Summer Squash

VEGETABLE CROPS PRODUCTION GUIDE FOR NOVA SCOTIA

Updated by:
Dr. Viliam Zvalo, Consultant (Horticulture)
Alana Respondek, Consultant (Horticulture)

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1.0 INTRODUCTION

Summer squash (*Cucurbita pepo*) is a member of the Cucurbitaceae or gourd family. It originated in the Americas and was cultivated by the ancient civilizations of Central and South America over 7000 years ago. Summer squash is the edible fruit of any species of *Cucurbita* that is used as an immature vegetable, before the seeds and rind harden.

Summer squash can be divided into the following groups:

1. Zucchini and Cocozelle: green and yellow types are available
2. Straightneck types: yellow bottle shaped with straight necks
3. Crookneck types: yellow bottle shaped with a curved neck
4. Scallop types: flatted and ridged around edge, may be white, green or stripped in colour

Summer squash is a warm season crop that is both cold weather and frost sensitive. The minimum temperature for seed germination is 15ºC, with a maximum of 38ºC and an optimum range of 21 to 32ºC. Best crop growth occurs at 18 to 25ºC, with a minimum of 10ºC and a maximum of 32ºC. Temperatures of 0^0C for more than an hour can kill plants. Plastic tunnels, row covers and/or plastic ground mulches benefit summer squash.

Well drained sandy loams, supplied with high amounts of organic matter are optimal for early production.

The harvesting window varies for each type and cultivar of squash. Generally summer squash can be harvested from the end of June to early October, providing there is no early frost. By using plastic mulch and row covers the season can be extended. Refer to section 3.1 Season Extension for more information. In Nova Scotia, summer squash is grown for the fresh market.

2.0 CROP ESTABLISHMENT

2.1 SEEDING/PLANTING

Summer squash can be direct seeded or grown from transplants. Regardless of the method used to establish plants, do not plant until the soil temperature is at least 15ºC. For direct seeding, some types of vegetable seeders and transplanters can be adapted to accommodate the size of squash seed. The seeding rate depends on the seed size, whether it is running or bush type and on the actual spacing.

Transplants and seed spacing requirements are different for each type of squash plant. For standard sized plants, place rows 1.5 – 2m apart and plants 60-90 cm apart. For semi-bush type plants, place rows 1.2-1.5 m apart and plants 45-90 cm apart. For small bush type plants, place rows 0.9 – 1.2 m apart and plants 45-90 cm apart. In all cases, seeds should be planted 2.5 – 3.75 cm deep. In Nova Scotia, the practice of using plastic mulch, to grow squash is becoming common. When using this method, double rows of plants can be placed on one row of plastic. The spacings between the double rows vary, but generally a 120-180 cm centre row to centre spacing is used.

About three to four weeks are required to produce squash transplants, so start in early May. Plants may be grown in plastic plant cells or peat pots/blocks/pellets. Slight hardening is beneficial, but severe hardening may stunt growth. Hardening is the process whereby, one week before planting, transplants are gradually acclimatized to the outdoor environment. When placing transplants into the ground, the roots must not be disturbed or slow establishment will result. Do not place transplants outside until the danger of frost is low and soil temperature is over 16ºC.

To ensure continuous supplies of high quality product through out the summer, begin staggered plantings of 10 to 14 days from the end of May until mid July.

3.0 CROP MANAGEMENT

3.1 SEASON EXTENSION

For direct seeded or transplanted summer squash, black or clear plastic mulch, floating row covers, and tunnel houses can be used effectively to extend the growing season in the spring and the fall. Economics dictate what is feasible for each type of cultivar for specific markets.

Black plastic mulch controls weeds, increases soil temperature, conserves moisture and protects fruits from ground rots. Clear plastic mulch is good at transferring heat to the soil, but does not control weeds. It is best to apply plastic mulch to the soil with the aid of a machine that can effectively place mulch close to the soil.

