PN-ABB-771

CHEMONICS

PROEXAG

NON-TRADITIONAL AGRICULTURAL EXPORT SUPPORT PROJECT

RASPBERRY AND BLACKBERRY PRODUCTION GUIDE FOR GUATEMALA

Assignment Number: ST/88-30

SUBMITTED TO:
Regional Office for Central American and Panama (ROCAP)
U.S. Agency for International Development
Guatemala City, Guatemala

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OCTOBER 1988

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PREFACE

The objective of the assignment was to monitor brambleberry (raspberries and blackberries) variety trials and provide technical support to bramble berry growers in Guatemala.

Numerous field visits were made to berry farms ranging in size from less than 0.1 manzana to over 21 manzanas. In addition, visits were made to sites ranging from 4000 to 7300 feet elevation. At each site, recommendations were made to growers as to type of culture, spray program, fertilization, harvesting technology, etc. for improvement on existing methods.

The author would like to acknowledge Dr. Jose Mondonedo (Chemonics Agricultural Production Advisor) for his excellent work in establishing raspberry and blackberry trials in Guatemala and Costa Rica. His professionalism and support during the author's one week stay in Guatemala were gratefully appreciated. Appreciation is also extended to Dr John Guy Smith and Mr. John Lamb for their guidance. Thanks also go to Ing. Ricardo Santa Cruz R., Lic. Alvaro Mayorga Ponce, and other officers of the GREMIAL (Non-Traditional Products Exporters Guild) for their hospitality. Finally, sincere appreciation is extended to Emilia Roberts (Chemonics, Washington, D.C.) for her help in making emergency air travel arrangements.

EXECUTIVE SUMMARY

Numerous field visits were made to observe trail plantings of raspberries and blackberries in Guatemala. Each grower used different cultural practices and degrees of management skill. Some growers were harvesting excellent yields of high quality fruit, but most growers did not utilize proper cultural practices (irrigation, fertilization, weed control, plant spacing, pest control, training methods, pruning, etc.) to ensure an economically profitable yield. This was to be expected with such a new crop.

Many questions need to be answered, but I am confident that there is tremendous potential for success of raspberry production in Guatemala for export. I am optimistic, but to a slightly lesser degree for blackberries. This is largely due to the more perishable nature of blackberry than raspberry fruit.

My recommendations are to base the raspberry industry on primocane fruiting cultivars. 'Heritage' is the best cultivar to use at this time. Trials should be made with 'Autumn Bliss' and the new breeding line from New York. Due to the potential lack of chilling hours and unknown time of fruiting, I do not feel summer fruiting cultivars like 'Meeker' will do well.

In order to obtain fruit during November through March, 'Heritage' transplants or root cuttings should be field set at staggered intervals from May through August. It will take between 3 to 4 months for shoot growth until flowering, depending on elevation.

The best chances of success will be in areas between 4000-6500 feet in elevation. Above 7000 ft. elevation, the chances of freeze damage to the flowers are too great (unless certain non-freezing microenvironments exist).

Further research is needed to establish optimal cultural procedures, training systems, and pruning methods. My specific suggestions are detailed in the accompanying PRODUCTION GUIDE.

The area needing much attention is postharvest handling to ensure adequate export grade fruit. Currently, nobody has proper facilities for cooling.

Raspberry and Blackberry Production Guide for Guatemala

David H. Picha

TABLE OF CONTENTS

Page

Background.....1

Botany.....2

Production Recommendations.....3

Site selection.....3

Soil preparation.....4

Variety selection.....5

Planting stock.....9

Plant spacing.....10

Planting.....10

Training.....13

Pruning.....14

Fertilization.....15

Irrigation.....18

Weed control.....18

Disease control.....19

Insect control.....27

Pollination.....31

Harvesting practices.....31

Postharvest handling.....32

Marketing.....35

Summary.....36

Raspberries and blackberries are closely related and have similar growing requirements. They are two of the most economically valuable fruits grown in the world. Production value per hectare for growers in the U.S. and Canada may range from $2000 to $15,000 per hectare. However, raspberries and blackberries are not easy to grow and are plagued with a number of insect and disease problems. They are extremely perishable and have a shelf-life after harvest of only several days.

Background

Raspberries and blackberries originated in Europe and North America. In North America, they are mostly grown in the Pacific Northwest (Oregon, Washington, British Columbia) California, Michigan, and Texas (blackberries only). Almost all the raspberries and blackberries grown in the Pacific Northwest are sold to processors who manufacture jellies, jams, preserves, juices, and frozen berries. The leading commercial raspberry variety is 'Willamette'. Average yield per acre in the Northwest is 4700 lbs. Most of the berries grown in California and Michigan are sold fresh. The leading raspberry variety in California is 'Heritage' and in Michigan is 'Heritage' and 'Boyne'. In Europe, most of the berries are grown in Britain and Germany although production exists in other northern European countries. The leading variety in Britain is 'Glen Clova' and in Germany is 'Schoenemann' . Production season in the U.S. and Canada is from late June through October. Chile produces raspberries for export into the U.S. from November through April. New Zealand and Australia also ship minor amounts of raspberries into the U.S. during the winter.

Some blackberries are native to the high altitudes of Central and South America. They grown best under cool, humid conditions at elevations

between 2000 and 4000 meters. However, these blackberries are a different genus than those grown in the U.S. and probably would not be accepted by U.S. consumers. Therefore, the Central America raspberry and blackberry industry must be based on varieties popular in the U.S. market.

Botany

Raspberry and blackberry plants are perennial with the roots living for many years. However, the stem or cane lives only two years. New canes are produced each year from underground roots or basal buds. Cane vegetative growth occurs during the first year. The first year canes (called primocanes) grow upright or semi-erect and may reach a height of 2 meters or more. Shortening days and falling temperatures cause the shoot to cease elongation at the end of the growing season. The canes then enter a dormancy period during the late fall and winter of the first years growth. They need a period of chilling (low temperature) to terminate bud rest and induce bud sprouting. Dormancy is broken by the gradually warmer temperatures of the following spring. The second year of cane growth (called floricanes) results in flowering and fruiting of the canes. After pruning of the terminal bud of the cane, the axillary buds of the first year produce lateral fruiting branches. Total yield is the product of the number of laterals per cane, number of fruits per lateral, and fruit weight. Inadequate winter chilling results in poor fruit production. After the cane fruits during the second year, it then dies and needs to be removed so the new first year vegetative canes can more fully develop. Every spring new shoots come up from crowns or root buds. Same raspberry varieties produce fruit on the upper portion of the first year cane growth during the late summer and fall. This same cane will then produce fruit on its lower

portion the following summer, after which it dies. An excellent variety having this type of fruiting pattern is 'Heritage'. The fall-bearing varieties offer the best potential for Central America, especially if inadequate winter chilling is a problem.

Raspberry fruit separates from the receptacle producing a hollow fruit with no core, while blackberry fruit does not separate from its receptacle and has a core.

Water is the primary component of raspberry and blackberry fruit, comprising about 84% of its total weight. Sugars are the next most important constituent and they comprise 5 to 6% of the total weight. The flavor of raspberries and blackberries is determined by their content of sugars, acids, and volatiles, which vary with variety and growing conditions.

