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KOSOVO NEW OPPORTUNITIES FOR AGRICULTURE PROGRAM

GREEN ASPARAGUS PRODUCTION REPORT AND MANUAL

June 2013

This publication was produced for review by the United States Agency for International Development. It was prepared based on a final report provided by Farmer-to-Farmer volunteer Robert Morris.

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DISCLAIMER
This report was prepared by the New Opportunities for Agriculture project team of Tetra Tech ARD based on a Final Report prepared by Short Term Technical Advisor, Robert Ll. Morris, a Farmer-to-Farmer volunteer. The authors' views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

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BACKGROUND

USAID supports economic growth in Kosovo through programs that strengthen and improve the competitiveness of Kosovo agribusinesses, improve the business environment, and encourage local economic development. Accordingly, USAID/Kosovo awarded Tetra Tech ARD the task order for the New Opportunities in Agriculture (NOA) in Kosovo Program.

The goal of the program is to increase economic growth in Kosovo through expanded, environmentally-sustainable production and sales of value-added agricultural products by enabling producers and processors to compete regionally and globally. The program has the following components:

1. Products and farmers linked with markets;
2. Agriculture products diversified and increased;
3. Food quality and safety improved;
4. Increased affordable and accessible credits; and
5. Improved coordination within the agriculture sector.

Developing the asparagus sector in Kosovo is in line with the profile and goals of the NOA program. Asparagus offers an opportunity to diversify the current agricultural production scheme in Kosovo, introduce a crop that has potential for the domestic as well as export markets, and add a safe and healthy food item to the population's diet. Planting asparagus will bring Kosovo in line with 62 other countries around the world that cultivate it. Only a few of Kosovo's neighbors such as Macedonia and Greece produce asparagus, so opportunities abound for the expansion and proliferation of the crop in the region.

PURPOSE OF ASSIGNMENT

The purpose of this activity was to promote and enhance asparagus production in Kosovo. In the past year of the NOA program, three varieties of asparagus were grown from seed by a Kosovar producer and field planted for evaluation. A CNFA Farmer-to-Farmer (F2F) volunteer had been brought in to train the producers in planting.

In June 2013, another F2F volunteer was brought to Kosovo to visit the plots, provide further training on harvest and post-harvest activities, and to update a manual on asparagus production.

Desired Impacts:

- Encourage domestic production of asparagus
- Increase agricultural production and diversification
- Promote new crops with other potential actors
- Increase knowledge and develop skills of local growers to produce asparagus

Tasks:

- Field visit to nurseries to support asparagus crown production
- Field visit to established plots from last year to give practical advice on production
- Practical training on weed control in the field
- Field visit to established plots from last year accompanied by newly selected growers
- Practical training on transplanting asparagus for selected growers
- Field visit to selected plots to technically support transplanting of asparagus
- Demonstration of harvesting asparagus and post-harvest activities

Deliverables:

1. Update the manual from 2012 for basic Kosovo asparagus cultural practices for both white and green asparagus. The growing manual should include a planting guide, fertilization schedule, spraying schedule, recommended herbicides and cultural practices.
2. Introduce recordkeeping practices and IPM for asparagus production.
3. Final report and recommendations or a road map for next steps.

EXECUTIVE SUMMARY

Farmer-to-Farmer volunteer Robert Morris was requested to update an asparagus production manual for Kosovo initially produced for the NOA project in 2012. In June 2013, Mr. Morris visited an asparagus nursery, several farmers who had planted field trials of asparagus in 2012 in cooperation with the NOA program, and suppliers of agricultural products in Kosovo. From these visits, the volunteer observed challenges that have occurred and potential problems which might occur in asparagus production in the country.

Overall, Kosovo shows great promise for the production and marketing of asparagus. It lies at a latitude well-suited to and known for asparagus production, and is surrounded by countries which import asparagus. However, the major limitations for asparagus to become an agricultural commodity for Kosovo include a lack of knowledge about asparagus production by producers, the small-scale of private farms, little to no local consumer knowledge about asparagus as a food choice, lack of postharvest facilities and cold chain, and poor linkages between producers and existing regional markets.

The updated asparagus production manual addresses production, harvesting, postharvest and marketing issues associated with producing asparagus in a temperate climate of the northern mid-latitudes. Its primary focus is on improving asparagus yield and quality for commercial markets. A PowerPoint presentation accompanies this manual for training Kosovo producers. The major headings of this manual are as follows:

- Basic Biology and History of Asparagus
- Site Selection for Asparagus Production
- Developing the Production Area
- Planting
- Integrated Pest Management (IPM) Strategies
- Irrigation
- Harvesting
- Post-Harvest Practices
- Sorting and Grading

Additional information on the production sequence, IPM, pesticides, and recordkeeping are included as annexes to this manual. In addition, recommendations for future NOA activities in asparagus production, post-harvest activities, and marketing are included.

FIELD ACTIVITIES TO ACHIEVE PURPOSES

Visits to Farmers:

- Presented asparagus knife used by Michigan asparagus growers.
- Met three farmers currently producing asparagus, including one who is producing crowns. Varieties being tested included Jersey Giant, UC157 and DePaoli.
    - Observations:
        - The first farmer has a test plot of several varieties of asparagus and is producing crowns. Soil was heavy with approximately 20% clay- a bit heavy for long-term asparagus production.
        - The second farmer has field plots of asparagus, a nursery business and cold storage room.
        - The third farmer's crowns were put in late.
        - Weeds are not being controlled, perhaps because it has been too wet. No pests noted.
        - Drip irrigation was with SDI dripline with 2L/hour emitters spaced 25cm apart.
- Visited a fourth farmer in Peja.
    - Observations:
        - Asparagus was healthy and vigorous.
        - Rocky soil in part of the field that would present problems with spear quality.
        - Herbicide damage (drift) noted from using 2,4-D ester rather than the amine or LV formulation. Asked what corn herbicides could be used on asparagus.
- Visited a fifth farmer who had not yet planted asparagus.
    - Observations:
        - Sandy loam soil and probably the best soil seen so far.
    - Applied Glyphosate to weeds. Will cultivate and prepare site for planting next week.
- Visited another farmer's site, near a river.
    - Saw more Spotted Asparagus Beetle. Many berries infested.

Other Activities:

- Visited Begisholli of Fitofarma in Ferizaj.
    - Observations:
        - This store has Eurodrip irrigation supplies and some pesticides including Mancozeb, Chlorothalonil and Sulfur Dust.
- Presented video of Michigan asparagus producers: *Asparagus! Stalking the American Life*

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE ACTIVITY

Asparagus is a new crop for Kosovo. At 36 degrees North latitude, Kosovo is at the same latitude and a similar elevation to Hart, Michigan- the self-proclaimed asparagus capital of the United States. Kosovo has the climate, soils, natural resources and human capital necessary for making asparagus a successful agricultural crop. Kosovo is surrounded by asparagus-importing countries such as Germany, France, Italy, Spain, Belgium and the Netherlands. Kosovo initially will be looking closely at those markets which are importers of fresh asparagus: Spain, Germany, Belgium and the Netherlands. Major competitors which produce fresh asparagus and sell to European Union member countries include Greece, Mexico, and Peru.

To build a successful asparagus sector, Kosovo must address fresh market production, post-harvest and cold chain weaknesses, as well as develop its marketing channels. Asparagus yields increase incrementally over the first three years, reaching a maximum in its fourth through eighth years of production. The first three years of production will give Kosovo producers just a short time to develop its local market and prepare its production for export. Currently, the fresh asparagus market in Kosovo is small, primarily consisting of restaurants catering to foreigners. Although not typically used locally in homemade meals, asparagus should be relatively easy to introduce due to influences of Turkish, Greek and Italian cuisine (which do incorporate asparagus) in Kosovo. Asparagus can be marketed locally with other spring foods, such as strawberries, arugula, beets and cherries. An export market in 2016 and beyond will require a large coordinated volume driven by farmer marketing associations or exporters.

To achieve these objectives, the following activities are recommended for NOA and Kosovo's asparagus sector in general over the upcoming two-to-three years:

Fresh Market Production

- Develop harvesting, sorting and grading standards for a targeted export market.
- Develop an IPM program based upon the identified Kosovo asparagus production problems. Aspects of an IPM program should include scouting, recordkeeping, identification and recording of pest problems, fertilizer recommendations based upon soil and tissue testing, etc.
- Develop irrigation recommendations for designing, installing and managing a drip irrigation system for asparagus production.
- Train producers on asparagus good agricultural practices (GAP) and good handling practices (GHP) appropriate for the targeted market(s).

Post-Harvest Challenges

- Develop a post-harvest handling procedure (from farm to market) for asparagus producers.

- Develop a model cold chain for producers. It is recommended to look at the Coolbot example being tested by the University of California at Davis in concert with USAID (http://hortcrsp.ucdavis.edu/main/9Coolrooms.html).

