

Crop Profile for Arugula in New Jersey

Eruca sativa Miller Capparales: Brassicaceae

Diplotaxis tenuifolia (L.) DC. Capparales: Brassicaceae



General Production Information

Yearly production: Approximately 200 acres.

% of crop for fresh market: 100%

% of crop grown for baby arugula market: 25%

% of crop grown for wholesale market: 60%

Production Regions

The majority of arugula production occurs in the southern New Jersey counties of Atlantic (50 acres), Cumberland (80 acres) and Gloucester (60 acres). Soils in southern New Jersey are light, ranging from sand to sandy loam with some areas of silt loam. Arugula production in the southern region extends from early spring to the first hard frost in late autumn. In this region, arugula is predominantly for sale at auction, with plants generally pulled, washed and bundled in quarter pound bunches with the roots on. Wholesale units are 24 count (bunch) crates. Some arugula in this region is produced for the retail market and sold at farm stands or directly to restaurants. In this case, arugula is generally sold by the bunch. In Gloucester County, approximately 50 acres of arugula production is for the “baby” market. In this production, arugula is grown and harvested before reaching the 4-inch leaf stage. Baby arugula is used exclusively in salad mixes or bagged and sold as baby arugula leaves. Baby arugula may be wholesaled or sold directly to restaurants.

In the northern counties of Hunterdon, Mercer, Morris, Warren, and Sussex, many growers produce arugula, but on minimal acreage. Soils in the northern region of New Jersey are typically Piedmont (heavy silt loams) and Appalachian (shaley) soils. There is typically a spring

and fall crop in the northern region. Here, arugula is grown exclusively for retail at farm stands and at community sponsored farmers markets. Typical growers in this region produce a quarter acre of arugula. Production is similar to that in the southern region, with plants sold as bare root, quarter pound bunches. Total acreage in the northern regions is approximately 10 acres.

Cultural Practices

Arugula is native to the Mediterranean basin, where wild plants were harvested for centuries prior to the advent of its cultivation. Arugula has become increasingly popular in the United States over the past 10-20 years, particularly in the more affluent coastal regions.

Arugula can be grown and harvested for baby leaves (as a salad green alone, or to be mixed with other salad greens), or when closer to maturity. In the latter case it is sold bunched and is cooked rather than eaten raw. Arugula is a very quick crop, with some varieties able to be harvested for baby arugula in as few as 18 days after seeding. Typical maturity ranges from 30-50 days.

Arugula types grown in New Jersey include the strap leafed varieties (*Eruca vesicaria* subsp. *sativa*) and the “wild type” varieties (*Diplotaxis tenuifolia* and *Eruca visicaria*). ‘Astro’, ‘Astro II’, and Johnny’s ‘Arugula’ are common varieties representing the strap leafed varieties grown in NJ. ‘Surrey’ (*E. vesicaria*) and ‘Selvetica’ (*D. tenuifolia*) are varieties grown in NJ where a more deeply lobed, wild type leaf is desirable.

Arugula for bunched sale is direct seeded into 3-4 row bare-ground beds. Baby arugula is sown in 22 rows on a 45 inch bed. Irrigation is typically overhead from solid set sprinklers, although a few growers put trickle tape over the beds. Many growers plant only in the spring and fall, with 2-3 plantings per season per year. In the southern counties, where wholesale arugula production is more common and soils are lighter, arugula is grown from spring through the fall, with new plantings established at 7-10 day intervals. Fertility may involve a broadcast application of a balanced fertilizer prior to bed formation followed by 1-2 sidedress or topdress applications of N in the form of urea or CaNO₃. Some growers apply fertilizer only as side- or topdress applications, while others rely on the initial broadcast application.

Bunched arugula is typically hand-pulled when leaves are approximately 10-12 inches, while baby arugula is harvested at a maximum of 4 inches. In the latter case, harvest is conducted with a band-saw harvester similar to that used in spinach production. If the market demand for baby arugula is strong, a second cut may be conducted, although quality typically declines after the first harvest. Retail prices for arugula range from \$1.50–\$4.50 per quarter pound bunch, or \$7.00–\$12.00 per 24 ct. crate. Wholesale prices range from \$5.00–\$7.00 per 24 ct. crate. Baby arugula wholesale price ranges from \$9.00–\$10.00 for a 4-pound box.

Insect Pests of Arugula in New Jersey

Although several lepidopterous insects—as well as whiteflies—feed on arugula, in New Jersey, growers indicate that flea beetles are the only serious insect pests of arugula. Aphids are an occasional, minor problem on arugula grown for bunched sale.

Flea Beetles

Crucifer Flea Beetle (*Phyllotreta cruciferae* (Goeze))

Striped Flea Beetle (*P. striolata* (Fabricius))

Occurrence: Annual, frequent. Adults emerge from overwintering sites in late April and May and immediately begin feeding and mating. Two overlapping generations occur during the summer, allowing for the presence of adults at all times during the growing season. In October and November, adults seek overwintering sites in brushy areas near host crops.

Damage: Both species of flea beetle are attracted to plants in the brassica family and feed heavily on the foliage. Feeding on leaves results in marginal necrosis or holes, when feeding is within the leaf margins. Feeding holes made on young, unexpanded leaves tend to enlarge as leaves expand. As leaves are the marketable portion, flea beetle injury reduces the quality of the crop, and when extreme, can kill small plants. No level of feeding is considered acceptable due to significant decrease in marketability.