Production recommendations

Site selection

The most favorable climate for raspberry and blackberry production is one providing a relatively cool, sunny summer (25°C average high temperature; 16°C average low temperature) with 3 cm of rainfall per week. Blackberries can withstand more heat and dryness than raspberries, but also grow best under cool, humid growing conditions. The winter must be sufficiently cold to satisfy the chilling requirement of approximately 800 hours below 1°C for summer bearing cultivars like 'Meeker'. It is possible that fall-bearing types like 'Heritage' will successfully produce fruit on first year shoots without the need for chilling.

Berries will not grow well in areas of hot, dry or windy weather. Windbreaks should be planted to reduce wind injury. Excess heat during ripening will cause fruit softening and sun scalding. Also avoid planting

in areas that are cloudy and damp during the summer. Overabundance of rainfall during the harvest season will cause low fruit sugar content, reduce softness, and result in a substantial amount of fruit rot caused by fungal infections. Avoid overhead irrigation during fruiting as this will promote Botrytis and rust development on the fruit.

Planting of berries on flat land will allow for easier management, but sloping land may provide for better air circulation and less fungal diseases. Avoid planting on windswept sites or too steep a slope where erosion may occur. Plant tree windbreaks to minimize wind damage and seed the area between rows in grass where dust accumulation on the fruit may be a problem.

Raspberries and blackberries should be planted in well-drained clay-loam, loam, or sandy-loam soils with a pH of 6.0 ± 0.5 units. The soil should be high in organic matter (about 3-6%). Avoid planting in poorly-drained clay soils or soils underlaid by a shallow hard pan. They restrict plant development and encourage root disease. Sandy and gravelly soils should be avoided unless irrigation is available and high levels of fertility can be maintained.

Soil preparation

After the proper site for planting has been selected, it is then important to test and prepare the soil before planting. A soil test should be taken at 15 cm and 30 cm depths at random locations throughout the future planting area. The soil test readings should include pH, % organic matter, soluble salts, P, K, Ca, Mg, and nematode analysis. Testing is done by various commercial companies and universities. If the results indicate a pH below 5.5, incorporate sufficient $CaCO_3$ (lime) at least 3 to

4 months before planting to raise the pH to between 5.5 and 6.5. For soils low in organic matter, add poultry manure, compost, or plant a legume cover crop the previous season before setting out the berries. Applications of commercial fertilizer are also likely needed. Follow the soil test recommendations for the amount and type of fertilizer needed.

The decision to fumigate the soil with a nematocide should be based on the nematode analysis. These microscopic worm-like organisms attack roots and transmit deadly fungal and virus diseases. It is absolutely essential to fumigate if any virus vector nematodes are found (Xiphinema (dagger), Longidorus, Trichodorus) or if there are more than 100 root lesion nematodes per pint of soil. Apply the nematocides several months before planting when soil temperature is between 16°C-22°C at 15 cm depth. The soil should be well pulverized, contain adequate moisture, and all organic matter should be well decomposed. Apply the fumigant uniformly at a depth of at least 20-25 cm. The fumigant will volatize through the soil surface. Fumigants should be sealed into the soil to be most effective. This can be accomplished by using a water seal, plastic covers, or packing the soil with rollers. It will be necessary to wait about 2 months for the fumigant to dissipate before planting. Nematocides should not be used on established plantings.

Eliminate perennial weeds before planting with either Roundup herbicide (Glyphosate), mechanical cultivation, or hoeing.

Variety selection

The success of the Central American raspberry and blackberry industry is dependent on finding suitable varieties adapted to this area. Red raspberry varieties are divided into two types. Summer-bearing types produce

vegetative canes during the first year of growth followed by fruiting of these same canes during the second year. Specific examples of this type include: 'Latham', 'Boyne', 'Newburgh', 'Willamette', and 'Glen Clova'. Fall-bearing types produce canes which bear fruit on the upper portion of the cane during the first growing season and on the lower portions of that cane during the following season. Many growers prefer to grow fall-bearing types for their first season's crop, followed by mowing down before next season's growth. 'Heritage' is an example of this fruiting type.

Blackberry varieties are also divided into two types, but based on the growth characteristics of their canes. The erect type of blackberries have upright canes. The trailing blackberries (dewberries) have canes that arch to the ground and are not self-supporting. Fruit clusters of the trailing blackberries are more open and the fruit is often larger and sweeter than erect types. Erect types are considerably easier to harvest.

The following varieties are the leading ones grown in North America or Europe and should be evaluated for their potential in Central America. However, there are many more varieties available that are not widely grown in the U.S. or Europe, but may be adapted to unique Central American growing conditions. They should be included in observational variety evaluation tests.

After becoming familiar with the environmental conditions in Guatemala, I do not recommend planting <u>any</u> summer bearing variety on a large scale. The raspberry industry in Central America should be based on 'Heritage' and perhaps several other fall bearing types like the NY breeding line or 'Autumn Bliss'. This is based on my feeling that the fruiting period for summer bearing types will not coincide with the November to March market window. It is not desirable to have fruiting during May through October

due to problems associated with the rainy season in Guatemala and domestic U.S. production during that period.

Raspberries (summer bearing)

Willamette (1943 release, Oregon, USDA). The leading variety grown in the Pacific Northwest of North America. Fruit are large, nearly round, dark red, fairly firm, and suitable for processing. Resistant to mosaic and bushy dwarf virus.

Meeker (1967 release, Washington). Second leading variety in Pacific Northwest. Fruit are large, bright red, and firm. Excellent for processing and fresh market. Low susceptibility to *Botrytis* fruit rot.

Chilcotin (1978 release, British Columbia). Vigorous and productive plants. Large, light bright red, fairly firm fruit. Long harvest season. Suitable for fresh market and processing. Mosaic virus resistant.

Nootka (1977 release, British Columbia). Vigorous plants, aphid immune. Medium-size, dark red, fairly firm fruit. Suitable for processing. Resistant to *Botrytis* fruit rot.

Boyne (1960 release, Manitoba Canada). Vigorous plants, heavy yield. Medium sized fruit, medium firmness.

Latham (1914 release, Minnesota). Vigorous plants but highly susceptible to mosaic virus. Heavy fruit yield. Berries are medium red and quite firm. Prominent variety in eastern U.S. Good for canning and freezing.

Newburgh (1930 release, New York). Vigorous plants. Berries are very large, bright red and medium firm. Second leading summer-type in eastern U.S.

Glen Clova (1969 release, Scotland). Most widely grown cultivar in Britain. High yield, long production season, vigorous vegetative growth. Long conical fruitshape. Low chilling. Crown gall, anthracnose, powdery mildew susceptible.

Malling Exploit (1950 release, England). Low chilling requirement. Leading cultivar in southern Europe. Spreading habit of growth and uneven fruit shape. Fruit lack firmness.

Lloyd George (1919 release, England). Leading variety in Chile in 1970's. Resistant to mosaic virus.

Fall bearing varieties

Amity (1984 release, Oregon). Vigorous, self-supporting canes. Very large, firm fruit. High yields.

Autumn Bliss (1983 release, England). Fall-bearing type. Large fruit, very heavy yielder, earlier than 'Heritage'. Allows for extension of harvest season.

Heritage (1969 release, New York). Fall-bearing type. Sturdy erect canes. Medium-large sized fruit, bright red, very firm. Leading variety in California. Major success in many parts of the world.