Marketing

- Develop a marketing plan for a typical Kosovar asparagus producer and assist in developing the marketing channels.

GREEN ASPARAGUS PRODUCTION MANUAL

Introduction and History

Asparagus is an ancient Mediterranean plant and member of the *Asparagaceae* family, formerly the Liliaceae family, and is closely related to onions, garlic and leeks. Asparagus is dioecious, having separate male and female plants. Asparagus is valued as a food primarily because of its edible young shoots, called spears (see Figure 2), that emerge from the ground in spring from a perennial crown (see Figure 3). If left unharvested, these shoots mature into feathery, fern-like fronds bearing flowers and thin, leaf-like needles called cladodes. *Asparagus officinalis* L., the commercial variety of asparagus, is classified as an herbaceous perennial crop and is commercially productive for ten to fifteen years after establishment. It is believed to have originated along the seacoasts of Europe and Asia and cultivated for over 2,000 years. The first record of its cultivation was by Macedonians around 200 BC. Asparagus has also been depicted in ancient Egyptian writings and grown in Syria and Spain in ancient times.

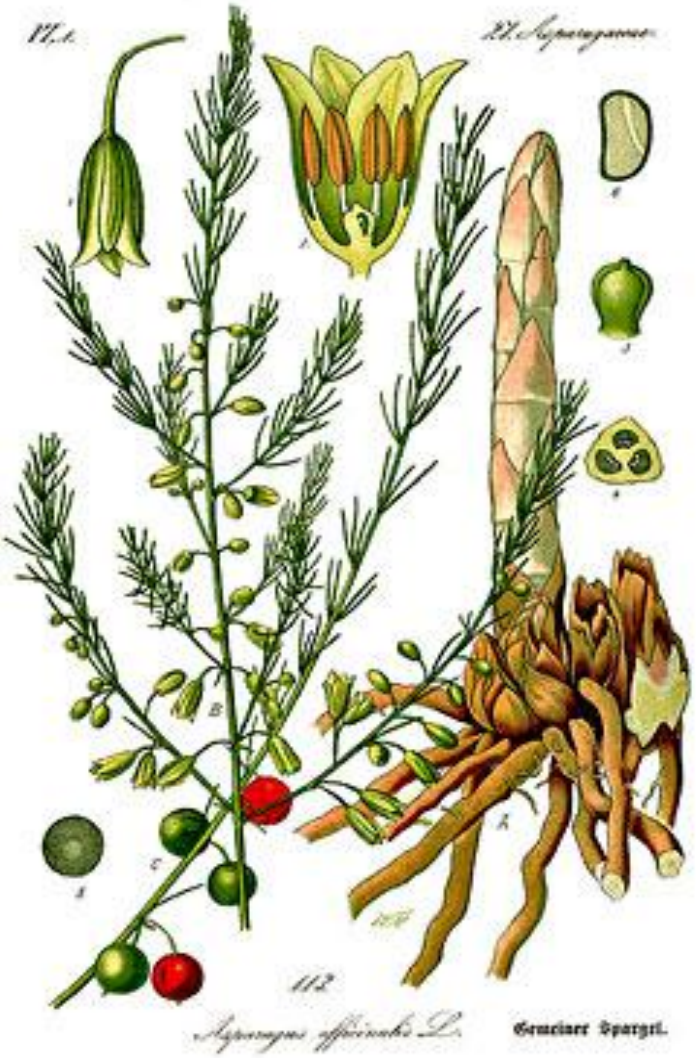

Figure 1. Asparagus officinalis (Illustration: Prof. Otto Wilhelm Thomé, Flora von Deutschland, Österreich und der Schweiz, 1885, Gera, Germany)

The asparagus plant consists of an underground crown that produces both the above ground spears and below ground roots. The edible spears develop from buds originating from the top of the crown (see Figure 3). The spears, if left to grow without harvesting, grow into a 1.0m to 1.5m “fern-like” growth that develop flowers, fruit (if female), and thin rudimentary leaves (see Figure 4). Flowers develop from the bases of the leaves. As indicated above, asparagus plants can develop either into male or female plants (dioecious), with male or female plants giving rise to exclusively all-male or all-female flowers. An asparagus plant will be either male or female. A male plant will bear exclusively male flowers while female plants will bear exclusively female flowers. Male and female flowers are never mixed together on the same plant, nor do individual flowers bear male and female parts.

The roots develop downward from the crown into two types: roots that primarily absorb water and nutrients, and roots that primarily store energy gathered from sunlight. The crown can be transplanted successfully and provide energy for next season's growth (spear production). Storage root development depends on strong and healthy fern production. Greater production is realized if all-male plants are grown.

Figure 2. Asparagus spears emerging.

The prolifically-cultivated vegetable is popularly consumed in many parts of the developed world and developing world. There are at least sixty-two countries producing asparagus in the world with an estimated total area of 195,819 hectares. Major asparagus exporters include China, Peru, Mexico, USA, Germany, Spain, and the Netherlands. Major importing countries include Spain, Germany, France, the USA, and Japan.

Green asparagus production in 2009 is up at 62% of the total volume with 78% marketed as fresh asparagus versus 57% green and 65% marketed as fresh in 2005. Domestic consumption of asparagus increased 4% from 53% in 2005 to 57% in 2009, and, conversely, worldwide export percentages decreased by 4%, from 47% in 2005 to 43% in 2009.

Figure 3. Asparagus crown with emerging white spears.

The popularity of the vegetable is generally attributed to the unique taste and to the symbolism of it arising first in early spring over other popular vegetables. There is also a growing realization of the health and nutritional aspect of asparagus, as it is found to contain 25 calories per serving of five spears and zero grams of fat, with no cholesterol or sodium, 1% of total carbohydrate and 8% of dietary fiber. It contains two (2) grams each of sugar and protein, and of the daily

recommended intake of essential vitamins and nutrients, it has 10% of vitamin A, 15% of vitamin C, and 2% of calcium and iron. It also contains beneficial quantities of vitamin K and folic acid.

Figure 4. Asparagus fern with female flowers, fruit and leaves (cladodes).

Ancient Greeks and Romans used Asparagus for its diuretic properties. They claimed it helped flush out the kidneys and help in the prevention of the formation of kidney stones. Chinese pharmacists saved the best Asparagus roots for their families and friends, believing that it increased feelings of compassion and love. In India, it was used to promote fertility, reduce menstrual cramping, and increase milk production in nursing mothers. Asparagus acts to increase cellular activity in the kidneys and thus increases the rate of urine production.

Site Selection

Climate. Asparagus can be grown anywhere in the world where the growing season is long enough. Most asparagus production in northern temperate regions occurs between the latitudes of 35 and 55 degrees, with harvest from January through May, depending on the latitude and elevation. Even in places where the growing season is too short, it can be grown in greenhouses or under protected culture. It is adaptable to growing areas where the minimum temperature is below 10˚ C or where drought in non-irrigated asparagus induces a dormant stage in the crop. It is also grown in the tropics with a ten month production cycle or with two main production seasons about six months apart.

The temperature range for seed germination is 16˚ to 30˚ C, with 24˚C considered ideal. Rhizome buds form at temperatures between 16˚ and 32˚ C. The growth rate of the spears is very temperature sensitive. The length of time required between harvests can vary from 5 days at 11˚ C to daily at temperatures above 30˚ C. High temperatures can cause the spear tips to begin “ferning” early in some varieties, resulting in shorter harvestable spear lengths.

Kosovo is at the same latitude and similar elevation to Hart, Michigan- the self-proclaimed US capital of asparagus production. Kosovo’s changes in elevation, unlike Hart, Michigan, may give small-scale producers a small climatic marketing advantage in the region. The 6 to 8 week production season at the lower elevations of Kosovo might begin as early as late April, and end at higher elevations as late as

early to mid-July. The earlier part of the production season might find a regional export market in northern latitude and higher elevation European markets. The latter part of the production season might fit well into southern latitude and lower elevation regional markets.

Soils. Asparagus can be grown in a wide range of sites and soils provided there is good drainage and moderate water-holding capacity.

When selecting a site for asparagus production, consider the following:

- Avoid lowlands with late spring frost
- Plenty of sunshine and air movement
- Close proximity to urban centers
- Avoid replanting in asparagus fields for 8 years
- Avoid fields known to have had Fusarium in the past
- Deep soils with good drainage
- Soils sandy in nature
- Avoid rocky soils
- Avoid wet depressions and high water tables

Since spears are harvested in the very early spring it is important to avoid lowlands with late spring frost. Frost damage can extend below ground and cause the spears to be unmarketable. Asparagus needs plenty of sunshine and air movement helps to reduce diseases like rust. Growing areas near urban centers help in its marketing and distribution. Asparagus should not be replanted in the same field for 8 years since it is allelopathic to itself, and nor should any of its waste be returned to the field. Asparagus has deep roots and so requires deep soils. Several root diseases occur on asparagus, so soils should drain easily and be sandy in nature. Rocks in the soil causes crooked spears, so rocky soils should be avoided. Asparagus tolerates up to ECe=10 mmhos. Asparagus is a poor competitor with weeds. If a site has weeds difficult to control, it will impact production and profits. Asparagus has fewer problems planted in light textured soils such as sandy and sandy loams.