Alternative management strategies used in combination with chemical control:

Crop rotation is helpful where possible. Avoid planting in areas that have had brassica crops within the past 2-3 years. Avoid successive plantings of brassica crops in the same fields. Separate the plantings as much as possible. Mechanical barriers such as Reemay® or other row covers may help exclude flea beetles, but care must be taken to seal all edges of the cover to prevent entry into the crop.

Chemical Control:

Soil Applied Materials

Imidacloprid (Admire Pro)

Percent acres treated: 30%

Active ingredient used (lbs.): 16.1

Rate and Frequency: 4.4-10.5 fl oz./A of Admire Pro at planting.

Method: Banded spray over row, at- or prior to planting.

REI: 12 hr.

PHI: 21 days.

Efficacy: Good

Notes: 10.5 fl. oz./A/crop is maximum allowable. This material also effectively controls aphids. Due to application method, there is little potential for worker exposure to this material. The dermal LD-50 is extremely high (>5000), making it quite safe for handlers as well. Imidacloprid is toxic to bees, but due to application method, exposure is unlikely.

Foliar Applied Materials

Azadirachtin (Aza-Direct)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 1-2 pt. of Aza-Direct/A

Method: 2-3 foliar sprays at 7-10 day intervals when beetles are present and damage is occurring.

REI: 4 hr.

PHI: 0 days.

Efficacy: Fair to poor.

Notes: 3.5 pt./A/crop is maximum allowable. This product also has fair to good efficacy against aphids. High dermal LD-50 (>2000) makes the product quite safe for workers, but growers indicate that it is not used. Azadirachtin is not toxic to bees.

Beta-cyfluthrin (Baythroid XL)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 0.8-3.2 fl. oz. of Baythroid XL/A

Method: Foliar sprays when beetles are present and damage is occurring.

REI: 12 hr.

PHI: 0 days.

Efficacy: Good.

Notes: 12.8 fl. oz./A/crop is maximum allowable. 3.2 fl. oz./A/crop in 7-day interval is maximum allowable. High dermal LD-50 (>5000) makes the product quite safe for workers. This material is toxic to bees, but because the crop is harvested in the vegetative state, exposure is unlikely. Worker exposure is a possibility due to the 0-day PHI. Growers indicate that it is not widely used.

Permethrin (Ambush 25W, Pounce 25W)

Percent acres treated: 35%

Active ingredient used (lbs.): 10.5

Rate and Frequency: 6.4-12.8 oz. of Ambush or Pounce 25W/A

Method: Foliar sprays when beetles are present and damage is occurring.

REI: 12 hr.

PHI: 1 day.

Efficacy: Good.

Notes: 2 lbs. AI/A/crop is maximum allowable. Permethrin will also temporarily control aphids. The dermal LD-50 is high (>4000). This material is toxic to bees, but because the crop is harvested in the vegetative state, exposure is unlikely. Short PHI makes the product attractive to some growers. Worker exposure during harvest is unlikely when PHI is observed.

Peppermint, Rosemary Oils (Ecotrol EC)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 1-3 pt. of Ecotrol EC/A in a minimum of 25 gal. of total solution.

Method: Foliar sprays when beetles are present and damage is occurring.

REI: 0 hr.

PHI: 0 days.

Efficacy: Fair.

Notes: This material also is labeled for aphid control. This material is not toxic to vertebrates, and not known to be toxic to bees. Growers indicate that this material is not used.

Pyrethrin + PBO (Evergreen EC 60-6)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 2-16 fl. oz. of Evergreen EC 60-6/A.

Method: Foliar sprays when beetles are present and damage is occurring.

REI: 12 hr.

PHI: 0 days.

Efficacy: Fair.

Notes: Evergreen is labeled for aphid control as well as flea beetles. This material has a reasonably high dermal LD-50 (>1800), and is moderately toxic to bees. Growers indicate that it is not used.

Zeta-cypermethrin (Mustang)

Percent acres treated: 30%

Active ingredient used (lbs.): 2.4

Rate and Frequency: 2.4-4.3 fl. oz. of Mustang /A.

Method: Foliar sprays when beetles are present and damage is occurring.

REI: 12 hr.

PHI: 1 day.

Efficacy: Good.

Notes: Mustang is also labeled for aphid control. 25.8 fl. oz. /A/crop is the maximum allowable. This material has a dermal LD-50 of >2000, and is highly toxic to bees but because the crop is harvested in the vegetative state, exposure is unlikely. Short PHI makes the product attractive to some growers. Worker exposure during harvest is unlikely when PHI is observed.

Imidacloprid (Provado)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 3.8 fl oz. of Provado /A.

Method: Foliar spray when beetles are present and damage is occurring.

REI: 12 hr.

PHI: 7 days.

Efficacy: Good

Notes: For Provado, 19 fl. oz. /A/crop is the maximum allowable. A 5-day minimum spray interval must be observed for resistance management. This material is also labeled for aphid control. The high dermal LD50 (>5000) makes the material quite safe, although it is toxic to bees. However, because the crop is harvested in the vegetative state, bee exposure is unlikely. Growers indicate that this material is not used due to the long PHI and the short duration of the crop.

Kaolin (Surround)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 12.5-25 lbs. of Surround /A.

Method: Foliar spray when beetle injury is anticipated.

REI: 4 hr.

PHI: 0 days.

Efficacy: Fair

Notes: This material is a feeding deterrent and provides some flea beetle suppression. Kaolin is not known to be toxic to bees or vertebrates. Dermal LD50 data is not available. Growers indicate that it is not used.