Blackberries

Thornless Evergreen (1930 release, U.S.). Semi-trailing canes. Vigorous and very high yields. Firm fruit, medium size, good flavor. Anthracnose resistant. Roots at cane tip. Leading variety in Oregon and U.S.

Brazos (1959 release, Texas). Very vigorous and productive. Fruit are large, fairly firm, and bear over a long period. Well adapted from south Florida to Arkansas. Resistant to rosette.

Cherokee (1974 release, Arkansas). Vigorous and productive. Fruit are medium to large size, firm, good color and flavor. Susceptible to rosette.

Comanche (1974 release, Arkansas). Vigorous and productive. Large firm fruit, good glossy black color. Low chilling requirement. Adapted to southern Brazil.

Shawnee (1985 release, Arkansas). Vigorous and productive. Fruit with good black color. Low chilling requirement.

Eldorado (1880 discovery, Ohio). Long fruiting season. Berries medium to large size, firm, sweet. Semi-resistant to orange rust. Leading variety in eastern U.S. until 1980's. Virus problem.

Flint (1957 release, Georgia). Needs only moderate winter chilling. Large fruit. Resistant to leaf spot and anthracnose.

Bedford Giant (1935 release, England). Leading variety grown in Britain.

Ebano (1981 release, Brazil). High yielding, thornless, semi-erect canes. Suited for hill culture. Adapted to mild humid climate of southern Brazil (less than 400 hr below 7°C). Glossy black, medium-large fruit, reasonable firm. Late maturing.

Planting stock

Always plant certified disease-free transplants. This is necessary to prevent the introduction of foreign diseases and insects. There are many nurseries in the U.S. which sell certified transplants in the form of either root pieces, dormant bare-root transplants, or rooted transplants with several small leaves, usually sold in 1 cm square pots. Prices vary with variety, type of transplant, and shipping distance, but range from $300 to $600 per thousand. Total cost CIF Guatemala will be close to $1 per transplant. Using planting stock form your own fields is not advised

because of the risk of introduction of viruses, nematodes, fungi, and insects into new fields. Eventually it may be shown that it is okay to use your own disease-free stock, but we must wait several years to determine what raspberry and blackberry pests are present in Central America. It would be foolish to risk the development of a very profitable industry by contaminating it with diseased planting stock.

It will be necessary to air freight planting stock to Central America. Then immediately upon arrival, the transplants should be set in the field. Do not let the roots of the bare-rooted cuttings become dry. In the interim period after arrival but before planting, cover the roots with moist burlap or dip in mud.

Plant spacing

Raspberries and blackberries can be grown in a hill system or hedgerow system. Hills are 2 meter apart in rows that are 2 1/2 to 3 meters apart. Hedgerows are a continuous series of plants in a row, with rows 2 1/2 to 3 meters apart. For most commonly used machinery, 3 meters between rows is necessary. About 1600 raspberry plants per acre or 4000 plants per hectare are required for the 1 meter x 3 meter hedgerow spacing.

Blackberries should be spaced 1.7 to 2 meters between plants and rows need to be spaced 3 meters apart. Vigorous trailing varieties may need a slightly greater distance between plants and rows.

My general observations in Guatemala were that many growers were using too close a spacing between rows and between plants.

Planting

Early spring planting (March, April) of transplants is recommended in the northern U.S. However, with first year cane fruiting varieties like

'Heritage', plantings should be made at different times of the year. In "eternally spring" climates like some parts of Guatemala and Costa Rica it is necessary to establish their time of fruiting response based on planting date. I recommend transplanting at monthly intervals from April through August. At 4000-4500 feet elevation it will probably take 3 to 3 1/2 months from planting until flowering (slightly longer time at higher elevations). An additional 5 week period is required for flowering, followed by about 2 months of fruit production. The goal is to transplant late enough so the canes are bearing fruit during the November through March market window. It is not desirable to have fruit production for export to the U.S. from June through October, as this overlaps the period of domestic production. The soil must be thoroughly prepared and moist, but not waterlogged, when the berries are transplanted. The plants can be set in hills and cultivated on all four sides, or set in rows and cultivated on two sides. In the hedgerow system, set raspberry transplants 1 meter apart and blackberries 1.7 meters apart in the rows. The hedgerow method of culture is preferred because the berries will yield more per hectare. The rows should be kept straight by following a tractor-drawn or hand marker, or the plants can be set along a string stretched over the row. Row orientation (north-south, east-west) does not matter.

Plants should be set in holes dug with a shovel. The roots of bare-rooted dormant transplants should be spread out and the soil well firmed with the foot. Do not leave air pockets in the soil or the roots will dry out. Irrigate right after transplanting if good moisture isn't present in the soil at planting time. Set the plants about 5 cm deeper than they were in the nursery. The row is completely covered with soil. Cut the tops of dormant bare-rooted transplants back so they are 15 cm long.

If planting is delayed by bad weather, transplants may be held in a shaded area. Dig a shallow trench, line the bundles of bare-rooted sets out in the trench, and apply soil to cover the roots. However, plant in the field as soon as possible to avoid injury.

Another method is to transplant into plastic liners (small bags) and acclimate for a month or two before field setting the larger transplants.

The first growing season should produce several canes per transplant or root piece. These canes will fruit the following year for the summer bearing type varieties. A crop of first year fruit will be produced in the fall on 'Heritage', 'Amity', and 'Autumn Bliss' canes.

During the second growing season, two or three new shoots usually come up from the base of each fruiting cane. Shoots will also come up between the plants and between rows. Hoe or cultivate out all shoots between the rows. Cut out all the new shoots except those in the hills if you are using a hill system of culture. Hoe out all new shoots and maintain a density of 5 to 6 first year canes and 3 to 4 thick, strong fruiting canes per linear foot of row if you use the hedgerow system (15 to 18 and 9 to 12 per linear meter of row, respectively). The width of the row should be kept to about 0.5 meters.) If you use the hill system, leave about 8 strong fruiting canes and about 12 first year canes per hill. Do not bunch canes together. The hills should be spaced 2 meters apart. Do not remove canes over 1.5 cm in diameter at the ground level, as thick canes have the highest yield potential. Remove surplus canes smaller than 1 cm in diameter.

Blackberries must be kept thinned or else the shoots will quickly grow out of control. Trailing blackberry varieties should be spaced 2 1/2 meters apart if the hill system is used. Tie 7 or 8 of the strongest canes in each hill to the stake.

A raspberry plantation that is properly managed should yield at least 4500 kg/ha by the second year (700 12 half-pint flats/ha) and a blackberry plantation should yield at least 6700 kg/ha (1000 12 half-pint flats/ha). However, considerably higher yields are possible. As much as 26,000 kg/ha yield for 'Brazos' blackberries have been recorded in Texas.

The expected productive life of a raspberry or blackberry planting is at least 10 years.

Training

For the hill system of culture, a stake should be driven into the ground about 30 cm from the plant several months after transplanting. As new canes emerge during the first and second year, tie them to the stake at about 1 meter and again at 1.5 meters above the ground.

