ADC Commercialisation Bulletin #10

# Asparagus

## Marketing

### 1
### Markets

The main import markets for fresh asparagus are North America, Europe, and Japan. These markets also have wide scale domestic production of asparagus, although seasonality of supply forces imports during the off-season. Consumers in Europe tend to prefer the extra large or jumbo sizes. Within Europe, individual countries have varying color preferences: German and French buyers tend to prefer the white spears, British consumers prefer green spears, and the Italian purchasers will more often accept both.

### 2
### Customers

Fresh asparagus is widely purchased by most consumers in the major markets. It is handled by a number of importers, who sell through wholesale markets or direct to retail outlets. Larger supermarkets usually buy on a contract basis with several importers/pre-packers but may sometimes enter into direct contracts with overseas growers. The importers of ethnic produce from Uganda do not trade in asparagus.

### 3
### Volumes

The Europe Union, the market with most potential for Ugandan exporters, imported 69 thousand metric tons of fresh asparagus in 1996, nearly 10 thousand tons of which was sourced from non-EU member states. Germany imported 42.7 thousand MTs, accounting for 62 percent of total EU imports. France was the second largest EU importer with nearly 9.5 thousand MTs, followed by the United Kingdom (4.4 thousand MTs), the Netherlands (3.1 thousand MTs), and Italy (2.9 thousand MTs). Much smaller amounts are also imported by Ireland, Denmark, Sweden, Finland, and Norway.

The main EU import markets of non-EU product are Germany, the UK, Spain, the Netherlands, and France; in 1996, these five markets accounted for 88 percent of total EU imports from outside suppliers (see Table 1).

### 4
### Prices

During the European off-season, wholesale European prices roughly average between US$5.50-US$7.50/kg for imported fresh asparagus. Prices begin dropping below US$5.50/kg once domestic European production comes on-line in April and low prices continue through the end of the European production season in July. Wholesale prices for asparagus tips are significantly higher -- ranging at US$12-US$14/kg. Average prices for various European markets and asparagus types are given in Table 2.

**Table 1: Main EU Importers of Fresh Asparagus**

| Market | 1996 Imports (MTs) | | |
|---|---|---|---|
| | EU Suppliers | Non-EU Suppliers | Total |
| Germany | 39.701 | 3.027 | 42.728 |
| France | 8,542 | 931 | 9,473 |
| UK | 2,319 | 2,062 | 4,381 |
| Netherlands | 1,963 | 1,181 | 3,144 |
| Italy | 2,570 | 374 | 2,944 |
| Belgium | 1,569 | 240 | 1,809 |
| Spain | 558 | 1,247 | 1,805 |
| Austria | 1,027 | 474 | 1,501 |

*Source: EUROSTAT*

**Table 2: Wholesale Prices for Fresh Asparagus in Major European Markets** (US$/kg, average of weekly high/low prices over the period Jan 97 through March 98)

| Market | Green | White | Tips |
|---|---|---|---|
| Austria | 6.43 | 7.74 | 12.17 |
| Belgium | 5.05 | 5.05 | 12.15 |
| Denmark | 6.10 | 5.60 | 11.77 |
| Finland | 7.50 | 8.10 | 15.44 |
| France | 5.28 | 4.08 | no report |
| Germany | 5.73 | 5.64 | no report |
| Netherlands | 5.90 | 6.01 | 12.02 |
| Italy | 5.52 | no report | no report |
| Norway | 6.80 | no report | no report |
| Spain | 4.92 | 5.41 | no report |
| Sweden | 6.67 | 6.74 | 17.44 |
| Switzerland | 5.42 | 5.14 | no report |
| UK | 6.54 | no report | 15.32 |

*Source: ITC Market News Service, weekly price reports from January 1997 through March 1998*

## 5
## Competition

Major extra-EU suppliers include Peru, the United States, South Africa, Hungary, Poland, Morocco, and Chile. Thailand is the primary non-EU supplier of asparagus tips. See Table 3.

**Table 3: Major Extra-Regional Suppliers of Fresh Asparagus to the EU, 1996, MTs**

| Supplier | Germany | France | UK | Netherlands | Other EU | Total |
|---|---|---|---|---|---|---|
| Peru | 85 | 113 | 635 | 485 | 879 | 2,197 |
| USA | 231 | 220 | 730 | 63 | 207 | 1,451 |
| S. Africa | 722 | 11 | 50 | 360 | 25 | 1,168 |
| Hungary | 791 | 0 | 0 | 4 | 265 | 1,060 |
| Poland | 966 | 0 | 0 | 78 | 11 | 1,055 |
| Morocco | 12 | 331 | 0 | 0 | 368 | 711 |
| Chile | 26 | 80 | 85 | 25 | 318 | 534 |
| Argentina | 56 | 125 | 68 | 43 | 40 | 332 |
| Slovakia | 45 | 3 | 0 | 0 | 266 | 314 |
| Thailand | 27 | 1 | 109 | 55 | 18 | 210 |
| Mexico | 11 | 29 | 77 | 4 | 29 | 150 |
| Ecuador | 6 | 2 | 89 | 21 | 1 | 119 |
| New Zealand | 0 | 0 | 67 | 0 | 0 | 67 |
| Zimbabwe | 0 | 0 | 66 | 0 | 0 | 66 |
| Other | 49 | 16 | 86 | 43 | 15 | 209 |
| Total | 3,027 | 931 | 2,062 | 1,181 | 2,442 | 9,643 |

*Source: EUROSTAT*

While Europe imports fresh asparagus year-round, its consumption peaks during time of local production. During the three month period of April-June, the five largest markets (France, Germany, UK, Netherlands, and Italy) import 77 percent of their total imports for the year. While consumption decreases in other months, non-EU suppliers have the largest market share. For more information on seasonality of imports, see Tables 4 and 5 below.

**Table 4: Extra-EU Supply of Fresh Asparagus to Main European Markets (percent of total volume supplied by month)**

| | France | Netherlands | Germany | Italy | UK |
|---|---|---|---|---|---|
| January | 41% | 83% | 28% | 58% | 98% |
| February | 67% | 87% | 23% | 75% | 99% |
| March | 16% | 62% | 17% | 17% | 91% |
| April | 7% | 8% | 1% | 4% | 25% |
| May | 2% | 4% | 6% | 2% | 30% |
| June | 1% | 38% | 14% | 0% | 10% |
| July | 8% | 69% | 3% | 2% | 95% |
| August | 67% | 78% | 3% | 25% | 100% |
| September | 61% | 99% | 2% | 81% | 99% |
| October | 80% | 89% | 85% | 65% | 99% |
| November | 33% | 89% | 73% | 95% | 69% |
| December | 77% | 77% | 42% | 71% | 90% |

*Source: EUROSTAT*

**Table 5: Imports by Month into Main EU Markets (MTs, including from EU suppliers, 1996)**

| | France | Netherlands | Germany | Italy | UK |
|---|---|---|---|---|---|
| January | 188 | 76 | 75 | 12 | 173 |
| February | 115 | 52 | 163 | 16 | 159 |
| March | 801 | 81 | 495 | 251 | 248 |
| April | 3,351 | 272 | 9,783 | 1,000 | 391 |
| May | 2,481 | 1,510 | 19,656 | 983 | 473 |
| June | 1,558 | 86 | 4,821 | 300 | 1,717 |
| July | 384 | 85 | 3,043 | 49 | 216 |
| August | 36 | 127 | 630 | 4 | 156 |
| September | 70 | 78 | 2,923 | 26 | 149 |
| October | 111 | 271 | 512 | 130 | 210 |
| November | 246 | 344 | 365 | 88 | 251 |
| December | 136 | 162 | 259 | 89 | 236 |

*Source: EUROSTAT*

# Production

## 6
## Method

**Climate.** Asparagus is adapted to a diversity 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 temperatures of 10E C or above. The optimal temperature for growth is between 18E - 29E C. Uganda has many areas with ideal temperatures for asparagus production. The areas near Lake Victoria, Kasese, and Kabale are all suitable temperature-wise for asparagus. 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.