Floating row covers can be used for four to eight weeks after seeding or placing transplants to increase the heat accumulated by the plant. It is imperative that the cover be removed as the plants begin to flower, to allow for pollination.

Tunnel houses are temporary structures placed over the crop to increase heat and protect from wind and rain.

3.2 POLLINATION

For the most part, summer squash plants are monoecious (separate male and female flowers on the same plant), but a few parthenocarpic (does not require fertilization) cultivars exist in the market place. Male flowers appear first, produce pollen and drop off. Fruit is only formed on female flowers and bees are needed to transfer pollen from male flowers to female flowers. Unpollinated female flowers result in poorly shaped fruit as well as excessive blossom drop. One to three colonies of honey bees per hectare is suggested. Locate the hive close to the edge of the field. Bees must visit squash flowers several times to get successful pollination. This may be difficult because cucurbit flowers are only open for one day and squash flowers are usually only open in the morning. It is best to place hives 3-5 days after the first blossoms appear, when 10-15% of plants have blossoms. This will create a more attractive field for the bees to stay and forage at. Most insecticides will poison bees so take precautions and spray when bees are least active (late afternoon and evening).

3.3 IRRIGATION

Squash is a relatively deeply rooted crop and can tolerate dry conditions, however the critical moisture requirement periods are between fruit set and harvest. If moisture is not available at these times, poor fruit set and poor fruit development will result. Apply 25-35mm of water per week during flowering and fruit development. Overhead and drip irrigation systems are used in summer squash production.

3.4 SOIL FERTILITY

Recommendations for supplemental organic matter, fertilizer, lime and manure should be based on a soil test and a Nutrient management plan. In Nova Scotia, soil tests are preformed by the provincial agriculture labs in Truro. To find out more about how to take a soil test, where to send the sample and fees for the tests, visit www.gov.ns.ca/agri or phone (902) 893-4683. Nutrient management plans balance the crop requirements and nutrient availability, with the aim to optimize crop yield and minimize ground water contamination, while improving soil productivity.

Manure

Summer squash responds well to applications of manure. The best is to use composted manure.

Lime

Lime should be applied to maintain the soil pH between 6.0 and 7.0.

Nitrogen
Up to 90kg/ha of actual nitrogen is required for summer squash. If manure is applied or a legume sod is plowed down, than a reduction in additional nitrogen is required. Two thirds of nitrogen can be broadcasted before planting and worked into the soil. Apply the remaining nitrogen as a side dress, just before the vines begin to run. A second sidedress may be needed on sandy soils. Nitrogen deficiency symptoms include yellowing of older leaves, slow growth and stunted plants.

Phosphorous
A soil test will determine the level of phosphorous requirements. Banded fertilizer would be effective in reducing the needed phosphorous. Use plant starter (with high phosphorus) on transplants for early crops. Phosphorous is important for root development. Deficiency symptoms include dull, emerald green young leaves, delayed maturity, stunted growth and poor fruit set.

Potassium
A soil test will determine potassium requirements. The requirement for this nutrient is not high especially if good quality manure is applied. Do not band potash (if possible) but broadcast and harrow it into the soil preplant. If potash is banded do not apply more than 100 kg of N plus potash per hectare. Deficiency symptoms include tip and marginal burn on older leaves and slow growth.

Magnesium
If soil magnesium levels are low, a fertilizer containing magnesium may be used. Foliar sprays may also be used.

Deficiency is fairly common especially on light acid soils where dolomitic limestone has not been applied. To avoid these problems, apply dolomitic limestone or add magnesium to the fertilizer. If the problem occurs during the season, spray the foliage with Epsom salts (magnesium sulfate). Deficiency symptoms include yellowing between older leaf veins and leaves curling upwards along the margins.

Sulfur
On sandy soils low in organic matter that has been intensively cropped, soil sulphate levels may be low. Application of gypsum should be considered on these soils. Deficiency symptoms include yellowing of young leaves and small weak plants.