For the row system of culture, a trellis should be installed during the summer or fall of the first year to support the raspberry or blackberry canes during later growth. The trellis wire support should consist of two No. 10 or 12 galvanized wires stretched along wooden or steel posts 8 to 10 meters apart in the row. The end posts are anchored or braced since they get most of the pull. The two-wire trellis has the wires spaced about 75 cm and 1.5 meters above the ground. The wire is fastened to the side of each post with hooks or bent nails or short lengths of wire. After the first seasons growth, the canes are tied to each wire. The purpose of the trellis is to hold the canes upright within the row, facilitate picking, and prevent cane breakage. To minimize rotting of the wooden posts, dip the part that will be in the ground in a 4% pentachlorophenol solution in kerosene for 1 week. Do not use freshly treated posts for 6 months.

Most growers use a standard I-trellis configuration, in which first year (primocanes) and second year canes (floricanes) grow together. Recent

research has shown that a V-trellis configuration in which the primocanes are separated from the floricanes, resulted in higher yields. The floricanes are tied to either one or two wires attached to posts at a 30° angle. Primocane growth is confined to the open center if floricanes are tied to both wires. If floricanes are tied to only one wire, the primocanes grow in the direction of the opposite wire. This V-trellis configuration should be experimented with. It will allow for better manipulation of fruiting. For example, if it takes 4 months from new shoot initiation until fruiting, train emerging shoots in August to one side of trellis for November-December harvest and emerging shoots in October to the other side for January-February harvest.

Pruning

Canes of upright blackberry varieties should be pruned at the top once they reach about 1 meter in height during the first summer's growth. This will stimulate lateral branch development on which fruit will be produced the following year. The laterals should be pruned back to about 30-40 cm in length the next spring before growth starts. Pruning height should be raised gradually up to 1.2 to 1.5 meters in subsequent years to increase yields. It is best to remove only 5 to 8 cm of each primocane top as more severe pruning wastes growth and produces weak laterals. Vigorous plantings may need to be pruned 3 to 4 times from early May through July. Lateral growth on both sites of the hedgerow must be trimmed to maintain a manageable row width (about 1 meter). Summer pruning of laterals is preferable.

Trailing type blackberries should be cut to the ground after fruiting and burned. The new growth of the last part of the season will fruit the following year.

No pruning should be done of red raspberry canes during the first season of growth. During the spring of the second year, but before bud break, raspberry canes should be pruned back to 1 1/2 meters in height. This encourages more lateral fruit bud development. Canes of fall fruiting varieties ('Heritage') grown in the northern U.S. are pruned to the ground in the early spring if only a fall crop is desired. It will be possible to get a smaller second crop (30-40% of total yield) of fruit on the lower portion of 'Heritage' canes if they are cut back to 1 meter. This second crop will flower several months after pruning back. However, due to the reduced yield and potential disease problems, I believe it will be more economical to have fruit production on the tips of new canes. Due to plant competition, it will not be possible to have economical yields from a mixture of older canes fruiting on the bottom and new canes fruiting on the tips. Experiments must be done to determine the length of time from shoot emergence in established plantings until fruiting. Knowledge of this time sequence will allow for manipulation of the fruiting period so production can occur during November through March or April.

All two-year old blackberry and raspberry canes should be removed and burned after fruiting in late summer. Canes should be cut off as close to the soil as possible, using a pruning shear or sharp hook device. Also, remove any spindly or weak new canes at this time.

Fertilization

The soil should be tested prior to planting in order to determine whether lime and/or fertilizer additions are required. Take 12-15 soil samples per hectare. Add lime several months before planting if the pH is less than 5.5. Throughly mix into the soil 1 to 2 tons of lime ($CaCO_3$) per

acre (2000-4000 kg/ha) if the soil pH is between 5.0 to 5.5 and incorporate 2 to 3 tons of lime per acre (4000-6000 kg/ha) if the pH is below 5.0. After the new plants are about 6 weeks old, apply N, P, and K at about half the recommended annual rate. Do not incorporate fertilizer or manure in the planting bed at the time of transplanting, as this may burn the roots. In established plantings of summer bearing varieties, apply the fertilizer at the recommended rate in the early spring as new growth begins. In established plantings of fall bearing raspberries, apply the fertilizer in two equal split applications, one in early spring, and one in early summer. Place the fertilizer in one or two bands 20-30 cm to the side of the plant and 5-10 cm deep. In March of all subsequent years (or when new growth begins) apply fertilizer according to soil and foliar test results. An example for phosphorus and potassium is shown below.

Phosphorus and potassium application should be applied as follows, based on the soil tests.

Phosphorus (P) soil test (lb/acre*)	Amount of P_2O_5 to apply (lb/acre)
0-20	50
21-40	25
40 +	0

Potassium (K) soil test (lb/acre*)	Amount of potash (K_2O) to apply (lb/acre)
0-100	100
101-200	50
200 +	0

*Some laboratories report P and K soil test results in ppm (ppm x 2 = lb/acre).

If manure is used, apply it in winter or early spring. Nutrients are more likely to be low in sandy soils or those soils low in organic matter. Most fields low in organic matter should be given 50-100 kg N per hectare, or 0.5 to 1 lb. per 100 ft^2 of 12-12-12 fertilizer. Nitrogen application

rates should be adjusted according to plant vigor. If cane growth is excessive and leaves are dark green, reduce N application rates. If growth is weak and the lower leaves are yellow, increase N application rates.

Foliar nutrient analysis of raspberry leaf samples taken in mid-summer should have the following levels of nutrients to obtain normal growth: nitrogen - 2.2%-4.0%; potassium - 1.0%-3.0%; phosphorus - 0.2%-0.6%; calcium - 0.6%-2.5%; magnesium - 0.3%-1.0%; sulfur - 0.2-0.5%; manganese - 30-300 ppm; iron - 30-200 ppm; copper - 2-20 ppm; zinc - 20-80 ppm; boron - 25-80 ppm. These concentrations are on a dry weight basis. The most recent fully extended leaves, plus stem, from first year canes should be used. Supplement the soil with adequate amounts of specific nutrients if they are below normal in the leaf tissue. In some cases, foliar sprays can help correct micronutrient deficiences. Reduced yields will occur if nutrient levels are below or much above normal.

Typical leaf symptoms of nutrient deficiency include:

Nutrient	Symptom
Nitrogen	Light green-yellow overall color
Phosphorus	Purple to dark green color of older leaves
Potassium	Bronzed coloration of older leaves. Yellowing and/or necrosis along leaf margins
Boron	Elongated, slender leaves giving a fern-like appearance
Iron	Young terminal leaves turn yellow or white, followed by browning of leaf margins and interveinal chlorosis/necrosis.
Manganese	Older leaves turn yellow between the veins. young leaves remain green

Irrigation

Blackberries and raspberries require about 3 cm of water per week for optimal growth and yields. It pays to irrigate berries on most soils and during most years. Yield increases result from larger berry size and more numerous, larger-diameter canes. The amount of increase depends on soil type and rainfall.

However, in humid regions irrigation is necessary only if soil moisture is deficient during flowering, fruit growth, and ripening.

The critical time for irrigation is during flowering and fruit sizing. Sprinkler irrigation during harvest generally will not increase amount of fruit rot, provided adequate drying conditions prevail. However, I recommend using dip irrigation since adequate drying conditions often do not occur.