Coarser textured soils allow for earlier production in the spring, reduced root disease problems and help keep growing beds intact during the rainy or harvest season. Sandy soils are best for outdoor crown production and soils that crust will interfere with high quality spear production. Expect lower productivity and less longevity in heavier soils. Soils should be deep, free of stones and gravel that could interfere with bed formation and spear development. Asparagus requires a rooting depth of one & one-half (1.5) meters. Organic material content in the soils above two (2) percent is favorable and five (5) percent is ideal. Also, asparagus should not be planted in areas planted to asparagus in the past.

When selecting a soil type for asparagus production, consider the following to be ideal:

- Sandy loam is best; avoid heavy soils since these promote root diseases
- Soil pH range from 6.5 to 7.5 with 6.8 ideal
- Moderate to low salt levels
- High organic matter
- Soils without rocks
- Deep soils that drain freely

- Soil never planted in asparagus
- Soils with no perennial weeds

Varieties. Asparagus varieties are now available that have been bred for rust resistance, all-male yields, and higher yields. Producers in the Eastern US prefer Rutgers varieties primarily due to their improved resistance to rust disease, as well as all-male varieties. Typically the Rutgers varieties perform well under high rainfall and higher humidity climates. In the Western US, producers generally prefer California varieties such as UC157, which produce a longer, more marketable spear under high temperatures. There are three new Rutgers varieties (all numbered at the moment) being released which claim to have a 20 to 30% increase in yield compared to the older varieties.

Figure 5. Asparagus cultivar evaluation at Rutger University with Dr. Stephen Garrison.

Four-year research trials at North Carolina State University measured higher yields with Jersey Giant, Jersey Knight, Jersey Gem and Greenwich (all Rutgers releases) over UC157 under the warm and high humidity climate of their research farm at 36 degrees north latitude and 130 m of elevation. Higher yields are realized with all-male plants and by keeping fields from contamination with female plants during production.

The advantages of using all male plants and rogueing out (removal) of female plants are as follows:

- Male plants do not produce fruits that divert resources from the crowns and roots, and therefore out-yield female plants over time. The yield advantage of an all-male field becomes increasingly apparent after the second or third year in production.
- Male plant emerges earlier in spring than female.
- Female plant has a tendency to lodge in heavy rain and strong wind, as its fruits increase the weight of the plant. Male plant is less likely to lodge under the same conditions.
- Male plant has no seeds that can produce unwanted volunteer seedlings. Generally, volunteer seedlings are inferior to elite F1 hybrids, and volunteer seedlings compete with F1 hybrid plants for nutrients.

The most common and universally-used variety around the world for commercial asparagus production is UC 157, F1 hybrid. It's adapted for warm to hot climates and moist soils and shows some tolerance to Fusarium and Rust diseases. Spear quality is good and the green spears tight-tipped, smooth and medium in diameter.

UC 115 F1 hybrid (aka DePaoli) is a hybrid variety well suited for early production in warm climates. The spear heads remain tightly closed until the spear is tall, resulting in a high level of spear quality. DePaoli has moderate levels of tolerance to Phytophthora spear rot.

Jersey Giant, Jersey Prince, Jersey Gem and Jersey Knight are all-male hybrids and Greenwich a male-dominant cultivar developed at Rutgers University. They are adapted to the temperate, humid and climates of the north and eastern US. Spear size range is typically larger than UC157 and yield potential is high in US climates similar to Kosovo. The color varies from green to green with slightly purple bracts. These varieties show resistance to rust, Phytopthora and crown rot diseases.

Developing the Production Area

Sequence to develop a production area:

- Soil test
- Weed control
- Soil preparation
- Trenching
- Soil modification

Soil test. When preparing a soil for production, perform an initial soil test to provide a benchmark for future soil testing. Once done, a soil test should be performed every three to four years. Amend your planting area to the following:

- pH, ECe, P, K, organic matter and other tests as necessary
- pH = 6.8 is ideal; pH = 6.5 to 7.5 acceptable
- ECe = 0-4 mmhos ideal
- OM = 4-5% or more ideal

Weed control. Perennial weeds may be a big problem for a new site and may even eliminate it for production if costs for keeping the field clean are too high. Perennial weeds that could be major problems include nutsedge, field bindweed, swamp smartweed, johnsongrass, and bermudagrass. If perennial weeds are not controlled during field establishment there is evidence that this may reduce future production levels. If weeds are not controlled during the production cycle, they can reduce crown vigor and spear density and ultimately asparagus yield and quality. Perennial weeds are difficult to control culturally or chemically without injury to the asparagus; therefore prevention is a major focus for improving yields.

- *Control all weeds at the site prior to planting*
- *Weed control during the 2 to 3 year establishment period is critical to future production*

Soil preparation. Good drainage is important to long term asparagus production. Any situation where water is ponded or soil is saturated for any extended period is prone to root disease problems like *Phytophthora* and *Fusarium*. The subsurface soil characteristics are also very important since asparagus can be a very deep-rooted crop. Deep soils that allow excess soil moisture to move out of the root zone are important. Since most of the storage root system on asparagus is found below the 60

to 90 cm soil depth, ripping and deep plowing of soil and incorporation of soil amendments should be considered.

Leveling the field with a mechanical grader with a final slope of one-half to one percent is recommended for gravity irrigation systems. This will also help get water off the field while avoiding erosion. The same slopes will work for drip irrigation. On sloping land, drip irrigation may be preferred taking into account elevation changes and designing the system appropriately for pressure changes due to head pressure. In some cases when drainage is a problem, asparagus should be grown only on raised beds about 25cm above the soil surface or drain tiles installed.

Trenching. Soil should be worked properly with appropriate tractors and implements so that it is loose enough to form into troughs and beds for planting asparagus. Soil should be workable to a depth of 45cm so that planting can be done at the 15 to 25 cm depth. Planting depth is shallower in heavier soils, but never less than 15cm. Row spacing is generally from 1.1 to 1.8m, but 1.6m is common. Closer spacing of rows and plants may increase rust disease and other foliar diseases later in the season due to poor air circulation. Soil is thrown to the outside of the trench for further modification to improve crown and root growth after planting. Amended soil is then placed back in the trench to the appropriate planting depth and amended soil is used to backfill around crowns, transplants or seeds.

Soil modification. Soil from the trench is modified with organic matter (OM), phosphorus and potassium before backfilling the trench. Manures and composted manures are highly beneficial to asparagus. Phosphorus (P) is relatively immobile in heavier soils, so applying P and OM at planting time provides the only time when these can be used for soil improvement at these depths. Phosphorous and potassium (K) should be provided so that the soil contains 250 kg of available P* and 300 kg available K* per hectare.

If not known, in rows that are 1.6m apart, apply 0-46-0 (P) at 200 kg/ha and 0-0-60 (K) at 200 kg/ha (or equivalents) to soil from the trenches. Adjust the application rate accordingly for different row spacings. Nitrogen (N) fertilizer does not need to be applied to the trenches at this time as it moves through the soil profile easily and is contained in most manures and composts used to increase the OM content. Nitrogen is applied to the soil surface as side dressing or through drip irrigation lines just before spear emergence (1/2) and again during fern development (1/2). Drip irrigation allows more frequent application of nutrients in smaller amounts resulting in less fertilizer used and less potential for leaching into groundwater and surface runoff.

Irrigation. Drip irrigation lines may be laid under the plant at the bottom of the trench or on top of the backfilled crowns, transplants or seed. Make sure the soil in the trench below the drip lines has settled prior to backfilling or make sure there is “slack” in the laterals to prevent them from being pulled out of the submains. Care must be made to not damage the drip lines when harvesting with a knife. Laying drip irrigation lines on the top of the soil can also be done, but may result in more problems from weeds or damage from machinery and animals. Once the drip lines have been laid, they should be tested to make sure they are operating correctly and flushed before they are buried.

Planting

Asparagus can be established by three methods: 1) planting of crowns, 2) transplants, and 3) direct seeding. Trench spacing, depth and planting distances are the same for crowns and transplants. The primary difference is in the amount of backfilling in the trench with amended soil once they are planted. It is important that phosphorus and any manures or compost be incorporated in the trench or backfill at the time of planting. Once the trench is filled, it is difficult or expensive to modify the soil around the roots. Soil preparation at this time will provide big dividends in crown establishment and an early harvest. Planting should occur in the spring after all threat of freezing has passed but before hot weather decreases survival. Transplants are more susceptible to loss than are crowns or seed.

Figure 6. Asparagus crown.