**Field Selection.** The criteria used in the selection of the field to be used for 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 asparagus production. A small clay fraction and 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 ten tons of manure/organic matter should be applied to an area beneath the planting furrow before transplanting. An additional five tons per hectare of manure/organic matter should be annually applied in two bands about ten cm deep and five cm wide on both sides of the row. The bands should be 35 to 45 cm away from the bed center. Optimal soil pH is between 6.0 to 7.0. 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% 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 that 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.

The subsurface soil characteristics are also very important since asparagus can be a very deep-rooted crop. 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 plowing of soil and incorporation of soil amendments 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.

The cultural operations for white and green asparagus vary sufficiently to warrant 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 effect the quality of the white spear by influencing the spear diameter and color 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. Green asparagus production does not require as fine a tilth as white asparagus production. Since green spears are either harvested at the soil surface or slightly below, the physical impedance to the cutting knife is not as important.

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 which predisposes the asparagus plant to stress and provides a medium for Phytophthora megasperma sporulation and infection. Asparagus should always be grown on raised beds, about 25 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 previously were cultivated with asparagus within the last 8 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**. Commercial asparagus plantations may be established in one of three methods: direct seedling, transplanting one year old crowns, and seedling (3-month old) transplants. Each method has advantages and disadvantages. The most practical method of establishing asparagus in Uganda is by purchasing seed and producing seedling transplants.

**Direct Seeding**. This method requires considerable expertise. The seed bed in the bottoms of the furrows must be thoroughly prepared. Irrigation may be needed for seed germination and plant emergence if dry weather persists. Weeds may become a problem before the slow-growing asparagus can be adequately cultivated. 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 15-20 cm below the prepared soil surface. Two rows per furrow, spaced 20-30 cm between rows, are 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 by fall. Final in-row spacing will be about 15 cm between plants. Plant populations will be about 44,500 plants per hectare. This will require approximately 2 kg 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$^{o}$C, emergence occurs in about 15 days, but at 15$^{o}$C about 24 days are required.

Advantages: More spear numbers and total production per acre as well as earliness in many cases.

Disadvantages: 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 plowing, apply fertilizer in accordance with soil tests and incorporate into the soil surface. Manure at the rate of 10-15 tons per hectare can be substituted for part of the chemical fertilizer if it is free of weed seeds.

In the nursery, seed is drilled 2.5 to 4.0 cm deep in rows about 30 cm apart on twin-row, 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.

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.

At the end of the first growing season, the tops are cut, raked up, and burned. After digging, the crowns are separated and graded. Those that weigh less than 45 gm and those that are severely injured should be discarded. Although is not 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 are dug and held in cold storage, loosely packed in a well-ventilated cooler at 2Æ C and 90% relative humidity. Drying and freezing of the crowns should be avoided. Dip crowns in a recommended fungicide solution before planting.

In advance of field 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 23 - 30 cm apart down the row. The trenches (eventual beds) are spaced 1.5 - 1.8 m apart. The crown should be placed by hand in an upright position with the roots spread out. Spear initiation in crowns planted upside down will be delayed and early production reduced. The crowns are then covered with 5 to 8 cm of loose soil and watered immediately. 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.

Advantages: Good spear size and production, long bed life potential
Disadvantages: Less than perfect stands, more disease problems generally, longer wait to begin getting a return on investment.

Growers contemplating establishment of a new asparagus planting must decide whether they should grow their own crowns or purchase them from a commercial plant grower. Crowns purchased from a nursery are

expensive and air freight to Uganda further adds to the establishment cost. Also, the crowns need to be refrigerated after arrival at the Entebbe airport or put in a refrigerated truck in order to prevent dehydration and loss of sprouting. The crowns should be planted in the field as soon as possible.

Commercially, asparagus crowns often are dug in the fall in temperate growing areas after the tops are completely dead from killing 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 1 or 2 years old. It is questionable practice to plant 2-year-old crowns, and never plant 3-year-old crowns. The older the crowns, the greater the injury when they are dug.

**Seedling Transplants.** The seedlings are usually produced in greenhouses and transplanted into commercial fields when they are 10 to 12 weeks old. A survival rate of between 92 and 98 percent can be expected in the field.

An advantage of using transplants is that the grower can transplant anytime weather conditions permit. Transplants can be grown in preformed trays having a plant density of one plant per every 10 to 16 square cm. There doesn't seem to be any standard recommendation for cell size. Excellent plants have been grown in cells 4 cm X 4 cm by 5 cm deep with 196 cells per tray. The soil mix should be porous- one part peat to one part coarse sand- to ensure good drainage. Seeds are planted 0.6 to 1.3 cm deep, one seed per space.
A greenhouse temperature range of 18EC (night) minimum to 29EC (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. If required, irrigate every 2 or 3 weeks with a complete nutrient solution containing the minor elements. High temperatures and too much nitrogen result in large tops and poor root development. If plants begin to get too large, growth can be slowed by reducing the temperature to $10^{o}$-$15^{o}$C, but do not overharden. Remove transplants carefully from the trays, and plant in the field by hand or with transplanters. Set the transplants slightly deeper than they were in the plant cell. As the plants grow, gradually close the furrows with cultivators or hoes until the soil surface is level or slightly ridged over the plant row by mid- or late August. Filling the furrows provides some weed control in the rows.

The field is prepared by furrowing out 15-20 cm 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 23-30 cm between plants. About 0.25 liters 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.

A modification of this system is also successful. Spacing between beds is 1.1 m, and the field is only furrowed out about 10 cm deep. The objective is to increase plant population and stimulate early production by not planting as deep. Some growers pre-irrigate the ground prior to transplanting with the modified method, while others work the ground, shallow furrow, and sprinkler irrigate (1-3 cm) immediately after planting. Both systems work quite well. The plant population in the older method of transplanting is 18,500 - 24,700 plants per hectare while the modified system gives 32,100- 43,200 plants per hectare.

Advantages: Excellent stand survival and uniformity, earlier return on investment, earlier production (particularly with modified system), possibly higher production per acre.

Disadvantages: Initial stand establishment costs are higher, possible weed competition problems, shorter bed life possible with use of modified system.

In all three methods of planting (except direct seeding) where furrows are used, light cultivation is practiced so that soil is thrown into the furrows during the course of the growing season, keeping weed competition to a minimum but allowing the young asparagus fern and crows to develop. By season?s send, the furrow or trench will be filled in to field level with the developing crowns buried 15-25 cm deep (10 cm deep in modified transplant system), and the resultant fern growth 0.6-1 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 (15-45 cm). The tops should be cut to the ground at the end of the first growing season (in the winter). Prior to the start of the first cutting season, soil will be thrown to the planted rows creating a raised bed 25 cm above the field level. 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, asparagus for market is harvested for about four weeks. After the harvest period is over, the tops are allowed to grow in order to replenish the carbohydrates in the crown. During the subsequent growing cycle, the field may be cut for about 6 weeks. Then the spears are allowed to grow vegetatively for at least 4 months before cutting the plants to the soil level. The plants should be cut to the ground 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. Never incorporate old asparagus plants back into the same field where asparagus is growing. Old asparagus vegetation exerts an allelopathic effect which will suppress new spear growth. After the tops have been disposed of, the field is disked or rototilled lightly, and a low ridge of soil is formed over the rows to hasten decomposition of the stubble. After the fourth or fifth year, care is necessary to keep from cutting the crowns as they approach the surface.