Micronutrients

Boron
Boron deficiency causes distorted young leaves and cracks in petioles and fruit. Boron should never be banded, however it can be foliar applied.

Manganese
Deficiencies may occur on sandy, over limed soils. Manganese deficiency causes yellowing between veins of young leaves. Leaves gradually turn pale-green with darker green next to the veins, petioles and stems. Foliar sprays of manganese sulfate may be necessary to correct a deficiency.

3.5 CROP ROTATION
There are many benefits to crop rotation including the suppression of diseases, insects and weeds. In addition, crop rotation improves soil fertility because it is allowed to replenish naturally and soil structure improves because of the alternating between deep rooted and fibrous rooted crops.

Crops within a family tend to be susceptible to the same pests, therefore rotation of non susceptible crops (or groups) for several years allow all plant material to decompose and pest cycles to become broken. Without the presence of susceptible plant material, the number of disease and insect organisms will begin to diminish.

Crop rotation aids in weed control because the growth habit of each crop differs, which causes a decrease in a weeds ability to compete for space. Also, tillage practices and timing are different for dissimilar crops resulting in a decrease in the weeds ability to permanently establish. Another benefit of crop rotation for weed management purposes is with certain crops, there is a better chance at controlling different weeds. For example, in a broadleaf crop, grass control will be easier because of the use of grass killing herbicides and visa versa.

To create a crop rotation schedule, there are several things to be considered including types of vegetables grown, size of root system, size of planting rows, amount of fertility required for the crop and how much organic matter is left in the soil by the crop. Start designing the crop rotation by making a list of all vegetables to be grown and group them together by botanical relationship (e.g. *brassicaceae, solanaceae, alliaceae*). Each year, change the location of the entire group within the field. This way, the same crop group will not be planted on the same piece of land two years in a row. Secondly consider the size of the root system of the crop to be grown. Deep rooted plants will help to break up the soil, while shallow rooted crops will not. Thirdly, consider the size of the plant rows. Wide rows will allow for more weed seeds to germinate, but on the other hand, tillage equipment may be able to go through them with more ease than in narrow rows. The fourth consideration should be given to whether or not the crop to be planted is a heavy feeder. A heavy feeder will deplete the soil of nutrients quicker than a non heavy feeder. The final consideration for a crop rotation is whether or not the crop will leave a lot of organic matter in the soil. Leaving organic matter behind is beneficial for replenishing the soil of nutrients lost to the crop while it was growing.

A long rotation of more than five years is better than a short rotation of two years. Also, ask yourself the following questions when putting together a rotation: Is the rotation profitable? Are the yields sustainable? Does it make use of nitrogen produced by an earlier crop? Are herbicide residues left?

Due to disease and insect pressures (refer to the pest management section of this guide) it is best to plant summer squash once every three years. This crop has imtermediately deep roots that will aid in improving soil structure and aeration. Summer squash has large seeds that do not require a finely manicured seed bed, therefore previous crop residues would be tolerated, however too much debris will delay the soil from heating up in the spring.

4.0 PESTS AND PEST MANAGEMENT

Effective management of any pest requires the use of multiple pest control techniques. Integrated Pest management (IPM) is a system that integrates Managerial, Cultural, Physical, Biological and Chemical control techniques to manage pests. A key to IPM is understanding what pests are in your crop, through scouting and adjusting production practices to discourage pests from becoming problems. IPM is a proactive approach to pest management, rather than just a reaction to pests as they occur. For more information on IPM techniques, refer to the AgraPoint Guide to Pest Management.

4.1 WEEDS

Successful weed control in summer squash is possible by integrating chemical, physical and cultural techniques. This crop should be planted to land free of perennial weeds, where the annual weed seed population has been reduced through previous cropping and tillage prior to planting. Recommended herbicides may not provide control for the entire season, therefore

cultivation may be necessary. Avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur.