The timing and amount of water to apply can be based on feeling the soil or by using tensiometers. A soil with adequate moisture will hold together in a ball when squeezed between the hands. Water should be applied if the soil particles fall apart and do not hold together upon squeezing in the hand. Tensiometers are moisture probes that are stuck in the soil at 2/3 to 1 meter deep. Once the moisture level at this depth drops below 40-50% of field capacity, it is time to begin irrigating. The effective rooting depth for blackberries and raspberries is 1.3 meters.

A crude method for monitoring the amount of water applied is to place several tin cans in the field and measure the depth of water.

Weed control

All berry shoots and weeds between the rows should be removed, either by hand, mechanical cultivation (rotary hoe preferred), or herbicide. All

weeds within the rows should also be eliminated by hoeing at frequent intervals throughout the year. Weeds compete with the berries for moisture, nutrients, and light. They also harbour virus-carrying insects and interfere with air drainage and fruit drying. Raspberry and blackberry roots are shallow and cultivation should not be deeper than 1 cm in order to avoid injuring the roots.

Devrinol (napropamide) at rate of 4 lb a.i./acre or Diphenamid (Enide) at 6 lb a.i/acre can be applied to newly planted fields within a few days after transplanting. Incorporate with 1 inch of H_2O within one week after application. Simazine at 1 lb a.i./acre followed by shallow soil incorporation and Surflan at 2 to 3.5 lb a.i./acre also can be used on recently planted fields.

Simazine [Princep-Ciba-Geigy)] herbicide used at the rate of 2 to 4 lbs active ingredient/acre (52g/1000 ft^2, a 9 level tbsp/1000 ft^2) and incorporated 1-3 cm deep should provide good yearlong annual and broadleaf weed control for established plantings. Apply the herbicide before the weeds and new canes emerge in early spring for established plantings. Simazine is sold as Princep 80W and therefore 2 1/2 to 5 lbs of 80W material should be used. Diuron (Karmex) at 1.6 lb a.i./acre or Terbacil (Sinbar) at 0.8-1.6 lb a.i/acre control weeds on established plantings.

Actively growing grasses can be killed by applying 2 pints/acre of Fusilade 2000 plus crop oil or 1.5 pints/acre of Poast (1.5E) plus spreader sticker as a postemergent contact spray to the grasses.

Disease control

Always plant disease resistant varieties. Initially, it will be hard to determine which are the best varieties because little information is

available on the common insect and disease problems of Central American bramble fruit. Purchase certified disease-free transplants from licensed nurseries in the U.S. or Canada. Maintain healthy plant growth and minimize plant stress. It is also necessary to use a vigorous chemical control spray program. This will include the use of insecticides for aphids, which are the primary vectors of virus diseases. Fungicides must be sprayed at frequent intervals to protect against cane, leaf, and fruit diseases. Application of lime sulfur or Bordeaux mixture in early spring before leaf growth or when leaves are 1 cm will reduce early disease development. Additional fungicide treatments may be required as leaves become fully expanded. Application of pesticides will require enough water and sufficient pressure to give thorough coverage of upper and lower leaf surfaces and canes. Nematocides are required to protect against soilborne nematodes and fungi.

Always remove and burn diseased plants. It is possible that some serious diseases of North America brambles will not appear in Central America provided an adequate disease control program is used. However, it is also possible that a serious new disorder not found in North America may plague Central America berries. Much is to be learned about the potential pest problems awaiting growers here.

Virus diseases are especially to be avoided. Once a plant becomes infected it cannot be cured and it will serve as a source of inoculum for virus transmission to nearby healthy plants. Shoots originating from virus infected plants will also be infected. Blackberries are generally more susceptible to virus diseases and fields should be kept isolated from raspberry plantings. Virus diseases are transmitted primarily by aphids (Amphorophora sp., Aphis sp) nematodes, or through pollination. Some virus

disorders adversely affect yield even though there are no obvious visible plant symptoms. Due to the ubiquitous nature of aphids, it is essential to maintain a regularly followed insecticide spray schedule, whether symptoms of viruses appear or not.

A simple bioassay to test for virus presence is to rub berry leaf sap on Chenopodium quinoa leaves. The presence of most virus in raspberries or blackberries is determined by grinding young berry leaves in 1% nicotine, 1% polyvinylpyrrolidone in phosphate buffer at pH 7.2 and applying the exact with foam pads of carborundum-dusted leaves of Chenopodium quinoa and Cucumis sativus cv 'Early Fortune'. Certain aphid borne viruses are not mechanically transmissible and grafting techniques with Rubus occidentales must be done for determining the presence of these viruses. A hypersensitive reaction will occur in the Chenopodium leaves in the presence of virus. Leaf shape will become distorted, mottled, and exhibit watersoaked spots.

The symptoms and control of the major berry diseases are listed on the following pages. However, many additional diseases occur, but are not as prevalent as the included ones. Some diseases (and insects) of raspberries and blackberries will occur every year and require routine preventive treatments. However, other diseases will be sporadic in frequency and location and should be treated only as the need arises. This will require constant vigilance by the grower so the problem will not advance beyond cure.

Raspberry and Blackberry Diseases

Virus Diseases	Symptoms	Control
Mosaic	Yellow to green leaf mottling, large green blisters surrounded by yellow coloration, mosaic leaf pattern Cane stunting Crumbly fruit	Plant certified disease-free stock Don't plant healthy plants near diseased plants or near black raspberries. Immediately remove and burn diseased plants. Use insecticides to reduce number of virus-carrying aphids. Parathion (highly toxic), diazinon, malathion. Insecticides will help, but not prevent virus transmission because they do not act fast enough to kill aphids before transmitting the virus as they feed.
Leaf curl	Rounded and downward curled dark-green leaves New canes are dwarfed, brittle, and don't branch Crumbly fruit	Same control as for mosaic
Ringspot	Pale green rings on new leaves in spring Weak, slow growing plants Small, crumbly fruit	Plant certified virus-free stock. Nematocides to control dagger nematode (*Xiphinema* sp.) (Telone, Vorlex, methyl bromide, Dowfume, chloropicrin) Plant on *Xiphinema* free land.
Vein chlorosis	Yellow or yellow green chlorosis of varying intensity in the small veins of leaves	Plant disease-free stock Insecticides to control *Aphis idaei* vector
Bushy dwarf	Symptoms not apparent, but some yellow vein netting of lower leaves in spring and general leaf chlorosis Weakened plants Crumbly fruit	Plant certified virus-free stock. Resistant cultivars (Willamette)

Virus Diseases (cont.)	Symptoms	Control
Sterility	Virus-like disease of blackberry Extra vigorous plants that fail to set fruit or produce mis-shapen berries	Plant virus-free stock Remove and burn infected canes
Fungal Diseases		
Anthracnose (*Elsinoe veneta*)	More severe on blackberries Initial light gray spots on canes, enlarging into ash gray centers with purple margin. Similar gray spotting of leaves, with purple margins. Shotholing of leaves Abnormally small and scabby fruit	Plant in site having good air drainage Keep planting free of weeds Use disease-free stock Apply lime sulfur fungicide at leaf budding and opening (1 part active ingredient to 10 parts H_2O). (Include spreader-sticker with all fungicides at a rate of 1 cup per 100 gallon H_2O. Lime sulfur should not be mixed with most pesticides. Apply Captan at flower budding (1 lb. active ingredient per 100 gallons H_2O). Apply Captan after petal fall (1 lb active ingredient per 100 gallons H_2O). Thoroughly spray plants. Do not apply in rainy weather.
Cane blight (*Leposphaeria coniothyrium*)	Dark brown cankers extend down cane several cm, usually on one side Lateral shoots wilt and die Canes turn grayish	Avoid wounding of canes to prevent fungal entrance Remove and burn diseased canes Apply lime sulfur
Cane canker (*Botryosphaeria dothidea*)	Primarily a serious disease of thornless blackberries Reddish-brown cankers develop at lateral buds of second year canes, eventually girdling stem Cane portion above canker dies usually as fruits are maturing	

