 16 hours [light level of 70-90 ,umol m-2 sec-l]. After 16 months of storage, the viability and re-culturing ability of the in vitro cultures were assessed. To date, the cultures have survived 2 years of storage with 100% success in regrowth back to their original growth form.

72. ANCYMIDOL, PHLOROGLUCINOL AND TRYPTONE ENHANCED *IN VITRO* ROOTING OF ASPARAGUS NODAL SECTIONS

D C N Chang & K H Peng
Department of Horticulture
National Taiwan University
Taipei, Taiwan, ROC (10617)

Rooting percentage of Tainan Selection #3 (TS #3) asparagus nodal sections in MS medium with NAA, kinetin and 3 % sucrose was only 1.7%. Tryptone (250 mg/l), phloroglucinol (PG; 162 mg/l) and Ancymidol (1.28 mg/l) were added to a modified MS medium containing NAA (0.15 mg/l), kinetin (0.15 mg/l) and 6% sucrose for inducing more rooting of asparagus in vitro. The asparagus rooting percentage in control medium was 18%, while in growth medium with tryptone, PG or Ancymidol,rooting percentage was 41, 59 and 63 %, respectively. In a combination of tryptone or PG with Ancymidol, the in vitro rooting of asparagus reached 73-78%.

The presence of PG or tryptone significantly increased shoot number and root length, while Ancymidol reduced shoot length, but significantly increased diameter of shoot and root and number of multiple shoots.

It is recommended that in modified MS medium, the addition of phloroglucinol or tryptone in the presence of Ancymidol could highly increase rooting percentage and resulted in more vigorous shoot growth and stronger root system for TS# 3 asparagus plantlets in vitro.

73. MALATE ACCUMULATES IN TIPS OF HARVESTED ASPARAGUS SPEARS

P L Hurst, D E Irving & P J Hannan
New Zealand Institute for Crop & Food Research Limited
Levin Research Centre
Private Bag 4005
Levin
New Zealand

Freshly harvested asparagus spears held at ambient temperatures rapidly lose soluble carbohydrates from their tips. The key enzymes of the glyoxylate cycle, malate synthase (EC 4.1.3.2) and isocitrate lyase (EC 4.1.3.1), appear in some carbohydrate-starved and senescing plant tissues concurrent with the mobilisation of lipids and a decline in the respiratory quotient. To see if these events occur in harvested asparagus *(Asparagus officinalis L.)*, we measured total lipid levels, respiratory quotients, and malate synthase and isocitrate lyase activities in 3 cm tip sections of whole asparagus spears stored at 20°C for up to 5 days. Within 24 h, the respiratory quotient dropped from near 1 to 0.65 before stabilising around 0.75 after 2 days. Over 5 days, nearly half of the total lipid in spear tips was lost. Malate synthase activity, which was absent at harvest, appeared after 1-2 days and continued to increase throughout the remainder of the storage period. Malate accumulated in the tips concurrently and reached 3- to 4-fold the harvest concentration by 4-5 days of storage. Isocitrate lyase activity was not detected at any time during the storage period. These results will be discussed with reference to other postharvest metabolic events in asparagus spear tips.

76. IMPROVEMENT OF DANISH ASPARAGUS CULTIVARS

L Sørensen
Department of Vegetables
Danish Institute of Plant and Soil Science
Aarslev
Denmark

Cultivation of green asparagus is limited in Denmark due to low yields and high variability in spear diameter and quality. The cultivars grown must be adapted to Danish climatical conditions and produce pure green spears which is a market demand. Evaluation of asparagus cultivars grown as green asparagus in Denmark indicated that the most suited cultivar for production in Denmark was 'Aarslev no. 270', bred at Department of Vegetables, Aarslev. Being a clonal hybrid, a population of 'Aarslev no. 270' is highly variable. Individual plants vary in yield and quality of spears. In addition anthocyanin colour is present on approximately 15 % of the spears. A new project on green asparagus was started in 1993 with the objective to improve 'Aarslev no. 270' by selection of parent plants and propagation by somatic embryogenese. Male plants will be selected for high yield of spears with uniform diameter, spear tip tightness and pure green colour of all the spears. Clones of 'Aarslev no. 270' will be evaluated in field experiments together with seed propagated populations. The emphasis will be on improved spear quality and uniformity.

77. HERBICIDE AND TILLAGE INJURY TO ASPARAGUS CROWNS

A F Senesac & D. Wilcox
Long Island Horticultural Research Laboratory
Cornell University
39 Sound Avenue
Riverhead, New York 11901
USA

Napropamide and metribuzin have been registered for several years in the United States for weed control in established asparagus plantings. Long term field studies on Long Island, have shown that the combination of metribuzin and napropamide can cause crown injury under tilled conditions. Greenhouse studies were conducted to examine the effect that soil disturbance and crown damage (simulated cultivation) may have on the activity of these two herbicides. An initial study compared metribuzin (1.1 kg/ha) or napropamide (2.2 kg/ha) applied to six month old asparagus cv. *Jersey Giant* grown in soil (Riverhead sandy loam) or soilless medium (peat:vermiculite 1:1). The results of a destructive harvest indicate that metribuzin, but not napropamide, had a negative effect on crown and root weight and bud number. Soil disturbance and crown damage prior to treatment had a minimal influence on herbicide activity. The treatment effects were more evident in the plants grown in the soilless medium than those grown in soil. In a second study napropamide (2.2 and 4.5 kg/ha) and metribuzin (0.56 and 1.1 kg/ha) were evaluated singly and in combination with and without simulated cultivation. Results indicate that only metribuzin (1.1 kg/ha), alone or in any combination, caused a significant reduction in crown and root weight and bud number.