Crowns. Crowns are grown in the greenhouse or open field. Select all-male varieties if possible. Crown planting should begin when soil temperature reaches at least 10C and all danger of frost has past. Generally one year old crowns are used but crowns older than this are sometimes available, usually for the homeowner market. The minimum diameter of good one-year old crowns is 60mm. They should weigh 50g or more and have a cluster of large, well-formed buds. All plants that show evidence of injury, disease or serious mechanical damage should not be planted. Also small crowns with fewer than 4 to 5 roots or with spots or off-color blemishes should be discarded.

Transplants. Transplants are asparagus seedlings that have been grown for 10 to 12 weeks prior to planting in the field. Transplants can be field or greenhouse grown but greenhouse growing will guarantee that they will be ready at the right time for spring planting. Greenhouse grown transplants also may be better protected from insects and disease than field grown plants. Transplants are less expensive but more subject to loss from drying, mechanical damage from planting and more tender in the field.

Figure 7. Asparagus transplants 8 weeks old in the nursery.

Direct seeding. Direct seeding of asparagus is the least commonly used

method of propagating asparagus for spear production because little is known about it. It is commonly used for growing transplants and crowns for resale. For this reason it is not recommended for producers until more research has been done. However, direct seeding has been done for commercial production in single and double rows. Planting depth has varied from 3 to 4 cm to the same depth as crowns and transplants with similar spacings. The timing for seeding is generally when soils have warmed to 15C and irrigation can be applied for more even germination of seed. Once asparagus seed germinates, it is very susceptible to losses from drought.

Figure 8. Direct seeding of asparagus into trenches and backfilling half done.

Steps for planting asparagus:

- Backfill trenches with amended soil to planting depth
- Plant 15 to 25 cm deep depending on soil type, spear emergence timing and desired spear size
- Space crowns, transplants and seed 24 to 30 cm apart
- Backfill crowns with 5-8 cm amended soil
- Backfill transplants up to bottom leaf with amended soil
- Backfill seed with 1 to 2 cm of amended soil
- Lay irrigation tubing
- Irrigate and apply nitrogen
- Backfill trench with amended as growth emerges until soil is level with surrounding soil

The bottom of the planting trench should not be less than 15 cm or more than 25 cm below the level soil surface for roots, transplants, or direct seeding. Crowns and transplants are typically planted 24 to 30 cm apart but may be planted as close as 15 cm. Do not plant into subsoil. Spears emerge earlier from shallower plantings. Deeper planting and later

Figure 9. Spacing asparagus crowns in the trench prior to planting.

emergence may be preferred where late frosts frequently occur. Spear size tends to be larger from more deeply planted crowns. Foliar disease problems like rust tend to be greater with closer plantings. Spacing between and within rows are the same for both crowns and transplants.

Some recommend 15 cm in-row spacings for seed. In early production years, yields are likely to be greater from more closely spaced plants, whether within or between rows. Eventually these yield differences decrease. Spears tend to be smaller from crowded plants during the early life of the asparagus field.

Figure 10. Spreading roots of the crown apart at planting time.

Seedling transplants or one-year old crowns are normally placed at the bottom of a furrow and soil is mounded over the plants as they develop to fill in and form a raised bed. Make a small mound at the bottom of the furrow as a seating for the planted crown. Be sure to segregate the crowns by size so that similar sized crowns are planted together in the same rows. Plant asparagus crowns or rhizomes (roots plus buds) so the tops of the crowns are 15 to twenty 20 centimeters below the top of the bed.

Place the crowns at the proper spacing, spreading the roots over the mound and making sure the buds of the crowns are facing up. Cover the crowns with no more than 5 centimeters of soil. As the ferns begin to grow, cover it gradually with soil removed in cultivation operations, either mechanically or by hand. Use the crown covering as part of a mechanical or hand weeding operation. The crown should be fully covered, shifting the adjacent soil over the crown before the winter dormancy and in time for the fern removal the following spring. A round bed with the apex at one and one half meters and the crown buried 15 to twenty 20 centimeters should be the final outcome.

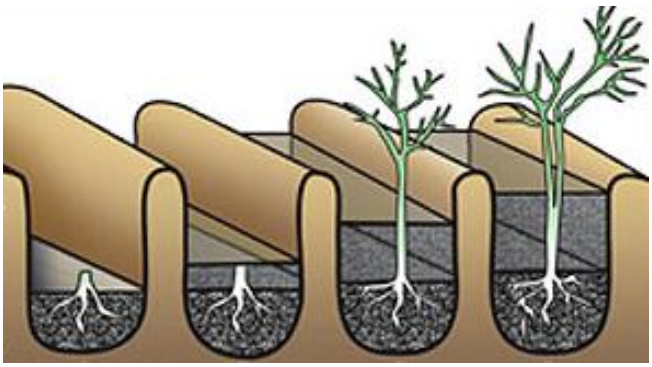

Figure 11. The trench should be filled as growth from the crowns emerges.

Crop Management Strategies

Fertilizer management. Baseline soil analysis (soil test before the field is in production and before any fertilizers have been applied to the crop) is important for future fertilizer applications. The soil analysis should be taken at the same depth that where the crowns are growing. After a baseline fertilizer analysis has been done, future soil tests may not be needed annually. Knowing the nitrogen (N) level of a field in production is informational, but not always an indicator whether N is needed. Always assume N is needed since it moves easily through the soil with water and is taken up by plants quickly and easily. A lack of nitrogen will result in decreased yields and slower growth. Nitrogen will always be applied annually unless manure or composted manure is substituted. Applying N in smaller amounts more often (such as in drip irrigation) will use less N per year and it will be used more efficiently by the crop. Sandy soils will need N more often than heavier soils, but in smaller amounts at each application.

Fertilizer applications of phosphorus (P) are very important at the time of planting since phosphorus does not move through the soil easily. Once P has been applied and adequate, future applications may not be needed as often or small amounts may be applied through drip irrigation. Once P is in short supply it is slow to move into the root zone of the crop without drip irrigation. Phosphorus deficiency is rare in asparagus.

Another critical element for asparagus is potassium (K). Potassium is removed from the field by asparagus nearly at the same rate as N. Most likely K will need to be applied at least once a year.

After the first year, apply 50 to 75 kg/ha N and 75 to 125 kg/ha K_2O twice each year. Make one application late winter or early spring just before spears emerge. Apply the same amount of fertilizer at the conclusion of harvest and during fern development. Apply the fertilizer to the top of the soil or through drip irrigation. Fertilizer can be applied as a sidedressing to the crop and watered into the root zone or through drip irrigation.

Growers may wish to use manure to increase soil OM and provide fertilizer. Manure can be beneficial, but is not necessary if soil OM is above 5%. Pre-plant applications of cattle or chicken manure are very valuable and will reduce the chemical fertilizer requirement during establishment and during maintenance of the crop. Manure will add significant amounts of nitrogen, phosphorous, potassium and essential micronutrients. Annual maintenance

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

Figure 12. Optimal ranges of major nutrients in asparagus tissue samples.

applications of chicken manure at rates between seven to twelve tons per hectare and applications of cattle manure at rates between fifteen and twenty-five metric tons per hectare tons acre incorporated into the tops and sides of the beds will maintain the nutrient level and contribute to the annual requirement of nitrogen for the next year's fern growth.

Tissue analysis is another way to gauge what fertilizer is needed and how much. Optimal range for nutrients in tissue analysis is given in the table to the right. The plant sample is taken from 15-30 cm tips of mature new ferns.

- Perform a baseline soil test before planting
- Soil test every 2 to 3 years
- Apply N early in the growing season; increases spear production and yield
- Apply N at fern development; helps rebuild crowns and roots
- Manure applications can reduce the need for fertilizer applications
- P and K may need to be applied less often than N
- Apply N in drip irrigation in small quantities every 2 to 4 weeks

Irrigation. Irrigation is critical for higher yields, disease management and good asparagus establishment. Flood, sprinkler or drip irrigation can be used for irrigating asparagus in Kosovo. Flood irrigation needs to be managed- especially during the harvest, as alternate beds can be watered as required to allow the labor to harvest on dry ground. Alternate rows can be flooded as the earlier rows dry to complete the cycle. Heavier cycles of flood irrigation are carried out after the end of harvest in tandem with the fertilization to push fern growth for the final summer accumulation of carbohydrates in the growing crown.

Figure 13. Long-lived dripline with built in dripper inside the tubing. Dripper is oriented up to avoid potential plugging from dirt and debris.

Sprinkler irrigation is an option, but tends to cause more bed erosion and weed problems over the field. It is difficult to manage during the harvest as labor walkways are wetted, causing a messy environment and leading to compaction by tractors or laborers.