Thiamethoxam (Actara)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 1.5-3 oz. of Actara /A.

Method: Foliar spray when beetle injury is detected.

REI: 12 hr.

PHI: 7 days.

Efficacy: Fair

Notes: This material must not be used again within 7 days of the previous application. Avoid more than 3 successive applications of IRAC (Insecticide Resistance Action Committee) Group 4A (neonicotinoid) insecticides. A maximum of 11 oz./A/season is allowable. A minimum of 10 gal. of water should be used for the application. Grower surveys indicate that this material is not used. A 7-day PHI may be prohibitive on a short duration crop like arugula. The dermal LD50 is high (>2000) and the material is toxic to bees, but because the crop is harvested in the vegetative state, exposure is unlikely.

Aphids

Green peach aphid (*Myzus persicae* (Sulzer))

Potato aphid (*Macrosiphum euphorbiae* (Thomas))

Cabbage aphid (*Brevicoryne brassicae* (Linnaeus))

Occurrence: Annual, sporadic. Aphids are a potential problem at any time during the arugula growing season, but due to the short duration of individual crops, they are infrequently encountered.

Damage: Aphids extract plant sap from tissue and can weaken plants and cause discoloration. In arugula, the greatest potential threat from aphids is that they serve as a contaminant when they are present on leaves at harvest. This threat is mitigated to varying extents with washing of the plants or leaves prior to sale.

Alternative management strategies used in combination with chemical control:

Separation of fields is helpful to limit easy access from recently harvested areas to new plantings. Some growers will opt to harvest arugula grown for bunched sale earlier if aphids begin to appear in the planting.

Chemical Control:

Soil Applied

Imidacloprid (Admire Pro)

Percent acres treated: 30%

Active ingredient used (lbs.): 16.1

Rate and Frequency: 4.4-10.5 fl oz./A of Admire Pro at planting.

Method: Banded spray over row, at- or prior to planting.

REI: 12 hr.

PHI: 21 days.

Efficacy: Good

Notes: 10.5 fl. oz./A/crop is maximum allowable. This material also effectively controls flea beetles. Due to application method, there is little potential for worker exposure to this material.

The dermal LD-50 is extremely high (>5000), making it quite safe for handlers as well.

Imidacloprid is toxic to bees, but due to application method, exposure is unlikely.

Foliar Applied

Azadirachtin (Aza-Direct)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 1-2 pt. of Aza-Direct/A

Method: 2-3 foliar sprays at 7-10 day intervals when aphids are present.

REI: 4 hr.

PHI: 0 days.

Efficacy: Fair to good.

Notes: 3.5 pt./A/crop is maximum allowable. This product also has fair to poor efficacy against flea beetles. High dermal LD-50 (>2000) makes the product quite safe for workers, but growers indicate that it is not used. Azadirachtin is not toxic to bees.

Flonicamid (Beleaf)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 2-2.8 oz. of Beleaf 50SG/A

Method: Foliar sprays when aphids are present.

REI: 12 hr.

PHI: 0 days.

Efficacy: Good.

Notes: 8.4 oz Beleaf 50 SG or 0.267 lb. AI/A/crop is maximum allowable. This material should be applied in a minimum of 10 gallons of water/A. This product causes specific feeding cessation in aphids and several other insects with sucking mouthparts. It is not toxic to bees. Worker exposure is a possibility due to the 0-day PHI although a high dermal LD-50 (>2000) for similar products (no data available for Beleaf 50SG) makes the product quite safe for workers. Surveys indicate that it is not widely used, although the product is new to the market and may be unfamiliar to growers.

Permethrin (Ambush 25W, Pounce 25W)

Percent acres treated: 35%

Active ingredient used (lbs.): 10.5

Rate and Frequency: 6.4-12.8 oz. of Ambush or Pounce 25W/A

Method: Foliar sprays when aphids are present.

REI: 12 hr.

PHI: 1 day.

Efficacy: Fair.

Notes: 2 lbs. AI/A/crop is maximum allowable. Permethrin will also control flea beetle. The dermal LD-50 is high (>4000). This material is toxic to bees, but because the crop is harvested in the vegetative state, exposure is unlikely. Short PHI makes the product attractive to some growers. Worker exposure during harvest is unlikely when PHI is observed.

Peppermint, Rosemary Oils (Ecotrol EC)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 1-3 pt. of Ecotrol EC/A in a minimum of 25 gal. of total solution.

Method: Foliar sprays when aphids are present.

REI: 0 hr.

PHI: 0 days.

Efficacy: Fair.

Notes: This material also is labeled for flea beetle control. This material is not toxic to vertebrates, and not known to be toxic to bees. Growers indicate that this material is not used.

Pyrethrin + PBO (Evergreen EC 60-6)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 2-16 fl. oz. of Evergreen EC 60-6/A.

Method: Foliar sprays when aphids are present.

REI: 12 hr.

PHI: 0 days.

Efficacy: Fair.

Notes: Evergreen is also labeled for flea beetle control. This material has a reasonably high dermal LD-50 (>1800), and is moderately toxic to bees. Growers indicate that it is not used.

Zeta-cypermethrin (Mustang)

Percent acres treated: 30%

Active ingredient used (lbs.): 2.4

Rate and Frequency: 2.4-4.3 fl. oz. of Mustang /A.

Method: Foliar sprays when aphids are present.