Fungal Diseases (cont.)	Symptoms	Control
Powdery mildew (*Sphaerotheca humuli*)	Symptoms range from mottled water soaked spots to blotchy light green upper leaf surfaces, to whitish, twisted, dwarfed leaves Spindly, elongated shoot tips	Wide plant spacing for good air drainage Avoid susceptible cultivars (Latham, Puyallup) Apply lime sulfur fungicide spray at leaf opening in spring (10 gallons of liquid lime sulfur in 90 gallons H_2O) Apply benomyl at blossoming (3/8 lb active ingredient/acre). Or dinocap for raspberries only at 3 ounces a.i. in 100-200 gallons H_2O. Apply at weekly intervals as needed, but not closer to within 3 days (benomyl) or 21 days (dinocap) of harvest. Dinocap may burn plants in hot weather.
Botrytis fruit rot (gray mold) (Major postharvest fruit rot) Other fruit rots include: Rhizopus, Cladosporium, Mucor, Alternaria, Penicillium	Gray mold on fruit, especially on bruised or overripe fruit. Tan colored cane lesions, which turn white in winter. Small brown leaf lesions.	Do not pick in wet weather. Do not bruise fruit while picking Do not let fruit overripen on plant Plant only firm-fruited varieties Refrigerate fruit (0°-1°C). Apply Captan, dichloram or benomyl fungicide beginning at bloom and continuing weekly during the ripening period if fruit rot is severe. Captan can be applied until harvest (25 ppm tolerance) Dichloram must not be applied within 1 day of harvest and more than 4 times a season (15 ppm tolerance) Benomyl must not be applied within 3 days of harvest (7 ppm tolerance) [1 lb a.i. per 100 gallons H_2O for Captan 3 lb of 75% WP for Botran; 0.75 lb of 50 WP for benomyl (Benlate). Combine Captan and Benlate for best control.]

Fungal Diseases (cont.)	Symptoms	Control
Leaf spot (Sphaerulina rubi)	Tiny greenish-black spots develop on upper leaf surface, eventually turning gray Leaf shotholing possible	Provide good air drainage Remove fruiting canes after harvest
Orange rust (Gymnoconia peckiana)	Severe fungal disease of blackberries, not found on red raspberries Abnormally small yellowish leaves with reddish-orange blister like pustules of spores on leaf undersides Weak and spindly new canes, lack spines Severe loss of yield	Plant rust free stock Remove and burn canes with symptoms (except if symptoms appear just before dormancy) Thin canes for adequate air drainage Fungicides generally ineffective since fungus becomes systemic inside plant
Spur blight (Didymella applanata) *widespread problem in Guatemala	Brown or purple spots at buds of infected canes, eventually darken and shrivel. Canes fail to branch and fruit. Especially evident on buds near ground level. Leaf symptom is a dead brown, wedge-shaped area	Apply lime sulfur fungicide when leaves mostly expanded in spring (1 part a.i. to 10 parts H_2O) Apply Captan when canes are 25 cm tall (1 lb a.i. per 100 gallons H_2O). Re-apply Captan 14 days later (same rate). Remove and burn infected canes
Verticillium wilt (Verticillium dahliae)	Leaves turn yellow, wither, and fall off, beginning with lower leaves. Canes turn blue and die, plants stunted Vascular tissue turns brown	Plant wilt free stock in Verticillium free soil Fumigate soil before planting Avoid soils previously cropped with Solanaceous plants Foliar fungicides ineffective
Rosette (double-blossom disease) (Cercosphorella rubi)	Blackberries only Short, broom-like growth emerge from fungal infected canes Large, coarse flower buds; blossoms fail to form fruit	Cut all canes close to ground after harvest and burn them Hand pick and burn infected blossoms Apply fungicide during flowering period (Benomyl at 3/8 lb a.i. per 100 gallons H_2O every 2 weeks as needed, but not within 3 days of harvest.

Fungal Diseases (cont.)	Symptoms	Control
Leaf and canespot (*Septoria rubi*)	Leaves and canes with whitish centers and brown or purple borders (Common problem in southeastern U.S.)	Remove and burn infected canes Apply lime-sulfur fungicide at leaf budding (1 part a.i. to 10 parts H_2O) Apply Captan at flower budding (1 lb a.i. per 100 gallons H_2O) Apply Captan after petal fall (1 lb a.i. per 100 gallons H_2O) Thoroughly spray plants Fall spray (late September) with fixed copper (4 lbs a.i per 100 gallons H_2O) or with Bordeaux mixture (8-8-100) at 4 lbs a.i. per 100 gallons H_2O plus 1 qt of spreader sticker. Apply two additional fixed copper sprays (4 lbs a.i. and then 2 lbs a.i. plus 1 qt spreader per 100 gallons H_2O in March for severe outbreaks (4 lb a.i. per 100 gallons = 1.8 kg per 378 l)
Bacterial Diseases		
Crown gall (*Agrobacterium tumefaciens*)	Wart-like growth on roots and the crown just below soil level Wart-like growth on canes in black raspberries Fruit small, seedy, often crumbly	Plant gall-free stock in clean soil Dig up and burn diseased plants Do not hoe or cultivate to induce wounds near crown where bacteria enter Sterilize pruning shears with alcohol or formaldehyde dipping in fields where crown gall is suspected
Nematodes (*Pratylenchus* spp; root lesion) (*Xiphinema* spp; dagger) Several others	Spindly stands, small canes, yellow foliage, leaf drop in dry weather, reduced fruit size and yield Roots often have galls, rotted, or matted. Transmit virus and venticillium wilt	Plant nematode-free stock Plant in clean soil or inject fumigant in warm, moist, well cultivated soil [methyl bromide, Telone (dichloropropene) Vorlex (methyl-isothiocyanate), chloropicrin] Allow at least 1 month from fumigation to transplanting Apply Nemacur 3 at 6 to 12 lb a.i. per acre on established plantings.

Insect Control

A large number of insects attack raspberries and blackberries. A list of the most common insects associated with brambles along with suggested control measures are included in the following table. The minimum days from last application to harvest is: Malathion, Rotenone - 1 day; Methoxychlor - 3 days; Diazinon, Sevin - 7 days; Parathion - 15 days.