Drip irrigation is a form of precision irrigation that can reduce pumping costs, fertilizer expense, reduce environmental pollution, reduce erosion problems, reduce weed problems and save labor while improving yields. It has the advantage of irrigating

the crop while allowing for labor and equipment to enter the field at nearly any time, even during irrigations. Subsurface drip irrigation (SDI) is buried below the soil surface in the planting trench with the dripper on the top. This keeps drip tubing out of the way of machinery and laborers and, with a mixing tank or fertilizer injector, allows for fertigation and the application of other chemicals directly into the rootzone. Putting the dripper on the upper surface helps to keep the dripper from plugging.

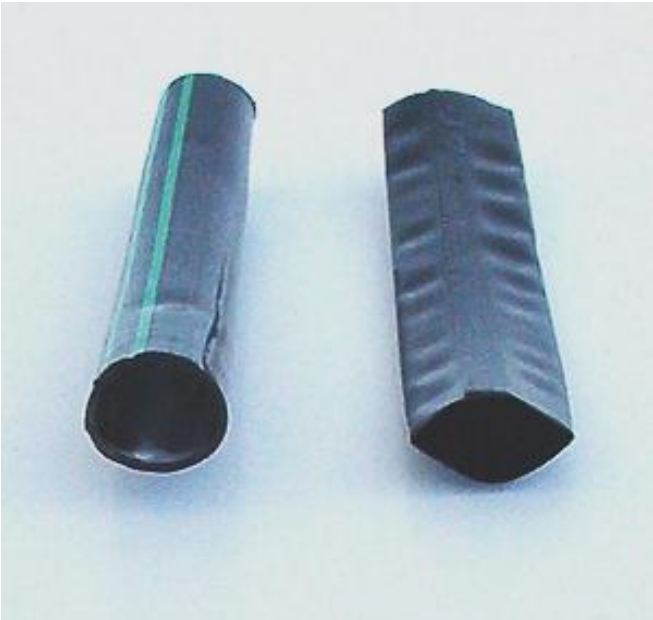

Figure 14. Thin-walled and short-lived drip tape on the right and thick-walled dripline on the left.

Drip irrigation tubing with embedded drip emitters is available as a short-lived drip tape (1 to 3 years) normally used for annual row crops and long-lived dripline intended for use with long-lived perennial crops. Since asparagus is a long-lived perennial crop (10 years or more) it is probably not a good idea to use short-lived, thin-walled drip tape. The length of time dripline lasts depends on how the system was designed, maintained and the care it was given. If given proper care and maintenance it would be reasonable to expect it to last the lifetime of the asparagus crop. Although more expensive, dripline with emitters spaced appropriately for the soil texture, would be a better choice than drip tape for asparagus.

SDI must be buried deep enough so that asparagus knives used for harvesting will not cut it and shallow enough so that the asparagus roots are bathed in the applied water as well as any fertilizer that is applied. If asparagus is harvested by cutting, the spear is cut at three to four cm below the soil surface. Driplines must be placed deep enough to avoid this operation. After the trench has been filled, the soil should settle before connecting driplines to submains or the driplines may separate from the submain as it settles. Flush all driplines and submains prior to operating the system.

Another consideration when selecting dripline for SDI applications are elevation changes in the field. Dripline normally comes with either pressure-compensated or nonpressure compensated drippers. There is usually a significant price difference between the two. Pressure compensated drippers will emit the same amount of water even if the pressure changes as much as 2 atmospheres along the operating system. Non-pressure compensating drippers have a flow rate that varies with changes in elevation in the operating system. If there are elevation changes that create changes in pressure in the drip system, the volume of water coming from the nonpressure compensated drippers also changes, giving significant changes in the volume of applied water. Thus, driplines with pressure compensated drippers are required in fields that contain elevation changes. Flat fields can use dripline with nonpressure compensated drippers.

Most likely irrigations will be infrequent if at all during spear production in Kosovo unless there has been no rain. To judge if irrigation is needed, soil from the root area should be sampled with a shovel or soil probe. The soil from this depth is squeezed hard into a ball in the palm of the hand. The soil ball is then bounced 4 to 5 cm high in the palm of the hand. If the ball does not break, do not irrigate. If the ball breaks, it is time to irrigate. Irrigate with enough water to penetrate to a depth of at least 30 cm.

Drip irrigation laterals and submains should be flushed monthly. All drip irrigation main lines and laterals should be filtered and pressure regulated. Consult Netafim's manual on drip irrigation for asparagus.
http://www.netafimusa.com/agriculture/download/asparagus-form

- Water is critical to yields during spear production and crown/transplant/seed establishment
- Asparagus is sensitive to drought stress and prefers moist soils but not overly wet soils
- Watering too often or poor drainage leads to root disease problems and loss of stand
- Soil moisture should be measured at crown depth (15-25 cm)
- As temperatures and fern growth increase, irrigations should become more frequent

Integrated Pest Management (IPM)

One definition of IPM is "an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment." (http://www.ipm.ucdavis.edu/GENERAL/ipmdefinition.html).

IPM strategies interact with the asparagus ecosystem and many have been woven through this manual in the sections on site selection, planting and crop management. Elements of IPM include but are not limited to:

- Soil testing
- Soil improvement
- Varietal selection
- Crop rotation
- Fertilization
- Irrigation and drainage
- Proper harvesting
- Scouting and pest identification
- Recordkeeping
- Pest control

Crop scouting. Crop scouting is one of the major components of an IPM program, if not its foundation. The goal of crop scouting is to provide accurate and unbiased pest and crop development data. Without this information an intelligent crop and pest management decision cannot be made. Scouting is observing. Is your production on schedule? Does the crop appear to be healthy? If not, what is wrong and how can it be fixed? What pests are present? Pests include weeds, insects, diseases and environmental problems. Is the pest causing damage? If so, does it need to be controlled? Chemical controls are recognized as a necessary component of IPM programs. However, appropriate non-chemical control options that are economically feasible should be implemented before pesticides are used.

Recordkeeping. (See Appendix E). Recordkeeping is an important part of IPM. Recordkeeping establishes what happened to the crop in previous years. When did harvesting occur in previous years? Is the crop on schedule, ahead, or behind schedule? When did pests occur in previous years? Which control measures controlled these pests and which did not?

Weed management. Elimination of noxious weeds prior to planting is critical for good crown establishment and future production. It is also critical during the first two years of establishment as poor weed control can lead to poor crop establishment and decreased production.

Asparagus is very poor at competing with weeds during the production year until the ferns are fully established. Once established in late summer and fall, asparagus competes effectively with annual weeds. Weed management is one of the most important management strategies that will determine the success of asparagus producers in Kosovo.

Weed management in asparagus can be divided into two periods: first two years during stand establishment and the third year and after when the stand is mature. Perennial weeds are the worst weed problem in asparagus. These may include nutgrass, barnyardgrass, field bindweed (morning glory) and bermudagrass.

Weed control strategies during the production year include weed control before spear emergence, during spear harvest, after spear harvest and fern growth. A very complete breakdown of weed control by production cycle can be found at http://www.ipm.ucdavis.edu/PMG/r7700311.html.

Before spear emergence. Leaving ferns established until two weeks before spear emergence helps to cool the soil 2-3˚ C and delay the harvest in frost-prone areas. Ferns are then mowed and removed from the field for burning or disposing. After fern removal is a good time for applying pre-emergence herbicides to control the germination of annual weeds and growth of seedlings from harvested ferns (berries). Light tillage, apply pre-emergent herbicides and spot spray perennial weeds.

During spear harvest. During the harvest period, spears provide virtually no shade to reduce weed competition. Annual weeds can be a problem in established stands at this time because the beds are open and exposed to light. It is most important to have beds weed-free to facilitate harvest and increase soil temperature. Hand

cultivate, light tillage and spot spray perennial weeds. During harvest of spears in-row cultivation opportunities are limited.

After spear harvest. The period between the end of spear harvest and beginning of fern growth is a good time for applying herbicides and light tillage. Once ferns have emerged and begin filling the rows, weed control is difficult to impossible. However, dense fern growth that can result from an N application competes effectively with weeds. Lightly till, apply pre-emergent herbicides, and spot spray perennial weeds. During fern growth (until fern growth limits activities), hand cultivate and spot spray perennial weeds.

Avoid damage to crowns by straddling the beds. At no time should tractor tires be driven on or across the rows. Cultivation between the rows with a high-clearance tractor and 3-point hitch-mounted row cultivators will control the bulk of inter-row weeds during the growing season. A row crop cultivator can also be used to reform the troughs and throw dirt up and onto the beds to reshape them and cover weeds. During the harvest of spears and fern production weed control opportunities are limited. Yet these weeds, if left uncontrolled, reduce yield the following growing season.

A list of some herbicides used in asparagus production in the US can be found at Appendix C.