80. PROPOSED PLANTING AND PRODUCTION CYCLE OF ASPARAGUS FOR ECUADOR

A Krarup
Instituto de Produccion y Sanidad Vegetal
Facultad de Ciencias Agrarias
Universidad Austral de Chile
Casilla 567
Valdivia
Chile

As of 1992 Ecuador has about 900 hectares of asparagus planted at altitudes of 2500 to 3500 meters over the sea level, intending to grow in surface due to their potential. Export of green fresh asparagus is their aim.

Due to the climatic conditions of the sierra, which has temperatures, throughout the year, that seldom are less than 4 to 6C or more than 20 to 22C, and an annual rainfall of 800 to 900 mm of water, the asparagus plants stay green the year round, having no natural recess. These conditions permit harvesting any time of the year.

According to market prices, the choice is to harvest twice a year, on July (30 days) and on December - January (60 days), providing enough recovering time for the plant between harvests. The proposed cycle of planting and production is presented as a diagram

81. BIBLIOGRAPHY OF THE MECHANICAL HARVESTING OF ASPARAGUS AND OTHER RELATED HORTICULTURAL AND PHYSICAL PROPERTIES SUBJECTS

D E Marshall
Department of Agricultural Engineering
Michigan State University
East Lansing, MI 48824
USA

For over 65 years producers, entrepreneurs, engineers, processors and manufacturers have been attempting to mechanise the harvest of asparagus, *Asparagus officinalis*. This bibliography contains references pertaining to unpublished and published reports, and popular press articles describing attempts worldwide at mechanizing the harvest of asparagus, including mechanical harvesting patents and harvest aids. Included also are related subjects, planting, transplanting, spacing, harvest schemes, physical properties, fibre content, length, sorting, spear orientation, post harvest handling, and storage research, economics and major cultural bulletins, etc. it has been compiled as an aid to ensure that the worldwide research is known and available to all scientists endeavouring to accomplish harvest mechanization.

84. TIPROT IS A PHYSIOLOGICAL PROBLEM

A Carpenter & R Lill
Levin Research Centre
Crop & Food Research
Private Bag 4005
Levin
New Zealand

We review the literature pertaining to tiprot (melting tip) to show the research leads that indicate that the syndrome is physiological rather than microbiological.

85. GROWING TEMPERATURE AFFECTS SPEAR QUALITY AND TIP BREAKDOWN DISORDER.

R E Lill, W M Borst & G J van der Mespel
Levin Research Centre
New Zealand Institute for Crop and Food Research Ltd
Private Bag 4005
Levin
New Zealand

The growing temperatures of asparagus plants can have an effect on the postharvest quality of spears, expressed as shelf-life and incidence of tip breakdown. Tip breakdown is a market disorder resulting from physiological deterioration after harvest. Symptoms include darkening of the tip, followed by development of soft rots extending 30-50mm down the tip.
Spears harvested at 3h intervals during two days were assessed for shelf-life. Spears harvested at 2am had approximately 1 day longer shelf-life than spears harvested at 2pm. This pattern followed the diurnal temperature pattern of both crowns and spears.

Tip breakdown was assessed in spears from potted asparagus plants forced under controlled temperatures. Spears from plants forced at 13C got no tip breakdown, whereas 26% of spears from plants forced at 17C got the disorder.

The involvement of growing temperature on spear quality will be discussed.

7.0 ITINERARY

19 November	Join Pre Symposium tour at Travellers International Hotel, Auckland. Boyds Asparagus Packhouse, Cambridge, Hamilton. Cambridge Stud, Nr Hamilton. Tomahere - Social Barbecue with Waikato Asparagus Growers Association
20 November	Ruakara Agricultural Research Centre, Blands Research Station, Nr Hamilton Trevor Syng, Arapuni Asparagus, Cambridge, Hamilton Maori Arts and Crafts Institute, Rotorua.
21 November	Agrodome Sheep Centre, Rotorua Rainbow Springs, Rotorua. Massey University, Palmerston North. Registration for Symposium
22 November	Symposium - Massey University, Palmerston North
23 November	Symposium - Palmerston North Levin Research Centre, Levin
24 November	Circle Pacific Asparagus Ltd, Napier, Hawkes Bay Grocorp Asparagus Packhouse, Napier Mission Vineyard, Hawkes Bay Grower Canneries Ltd, Hawkes Bay Lawn Road Research Centre, Hawkes Bay - Social Barbecue with Hawkes Bay Asparagus Growers Association
25 November	Symposium, Palmerston North
26 November	Symposium, Palmerston North Additional visit - Alastair Hogg, Rangitiki Asparagus, Halcombe, Manawatu

8.0 ACKNOWLEDGEMENTS

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I would also like to thank Dr Mike Nichols at Massey University, Palmerston North, New Zealand, and the organising Committee for presenting a very well run Symposium and associated technical tours; and all the companies, growers, Asparagus Growers Associations who extended a warm welcome and for their time to answer questions and show me their production units.

9.0 DISTRIBUTION

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Mr E Kennedy, Chief Executive and Secretary
Dr E R Moorhouse
Dr J Braunholtz

Author: Wilson Dyer
ADAS Bury St Edmunds
Southgate Street
Bury St Edmunds
Suffolk
IP33 2BD
Tel. (0284) 753271 Ext. 216