**Planting Depth**. The bottom of the furrow should not be less than 13 cm or more than 20 cm below the level soil surface for roots, transplants, or direct seeding. Do not plant into subsoil. Spears emerge earlier from shallower plantings. Deeper planting and later emergence may be preferred where late frosts frequently occur. Spear size tends to be larger from deep, compared with shallow, planted crowns.

**Plant Spacing**. Spacings between and within rows are the same for both crowns and transplants. Recommendations for between-row distances are 1.5 to 1.8 meters. Recommendations for within-row spacings generally are from 23 to 30 cm (with direct seeding at 15 cm). 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.

**Harvesting**. The age of the plant at which the first harvest can be carried out and the duration of the harvest differ between production areas, and type of cultural practice used. Asparagus should not be harvested during the first year of planting. It should be allowed to grow and develop a strong storage root system. Harvest can begin in the second year. A harvest period of three weeks is possible during the second year. In subsequent years, the harvest season is extended to about 6 weeks. Because the length of harvest season will vary from year to year depending on temperature, stopping the harvest when three-fourths of the spears have a diameter of less than 1 cm (about the diameter of a pencil) is a better guide than harvesting for a specified number of weeks. Experience gained by growing the crop will make it easier for

the grower to know when to discontinue the harvest. Over-harvesting will weaken the crown, reducing the amount of carbohydrates stored, and will lead to further decline of the planting, putting plants under stress and making them more susceptible to insects and disease.

The spears for white asparagus production must be kept completely covered by soil, usually by raised beds about 35 cm. tall. (An alternative is to grow the spears inside a black plastic covered row tunnel. The covering is opened on one side for harvest, then placed into position again). The spears are harvested before the tip emerges from the soil, using a special asparagus knife. This will give a spear length of at least 25 cm. Care must be taken not to injure other buried spears or cut into the crown. In order to harvest asparagus spears with a compact tip (i.e. not partially opened) and white color, they should be harvested daily. After harvesting, the white spears should be kept in a cool protected location, out of the sunlight. A pink or purplish hue will be imparted to the tips and upper part of the spears exposed to sunlight. This is due to anthocyanin pigment formation. Covering the spears with a wet burlap sack is helpful in both cooling the spears and eliminating light.

Green asparagus spears are cut 25 to 30 cm long. Usually the cutters do not harvest according to the length of the green part alone, but cut spears about 5 cm below the soil surface. Spears are later trimmed to 23-cm lengths at the packing shed for fresh-market asparagus. Marketable spears must have compact, tight tips and good green color. Freezer asparagus is cut in the same way as fresh-market asparagus. Asparagus to be delivered to processors is trimmed to an 18 cm length and must have a minimum of 14 to 15 cm of green.

Injuries to growing spears, even if only slight, cause them to bend toward the side where the injury occurred. Injuries result from several causes. Spears grow bent in one direction toward a strong wind. If all the spears bend sharply in one direction, the wind drove sand or dirt particles into them. Other causes of crooked spears are crusted soils, stones, insects, cutting knives, and harvesters' footsteps. Windbreaks of king grass or other appropriate vegetation should be planted around the perimeter of the asparagus fields in order to minimize spear damage.

During periods of high temperatures, the tips tend to open. Consequently, the spears must be harvested sooner and more frequently in hot areas than in areas with cooler weather. It may be necessary to harvest twice per day when the temperature is high.

Spear harvesting early in the day is preferable to harvesting later in the day. Individual spear weight is greatest in the pre-dawn hours and then decreases with time. The greater spear weight early in the morning is because of higher cell turgor and more water in the spear. Air temperatures are lowest in the pre-dawn hours as is the pulp temperature of the spears. Since the spears are cooler in the early morning, the postharvest changes will occur more slowly. Also, the energy required to cool an already cool spear will be less than the energy to cool a warmer spear.

Collecting the harvested spears can be accomplished in many ways. Individual carrying baskets, boxes or cartons are used in smaller fields or where the row length is long. Wind-rowing the cut spears by hand (moving previously cut spears across the row to a given pick-up row) is also used. Where spears are hand moved to a given pick-up row, hand pushed wheelbarrows with field lug boxes or tractor mounted pick-up boxes are used to pick up the collected spears. The spears are oriented so that they all face in one direction. Wet burlap bags may be placed over the loaded boxes to protect the tender spear tips and maintain freshness while en route to the packing shed.

## 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.

Considering Ugandan environmental conditions, it is recommended to trial the following cultivars as they all may have commercial possibilities: UC 157$F_1$, Atlas, Jersey Giant, Jersey King, Jersey Supreme, Ida-Lea and Cipres. The male hybrids from New Jersey have an excellent yield potential. 'Atlas' seems to be an improvement over UC-157 $F_1$, and is doing well in Peru. A description of the recommended cultivars to trial in Uganda follows.

**Atlas** is a dihybrid plant that resulted from a cross between a selected UC 157 female and a male selected from a hybrid of eastern U.S. development. The spears are cylindrical, tapering to a tight, compact head. Bud scales are closely attached to the side of the spear. The spear color is green with a slight purple cast to the butt of the spear during cool growing conditions. Bud scales and spear tip are tinged with a slight purple color. It is very vigorous, with excellent yield and spear quality. Average 9-inch (23 cm) spear weight is about 27 grams. It does well in Peru, with 50% greater yield than UC 157. It is a good fresh market and processing cultivar. The tolerance of Atlas to Phytophthora appears to be the same as UC 157 $F_1$. The exceptional vigor of Atlas may provide a greater advantage in relation to the damage caused by Fusarium.

**UC 157 $F_1$** is the major cultivar worldwide and is the principal cultivar grown in California. It has an average 9-inch spear, with a weight of 18 gm, and a tight tip. It is well adapted to warm spring temperatures, has a good tolerance against Fusarium wilt, but is rust susceptible.

**Ida-Lea** is adapted to warm desert growing areas; it is not adapted to areas of high winter rainfall.

**Cipres** is a clonal hybrid from Spain, with thick spears, a closed tip, and a high yield. It is adapted to a wide climatic range, for both green and white production.

**Jersey Giant** is an all male hybrid. Widely adapted, it has large green spears and purple bracts, is rust resistant, and Fusarium tolerant.

**Jersey King** is an all male hybrid and is very high yielding. It has a high percentage of large diameter spears, with purple bracts. It does well in California and is good for warmer growing areas. It is Fusarium tolerant and holds its spear quality well.

**Jersey Supreme** has a 10 percent greater yield than Jersey King, but with smaller spear size and tighter tip. It? s size is similar to UC 157.

**Gijnlim** is a Dutch cultivar, rated one of the best in Kawanda Research Station trials.

Other cultivars of potential include **Jersey Prince** and **Jersey Deluxe**. However, Jersey Prince is being discontinued by the seed company and Jersey Deluxe is currently not available for commercial sale due to a very limited seed volume.

All the New Jersey cultivars have a high level of resistance to rust, *Puccinia asparagi*, although no cultivar is immune. A resistant cultivar can be attacked when the environment is highly favorable for infection and may require fungicide sprays. Rust is not a problem every year, but susceptible cultivars will eventually become unproductive because of this disease. Severe rust symptoms were observed in asparagus growing near Lake Victoria, although it can probably be controlled by better cultural practices and more timely fungicide sprays. No rust was observed in the Kasese irrigation project trial plantings.