Insect management. Various insects can be found feeding or damaging asparagus spears, ferns and roots. Some of these insects that have been found to be damaging and the location of the damage include:

- Armyworms – young spears and ferns
- Asparagus beetle - ferns
- Spotted asparagus beetle - ferns
- Asparagus miner – ferns sometimes spears
- Cutworms – young spears
- European asparagus aphid – distorted ferns, virus transmission
- Symphylans – roots, particularly damaging to white asparagus spears
- Thrips – young seedlings and ferns

Control by planting resistant varieties is very limited. Weed control and removing places where insects can overwinter will always reduce their numbers. Some insect pests of asparagus are below.

Armyworm. Larvae of these moths feed mostly at night on the epidermis of asparagus fern branches, often girdling the branch and causing the ferns to die. Good weed management can help prevent the build-up of armyworm. Scouting for this insect should be twice a week during fern development and until weather becomes cold.

Figure 15. Armyworm.

Asparagus miner. This is a typically a minor pest of asparagus which infests the fern during its development, not the spears. The insect may cause spears to turn yellow

and die due to the tunneling of its larvae in the stem. Natural predators normally keep this insect under control.

Asparagus Beetle and Spotted Asparagus Beetle. Two types of asparagus beetle cause damage: the Asparagus Beetle and the Spotted Asparagus Beetle. Asparagus beetles in general cause damage by feeding on tender young spears in the spring and on the ferns later in the season. Spotted asparagus beetle has been identified on asparagus in Kosovo feeding on asparagus fruit and leaves. If injury to the fern is severe, the crown is weakened, particularly if the asparagus stand is young. Weed control and sanitation (removal of old ferns) is essential as they overwinter in the stems of old ferns and weeds. Allowing some spears to begin ferning early in the season can "trap" these insects at the edge of the field.

Figure 16. Spotted Asparagus Beetle.

Cutworms. Cutworm larvae feed at night on young emerging tips of asparagus spears either above or below ground. The feeding leaves holes in the spears making them unmarketable. Keep weeds under control and scout for damage to young spears during their emergence and harvest. An Inspection of harvested spears may reveal their damage.

Figure 17. Cutworm larva.

European Asparagus Aphid. The asparagus aphid can be very damaging to asparagus plantings and is present all through Europe and Asia. Asparagus feeding causes stunted ferns (bonsai) with sticky exudate from the aphids. Ants and bees may also be present feeding on the sugary, sticky excrement. The asparagus aphid feeds only on the ferns of asparagus plants. Although a parasitic wasp lays eggs in the aphid, it provides no more than 10% control of the aphid population.

Figure 18. Distorted growth from feeding of European Asparagus Aphid.

Symphylans. These pests of asparagus feed on crowns and the underground portion of the spear. They can be particularly devastating to white asparagus production. They are not insects but resemble "white centipedes" about 8 mm long and live only underground. Their feeding damage can lead to root disease problems, particularly after extended wet weather.

Figure 19. Garden symphylan.

Thrips. Thrips can damage young seedlings or transplants, but also feed on the ferns of asparagus. Their feeding damage on flowers and leaves causes the plant to appear off color and "rough" looking. It is important to maintain good weed control in the field.

IPM measures for asparagus insects can be found in Annex D.

Disease management. The major strategy for plant disease control is to focus on one or more of the three pillars of disease activity: the presence of a pathogen, an environment that encourages disease activity and a host (variety) susceptible to the disease. Selection of planting sites not conducive to disease development is extremely important. Selection of a variety known to be resistant to potential disease problems is also important. The timing and application of appropriate crop management activities will also help to discourage disease. Recordkeeping (Annex E) helps to identify when future diseases are likely to occur and what management strategies have worked in the past.

After everything has been done to prevent the disease and disease pressure increases, fungicides should be applied to reduce the spread of a disease. Fungicides are primarily preventive in nature and should be applied at the early stages of an infestation or applied when environmental conditions are conducive to its development.

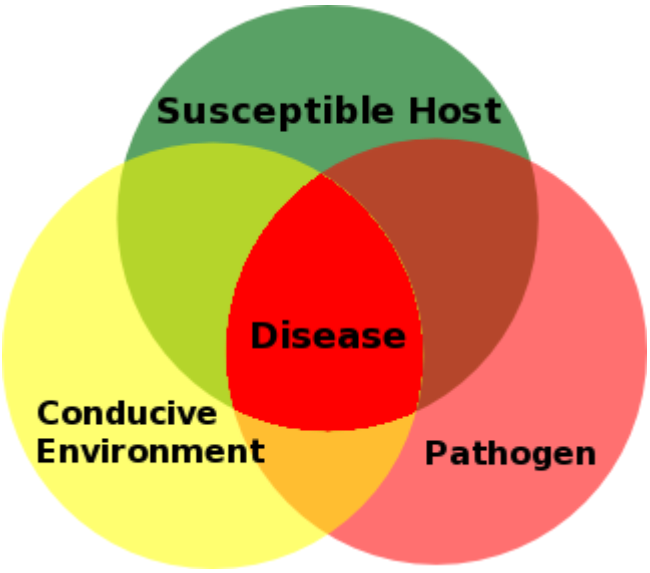

Figure 20. The three pillars of disease activity.

Diseases of asparagus can be divided into diseases of the ferns and diseases of the roots and crown.

Diseases of the ferns
- Rust
- Asparagus viruses

Diseases of roots and crowns
- Fusarium - roots and crowns
- Phytophthora – crown and spear rot

Rust has been identified on asparagus in Kosovo. As in all cases, some varieties are more susceptible to disease than others. Always select a variety with improved disease resistance if the disease is known to be in the area.

Figure 21. Evidence of earlier rust disease on the fern stem.

Asparagus rust and Cercosopora stem and leaf spot are two fungal diseases affecting the asparagus fern. They may require chemical control during some years. Good irrigation management, wide row spacing, orientation of planted rows with the prevailing wind may help reduce the incidence of asparagus rust. As with crown and spear rot, good drainage and

soil leveling reduce the possibility of a wet environment.

Fusarium wilt is the most serious disease affecting asparagus production worldwide. It causes a slow decay of the crown and reduction in spear size and number, ultimately leading to lower yields. The problem increases with the age of the crop. Severity of the disease can be reduced with the selection of vigorous growing varieties (hybrids), use of clean seed and one-year-old crowns grown in non-infested soil, and good irrigation management. Replanting asparagus into the same field should be avoided for at least an eight year period.

Asparagus crown and spear rot is a soil-borne fungal disease that is a problem particularly in soils that are saturated due to poor drainage. Crown rot and spear rot can occur if corrective and preventative measures are not employed resulting in stand loss and reduced production. Chemical and cultivation controls can be employed against this disease. Also, good drainage by sub-soiling, high bed construction, and leveling the soil with 0.5% slope to facilitate water runoff prior to planting helps to avoid the environment suitable for fungus development.

Figure 22. Asparagus crown rot causes dieback of the ferns and is primarily associated with heavy or wet soils.

There are few organic control methods for asparagus diseases except the use of resistant varieties, weed and insect control. Most controls are associated with use of sensible cultural practices, use of clean seeds and transplants, and incorporation of manure and compost to ensure good drainage prior to planting.

Chemical controls for asparagus diseases are listed below. Always refer to the label for harvest interval and reentry period.

Disease	Active Ingredient
Crown Rot	Mancozeb*
Phytopthora crown & spear rot	Mefenoxam Fosetyl-AL
Rust	Myclobutanil* Sulfur* Tebuconazole*
Rust, Cercospora Leaf Spot	Mancozeb* Chlorothalonil* Myclobutanil*

* Active ingredients registered with the Republic of Kosovo

A summary of the *Management of Asparagus for the First Three Years* can be found in Appendix A.

A summary of the *Production Sequence of Asparagus* can be found in Appendix B.

Harvesting Asparagus

Once the soil temperature gets to 10˚ C the spears begin to emerge. The ideal time for harvesting is early in the morning as the spears are cool and require less cooling (saving energy) and contain more water so they are heavier. In California asparagus spears are harvested when they reach a height of 12.5 to 22.5 cm above the soil with a diameter of at least 1 cm or greater. Many commercial asparagus growers cut below the soil with a knife because the fibrous butt end of the spear helps to slow water loss in the tip of the spear so it can survive several days of transit.

Figure 23. Spears harvestable size. Spears in this field are harvested by snapping.

In other parts of the world green asparagus spears are harvested at 25 to 30 cm long and cut spears about 5 cm below the soil surface. Spears are later trimmed square to 23 cm at the packing shed for fresh-market asparagus. Freezer asparagus is cut in the same way as fresh-market asparagus. Asparagus to be delivered to processors is trimmed to 18 cm and must have a minimum of 14 to 15 cm of green.

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 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

Figure 24. Snapping an asparagus spear.

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. Overharvesting will result in loss of stand, decreased yields and root diseases like Fusarium.

Figure 25. Harvesting asparagus with a long-handled asparagus knife.

Marketable spears must have compact, tight tips and good green color. Asparagus can be harvested by snapping or cutting. The spear snaps at the point where fiber starts to develop and results in shorter harvested spear. Snapped asparagus should command a higher price than cut asparagus.