Raspberry and Blackberry Insects

Insect	Description	Control
Raspberry beetle or Raspberry fruit worm (Byturus sp.)	adult - 5 mm long; light brown to gray brown color; feeds on terminal growth and flower buds larvae - feed on fruit	Spray at pre-blossom stage Diazinon (1 qt of 4EC or 2 lb 50WP/acre) (highly toxic to bees) Rotenone (2 lb of 5WP/acre)
Weevils (Otiorhynchus)	adult - clay colored weevil: clay colored, brown, wingless; feeds on petioles, flower buds, canes; night feeder only adult - black root weevil: feeds on roots and crowns	Malathion (1.5 pt of 5EC per acre) or Guthion (azinphosmethyl) at 2 lb of 50WP/acre Apply to soil and crown area only; not to leaves Sevin (4 lb of 50WP/acre) on foliage when damage first appears
Raspberry moth (borer) (Lampronia sp.)	adult - shiny purple-brown wings marked with two conspicuous yellow spots and several smaller ones; feeds on lateral leaf buds near cane base, eats hole in pith of primocane larvae - feed on fruit receptacle	Diazinon, Guthion, Parathion; all at 1 lb a.i./acre in 100 gallons H_2O
Raspberry crown borer (Pennisetia sp.) *noticed frequently in Guatemala	adult - moths are clear winged with black and yellow bands on abdomen, resembling a wasp; feeds on bark, forms galls, and girdles the cane	Diazinon, Guthion, Parathion, all at 1 lb a.i./acre in 100 gallons H_2O, at cane base in October; burn wilted canes
Cane borer (Oberea sp.)	adult - slender black beetle with prominent antennae and two black dots on yellow midsection; burrows downward inside cane and girdles it causing cane tips to wilt. Also produces galls on lower part of cane with splits in bark	Sevin (carbaryl) 2 tbsp 80% WP/gallon H_2O. Do not spray when fruit is present Prune out infested canes a few inches below the girdle
Leaf rollers (Clenopseustis sp.)	larvae - pale to dark green in color; feeds on buds in winter and terminal growth in summer, producing a white	Guthion (1 pt of 2EC/acre or 1/2 lb of 50WP/acre), apply no later than 2 wks before bloom

Insect	Description	Control
	web causing leaves to stick together; also feeds on fruit	Sevin (4 lb of 50WP/acre), apply no later than 2 wks before bloom Malathion (7 lb of 25WP/acre) Diazinon (2 lb 50WP/acre) Dipel (Bacillus thuringiensis) during harvest Methoxychlor (50WP)
Cane maggot (Pegomya sp.)	adult - resembles a small house fly larvae - burrow into cane causing wilting, breaking off of cane	
Mites Phyllocoptes sp.)	larvae - invisible to naked eye; feeds on underside of leaves and flower buds, canes are stunted and fruit malformed	(Dicofol) Kelthane EC, 2 tbsp/gallon H_2O, or 0.7 lb a.i./acre in 100 gallons H_2O. May apply up to 2 days before harvest; or lime-sulfur as buds begin to swell in late winter.
(Tetranychus sp.)	adult - light tan or greenish in color with a dark spot on each side of its body; feeds on leaves, causing browning	Kelthane EC (3 pts. of 18.5% EC per acre or 2 lb of 35WP per acre); or lime-sulfur
Aphids (Amphorophora sp.)	adult - large, green, vectors of virus diseases; feeds on leaves	Malathion (1 tbsp of 57% EC/gallon H_2O. May apply up to 1 day before harvest. (3 pts of 5EC or 7 lb of 25WP/acre) Parathion (methomyl) apply at 0.5 lb a.i. in 100 gallons H_2O per acre. Diazinon - 1 lb a.i. in 100 gallons H_2O per acre Spray on foliage as needed
(Aphis sp.)	adult - small, sedentary aphid; feeds on undersurface of young leaves. Causes leaf curl, stunting of shoot tips which become a sticky mass of honeydew	

Insect	Description	Control
Leafhoppers (*Macropsis* sp.)	larvae - suck sap; feeds on flowerbuds, fruit and excretes honeydew on fruit	Malathion (7 lb of 25WP/acre) on foliage as needed
Sawfly (*Monophadnoides* sp.)	adult - black, four-winged fly with yellow and red markings. larvae - spiney pale-green; feeds between leaf veins, eating irregular holes out	

Pollination

Raspberries and blackberry flowers need to be pollinated by bees in order to set fruit. At lease 5 hives of honey bees per hectare are recommended. Bumble bees and wild bees may also be active, but research has shown that honeybees are responsible for 90% of berry pollination.

Many of the insecticides recommended are highly toxic to bees and should not be used during bloom. Sevin is deadly on bees. Methoxychlor may be used during bloom if it is applied in the early morning or late in the evening and malathion can be used if it is applied late in the evening when bees are not active. Lack of adequate fruit pollination may result in crumbly berries. None of the recommended fungicides for plant disease control are toxic to bees.

Raspberry fruits usually ripen 30 to 36 days after pollination and blackberry fruits 40 to 70, depending on variety and temperature.

Harvesting practices

The harvesting season for blackberries and raspberries ranges from 4 to 8 weeks, depending on variety and environmental conditions. Harvesting in North America begins in June and goes through early August for summer-bearing types. Varieties that fruit on first year canes ('Heritage') are ripe in late August through October.

The number of hand pickers needed will vary with the yield, weather, and skill of the workers. About 15 pickers are needed per hectare for the first and last pickings, but the peak crop will require 30-50 good workers per hectare.

It is essential to harvest the fruit every other day for export market sales. Longer intervals between harvest will produce overmature fruit with poor holding quality.

Raspberries and blackberries should be picked early in the morning when it is cool. This also circumvents worker fatigue. The fruit should be picked very gently. Avoid bruising or squeezing of the berries. (Pickers should be instructed to remove berries with a light grasp of the thumb and two fingers, using a turning motion rather than a pull or jerk. They should not squeeze the berries or hold too many in the hand before transfer to the packing containers.) Pick only when the fruit are dry. Severe mold will develop on wet berries. The fruit should be picked in its final saleable half-pint container, rather than going through an extra grading and handling step. However, the field container the half-pints are put in will be exchanged for a new fiberboard 12 half-pint export flat. It will be essential to maintain careful guidance over the pickers so quality standards are not compromised.

Only firm-mature or slightly immature fruit should be picked. Do not put overripe, underripe, diseased, or insect damaged fruit in the containers. The berries should be put in a cool shady location during the very brief timespan between harvest and cooling.

Postharvest Handling

Within 2 to 3 hours after harvest the field heat must be removed from the fruit. This should be accomplished by using forced-air cooling. The 12 half-pint shipping flats should be stacked in a coldroom (0-1°C) about 10 high in two single rows with a walkway in between rows. There should be no space between stacks. A fan should be placed at the front of the walkway in-between both stacks. Canvas or fabric should then be draped over the top and back of the walkway creating a tunnel. The tops of the stacks should be exposed to the cooling air. When the fan is started it

will pull air through the sides of the berry stack, removing the heat from the fruit. The fan exhausts the air from the hollow airspace between stacks creating a slightly negative air pressure. Cold air from the room then moves through the ventilation openings in or between containers toward the area of negative pressure. Usually 7-6% of the side panel surface area of the container stack must be open for ventilation to ensure adequate cooling. Speed of cooling is regulated by adjusting the rate of air volume movement. Rapid cooling can be accomplished with adequate refrigeration and a large volume of air flow per unit of berries. The exhaust fan can be a portable unit directing the warm exhaust air toward the air return of the cold room, or it can be a permanent unit which circulates the air over the cooling surface before returning it to the cold room. In order to remove 7/8 of the fruits heat within 2 hr, you must use a fan that can provide 1.4 cfm/lb product at 0.2 inches static pressure. Therefore, for 1 ton of fruit it will be necessary to use a fan capable of providing 2800 cfm at 0.2 inches water guage static pressure.