REI: 12 hr.

PHI: 1 day.

Efficacy: Good.

Notes: Mustang is also labeled for flea beetle control. 25.8 fl. oz. /A/crop is the maximum allowable. This material has a dermal LD-50 of >2000, and is highly toxic to bees but because

the crop is harvested in the vegetative state, exposure is unlikely. Short PHI makes the product attractive to some growers. Worker exposure during harvest is unlikely when PHI is observed.

Imidacloprid (Provado)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 3.8 fl oz. of Provado /A.

Method: Foliar spray when aphids are present.

REI: 12 hr.

PHI: 7 days.

Efficacy: Good

Notes: 19 fl. oz. /A/crop is the maximum allowable. A 5-day minimum spray interval must be observed for resistance management. This material is also labeled for flea beetle control. The dermal LD-50 is high (>5000) and the material is toxic to bees, but because the crop is harvested in the vegetative state, exposure is unlikely. Growers indicate that this material is not used due to the long PHI and the short duration of the crop.

Acetamiprid (Assail)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 0.8-1.7 oz. of Assail /A.

Method: Foliar spray when aphids are present.

REI: 12 hr.

PHI: 7 days.

Efficacy: Good

Notes: .375 lbs./A/crop is maximum allowable. There is a 5 application maximum /A/crop and applications must be not less than 7 days apart for resistance management. This material will also control flea beetle. The dermal LD-50 is >2000, and this product is moderately toxic to bees, but because the crop is harvested in the vegetative state, exposure is unlikely. Growers indicate that this material is not used, likely due to the long PHI.

Pymetrozine (Fulfill)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 2.75 oz. of Fulfill /A.

Method: Foliar spray when aphids are present.

REI: 12 hr.

PHI: 7 days.

Efficacy: Good

Notes: 5.5 oz./A/crop is maximum allowable. Applications must not be less than 7 days apart for resistance management. Fulfill causes paralysis of the esophageal muscle in sucking insects like aphids, and has minimal impact on non-target and beneficial insects. The dermal LD-50 is >2000, and this product is not toxic to bees. Growers indicate that this product is not used likely due to the long PHI.

Malathion (Cythion 8)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 1-2 pt. of Cythion 8/A.

Method: Foliar spray when aphids are present.

REI: 12 hr.

PHI: 7 days.

Efficacy: Good

Notes: Malathion, an organophosphate (OP) insecticide, has a dermal LD-50 of >2000 and is highly toxic to bees but because the crop is harvested in the vegetative state, exposure is unlikely. Growers indicate that this material is not used, likely due to the long PHI.

Dinotefuran (Venom)

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 1-3 oz. of Venom/A.

Method: Foliar spray when aphids are present.

REI: 12 hr.

PHI: 7 days.

Efficacy: Good

Notes: For Venom, 6 oz./A/crop is maximum allowable. Three applications are the maximum allowable. This product has a dermal LD-50 of >5000, and is highly toxic to bees, but because the crop is harvested in the vegetative state, exposure is unlikely. Growers indicate that this material is not used, likely due to the long PHI.

Notes on insecticides and nematicides:

Generally, pesticides available for insect and nematode control in arugula are covered by broader labels for either brassica or non-brassica leafy greens. As a result, there are a number of insecticides that are labeled for arugula but not used either due to the target pest not affecting arugula, or that pest not affecting arugula in New Jersey. This group of insecticides/nematicides includes:

<u>Compound</u>	<u>Trade Name</u>	<u>Target Pest(s)</u>
Bacillus thuringiensis st. azawai	(Agree)	Lepidopteran larvae
Bacillus thuringiensis st. kurstaki	(Crymax, Dipel)	Lepidopteran larvae
Abamectin	(Agri-Mek)	Mites, leafminer
Tebufenozide	(Confirm 2F)	Lepidopteran larvae
Spinosad	(Entrust, Spintor)	Lepidopteran larvae, thrips leafminer
Methoxyfenozide	(Intrepid 2F)	Lepidopteran larvae
Thiodicarb	(Larvin 3.2)	Lepidopteran larvae
Indoxacarb	(Avaunt)	Lepidopteran larvae
Spinetoram	(Radiant)	Lepidopteran larvae
Spiromesifen	(Oberon)	Mites, whitefly
Emamectin benzoate	(Proclaim)	Lepidopteran larvae, leafminer
Cryomazine	(Triguard)	Leafminer
1-3 dichloropropene + chlorpicrin	(Telone)	Nematodes
Myrothecium verrucaria	(Ditera)	Nematodes

Diseases of Arugula in New Jersey

New Jersey arugula growers cite only three major disease problems on the crop: downy mildew, bacterial leaf spot, and damping-off. Downy mildew and bacterial leaf spot are the most common diseases, while damping-off occurs infrequently.

Fungicide Resistance Management:

Fungicides are the primary tool for controlling diseases like downy mildew and damping-off in arugula. Some diseases have shown the ability to develop resistance to certain fungicidal compounds, and some fungicides have been demonstrated to elicit resistance in fungal plant pathogens. As a result, the Fungicide Resistance Action Committee (FRAC) has rated fungicidal compounds as to their likelihood for causing resistance in specific pathogens if not used judiciously. This information can help growers determine how best to manage specific disease organisms while delaying the onset of fungicide resistance.