Weeds can be controlled in summer squash by planting seed or transplants in black plastic mulch. A stale seedbed technique may be used for direct seeding or transplants.

4.2 DISEASES

Bacterial Wilt
This disease is caused by the bacteria *Erwinia tracheiphila* and is vectored by the stripped cucumber beetle. Symptoms first appear on leaves as dull green patches that quickly increase in size. The leaf lobe wilts, followed by the rest of the leaf, the branch and entire plant. The wilting is a result of the vascular system being clogged by a lot of bacteria. The pathogen overwinters in the gut of the adult stripped cucumber beetle and is transmitted to the plant when the insect feeds on plant tissue. If beetle populations are high, the severity of this disease is greatly increased.

Control:
Once bacteria have entered the vascular system of the plant, control of this disease is impossible. Prevention lies in controlling populations of the cucumber beetle. Be sure to remove wild or volunteer cucurbit plants from nearby areas, and choose varieties that flower later in the season. See the section on stripped cucumber beetles for control options.

Alternaria and Septoria Leaf Spot
Alternaria fungus causes small circular spots which enlarge to 1 to 2 cm in diameter with dark concentric rings within the spots. Spots may coalesce to affect larger areas of the leaf. Black sunken lesions may occur on the fruit. *Septoria* fungus causes numerous small leaf lesions with white centers which may lead to defoliation. It also causes raised, pimple-like lesions on fruit. These fungi will overwinter in soil for one season and possibly 2 years.

Control:
Treat seed and rotate with non-cucurbit crops for at least two years. If using chemicals, scout plants frequently and apply appropriate fungicides at first sign of the leaf spots and at 7 to 10 day intervals. Refer to the AgraPoint Guide to Pest Management for a listing of fungicides and their application methods.

Powdery Mildew
Powdery mildew (*Erysiphe cichoracearum*) causes a white powdery growth on the lower and upper surfaces of leaves. As the diseases advances, leaves turn yellow, brown, wither and die. Fruit may be malformed, sunburned and ripen prematurely resulting in poor flavour and texture, and an overall decrease in size and quality. Powdery mildew is favored by temperatures of 20^0C – 26^0C and humid, wet weather.

Control:
Many resistant varieties exist and should be used whenever possible. Good weed control and sanitary practices will help to control this disease. Avoid over head watering and remove and destroy vines at the end of each season. If using chemicals, scout plants frequently and apply appropriate fungicides at first sign of disease and at 7 to 10 day intervals. July and August is usually the most critical control period. Refer to the AgraPoint Guide to Pest Management for a listing of fungicides and their application methods.

Cucumber Mosaic Virus
Cucumber mosaic virus (CMV) will infect plants at any stage of growth. If seedlings are infected, the cotyledons wilt, turn yellow and generally the plants are stunted. Younger leaves develop a dark green, yellow mottled and wrinkled look. On older leaves, 1-2 mm greenish-yellow

translucent lesions form. The leaf edges curl downwards and the leaf surface becomes wrinkled and mottled with yellow and green colouring. Eventually older leaves die. Once infection occurs, few fruit develop, however, if they do, a green-yellow mottling will occur on the stem and entire fruit surface, along with green warts. CMV is transmitted by aphids and cucumber beetles. It also survives in plant sap and can be transmitted by pruning knives or pickers hands.

Control:
Eliminate all weed hosts and avoid planting two consecutive summer squash crops. Scout regularly to monitor for the presence of aphids. Refer to the AgraPoint Guide to Pest Management for a list of insecticides and their application methods. Farm workers should follow good hygiene practices to decrease the chance of spreading the disease. Use varieties that have tolerance or resistance to this disease.