This is based on a California style strawberry flat to contain the fruit. As a rule of thumb, a 1/5 HP motor (150W) will provide between 400-600 cfm. The high velocity air flow will not increase water loss from the fruit if it occurs only during the cooling period. The high air velocity must be reduced after the berries reach 0°-1°C or else dessication will occur.

Sufficient refrigeration cooling capacity must also be provided. The amount of heat generated (in BTU's) from each of the following sources must be added to estimate the refrigeration load required:

1) field heat (temperature of the berries)

2) heat of respiration

3) container and pallet heat

4) heat leakage (open door, poor insulation)

5) utility heat (fork lifts, workers, lights, fans)

The BTU's of heat generated from field heat is determined by the formula: lb. berries x 0.95 x °F temperature difference (between at harvest pulp T° and desired storage T°).

The BTU's of heat generated from removing the field heat of 2000 lb. of fruit at an 80°F (27°C) pulp temperature down to 32°F (0°C) storage temperature will be: 2000 lb x .95 x 48°F = 91,200. To cool the fruit in 2 hours will require a refrigeration load capable of removing 91,200 BTU/2 hr (45,600 BTU/hr). By definition, 1 ton of refrigeration absorbs 12,000 BTU of heat/hr. Therefore, it will require 3.8 tons of refrigeration to cool the berries in 2 hr. (45,600 BTU/hr ÷ 12,000 BTU/ton/hr). This will be the primary source of heat, but we generally should add another 33% to the total refrigeration capacity to account for heat removal from sources #2-#5 listed above. Therefore, it will require a minimum of 5 tons of refrigeration capacity to remove the berry field heat from 2000 lb of product. Additional refrigeration capacity will be required with more product to be cooled or if the room will also be used for temporary product storage in addition to field heat removal. Always plan for enough refrigeration capacity to meet peak volume cooling needs.

The berries must be refrigerated at 0° to 1°C, 90% to 95% relative humidity, before transit to the airport. They must be transported to the airport at 0° to 1°C in refrigerated trucks and loaded onto refrigerated cargo containers. Moisture condensation on the berries will occur if the truck or airplane cargo container are not held at 0° to 1°C. This will result in potentially severe mold growth and a rejected load upon arrival in the U.S.

Raspberries and blackberries are extremely perishable and must be air shipped to the U.S. the same day or no later than 1 day after harvest. They should be packaged in attractive strong containers with the product temperature requirement clearly indicated for the wholesale receiver and retail produce manager to see.

Raspberries and blackberries have a maximum shelf-life of 3 to 4 days at 0°C. Blackberry fruit is more tender and generally has one less day of shelf-life than raspberry fruit.

Shelf-life can be enhanced by proper usage of individual half-pint plastic overwraps. This retards shriveling and offers some protection against bruising and mishandling. However, do not completely wrap the half-pint (only the top third or half) because it would interfere with removal of field heat and tend to promote decay if the fruit wasn't totally dry. This plastic overwrapping step can be done immediately after harvest or right after cooling.

Marketing

Raspberries (and perhaps blackberries) from Guatemala and Costa Rica can be placed on the U.S. market in prime condition if they are properly handled. Market demand will probably be greater in northern U.S. cities due to more consumer familiarity. Less emphasis should be given to developing markets in southern U.S. cities, at least initially. Consumer test marketing surveys should be conducted to determine the most favorable export location.

High quality product and reliable supply are essential ingredients to the establishment of a successful berry export industry. Only the very best quality product should be exported. Never compromise on grade standards and quality. A one-time sale of inferior quality product will more

than negate the many previous good offerings, and will lose markets and buyers fast. The berries must be packaged in clean, sturdy, attractive half-pints and master containers (12 half-pint flats).

The expected wholesale market price of raspberries and blackberries upon arrival in U.S. markets during the winter season (November through April) should average around $10 per 12 half-pint flat.

Summary

Raspberries and blackberries are two of the highest valued fruits grown in the world. There is a great potential to export these fruits for high prices in the U.S. from November through April. Since little is known about their culture in Central America, considerable variety evaluation and cultural development work needs to be done before their potential will be realized. The varieties selected for export production must have firm fruit and resistance to fruit rots. Emphasis should be strongly placed on developing the proper cultural methods for fall-bearing types (i.e. 'Heritage') where first year cane production occurs 3 to 4 months after transplanting. This is followed by another crop several months later on the old canes pruned back to 1 meter, or a new crop from newly emerging shoots 3 to 4 months after emergence. It should be possible to manipulate the harvesting season with 'Heritage' by altering the time of planting, N fertilization, and elevation of growth (i.e. summer temperature). Research needs to be conducted using different times of transplanting, different types of propagative material (root pieces, transplants) and at different elevations to fully characterize the timing sequence from planting to fruiting.

A major problem for growing summer bearing raspberries in Central America (i.e. 'Mecker') may be the lack of sufficient cold to break winter

dormancy. This may result in delayed and incomplete bud break. The canes frequently have too few fruiting laterals because their bud dormancy is not lost by the time temperatures rise in the spring. The problem of inadequate chilling may be overcome by using one or more of the following approaches: 1) use varieties with low chilling requirements; 2) plant in areas with different microenvironments; and 3) induce fruit bud break by chemical treatments. A low chilling requiring selection of 'Malling Exploit' looked promising in Mexico. The choice of cultivar is especially critical in Central America. 'Lloyd George' has a low chilling requirement and was the leading cultivar grown in Chile in the 1970's. Israeli researchers have successfully substituted chemicals for chilling. Canes were sprayed with 2 or 4% hydrogen cyanamide just before the expected time of bud-burst and fruiting lateral development was stimulated. However, cyanamide can be toxic if applied too late or to sensitive varieties.

First year fruiting varieties like 'Heritage' can be grown in Central America and produce an acceptable first year yield, irrespective of the winter climate. If 'Heritage' or either varieties cannot be grown as a perennial due to inadequate chilling, it still may be possible to have a viable raspberry industry by annual transplanting 'Heritage' sets and using close plant spacings (i.e. 30 cm apart?). This would reduce growing costs because there would be no need for pruning and a reduced wire support training system could be used. Another strong possibility is that 'Heritage' will not need chilling since fruiting occurs on the tips of first year canes. Experiments need to be undertaken to determine if their is a gradual yield loss over the years with 'Heritage' (i.e. will the original planting slowly lose vigor?). Accurate record keeping is essential.

Lack of sufficient rainfall during the dry season will necessitate use of supplemental drip irrigation.

Frost protection during January and February for the tender flowers of 'Heritage' may be needed at elevations around 7000 feet. Another scenario is to accept low yields during these months and time the pruning so fruit production will be from November through December and from late February through April. Also, there are some microenvironments at 7000 feet that do not receive freezing temperatures.

Special emphasis must be put on rapid cooling of the berries immediately after harvest. This must be coupled with an expeditious transport of refrigerated product to the airport for exportation to the U.S. within 1 day after harvest. The cooling facilities and transportation infrastructure must be in place prior to harvest. Much development needs to be done in this area before berry production in large volume will be a commercial reality.

The key to export market success for the Central American berry industry is to be able to provide a consistent supply of high quality fruit over an extended marketing period.