The fungicides are organized into various classes called FRAC codes (see Table 1), based on chemistry. Members of a FRAC code are often analogs built from the same basic chemical structure. They generally have a similar mode-of-action, control similar types of fungi, and share the same risk for resistance development. Overuse or misuse of some classes of fungicides, such as the QoIs (FRAC code 11), DMIs (FRAC code 3), phenylamides (FRAC code 4), and benzimidazoles (FRAC code 1) may result in the development of resistant populations of fungi. Fungicides in FRAC codes such as these are referred to as “high-risk” fungicides. Therefore, do not apply fungicides in these FRAC codes exclusively in a disease control program. Fungicides considered high-risk should be tank-mixed or rotated with fungicides from other FRAC codes. Protectant fungicides (FRAC group M1, M3, M5), should be tank-mixed with at-risk fungicides whenever possible to delay the development of resistant strains of fungi. Do not use high-risk fungicides as rescue treatments for disease control. The FRAC table for arugula (Table 1, below) shows the relative likelihood of available fungicides resulting in resistant populations of arugula disease organisms if used improperly.

Table 1. FRAC table for fungicides labeled on arugula in New Jersey

Fungicide	Active	Arugula					Fungicide Resistance Management Guidelines*
		FRAC CODE	Risk Management	Pythium damping-off	Downy Mildew	Bacterial Leaf Spot/Blight	
Ridomil Gold EC	mefenoxam	4	H	x			Low risk for resistance in Pythium control
Apron XL	mefenoxam	4	H		x		
Cabrio	pyraclastrobin	11	H		x		High risk. Rotate with other FRAC codes
Quadris, Heritage	azoxystrobin	11	H		x		
Alette	aluminum tris	33	L		x		Low risk for resistance development. Rotate with high-risk fungicides
Fosphite, Fungi-phite, Prophyte, Topaz	potassium phosphite	33	L		x		
Phostrol	phosphorous acid	33	L		x		
Oxidate	hydrogen dioxide	NC	L		x	x	disinfectant only
Sporan	clove, rosemary, thyme oil	NC	L		x		low risk, see labels for specifics
Trilogy	neem oil	NC	L		x		
Rhapsody, Serenade	<i>Bacillus subtilis</i>	bio	L		x		biological, see label

*Fungicide resistance management guidelines for arugula grown in mid-Atlantic region - 2008

FRAC code: M = multi-site MOA, numbered codes = chemistries with similar mode-of-action, specific site (MOA)
 Risk management: L = low risk, M = moderate risk or H = high risk for fungicide resistance to develop, NC = not classified
 High-risk fungicides with similar MOA (ie. same FRAC code number) should not be sprayed consecutively

Damping-Off caused by *Pythium* spp.

Occurrence: Annual, sporadic. Favored by damp soil.

Damage: Damping-off results in poor stands as the fungal pathogen attacks and kills seedlings after germination either pre or post-emergence. In general, conditions that promote quick seedling emergence help limit the incidence of damping-off. Mature plants are less susceptible to damping-off.

Alternative management strategies used in combination with chemical control:

Crop rotation with less-susceptible crops such as corn is helpful. Improvement of soil drainage with cultivation, allowing water to run off the field, and eliminating or avoiding low spots will help mitigate losses from damping-off.

Chemical Control:

Mefenoxam (Ridomil Gold 4EC) FRAC code 4

Percent acres treated: 2%

Active ingredient used (lbs.): 1 lb.

Rate and Frequency: 1-2 pts. of Ridomil 4EC/treated A. as a soil application with water or liquid fertilizer and incorporated into the top 2 inches of soil.

Method: Pre-plant incorporated.

REI: 0 hr. when material is incorporated into soil.

PHI: N/A

Efficacy: Good

Note: This product is not to be used at any other time on a planting if it has been used as a pre-plant incorporated treatment.

Downy Mildew (*Peronospora parasitica* (Pers. ex. Fr.) Fr.)

Occurrence: Annual, sporadic. Favored by cool, damp weather.

Damage: Downy mildew (DM) of crucifers is a fungal pathogen that infects foliage, resulting in necrotic spots on the upper leaf surface while producing cottony white growth on the lower surface. The spots coalesce over time to result in considerable foliar necrosis. Affected leaves are unmarketable. The presence of undetected downy mildew in harvested arugula leaves can result in poor quality produce, as the infection progresses on harvested tissue held in cool, moist conditions, as with refrigeration.

Alternative management strategies used in combination with chemical control:

Avoiding a succession of brassica plantings in close proximity to one another helps minimize spread, as the fungus requires brassica host tissue to survive and produce spores. Crop rotation and complete incorporation of previous brassica crop debris are important, as brassica debris can serve as a source of inoculum. Earlier harvest of arugula limits exposure of leaves to the

pathogen in the field. Additionally, immature tissue tends to be somewhat less susceptible to infection than mature, fully expanded foliage.

Chemical control:

Fosetyl-AI (Aliette) FRAC code. 33

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 2-5 lbs. of Aliette/A. at 7-21 day interval as conditions warrant.

Method: Foliar spray when DM is expected.

REI: 12 hr.

PHI: 3 day.

Efficacy: Good.

Note: 7 applications per crop per season is maximum allowable. Growers indicate that this product is not used, most likely due to the availability of other effective products.

Azoxystrobin (Quadris, Heritage) FRAC code 11

Percent acres treated: 35%

Active ingredient used (lbs.): 12.25

Rate and Frequency: 4-5 oz. of Quadris or 3.2-8 oz. of Heritage/A at 7-14 day interval.