Cutting spears below the soil with a knife adds more length and weight to the spear but the lower 1/3 of the spear is tough and fibrous and has to be discarded. Cutting asparagus with a knife should be done about 2 to 4 cm below the soil surface. Care must be taken not to damage the crown, other emerging spears and the irrigation drip tubing. Fiber development (toughness) of the spear is related to the tightness of the spear tip. The tighter the tip, the more tender the spear. Spear diameter has no bearing on toughness.

Early in the season fields are harvested every two to three days. Spindly and otherwise deformed spears are discarded to allow for growth of the marketable spears. Harvested spears are collected and placed on the beds in bunches or carried to collection centers around the field.

Figure 26. Harvesting asparagus with a riding Harvesting Aid.

It is highly recommended to harvest the asparagus in the early hours of the morning or alternatively in the late afternoon hours when daylight temperatures are at their lowest. Spears should ideally be packed in light colored, well ventilated crates to reduce heat absorbance. Crates should not be filled to more than ¾ of their depth so that ventilation is not impaired and mechanical damage is

minimized. After harvesting, crates should be kept in the shade until transporting them to the packing house. When packing in crates, make sure that they do not come into direct contact with the soil as this is likely to result in contamination which will increase the risk of decay. Then they are taken out of the field and hauled to sheds for grading, packing, trimming and cooling. It is advised to make frequent trips to the packing house to enable prompt removal of field heat.

Figure 27. A perfect asparagus spear with tight scales.

After unloading into the packinghouse, classification and selection of the asparagus is done in accordance with the relevant standards for the specific market. Eliminate bent spears, double spears, and those with open bracts. Defects and loss of production can occur for various reasons. Prolonged wind or pelting by hailstones can cause the spears to bend. Freezing temperatures during spear emergence can cause “frosting”, discoloration of green spears. Frosted spears may still be marketable but will deteriorate quickly and lose quality and should be discarded to prevent market rejections.

Large spears are washed with chlorinated water. A sterilized knife trims them square to a uniform length. Most export markets require the spears to be cut to a uniform length (23 cm). It is imperative that neither the tips nor the skin are damaged, since injuries will facilitate the entrance of bacterial soft rot organisms. Cutting tables must be sanitized frequently.

Figure 28. Crooked spears are caused by damage to the incurve side. These must be discarded.

The spears should be clean, firm, tender, well-trimmed, straight, and 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 left in a warm packing shed. Asparagus roots and ferns or emerging spears grow best between temperatures 18˚ C and 29˚C, with reduced development at temperatures lower than 13˚C and higher than 29˚C. Low temperatures reduce the number of new buds coming from the crown. High temperatures cause the spear

tips to open prematurely (called feathering), requiring the spear to be harvested earlier, at a smaller length.

Fields in the second year of production after transplanting crowns or seedlings may be harvested for 3 to 4 weeks, yielding 750-1,000 kilograms per hectare. A full cutting season of five to eight weeks may begin the third or even the fourth year after planting. Asparagus can be harvested fully in the third to fourth year. Yields of 3,000-6,000 kilograms per hectare per year are typical production volumes for a continuously cropped field.

Figure 29. Sorting and grading asparagus.

Excess harvesting leads to a reduction in stored carbohydrates, decline in production and a proliferation of small spears. They should only be harvested during the optimum periods, and for three to four weeks at the most. Any excess harvest will debilitate the crown and reduce production over the life of the crop.

Asparagus fields should produce good yields for eight to ten years. Asparagus is capable of a much longer production life, but it is usually limited in later years by weed infestations, disease infections, and overcutting of the beds.

Asparagus Cold Chain

Asparagus has a high moisture requirement so it is necessary to minimize the time left out in the field under the sun, or left on the field trailer waiting for transport to the packing shed. Taking the “field heat” out of the product is the key. Some field trays or bins include a lining of wet burlap sack or other water absorbent material to keep the asparagus temperature from rising and maintain hydration. In some cases the trays or bins are hydro-cooled as soon as they arrive at the packing shed, especially if they are going to be stored for a long time prior to packing. Some of the field trays are stored in refrigerated containers or in a cold storage shed to prevent further rises in temperature. In other cases hydro-cooling occurs after packing and before storage in the refrigerated warehouse. To hydro-cool the asparagus, chlorinated water at approximately 1˚ C to 3˚ C is drenched over the shoots for approximately 15 minutes to remove the field heat from the spears. To maximize shelf life, asparagus needs to be stored at 2˚ C to 4˚ C with 90% to 95% relative humidity.

Preparing the asparagus for transportation requires arranging the cartons of asparagus on pallets and using corner posts and straps to consolidate and unitize

the load. Pallets are arranged inside the containers with considerations for adequate cold air movement around the outsides of the boxes. Asparagus can continue to respire, even in the container. Poor air circulation can lead to quality issues and loss of shelf life.

Figure 30. Asparagus sorted and bundled, ready for cold storage.

At high temperatures, asparagus spears lose natural sugar, flavor, and vitamin C, and also become tough and start to decay. If rapidly cooled and held at 2˚ C, asparagus may be kept for two to three weeks. Desiccation can occur rapidly if the butt ends of the asparagus spears are not placed on wet pads. Spears will continue to elongate if not properly cooled and hydrated.

Postharvest Asparagus Classification

For the European market, bundles are packed in one kilogram bunches with six bunches per box or in a loose pack of seven kilograms.

Shoots are packed according to “Extra Class” or Class I.

“Extra Class”. *Superior Quality*. Very well-formed and practically straight. Very compact tips. A few slight traces of rust (removable by normal peeling). No traces of woodiness. Green asparagus must be totally green. The cut at the base must be square. When packed in bundles, outside shoots can be beveled less than or equal to 1 centimeter. Tolerance: 5% by number or weight out of standards, but conforming to Class I standards, or exceptionally coming within Class I tolerances, or having slight unscarred, after-harvesting cracks.

Class I. *Good quality*. Well-formed and may be slightly curved. Compact tips. Slight traces of rust (removable by normal peeling). A trace of woodiness on the lower part is permissible, provided it disappears with normal peeling. Green asparagus must be green for 80% of the length. The cut at the base must be as square as possible. Tolerance: 10% by number or weight out of standards, but conforming to Class II standards, or exceptional coming within Class I tolerances, or having slight unscarred cracks appearing after harvest.

Class II. Not considered because of poor commercial quality. May be sold locally, but poor quality does not even merit commercial consideration.

Sizing Extra & Class I. Length is not less than 17 centimeters with a maximum length of 27 centimeters. Maximum difference in length of shoots packed in firmly bound bundles is less than or equal to five (5) centimeters.

Minimum diameter is three (3) millimeters with the variation between the thinnest and the thickest shoot in the same package or the same bundle is eight (8) millimeters maximum. Size tolerance: 10% by number or weight of shoots out of specification with a deviation of plus or minus one (1) centimeter in length and plus or minus tow (2) millimeters in diameter.

Uniformity: in origin, quality, color group, and size (where sizing is compulsory). Visible part representative of the entire content. Color: shoots of different color groups may be allowed within the following limits: 10% by number or weight of another color group.

Packaging. The produce must be packed in a way that ensures its protection. Materials must be new, clean and of a proper quality. Non-toxic ink or glue. Packages must be free of all foreign matter. Material is generally water resistant since it is subject to hydro-cooling and high moisture environments.

Presentation.

(a) Bundles firmly bound and protected by paper. Outside shoots must correspond in appearance and diameter with the average of the whole bundle. “Extra” Class shoots in a bundle must be of the same length. In any one package, bundles must b of the same weight and length and evenly arranged.

(b) Unit packages, or arranged but not bundled in the package. This could be defined as “loose pack.”