Fruit Rots in Storage
A number of diseases attack summer squash in storage. *Didymella* Black rot*, Alternaria alternata, Rhizopus* Soft rot*, Botrytis, Fusarium, Penicillium* and *Cladosporium* Scab all may occur as fruit rots in storage. Rots can originate from actual fruit infection in the field or from a dusting of fungus spores that later infect the fruits in storage.

Control:
Involves the season long practices of seed treatment, good field drainage, rotation, insect control, fungicide sprays, harvest care and especially post harvest storage temperature and humidity control.

4.3 INSECTS

Seedcorn Maggots
Seedcorn maggots (*Delia platura*) are small yellowish-white maggots 6 mm long with a pointed anterior end (head). The adult is a small, 5 mm grayish-brown fly. Maggots feed on seed and roots, causing poor plant growth. Seedcorn maggots attack deeply planted seeds. Maggots are usually a problem in direct seeded crops during cool, wet springs when germination is delayed.

Control:
Plant as shallow as needed in a well prepared seedbed. Early germination is necessary to get good plant stands and prevent injury. Later planted crops are not as susceptible to this pest. Good weather conditions are necessary to completely control the pest. Avoid planting susceptible crops in fields very recently manured. Chemical seed treatment is essential. Refer to the AgraPoint Guide to Pest Management for a listing of insecticides and their application methods.

Stripped Cucumber Beetle
The adult stripped cucumber beetle (*Acalymma vittatum*) is 5 mm long with a black head, yellow thorax and three longitudinal black stripes on yellow forewings. This insect overwinters in the adult stage under leaves or dense grass, emerging in May or early June. Two weeks after emerging the beetles mate while feeding on plant tissues and flowers. The orange-yellow eggs are laid in the soil at the base of host plants and hatch within 10 days. Upon hatching, the larvae burrow into the soil, feed on the roots of the plant for about a month, and then pupate in the soil. In July, the next generation of adults emerges and they feed on the rind of squash fruit until frost forces them to seek shelter. In Nova Scotia, there are two generations per year.

This insect is a vector for two problematic summer squash diseases; bacterial wilt and cucumber mosaic virus. These two diseases are transmitted to the plant while the insect feeds.

Control:

Cultural control methods include using varieties that are less attractive to beetles and rotating crops to distant fields to delay infestations. Sanitation is very important. Do not leave cucurbit debris in fields over winter, plow debris under after harvest. Another method to reduce the chance of over-wintering adults is to plant a cover crop. Blue Hubbard squash can be used as a trap crop. Be sure to plant the trap crop completely around the cash crop for best protection. Spray the trap crop on a cool morning after attracting the beetles. Finally, try avoiding peak beetle infestations by planting later in the growing season, or using transplants that may be more tolerant of feeding activity.

Physical control methods include using floating row covers can be used to protect young plants, but it must be removed when flowers first appear. Another method of control includes using yellow sticky cards or tape to trap the adult beetles. Replace them regularly as they become covered with insects and debris.

Biological control involves using natural enemies such as soldier beetles, tachinid flies, brachonid wasps and bats, but they may not be effective in substantially reducing beetle damage.

If using chemical controls, scout plants frequently and apply an insecticide when the threshold has been reached. It is best to scout for this insect in the early morning or evening, and be sure to examine the foliage and soil-stem areas. Apply a spray when beetles exceed 0.5-1 per plant. Refer to the AgraPoint Guide to Pest Management for a list of insecticides and their application methods.

Flea Beetle

Flea beetles (*Phyllotreta* spp.) are small shiny black beetles about 2 mm in length. The adults have hind legs well developed for jumping, and they are very active early in the growing season, especially during periods of dry sunny weather. Adults seriously damage seedlings and transplants, and to a lesser extent larger plants, by chewing small pinholes through the leaves. Adults overwinter in the soil and emerge early in the spring to feed on young plants. Eggs are laid on or near the roots where white larvae feed. Mature larvae pupate in the soil near the host plant. Depending on species, there are one or two generations a year.