None of the commercially available cultivars are completely resistant to *Fusarium oxysporum* f. sp. *asparagi* and *Fusarium moniliforme*, root and crown rotting fungi, which eventually invade every planting. Some varieties, however, have considerable tolerance to Fusarium. The best methods of combating Fusarium are with the use of tolerant varieties and cultural practices that maintain plant vigor. The additional vigor inherent in the male hybrids from New Jersey should be an advantage in the control of Fusarium.

## 8
## Yield

There is a wide range in average yield of asparagus, depending on numerous environmental and genetic factors. Typical average annual yields from different growing regions in the world are as follows:

| Location | Kg/Hectare |
|---|---|
| Washington | 3,600 |
| California | 3,800 |
| New Jersey | 2,600 |
| Spain | 2,500 (unirrigated), 6,000 (irrigated) |
| Peru | 8,000 (irrigated) |

Trials are currently in progress at Mubuku to identify suitable varieties and to assess the yields which can reasonably be expected there. Using the recommended spacing of 1.5 m x 30 cm, yields are expected to be about 2,500 kg to 5,000 kg per hectare after 18 months.

## 9
## Time to First Harvest/Seasonality

Under the appropriate year round temperature conditions (10E- 33EC) asparagus can be grown on a six month cycle and harvested twice per year. This is the type of harvest cycle used in tropical highland areas of Central America and also in the coastal area of Peru. In these areas, temperatures do not get low enough to induce vegetative dormancy. Growers generally schedule when to harvest, based on market demand. Generally, the asparagus plants are allowed to grow vegetatively for about 4.5 months, the ferns are cut back to soil level and removed from the field, followed by about a 6 week harvest cycle. After the harvest period, the spears are allowed to elongate vegetatively for the next growth cycle.

In more temperate growing regions of the world, asparagus is harvested only once per year. This is during the spring, after winter dormancy. Commercial growers in California use this system, but it is not the appropriate system for Ugandan growers. In Uganda, it will be possible to obtain two harvests per year. The first harvest cycle should be in July/August for about 6 weeks, followed by vegetative growth for about 4.5 months, then cutting of the ferns to the soil level, and harvest of the spears for another 6 week period in December/January. A clean -cut production system should be used instead of the mother fern (Taiwanese) system in order to concentrate the harvest period and minimize rust pressure. The best market windows in Europe for fresh asparagus are generally July/August and December/January. Fortunately, these months also coincide with the drier months in Uganda, which will help minimize disease pressure and give better spear quality.

## 10
## Pests and Disease Prevention

### 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. 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 seed selectivity, there are some weeds that get through most control programs. The two tables below list the most affective herbicides for asparagus:

**Herbicides Available for Use During Establishment of Direct-Seeded and Crown Planted Asparagus**

| Common Name | Trade Name | Remarks |
|---|---|---|
| Paraquat | Paraquat Plus, Gramoxone (0.4-0.9 kg/ha active ingredient) | Apply to growing weeds before crop emerges. |
| Chloramben | Amiben (3kg/ha acid equivalent) | Apply before emergence of weeds and crop. Direct seeded asparagus only. |
| 2,4-D Sodium Salt | 2,4-D Sodium Salt (1 kg/ha acid equivalent) | Apply to weeds less than 1 cm tall. |
| Linuron | Lorox (1-2 kg/ha active ingredient) | Apply preemergence to asparagus planted with carbon band or postemergence to crop. |
| Terbacil | Sinbar (0.8-1.6 kg/ha active ingredient) | Apply preemergence to asparagus planted with carbon band. |
| Fluazifop | Fusilade (0.25-0.4 kg/ha active ingredient) | Apply to emerged actively-growing grass weeds. Use a crop oil or non-ionic surfactant. |

**Herbicides Available for Use in Established Asparagus**

| Common Name | Trade Name | Remarks |
|---|---|---|
| Glyphosate | Roundup (0.7-3.5 kg/ha acid equivalent) | Apply to actively-growing weeds prior to crop emergence, after last harvest or after ferning. |
| | 2,4-D Sodium Salt | |

| Herbicides Available for Use in Established Asparagus | | |
|---|---|---|
| **Common Name** | **Trade Name** | **Remarks** |
| 2,4-D Sodium Salt | (1 kg/ha acid equivalent) | Apply to actively-growing broadleaf weeds. |
| 2,4-D Alkanolamine Salt | Formula 40 (1.4-2.0 kg/ha acid equivalent) | Apply to actively-growing broadleaf weeds. |
| Dicamba | Banvel (0.25-0.5 kg/ha acid equivalent) | Apply to actively-growing broadleaf weeds. |
| Diuron | Karmex, Direx, Diuron (1-2 kg/ha active ingredient) | Apply during fall or spring at least 4 weeks prior to asparagus emergence and /or after harvest. |
| Linuron | Lorox (1-2 kg/ha active ingredient) | Apply prior to or after weed and asparagus emergence. |
| Metribuzin | Sencor, Lexone (0.5 kg/ha active ingredient) | Depending on product, apply before asparagus emerges, or as a split application, preemergence and after harvest. |
| Simazine | Princep (2-4 kg/ha active ingredient), Sim-Trol | Apply in fall, following fall reworking of field. |
| Napropamide | Devrinol (4 kg/ha active ingredient) | Apply in fall or spring prior to crop and weed emergence. |
| Trifluralin | Treflan (0.5-2 kg/ha active ingredient) | Apply and incorporate in winter or early spring before crop emerges and/or after harvest. |

Sencor of Lexone (metribuzin) is usually the standard to include in a combination program, and can be used in either a one time pre-emergence, or two time split application (pre-emergence/post harvest). As it is active on many germinating and young weed seedlings, it is a good general herbicide and it provides residual weed control. However, another herbicide should be added with metribuzin for more thorough weed control.

The chemicals need to be chosen based on individual situations; know what weeds you are going after. For example, in the case of nutsedge (Cyperus sp.), the best combination is Devrinol plus Sencor/Lexone. The chemical needs to be in the nutlet sprouting zone to be effective - i.e., soil moisture or incorporation.

### Diseases

Trials in Uganda have indicated that *Stemphylium*, *Puccinia (rust)* and *Phytophthora* are the most common disease problems. However, since other diseases may become serious under commercial conditions, the most common ones encountered in other producing countries are also described below.

**Asparagus rust** (Puccinia asparagi). Asparagus rust can be a serious disease in high rainfall areas. High humidity and moderately warm temperatures favor disease development. Avoid planting asparagus beds in

areas with poor air drainage, or where dew frequently occurs, since moisture on plant foliage favors rust development. The fungus requires moisture from rain or sprinkler irrigation to infect asparagus. Furrow irrigation, coupled with heavy fern growth that does not allow good air flow down the rows, can promote rust when warm temperatures occur. Well-timed irrigations, wide-row spacings, 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 weight and number of spears produced by cultivars susceptible to rust. The effects of rust are cumulative. Yield reductions on asparagus are greater after two years of infection than after one year.
Rust was observed to be quite severe in the area near Lake Victoria. However, control is possible through more judicious monitoring of the situation and more timely fungicide applications. It is important to use a high pressure mist type sprayer to allow adequate penetration of the fungicide into the thick asparagus canopy.

Rust produces three different types of pustules during the growing season. The first pustules to appear on plant foliage, *aecia*, are oval in shape, and light orange in color. The blisters are raised at first; later the center of the pustule sinks as it ages. The most commonly noticed pustules are the *uredia* that appear on fern foliage from early to late summer. Summer stage pustules arise as blisters, and rupture the outer layer to expose brownish-red powdery spores. These wind-borne spores infect healthy plants. Repeated infections of the wind-borne summer spores occur every 10 to 14 days during wet weather. Pustules with black spore masses, called *telia*, replace the spore-spreading summer stage pustules in early fall. Spores overwinter in these fall 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. The all male hybrids from New Jersey are resistant; UC 157 is moderately susceptible. Fungicide applications may be necessary. Monitor fields carefully and regularly for spore-forming *uredia*. A small number of these pustules can rapidly produce high levels of disease. Apply a labeled fungicide, mancozeb (Dithane M-45, Manzate 200) or Zineb when these pustules are found. Fungicides are not effective after high levels of disease are reached or when the black pustule stage forms.