Annexes

Annex A. Management of Asparagus First Three Years

First Year Management

- Lime if pH is below 6.5
- Weed control: extremely critical for good stand establishment
- Scout for insects and diseases
- Apply ½ N just before spear emergence
- Apply ½ N during fern development
- Irrigate as needed, but prevent drought stress
- Harvest 1 cm diameter or bigger spears for 2 -3 weeks
- Post-emergent weed control
- Inspect weekly for insects and diseases
- Cut and burn or mow ferns in early spring 3 weeks before spear emergence

Second Year Management

- Lime if pH is below 6.5
- Pre-emergent weed control
- Apply NPK (1/2N) in early spring before spear emergence
- Harvest spears over 1cm in diameter for 4 weeks
- Apply 1/2N after harvest during fern development
- Post-harvest weed control
- Irrigate when necessary
- Scout for insects and diseases
- Cut and burn or mow ferns in early spring 3 weeks before spear emergence

Third Year Management

- Lime if pH is below 6.5
- Pre-emergent weed control
- Apply NPK (1/2N) in early spring before spear emergence
- Harvest spears over 1cm in diameter for 8 weeks
- Apply 1/2N after harvest during fern development
- Post-harvest weed control
- Irrigate when necessary
- Scout for insects and diseases
- Cut and burn or mow ferns in early spring 3 weeks before spear emergence

Annex B. Asparagus Production Sequence

Before spear emergence

- Fern removal (delay to help prevent early spear emergence)
- Weed control and herbicide applications
- Lime if pH below 6.5
- Apply fertilizer
    - 1/2 annual N application if surface applied
    - Apply N every 3 to 4 weeks if injected
    - Apply manure in place of N or to supplement N
    - Apply K at annual rate
    - Apply P only if soil or fern analysis indicates a deficiency
- Scout weekly
- Control insects and diseases as necessary

Spear emergence

- Weed control
- Scout weekly
- Control insects and diseases as necessary (observe Restricted Entry Intervals) (REIs)
- Irrigate when necessary

Harvest

- Stop harvesting when 75% of the spears are less than 1.0 cm
- Scout weekly
- Control insects and diseases as necessary (observe REIs)
- Irrigate when necessary and does not interfere with harvest
- Weed control

Fern development

- Apply ½ nitrogen (immediately after harvest)
- Weed control (immediately after harvest)
- Scout weekly
    - European asparagus aphid
    - Armyworm
    - Rust disease
- Control insects and diseases as necessary (observe REIs)
- Irrigate weekly, decreasing frequency as temperatures drop in the fall

Annex C. Herbicides for Asparagus Production

Preemergence Herbicides for Asparagus			
Common Name	**Mode of Action**	**PHI**	**Weeds Controlled**
mesotrione	HPPD inhibitor	None	Annual broadleaves and grasses
flumioxazin	PPO inhibitor	14 day	Annual grasses and broadleaves
s-metolachlor*	Cell division inhibitor	16 day	Annual grasses and broadleaves, nutsedge
diuron	PSII inhibitor	None	Annual broadleaves, crabgrass
Pendimethalin*	Mitosis inhibitor	14 day	Annual grasses and broadleaves
Metribuzin*	PSII inhibitor	14 day	Annual broadleaves and grasses
norflurazon	Pigment synth. inhib.	14 day	Annual grasses
sulfentrazone	PPO inhibitor	14 day	Annual broadleaves, pigweeds
terbacil	PSII inhibitor	5 day	Annual grasses and broadleaves, quackgrass

During harvest and immediately after final harvest, growers may apply post-emergence foliar-active herbicides to kill emerged weeds. Post-emergence herbicides should be chosen based on the weeds they control and the time of application.

Postemergence Herbicides for Asparagus			
Common Name	**Mode of Action**	**PHI**	**Weeds Controlled**
Dicamba*	Auxin disruption	1 day	Annual and perennial broadleaves
Dicamba*	Auxin disruption	1 day	Annual and perennial broadleaves
2, 4 – D*	Auxin disruption	3 day	Annual broadleaves, dandelion
Linuron	PSII inhibitor	1 day	Annual broadleaves
Halosulfuron	ALS inhibitor	1 day	Annual broadleaves, horseweed, pigweed, nutsedge
Glyphosate*	EPSP synth. inhib.	5 day	Most annual and perennial weeds
Paraquat	PSI inhibitor	6 day	Most green plants; burn-down only
Sethoxidim	ACCase inhibitor	1 day	Annual and perennial grasses
Fluazifop – p*	ACCase inhibitor	1 day	Annual and perennial grasses
Clethodim	ACCase inhibitor	1 day	Annual and perennial grasses

* Active ingredient registered with the Republic of Kosovo

Appendix D. IPM – Insect Control

Asparagus Pest	Organic	Chemical Treatment
Armyworms. Larvae feed mostly at night on the epidermis of asparagus fern branches, often girdling the branch and causing the ferns to die.	Good weed management. *Bacillus thuringiensis* and spinosad are acceptable for organic production in the US.	Chlorantraniliprole, *Bacillus thuringiensis* ssp. Aizawai, Chlorpyrifos*, Spinosad, Methomyl*, Carbaryl, Permethrin
Asparagus Beetle *Spotted Asparagus Beetle* Feed on the tips of tender young shoots. Beetles and larvae feed on stems and devour the leaves. If injury is severe, the crown is weakened.	If beetles are feeding on spears early in the season, let some plants near the edge of the field produce fern growth to attract the beetles away from the spears.	Spinetoram, Chlorpyrifos*, Methomyl*, Carbaryl, Permethrin, Pyrethrin/ Rotenone combination
Asparagus miner. Injures during the fern growth stage and can damage spears but seldom happens.	Natural predators. If heavy infestations, burning to destroy the pupae may help. Spraying insecticides to control asparagus miner is rarely justified.	None.
Cutworms. Larvae feed at night on new asparagus spear tips where they eat small holes. May also cause the spears to curve. Fern damage is generally rare.	Good weed management and field cultivation.	Carbaryl, Methomyl*, Permethrin
European Asparagus Aphid. Damage causes shortened internodes resulting in a tufted appearance that is called “bonsai growth”.	Cleaning fields of crop debris and encouraging natural enemies. Monitor field edges regularly.	Chlorpyrifos*, Pyromezine, Pyrethrins, Oils*
Garden Symphylan. Chew large numbers of small, round holes in storage roots, crowns, and on the belowground portion of the spears.	Flood fields before planting or in winter. Cultivation to dry out the surface soil has reduced injury.	Telone** (VOC), Chlorpyrifos*
Thrips. Greatest damage to young seedlings but can damage mature ferns. Feeding causes plants to look ragged.	Good weed management is important. Monitor young plantings for thrips when the fern is present and flowering. Treat with spinosad if needle drop is observed.	Disulfoton, Spinosad, Pyrethrin/Rotenone combination

* Active ingredient registered with the Republic of Kosovo
***Volatile Organic Compound*

Annex E. Asparagus Field Records

Producer Records: Planting

Planting Records

Field Name: _____

Field Location: _____

Soil Type: ___ Heavy ___ Medium ___ Sandy

Variety: _____ Date Planted: _____ Location: _____
___ Crowns ___ Transplants ___Seed
Planting Rate: _____ per hectare
Preplant Fertilizer: Type_____ Rate _____/hectare

Notes*: _____

Variety: _____ Date Planted: _____ Location: _____
___ Crowns ___ Transplants ___Seed
Planting Rate: _____ per hectare
Preplant Fertilizer: Type_____ Rate _____/hectare

Notes*: _____

Variety: _____ Date Planted: _____ Location: _____
___ Crowns ___ Transplants ___Seed
Planting Rate: _____ per hectare
Preplant Fertilizer: Type_____ Rate _____/hectare

Notes*: _____

Variety: _____ Date Planted: _____ Location: _____
___ Crowns ___ Transplants ___Seed
Planting Rate: _____ per hectare
Preplant Fertilizer: Type_____ Rate _____/hectare

Notes*: _____

*Notes might include planting depth, distance, rocky soil, weed problems, depth to water table, drainage problems, etc.

Producer Records: Soil Testing and Fertilizer Application

Field Name: _____

Field Location: _____

Soil Testing and Analysis						
Year	*pH*	*P**	*K**	*Other**	*Notes*	*Date*

*VL= Very Low; L=Low; M=Medium; H=High; VH=Very High

Fern Analysis				
NO_3-N*	P*	K*	Notes	Date

*VL= Very Low; L=Low; M=Medium; H=High; VH=Very High

Lime & Fertilizer / Manure / Compost / Other Nutrient Sources Applied			
*Applied**	*Rate (Kg/ha)*	*Notes*	*Date*

* Broadcast, sidedressed or injected into drip irrigation

Producer Records: Labor and Equipment

Field Name: _____

Field Location: _____

Task	Hours Labor	Hours Equip.	Date	Notes

Producer Records: Irrigation

Field Name: _____

Field Location: _____

Date	Type[1]	Duration[2]	L/plant[3]	Notes[4]

[1] Drip, flood, furrow, border, etc.
[2] How many minutes
[3] Drip irrigation only
[4] Mention if fertilizer was injected into the drip irrigation

Producer Records: Weed Control

Field Name: _____

Field Location: _____

Problem Weeds: _____

_____

Date	Target Weeds	Chemical[1]	Formulation[2]	Rate[3]	REI[4]

[1] Use chemical name
[2] Granular (G), Wettable Powder (WP), Emulsifiable concentrate (EC), etc.
[3] Rate applied per hectare
[4] Re-entry interval

Producer Records: Scouting and Insecticide/Fungicide Applications

Pest Monitoring – Scouting Reports

Date	Pest	Level[1]	Date	Pest	Level[1]

[1] 1=Low; 2=Medium; 3=High

Pesticides Applied

Date	Pest[1]	Chemical[2]	Rate[3]	REI[4]

[1] Pest identified for control
[2] Chemical name
[3] Kg/l/ha
[4] Re-entry interval

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