Method: Foliar spray when aphids are present.

REI: 12 hr.

PHI: 0 day.

Efficacy: Good

Note: 1.5 lb. of active ingredient per crop per season is maximum allowable. Fungicides in FRAC code. 11 should not be applied more than twice in sequence in order to delay the development of resistance. There is potential for worker exposure due to the 0-day PHI, although there would be little value in applying the material within 1-2 days of harvest. Azoxystrobin has little risk to workers, with a dermal LD-50 of >5000.

Mefenoxam (Apron XL Seed Treatment) FRAC code 4

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: .085-.64 oz. of Apron XL/100lbs. of seed.

Method: Seed treatment.

REI: 0 hr. when seed is incorporated into soil.

PHI: N/A

Efficacy: Good

Note: Growers indicate that this product is not used.

Pyraclostrobin (Cabrio) FRAC code 11

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Rate and Frequency: 12-16 oz. of Cabrio /A at 7-14 day intervals.

Method: Foliar spray.

REI: 12 hr.

PHI: 0 days.

Efficacy: Good

Note: Four applications and 64 oz./crop/A are maximum allowable. There is potential for worker exposure due to the 0-day PHI, although there would be little value in applying the material within 1-2 days of harvest. Pyraclostrobin has little risk to workers, with a dermal LD-50 of >4000.

Growers indicate that this product is not used.

Potassium phosphite (Fosphite, Fungi-phite, Prophyt, Topaz) FRAC code 33

Percent acres treated: 30%

Active ingredient used (lbs.): 95

Rate and Frequency: 1-2 qt. of potassium phosphite/A at 14-21 day intervals.

Method: Foliar spray.

REI: 4 hr.

PHI: 0 days.

Efficacy: Good

Note: There is some potential for worker exposure to this material due to the 0-day PHI. The dermal LD-50 is >5000, thus the product is quite safe for workers.

Phosphorous acid (Phostrol) FRAC code 33

Percent acres treated: 30%

Active ingredient used (lbs.): 192

Rate and Frequency: 2.5-5 pt. of Phostrol in 10-50 gal. of water/A at 7-21 day intervals.

Method: Foliar spray.

REI: 4 hr.

PHI: 0 days.

Efficacy: Good

Note: 7 applications /crop/A is maximum allowable. There is some potential for worker exposure to this material due to the 0-day PHI. The dermal LD-50 is >5000, thus the product is quite safe for workers.

Hydrogen dioxide (Oxidate) Not classified as to FRAC code.

Percent acres treated: 65%

Active ingredient used: 35 gal.

Rate and Frequency: 1 gal./100 gal. water of Oxidate/A at 5-7 day intervals.

Method: Foliar spray.

REI: when dry.

PHI: 0 days.

Efficacy: Fair

Note: There is some potential for worker exposure to this material due to the 0-day PHI. The dermal LD-50 is >1410 at a 10% soln. Use rate is 1%, and the main risk is that the material is corrosive to skin and eyes at high concentrations. Overall, the product is quite safe for workers, particularly once it has dried on foliage. Hydrogen dioxide is toxic to bees when in contact with spray solution. This material is a surface disinfectant and has no residual activity. Hydrogen dioxide is also labeled for management of bacterial pathogens.

Bacillus subtilis st. 173 (Rhapsody, Serenade) Not classified as to FRAC code.

Percent acres treated: 0%
Active ingredient used (lbs.): 0
Rate and Frequency: 3-6 qt./100 gal. water of Rhapsody or 1-3 lb/A of Serenade/A at 7-10 day intervals.
Method: Foliar spray.
REI: 4 hr.
PHI: 0 days.
Efficacy: Fair.
Note: There is some potential for worker exposure to this material due to the 0-day PHI. This material is not known to have mammalian toxicity. This material is a biological control agent. Growers indicate that this material is not used.

***Bacillus pumilis* st. 2808 (Sonata)** Not classified as to FRAC code.

Percent acres treated: 0%
Active ingredient used (lbs.): 0
Rate and Frequency: 2-4 qt. of Sonata/A at 7-14 day intervals.
Method: Foliar spray.
REI: 4 hr.
PHI: 0 days.
Efficacy: Fair.
Note: There is some potential for worker exposure to this material due to the 0-day PHI. This material is not known to have mammalian toxicity. This material is a biological control agent. Growers indicate that this material is not used.

Clove, Rosemary, Thyme oil (Sporan) Not classified as to FRAC code.

Percent acres treated: 0%
Active ingredient used (lbs.): 0
Rate and Frequency: 1-3 pt. of Sporan/A as conditions warrant.
Method: Foliar spray.
REI: 0 hr.
PHI: 0 days.
Efficacy: Fair.
Note: There is some potential for worker exposure to this material due to the 0-day PHI. This material is not known to have mammalian toxicity. Growers indicate that this material is not used.

Neem oil (Trilogy) Not classified as to FRAC code.

Percent acres treated: 0%
Active ingredient used (lbs.): 0
Rate and Frequency: 0.5-1% soln. of Trilogy in 25-100 gal. water /A at 7-14 day intervals.
Method: Foliar spray.
REI: 4 hr.
PHI: None indicated on label.
Efficacy: Fair.

Note: 2 gal. of Trilogy per application is maximum allowable. There is some potential for worker exposure to this material due to the 0-day PHI. This material is not known to have mammalian toxicity. Growers indicate that this material is not used.