**Fusarium wilt and Fusarium crown rot** (*Fusarium oxysporum* sp. *asparagi*) and (*Fusarium moniliforme*). Fusarium is probably the most prevalent soil-borne fungus disease that affects asparagus. Infected seedlings may fall over on the ground, due to destruction of seedling tissue near the soil line. On young 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. No Fusarium symptoms were observed in the trial plantings in Uganda. However, it is likely to occur in the future.

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*, causes 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, an intact root system.

Because *Fusarium* species are present in most agricultural soils, the diseases are almost impossible to avoid. Control is therefore directed at minimizing infection early in the life of 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 8 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 1 part sodium hypochlorite bleach in 5 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 fellow 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 3 to 15 mm in length with dark purple margins. This disease was observed in Uganda, but not in high amounts. 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 windblown 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 vigor 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%. Plants infected with both AV-1 and AV-2 decline and die, usually within 2 to 3 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 noninfected 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 seedborne 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 which 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** (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 odorless decay accompanied by white mold growth. Rotting is usually predominately at the base of the spear. Infection occurs after heavy or prolonged rain. No commercial cultivar is resistant of Phytophthora. Control is mainly achieved by using the fungicide metalaxyl (Ridomil) as a soil drench. Ugandan growers should cultivate asparagus on raised beds (about 25 cm high) to facilitate drainage during periods of high rainfall. This will help to minimize Phytophthora infection.

**Insects**

*Thrips* damage is the most common insect problem encountered so far in trials carried in Uganda. However, asparagus is plagued by a number of insect pests in other producing countries and these may become significant if commercial production is developed. The most common are described below.

**European asparagus aphid** (Brachycolus asparagi). Aphids are about 1 to 2 mm long, powdery gray-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-gray 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 rosetting 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.

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. Collect one secondary branch from each of 200 plants. Treat the field if any aphids are found. Destruction of dormant foliage in the fall and shallow rototilling of the field in the spring greatly reduce aphid populations. Malathion at 2 kg active ingredient per hectare controls asparagus aphid, but Di-Syston at 1 kg active ingredient per hectare, probably provides the best chemical control.

**Garden centipede or symphylan** (Scutigerella 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 2 weeks and soil fumigation of the beds before planting have helped reduce damage in affected areas.

**Thrips** (Frankliniella sp.). Thrips infestations can cause considerable damage in asparagus. The insects remove moisture from the fern, weaken its vigor, and can even kill the tops of small seedlings. They are very minute insects of 1 to 2 mm long. They migrate or are blown into asparagus fields during the cutting season from neighboring 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 colored, with dark blue wing covers rimmed in red, and with three variously-shaped, cream colored markings on each wing cover. Their heads, legs, and antennae are black, while the thorax (mid-section) is dark red. The twelve-spotted asparagus beetle is reddish-orange, with six black spots on each wing cover. Both beetles are about 6 mm long. They are found wherever asparagus is grown. The pest injures the plant by gnawing the epidermis of the stems of tender young shoots.

Larvae are dull blue-gray with black head capsules. Beetles overwinter 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 2 to 7. Spotted asparagus beetles do not begin oviposition (egg-laying) until shortly before seed pods begin forming, attaching their eggs sideways onto the fern. After 3 to 14 days of incubation, eggs hatch into small, dull-grey to olive-green larvae with black legs and heads. Larvae feed on 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 5 to 14 days, adults emerge, completing the entire life cycle in 3 to 7 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 cladophylls (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:

1. Reduce weeds.

2. Clean cut all asparagus spears during harvest to reduce food sources.

3. Destroy nearby wild asparagus which could harbor beetles.

4. 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.

Sample 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 5 cm long when full grown. Adults are heavy bodied, dull-colored nocturnal moths. Eggs are laid in grassy and weedy areas within the crop or in headlands.

Cutworm larvae feed on asparagus spears either above or below the soil line. Affected spears and fern are malformed, usually curving towards the injured side, or have areas of tissue chewed or severed 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 labeled 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 6 mm long, oval, straw green to dark brown insects with yellow, brown, and black markings. APB adults are 8 mm long, having a more elongated oval shape than the TPB, and green with cream colored markings. Nymphs (young) of both species are light green or yellow-green, smaller than adults, and lack fully developed wings.

TPB adults overwinter in fencerows, crop refuse, and weedy, sheltered areas, emerging in spring to feed on weeds and plant buds. Eggs are laid in stems and petioles of weeds and other vegetables and hatch within 10 days. After 3 to 4 weeks, nymphs become adults. Thus, there are one or two overlapping generations per year, depending upon the climate. APB have 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 mouthparts are often visible at or below the area of distortion. When terminal buds during fern growth are

killed, auxillary 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 some control.

**Asparagus Miner**. The asparagus miner fly is small, 3 mm long, and metallic black, with two clear wings. Flies lay eggs beneath the epidermis (skin) of the asparagus stalks. Pale white, legless larvae tunnel beneath the epidermis both above and below ground. After growing to about 3 to 5 mm long, larvae change into pupae with a brown, oval case of about 3.5 to 5 mm long. Egg, larval, and pupal stage each require 2 to 3 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 been 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.

## 11
## 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 Uganda are acidic. 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 a large amount of lime is required to raise the pH to the desired level, low down half of it and incorporate the remainder after plowing. If possible, apply the lime several months before planting. It is recommended to incorporate about 4 tons per hectare of finely pulverized limestone ($CaCO_3$) on soils with a pH of between 5.0 to 5.5. Annual applications of limestone may be necessary to maintain the desired pH of 6.5 to 7.0.

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 plow 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 tons 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 center of the row in order to avoid crown damage.

The specific fertilization recommendations should be based on annual soil and foliar analyses. Critical nutrient concentrations in asparagus fern tissue (15-30 cm tip of mature new fern) are listed in the table below:

| Nutrient | Optimal Concentration Range |
|---|---|
| N | 2.5-4.0% |
| P | 0.2-0.4% |
| K | 1.7-3.0% |
| S | 0.3-0.45% |
| Ca | 0.7-1.5% |
| Mg | 0.2-0.3% |

| Nutrient | Optimal Concentration Range |
|---|---|
| Fe | 50-200 ppm |
| Cu | 5-15 ppm |
| Mn | 30-120 ppm |
| Zn | 15-30 ppm |
| B | 30-150 ppm |
| Mo | 0.1-0.4 ppm |

Growers that have drip irrigation should apply nitrogen through the irrigation water on a bi-weekly or monthly basis.

## 12
## Water Requirements

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 is not advisable after the row canopy thickens, since it will render the foliage more susceptible to fungal diseases, especially rust.

If tensiometers are used to schedule irrigation, they should be placed at a depth of 15 cm, measured from the 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 the 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.

## 13
## Postharvest Handling & Product Specifications

**Grading**

After unloading into the packinghouse, classification and selection of the asparagus is done in accordance with the relevant standards for the specific market. A pre-selection is normally required to eliminate bent spears, double spears, and those with open bracts. The large spears are placed on a moving belt and washed with water sprays (usually chlorinated at 150 ppm). In order to trim the spears to the length stipulated by the export standard, they are held together in bundles and gently placed in a horizontal position on a counter. A sharp cutting instrument (knife or saw) is then used to trim them at the base, taking care to make the cut flat and even. It is imperative that neither the tips nor the skin be damaged, since injuries will facilitate the entrance of bacterial soft rot organisms.