Control:

Heavy damage can occur quickly, usually under hot humid weather conditions, just after crop emergence from the soil. Apply insecticides only if insect populations are high. Refer to the AgraPoint Guide to Pest Management for a list of insecticides and their application methods.

Aphids

Aphids (*Aphis gossypii*) may cause serious damage to summer squash and certain species can transmit viral diseases to this crop. Aphid feeding may cause leaves to become distorted, and honeydew, excreted by the insect, may serve as a growing point for mold.

Control:

Use reflective mulches and plant later crops away from existing fields. Natural enemies can be used to control aphid populations, but if the weather is very hot, natural enemies will not be enough to control rapidly increasing aphid populations. Eliminate all virus host plants, mainly perennial broadleaf weeds. If using chemicals, scout plants frequently and apply a spray when insects are first noticed. Refer to the AgraPoint Guide to Pest Management for a list of insecticides and their application methods.

Squash Bug

Squash bug (*Anasa tristis*) is a periodic pest of summer squash. The adult is 1-2 cm long and dark to grey brown in colour. The tops of their bodies are flattened with wings not completely covering the orange and brown edges of the abdomen. It prefers sheltered areas, under vines

and fruit, and overwinters as an adult to emerge in mid summer. Squash bugs suck sap from the pant, while at the same time inject a toxin into the plant when it feeds. The toxin can cause wilting of young plants and dried, black areas on older plants.

Control:
Remove all plant debris, or disk in immediately after harvesting the crop. It is also possible to trap the adults. At night, adults will gather under a board placed on the ground near squash plants. In the morning, gather and destroy the insects.

If using chemical control, scout plants frequently and spray when there is a more than one egg mass per plant before or after flowering. Refer to the AgraPoint Guide to Pest Management for a listing of insecticides and their control methods.

4.4 PHYSIOLOGICAL DISORDERS

Oedema
This is a physiological disorder that affects cucurbits during fruit enlarging when moisture availability is uneven. The stress causes raised, circular shaped lesions that are corky or crusty on the fruit surface. These lesions may be irregularly spaced or just on the side exposed to sunlight.

5.0 HARVESTING AND HANDLING

The entire fruit of summer squash is edible, either cooked or raw, with the exception of the stem. In Nova Scotia, the harvest period ranges from the end of June to early October. The best quality summer squash fruit comes from plantings harvested for only two – three weeks. Generally, harvesting commences 2-6 days after the blossoms fall off, when fruit are shiny, young, tender and sweet. Size of marketable summer squash varies by type. Crookneck and straightneck varieties should be 4-5 cm in diameter, zucchini 17.5 -20 cm long and 4-5 cm in diameter and scallop types should be 7.5-10 cm in diameter. Some markets may call for smaller sizes and usually 2.5-5 cm of stem is required to remain attached to the fruit. To keep a high quality product, be sure to avoid cuts and bruises to fruit as young skin is easily damaged. Fruit should be hand harvest with the aid of a sharp knife, rather than pulling and twisting fruit away from the plant, every 1 to 3 days. If the seed coat has hardened and the external shiny colour of the fruit has turned dull, the fruit is unmarketable. Do not allow defective or large fruit to remain on the plant as this reduces additional fruit set and thus marketable yields.

5.1 STORAGE AND CONDITIONING
Summer squash are soft skinned and highly perishable, and dehydration and water loss are very common after the fruit is harvested. To reduce water loss, the fruit must be rapidly cooled after being removed from the plant, and can also be treated with approved waxes or oils. The optimum storage conditions are a temperature between 5-10^{0}C and 95% relative humidity for no more than 10 days. Storage below 5^{0}C for 3-4 days results in chilling injury. Shriveling, yellowing and decay are likely to increase following storage beyond two weeks, especially when fruit is returned to retail conditions. This fruit has low to moderate sensitivities to ethylene, and has shown little benefit to controlled atmosphere storage or shipping.

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