**Bacterial Leaf Spot or Bacterial Blight (probable causal organism
(*Pseudomonas syringae* pv. *alisalensis*))**

Occurrence: Annual, sporadic. Favored by moderate, damp weather.

Damage: Bacterial leaf spot of arugula is a pathogen that infects foliage, resulting in necrotic spots on the both leaf surfaces. Lesions begin as angular water soaked spots, and mature to a tan color often with a purple margin. The spots remain angular as they mature. No sporangia are produced as with the fungal pathogen, downy mildew. Affected leaves are unmarketable. Bacterial leaf spot or blight is favored by moderate temperatures (75-80F) and moist conditions.

Alternative management strategies used in combination with chemical control:

Avoiding a succession of brassica plantings in close proximity to one another helps minimize subsequent infections, as the bacteria may persist for several months on undecomposed host debris. Crop rotation and complete incorporation of previous brassica crop debris are important. Earlier harvest of arugula limits exposure of leaves to the pathogen in the field.

Chemical control:

Hydrogen dioxide (Oxidate) Not classified as to FRAC code.

Percent acres treated: 65%

Active ingredient used: 35 gal.

Rate and Frequency: 1 gal./100 gal. water of Oxidate/A at 5-7 day intervals.

Method: Foliar spray.

REI: when dry.

PHI: 0 days.

Efficacy: Fair

Note: There is some potential for worker exposure to this material due to the 0-day PHI. The dermal LD-50 is >1410 at a 10% soln. Use rate is 1%, and the main risk is that the material is corrosive to skin and eyes at high concentrations. Overall, the product is quite safe for workers, particularly once it has dried on foliage. Hydrogen dioxide is toxic to bees when in contact with spray solution. This material is a surface disinfectant, and has no residual activity. Hydrogen dioxide is also labeled for management of fungal pathogens.

Nematode Pests of Arugula in New Jersey

Although nematodes are capable of causing injury to arugula, and two nematicides are labeled for use on arugula in New Jersey, grower surveys indicate that no controls are applied for these pests.

Major Weed Pests of Arugula in New Jersey

Annual Grasses:

Barnyardgrass (*Echinochloa crus-galli*)

Barnyardgrass is a summer annual grass that may grow to 4' tall, with an upright habit and a seed head that may be green, or reddish in color. Barnyardgrass reproduces by seed that germinates from spring through summer, and can spread by tillering. It does very well in warm irrigated soils.

Crabgrass (*Digitaria* spp.)

Crabgrass species are summer annual grasses with prostrate or ascending growth habits. Seeds germinate when soil temperatures exceed 55°F for 7-10 consecutive days, and soil is adequately moist. Reproduction is by seed or rooted tillers.

Fall Panicum (*Panicum dichotomiflorum*)

Fall panicum is a summer annual grass that can reach a height of 6-7' and is characterized by a stem that develops a zig-zag pattern due to bending at the nodes. Reproduction is by seeds, which overwinters. The seeds are borne on an open panicle and germinate throughout the summer.

Foxtail (*Setaria* spp.)

Foxtail species are clump forming annual grasses that have a prostrate to erect growth habit. Reproduction is by seeds, which germinate in the late spring and summer when soil temperatures are warm. All species are characterized by a bushy, "foxtail like" seed head.

Winter Annual Grasses:

Annual Bluegrass (*Poa annua*)

Annual bluegrass is a clump-forming light green grass that may grow to a height of 5-6". It reproduces by seed that germinates in the late summer and fall as soil temperatures begin to fall. Seeds may be produced as quickly as 8 weeks on new plants. Plants grow quickly in the spring as the soil warms, but may not thrive in the hot summer months.

Broadleaf Annuals:

Common lambsquarters (*Chenopodium album*)

Common lambsquarters is a summer annual growing to 3.5 ft. with light green, triangular leaves. Flowers are produced from July to Sept. and reproduction is by seed. Seed overwinters and germinates in disturbed soil the following spring.

Common purslane (*Portulaca oleracea*)

Common purslane is a prostrate succulent summer annual plant that spreads out from a central rooted stem. Stems may be up to 12" long with oval, fleshy, stalkless leaves. Reproduction is by seed, and sometimes vegetatively as broken stems re-root with adequately moist soil. Flowering occurs from mid-summer through fall. Seeds germinate the following spring, although they may persist in the soil for many years. This is probably the most important weed pest in arugula production.

Jimsonweed (*Datura stramonium*)

Jimsonweed is a summer annual growing to 5 ft. with broad, coarsely serrated leaves, white or purple trumpet shaped flowers, and oval, plum-sized seed pods covered with spines. Reproduction is by seed. Seeds germinate the following spring when soil temperatures are sufficiently warm. The entire plant is toxic to humans and animals.

Galinsoga (*Galinsoga ciliate*)

Galinsoga is a summer annual growing to around 2 ft. with opposite, oval, toothed leaves and small yellow and white rayed flowers. Stems and leaves are hairy. Flowers are produced from June through autumn. Reproduction is by seed, which germinate during the current season, or the following spring.

Common cocklebur (*Xanthium strumarium*)

Common cocklebur is a summer annual that grows to 3 ft. with rough, heart-shaped, toothed leaves. Reproduction is by seed. Flowers are produced late summer through fall, and seeds are contained within bristly burs. One seed per bur germinates the following season, while others are dormant until the second year.