Most export markets require the spears to be cut to a uniform length of 23 cm (9 inches). The spears should be clean, firm, tender, well trimmed, fairly straight, and nearly free of mechanical, insect, and disease damage. If the asparagus cannot be trimmed, graded, and packed immediately on arrival from the field, it should be placed in the cooler, rather than leaving it in a warm packing shed.

**Postharvest 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 $CO_2$ and heat. Also, the tip of the spear keeps elongating and the fiber content increases as a consequence of the lignin that is produced in the vascular bundles over time, especially at temperatures above $2^oC$. Spear elongation will occur more rapidly with increasing temperature. Spears held at $1^oC$ for 8 days will have about 3.5 mm elongation, while spears held at $13^oC$ will elongate 25.4 mm. Higher storage temperatures will cause more rapid elongation. The result of spear elongation during shipping and storage is broken and misshapen tips. It has been shown that as much shelf life and quality is lost in one hour at $20^oC$ as is lost in 19 hours at $1^oC$. Lowering the pulp temperature of asparagus to $1^oC$ reduces the rate of respiration low enough to allow the spear to be stored for 2 to 3 weeks with significant deterioration of quality.

For maximum quality preservation and shelf life, asparagus should be hydrocooled to $0^oC$ to $1^oC$ as soon as possible and 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 dessication, spear shriveling, and fiber formation. Moisture should be abundant at the spear butt to prevent butt 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 cause 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 hydrocooling 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. Hydrocooling is the most efficient method of lowering the pulp temperature of asparagus. Hydrocooling is a process in which the commodity is passed through or immersed in cooled water for a given period of time. During the immersion heat from the commodity is transferred to the water which is then recirculated. Usually a 15 minute immersion will reduce the asparagus pulp temperature from $25^oC$ to $1^oC$ if the water temperature is $0^oC$.

One type of hydrocooling method is to put the packed asparagus boxes on a continuous belt or chain conveyor that moves the product through an overhead shower of cold water. The water is recirculated through pipes and over cooling elements to the top of the hydrocooler. Optimum water flow should be 800 to 1000 liters per minute per square meter of hydrocooler area. The distance between the shower pan and the top carton of asparagus should not exceed 20 cm in order to prevent surface pitting or water soaked areas.

A submersion type of hydrocooler involves putting the packed boxes in cold water for a long enough time to reduce the pulp temperature to 1°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 hydrocooling. Circulate the water with propellers or pumps at a flow of 15 ft/min (0.076 meters/sec). 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 the spread of disease organisms. Organic matter and dirt in the hydrocooling water will de-activate the chlorine.

The ideal method of handling cut asparagus is to first hydrocool the cut spears then store them in a cold room until they can be packed. Following packing, the containers should be rehydrocooled and placed back in the cold room prior to shipment in refrigerated containers.

High humidity forced air cooling is less desirable, but can be used if hydrocooling is not available. Forced-air cooling is accomplished by drawing cold air through he asparagus from the cold room into a central tunnel. It is then discharged across evaporator coils where it is cooled, then returned to the cold room to be recirculated through the asparagus. The air should be humidified after being cooled by the evaporator coil by installing a misting nozzle in front of the evaporator.
In circumstances where the air has not been humidified, the asparagus should be sprinkled with clean, chlorinated water ( 100 to 150 ppm chlorine) before commencing the forced-air cooling process. When choosing a fan to draw air through asparagus in a forced-air system, a good rule of thumb is the fan should be rated at 0.08 to 0.12 cubic meters/minute/kg of product (1.5 to 2 cfm/lb). This volume of air at 0° C should cool the product in less than 2 hours to 2°C. When the asparagus in a forced air cooler has cooled to a temperature which is within 2°C of the air being drawn through the product, it should be removed from the forced air cooling unit an held under normal cold room conditions at 0°C. Moisture loss from the asparagus, due to the large volume of air being drawn over it in a forced-air system (even at cold temperatures), is relatively rapid if the humidity is less than 80%. This loss of quality through drying, even when absorbent pads are used, could be greater than any gain obtained from trying to cool to that last 2°C in a forced-air cooler. It is better to finish the cooling process under standard cold storage conditions.

For asparagus to be cooled efficiently, you need to match the refrigeration to your daily volume of asparagus. Design a system that will handle a relatively high volume. It is when the temperature is high that the volume of asparagus being harvested will be the heaviest, and the need for refrigeration will be the greatest.

A good rule of thumb is that you need 1 horsepower of refrigeration per ton of asparagus per day being cooled. Such a system would handle asparagus that is being harvested in daytime temperatures as high as 27°C (80°F). This rule of thumb applies to asparagus being cooled by forced air or hydrocooling.

*Investment in cooling infrastructure in Uganda will be necessary in order to develop asparagus as*

*an export crop.*

**Storage**. The optimal storage conditions for asparagus are 0°C to 1°C, 95-98% relative humidity. Shelf life under these conditions is up to three weeks. Storage life and quality are dramatically reduced at temperatures above 5°C. Exposure to ethylene should be avoided as spear damage will result at concentrations above 10 ppm.

Also, temperatures below 0°C should be avoided, since asparagus begins to freeze at -0.8°C. Frozen spears completely lose their market value. Therefore, the temperature within the temporary cold storage area and within the transport container should be set at 1°C, with a fluctuation of no greater than +/- 1°C.

**Packinghouse Equipment Sanitation**. Sanitation in the packing house is as important as having clean harvesting containers. Conveyor belts, trimming knives, and packing tables can soon become saturated with juice from asparagus. This juice provides ideal conditions for the growth of soft rot bacteria (*Erwinia* sp.). When these areas are continuously wet and never sanitized, very rapid bacterial growth can occur. These bacteria are transferred to the asparagus by direct contact.

Each day after packing, all equipment should be thoroughly washed and sanitized with chlorinated water (100 to 150 ppm hypochlorite). Use the higher concentration if you have a soft rot problem. After cleaning and sanitizing, the equipment should be dried thoroughly. This can be accomplished by using a fan or by ventilating with fresh outside air.

Using *granular* calcium hypochlorite (containing 65% calcium hypochlorite) as the source of chlorine, a solution containing 100 ppm hypochlorite can be made by adding together the following specified quantities of calcium hypochlorite and water:

(1) 96.2 g of calcium hypochlorite and 450 L of water
(2) 9.6 g of calcium hypochlorite and 45 L of water
(3) 110 cc of calcium hypochlorite and 450 L of water
(4) 11 cc of calcium hypochlorite and 45 L of water
(5) 2 cup of calcium hypochlorite and 100 gallons of water
(6) 2 teaspoons of calcium hypochlorite and 10 gallons of water

**Air Transport**. The only viable mode of transport at the present time for fresh asparagus from Uganda is by airplane, either in the cargo bay of regularly scheduled passenger planes or in dedicated cargo planes.

The asparagus should be taken to the airport in refrigerated vehicles (1°C), and should remain in them as long as possible before being loaded into the plane. If the asparagus remains at the airport for hours without being refrigerated, the interruption of cooling will cause irreversible damage. Heat, dryness, light, and any ethylene present are all capable of reducing the quality of the asparagus in just a few hours. The containers of the aircraft should be loaded as quickly as possible. Inside the plane, precautions should be taken to make sure that ethylene exposure does not occur, and that the asparagus is not allowed to warm up excessively. The disadvantages of transport by air are the high costs and the frequently limited availability of cargo space.

Asparagus produced in northern Uganda, around Kampala, or in the Lake Victoria area should obviously be exported out of Entebbe airport. Asparagus produced in the Kasese area may use either Entebbe or the Kigali, Rwanda airport. Production in the Kabale area is much closer to the Kigali airport.

**Sea Transport**. In the future, it is not out of the realm of possibility to consider refrigerated controlled atmosphere sea container transport through the port of Mombassa, Kenya. However, this would require sufficient product volume to fill a 20 or 40 foot container, and is some years away from becoming reality. For future marine transport through Mombassa, the asparagus should be loaded directly in the container at the packinghouse. The empty container should be cooled to 1°C before loading. The asparagus packages should not be placed in direct contact with the trailer's side walls or floors, as these are heat sources. Trailers should be precooled before loading, and the temperature should be kept at 1°C during the entire transit period. For long distance international exports of asparagus by sea container, it is recommended to use a controlled atmosphere (CA) unit. The term controlled atmosphere (CA) refers to control of the oxygen and carbon dioxide levels in the internal atmosphere of the container. The optimal atmospheric gas concentration is 2-3% $O_2$ and 5-10% $CO_2$. Shelf life may be increased up to two more weeks using this relatively new form of sea transport. In addition, access to distant international markets (e.g. Europe, Japan) may be possible. Use of this system for transport of asparagus offers the following advantages:

- The rate at which natural deterioration proceeds is significantly reduced.
- The growth of fungi that can cause spoiling (e.g. Botrytis) is slowed or even completely suppressed.
- Lignification (toughening of the spear) of the asparagus is eliminated.
- With white asparagus, purpling of the tips is minimized.
- Green asparagus does not yellow or discolor and retains a dark green color after being cooked.

The asparagus can remain in transit for up to 3 or 4 weeks without suffering a loss of quality.

**Postharvest Problems**. Asparagus is susceptible to a number of postharvest problems, all contributing to quality reduction and market loss. The more common problems include:

- Wilting

- Loss of spear turgidity is due to improper cooling and poor temperature/humidity management.
- Wilting occurs rapidly at temperatures above 5°C and relative humidities below 75%.

- Yellowing. Spear discoloration is due to exposure to high temperature and ethylene.

- Toughening. Toughness of asparagus is due to the development of cells with thick walls containing a material called lignin. Most rapid fiber formation occurs during the first 24 hours after harvest and this fiber formation can be slowed down dramatically by cooling the asparagus as soon as possible after harvest. There is a slow increase in fiber with time in storage. Water loss after harvest tends to increase fiber development. Decreasing water loss by raising the relative humidity, using film wraps, or placing the butt ends on a moisture-containing pad will decrease fiber development. Storage of asparagus in controlled atmosphere can arrest fiber development (2 to 3 percent oxygen and 5 to 10 percent carbon dioxide). Small diameter spears contain a higher percentage fiber on a weight basis and are perceived to be tougher than larger diameter spears.

- Mechanical damage. Broken tips and crushed spears are the most common mechanical

damage and normally occur during grading, bundling, and packing. Careful handling can eliminate this problem.

? Freezing damage. Spear freezing occurs at -0.8°C. Damage is characterized by limpness and gray discoloration of the tips. When the temperature increases, the spears become soft and develop off-flavors.

? Curvature. Bending or curved growth occurs when the stems are placed horizontally for more than one day at temperatures above the optimum. It also occurs after packing, when the stems reach the top of the carton and grow horizontally. Bending can be minimized by storage at 0 to 1°C and maintaining the spears in a vertical, upright orientation.

? Feathering. When the bracts unfold due to stem growth, they undergo feathering. This is a sign of senescence or aging, and is indicative that the stem was harvested over-age or not stored correctly. Feathering is prevented by regular harvesting, good field selection, and maintenance of a 0° to 1°C storage temperature.

? Bacterial soft rot (Erwinia carotovora). This is the most common postharvest disease in asparagus and is characterized by pale grey tips and watery stems. It begins with bacterial growth at the cut surface which exude droplets. Later development results in the lower part becoming soft and watery, and subsequently collapsing. The bacteria enters through the cut surface or areas with mechanical damage and is seen mainly in stems with feathering. Incidence is reduced by storage at 0°C to 1°C and eliminating bruised, damaged, or feathered stems. Maintenance of 100-150 ppm chlorine in the wash or hydrocooling water will also reduce the amount of soft rot bacteria.

? Fusarium rot. Characterized by white mold which grows mainly on the bracts and tips and results in soft watery lesions which turn yellow or dark green. This disease occurs within several days at 2°C or after 4 weeks at 1°C.

**Grade Standards**

Asparagus is a high-value, but very perishable product. Consequently, the quality requirements are very stringent on the international markets. The actual quality standards in the principal importing countries must be taken into account.

Asparagus that is exported to any member country of the European Union must comply with the quality standards of the relevant EU Regulation (no. 183/64 of November 17, 1964, amended by Regulation No. 1677/88). Observance of this quality standard becomes mandatory as soon as the asparagus enters the EU.

The description below of the EU quality regulations for asparagus only covers the requirements for class ?I" merchandise, since that is the only category that is likely to be selected for export to the countries of the European Community. The quality standards are revised now and then at the request of the market of producers. In view of this fact, it is recommended that the new text be obtained each time; it is published in the official periodicals released by the EU.

**European Standards for the Fresh Market.** This standard applies to fresh market asparagus. Asparagus spears are classified in four groups according to color:

1. White asparagus
2. Violet asparagus, having tips of a color between pink and violet or purple
3. Green asparagus, having the tips and a part of the spear green
4. Green-purple asparagus

The purpose of this standard is to define the quality requirements for asparagus at the dispatching stage, after preparation and packaging.

Minimum Quality Requirements

Spears must be:

- ? Whole
- ? Fresh in appearance and fresh-smelling
- ? Sound
- ? Free from damage by rodents or insects
- ? Practically unbruised
- ? Clean, i.e. practically free from soil or dirt
- ? Free from any undue external moisture (i.e. adequately ? dried? if they have been washed)

The cut at the base of the shoots must be clean and square. After cutting the asparagus must not have undergone any treatment other than re-cooling to preserve or restore its fresh appearance. In addition, shoots must be neither hollow, split, peeled, nor broken. The condition of the produce must be such as to allow it to withstand transport and handling and meet market requirements at the place of destination.

Classification for Class ? I?

Shoots in this class must be well formed. They may be slightly curved. Their tips must be compact. A few slight traces of rust removable by normal peeling by the consumer are allowed. For the ?white? asparagus group, the tips may be slightly colored before cutting and a faint pink tint appearing on the shoot after cutting is allowed provided these colorations disappear after cooking. In the ?white? asparagus group, no woody shoots are allowed. In the ?violet? and ?green? asparagus groups, a trace of woodiness is permissible.

Sizing

Shoots are sized by length and diameter.

Sizing by length

The length of the shoots must be:

* above 17 cm (17+) for long asparagus
* between 12 and 17 cm for short asparagus
* under 12 cm (<12) for asparagus tips

Sizing by diameter

The diameter of shoots shall be measured at the mid-point of their length. The minimum diameter and the sizing of class I shoots shall be: (within the same bundle)

| | White asparagus (and purple) | | Green asparagus (and green-purple) | |
|---|---|---|---|---|
| Length: | 22 cm maximum | | 27 cm maximum | |
| | Sizing | | Sizing | |
| Diameter: | 10-16 mm | >16 mm (+ 10 mm) | 6-12 mm | > 12 mm (+ 8 mm) |
| Variation within the same bundle: | e.g. 16- 26 mm or 17- 27 mm etc. | | e.g. 12- 20 mm or 13- 21 mm etc. | |

Packaging and Presentation - Uniformity of Class ?I?

The contents of each package or each bundle in the same package must be uniform, and consist only of shoots of the same quality, the same color, and the same size. However, shoots of a different color may be allowed within the following limits:

? White asparagus: 10% of violet asparagus
? Violet and green asparagus: 10% of another color.

Packaging

The packaging must be such as to ensure adequate protection for the asparagus. Any paper or other material used inside the package must be new and harmless to the consumer. Where printed matter is used, the printing must be on the outside and not come into contact with the asparagus. Shoots may be

packed in several ways:

? In bundles (firmly bound) of 500 g, 1 kg, or 2 kg. Shoots on the outside of each bundle must correspond in appearance and size with the average of the whole bundle. Shoots packed in this way must be of uniform length. Bundles must be arranged evenly in the package; each bundle may be protected by paper. In any one package, bundles must be of the same weight and length.

? In bulk, in packages.

Marking

Each package must state the following, legibly marked on the outside:

Identification

| | |
|---|---|
| Packer | Name and address |
| Dispatcher | or code mark |

Nature of produce

? Asparagus? followed by the indication ? white? , ? violet? , ? green? , or ? green-purple? when the contents of the package are not visible from the outside and, where appropriate, the indication ? short? or ? tips? .

Origin of produce

Country of origin, or national, regional or local trade name.

Commercial Specifications

* Quality class
* Size: the maximum and minimum diameters of the shoots
* For asparagus packed in bundles, the number of bundles and the unit weight per bundle.

## 14
## Packaging

**Field Packaging**. Stackable plastic boxes are usually used to transport the harvested asparagus to the packing facility. These boxes should be well ventilated on the sides and bottom. After use, their insides should be thoroughly cleaned of any dirt or debris using soap, detergent, or a high pressure water spray. This will reduce the spread of bacterial soft rot (*Erwinia* sp.) and other diseases from the field container to the freshly harvested asparagus.

**Wholesale/Retail Packaging.** It is very important to use a well-designed container with good top and bottom venting that allows for efficient hydrocooling and storage. The design and strength of the final wholesale/retail package depends on the type of transport, distance to destination market, and buyer preference. 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, a special water-resistant packaging material should be used, for example cardboard coated with polyethylene.

For the European market, the typical final package is a 5-kg polyethylene reinforced carton (40 x 30 cm). Ten 500 gm 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. A moist absorbent pad thoroughly wetted with 150 ppm chlorinated water should be placed in the bottom of the carton to prevent spear dehydration during transit. The butt end of the spears rest on this pad. This ensures a high humidity, maintains stem freshness through water absorption, and allows the spear to continue growing. Space is left (20 mm) at the top of the container to accommodate any elongation of the spears during transit. This will also allow for some sag when the boxes are stacked and prevent tip bruising or breakage. Effective ventilation is essential to keep the asparagus cool. A minimum of 8% of the surface area of the walls of the packages should be open ( holes, slits and other perforations).

In addition to the typical 500 gm bundles, another type of retail package in Europe is the 250 gm bag, either loose or in a bunch. The English market also likes a 200 gm asparagus tip pack, using a clear plastic clamshell package. Length of the tips is 10 cm.

The way in which the packages for transport are labeled is also stipulated by standards. According to the quality standard of the European Community, the label should be appropriately printed directly onto the packaging. The labeling should be situated on one side of each package, and should be visible and clearly legible (in a current language and in letters of sufficient size). It should not be easily wiped off. Besides the mandatory information, other data can also be added, such as the optimum storage temperature, advertising, and the brand. The packaging units intended for consumers (bundles, foodtainers) do not need to be labeled.

# Investment

## 15
## Cost of Production

Costs of production estimates are given in Table 3. Costs include: seed, tractor rental, labour (for making beds/trenches, spraying, application of fertilizer, slashing, weeding, irrigation, harvesting, grading, packing, and weighing), fertilizer, fungicides/insecticides, and miscellaneous expenses (water, fuel, depreciation, etc.). For one acre of asparagus, total costs of production are estimated at Ushs 1,518,000.

## 16
## Profitability

Table 6 shows that a farmer who grows asparagus can expect an annual gross margin of Ushs 482,000 per acre.

## 17
## Investment Requirements

In order to market asparagus successfully in Europe it is essential to have a fully-equipped packhouse and cold chain which meet EU food safety and environmental regulations. Table 7 gives indicative figures for establishing 15 hectares of asparagus.

**Table 6: Projected Gross Margins for Ugandan Producer of Fresh Asparagus** (Ushs/acre)

| | | |
|---|---|---|
| **Revenue** | | |
| Yield[1] (kgs/acre) | 2,000 | |
| Sales Price (Ushs/kg) | 1,000 | |
| Total Revenue | | 2,000,000 |
| **Expenses** | | |
| Seed/Plants[2] | 100,000 | |
| Land Cultivation[3] | 290,000 | |
| Fertilizer[4] | 400,000 | |
| Chemicals[5] | 144,000 | |
| Labour[6] | 340,000 | |
| Processing[7] | 244,000 | |
| Total Expenses | | 1,518,000 |
| GROSS MARGIN | | 482,000 |

[1] The yield is a conservative estimate for irrigated production using good seed and basic level of inputs and weed control.

[2] 0.25 kg per acre @ Ushs 400,000/kg

[3] Two times tractor ploughing @ Ushs 25,000/each; 160 days beds/trenches @ Ushs 1,500/day

[4] 200 kgs per acre @ Ushs 2,000/kg

[5] 12 litres of fungicides and insecticides @ Ushs 12,000/litre

[6] spraying (50 days @ Ushs 1,500/day); fertiliser application (8 days @ Ushs 1,500/day); slashing (Ushs 10,000/acre); clearing field ditches (4 times @ Ushs 3,000); irrigation (Ushs 12,000 per season); weeding (60 days @ Ushs 1,500/day); harvesting (96 days @ Ushs 1,500/day)

[7] grading, packing, weighing (96 days @ Ushs 1,500/day); miscellaneous, including water, fuel, depreciation, etc (5 percent of total revenue)

**Table 7: Estimated Investment Costs for a 15-Hectare Asparagus Farm in Uganda, US$**

| | | |
|---|---|---|
| Land | *15 hectares x US$2,500/ha* | 50,000 |
| Seeds | *$250/ha x 15 hectares* | 3,750 |
| Chemicals (soil fumigation) | *$750 x 15 hectare* | 11,250 |
| Chemicals (operations) | *$360/ha x 15 hectares* | 5,400 |
| Packhouse Building | *$30 ft2 x 5,000 sq ft* | 150,000 |
| Fertiliser | | 15,000 |
| Packhouse Equipment | | 30,000 |
| Cool Room | | 70,000 |
| Truck | *2nd hand delivered* | 32,000 |

**Table 7: Estimated Investment Costs for a 15-Hectare Asparagus Farm in Uganda, US$**

| | |
|---|---|
| Irrigation | 90,000 |
| Total | 457,400 |

## More Information

Additional information on production, postharvest handling, and marketing of fresh asparagus is available at the ADC. In addition, weekly price reports are available that report on wholesale prices in major European wholesale markets.

*ADC Commercialisation Bulletins are published by the Agribusiness Development Centre of the USAID-funded Uganda's Investment in Developing Export Agriculture (IDEA) Project. The bulletins provide potential investors with a quick reference to production and market characteristics for various nontraditional export crops. For additional technical details, contact:*

*Agribusiness Development Centre*
*Plot 18, Prince Charles Drive*
*P.O. Box 7856*
*Kololo, Kampala, Uganda*
*Tel: (256) 41 255482/83/68*
*Fax: (256) 41 250360*
*Internet: adc@starcom.co.ug*