Ragweed (*Ambrosia spp.*)

Common and giant ragweed are summer annuals that may grow to 3 ft. and 15 ft. respectively. Leaves are deeply lanceolate. Reproduction is by seed. Flowers are produced from August through autumn, and seeds germinate the following spring and may remain viable for 5 years.

Pigweed (*Amaranthus spp.*)

The pigweeds are summer annuals growing to 4 ft., and are inhabitants of disturbed soils. Leaves are oval and somewhat rough. Inconspicuous flowers are produced from mid-summer through autumn. Reproduction is by seed. Thousands of seeds are produced by a single plant, and germinate the following spring.

Morning glory (*Ipomoea spp.*)

Morning glories are summer annuals having a vine-like growth habit. They become entangled in crop plants and can become difficult to control. Reproduction is by seed. Seeds are produced during the summer months and germinate in the spring.

Velvetleaf (*Abutilon theophrasti*)

Velvetleaf is a summer annual growing to 3-8 ft. Plants have large heart-shaped leaves and are completely covered with soft, fine hairs. Reproduction is by seed, and flowers are produced from July through October. Seeds germinate continuously through the season, as warm conditions permit.

Winter Annual Broadleaves:**Shepherd's Purse (*Capsella bursa-pastoris*)**

Shepherd's purse is a winter annual that grows as a rosette of leaves and produces a flower stalk that may grow to 24". Seed capsules are heart-shaped or triangular in shape. Reproduction is by seed. Seeds germinate in late summer and early fall. Plants remain dormant through the winter. Growth resumes in the spring and seeds are produced prior to summer, when plants die.

Perennial weeds:**Yellow nutsedge (*Cyperus esculentus*)**

Yellow nutsedge is a perennial that grows from tubers (nutlets) and rhizomes and may reach a height of 2 ft. Stems are triangular in cross-section, and leaves are yellowish-green in color. Yellow nutsedge tolerates moist conditions and is capable of forming dense stands. New plants may emerge through some types of black plastic mulch.

Quackgrass (*Elytrigia repens*)

Quackgrass is a rhizomatous perennial grass having an upright growth habit and may grow to 4 ft. Reproduction is by seed rhizome. Stems grow from nodes on the rhizomes, and may produce seed heads. Rhizomes may fork, expanding the patch.

Weed Controls Used in New Jersey Arugula Production

Occurrence: Annual, frequent (depending on field conditions, weed and crop history).

Damage: Competition from weeds for nutrients, water, and sunlight can result in yield reduction and poor quality crop. Additionally, weeds can block foliar pesticide treatments, and when dense, increase canopy moisture. Both are factors in decreased insect and disease control. Some weeds are alternate hosts for pests of arugula. Excessive weed growth increases harvest time as workers seek less weedy areas or try to sort weeds from harvestable arugula leaves. When mechanically harvested (as with baby arugula), weeds may also serve as a contaminant because they may be cut along with the crop.

Timing of control measures: Pre-plant, pre-emergence, post-emergence, post-harvest.

Cultural controls: Crop rotation, hand weeding, cultivation, early harvest.

Post-harvest control measures: Non-selective herbicide for destruction of weeds and crop residue, cut-harrowing to destroy crop and weeds.

Alternative management strategies used in combination with chemical control: Hand weeding and mechanical cultivation are common practices in New Jersey arugula production. Surveys indicate that smaller acreage growers often do not use herbicide on this crop.

Chemical Control:

Pre-plant, pre-emergence weed control (fallow or stale seed bed application):

A number of materials are labeled in arugula production in New Jersey that may be used to eliminate weeds from arugula beds prior to seeding. For this use, beds are prepared well in advance of seeding and weeds are allowed to germinate. Once weeds develop, a “burn-down” application of one of the following non-selective herbicides is made:

Carfentrazone-ethyl (Aim EC)

Target weeds: non-selective (foliar desiccant).

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Average rate and frequency of application: up to 2 fl. oz. of Aim EC /A one time.

Method of application: Pre-plant spray to soil surface where weeds have emerged.

REI: 12 hours.

PHI: Pre-plant application only.

Efficacy: Good for actively growing weeds up to 4 inches.

Glyphosate (Roundup and other generic forms)

Target weeds: non-selective (systemic).

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Average rate and frequency of application: 16-32 fl. oz. of Roundup Original in 3-10 gal. of water/A one time.

Method of application: Pre-plant spray to soil surface where weeds have emerged.

REI: 12 hours.

PHI: Pre-plant application only.

Efficacy: Good for annual weeds, particularly when small.

Paraquat dichloride (Gramoxone Inteon)

Target weeds: non-selective (foliar desiccant).

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Average rate and frequency of application: 2-4 pt. of Gramoxone Inteon /A one time.

Method of application: Pre-plant spray to soil surface where weeds have emerged.

REI: 12 hours.

PHI: Pre-plant application only.

Efficacy: Good for annual weeds, particularly when small.

Pelargonic acid (Scythe)

Target weeds: non-selective (foliar desiccant).

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Average rate and frequency of application: 75-200 gal of 3-5% solution of Scythe in water /A one time.

Method of application: Pre-plant spray to soil surface where weeds have emerged.

REI: 12 hours.

PHI: Pre-plant application only.

Efficacy: Good for desiccation of actively growing succulent tissue.

Pyraflufen-ethyl (ET Herbicide)

Target weeds: non-selective (foliar desiccant).

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Average rate and frequency of application: 0.5-2.0 fl. oz. of ET Herbicide in a minimum of 10 gal. of water/A one time.

Method of application: Pre-plant spray to soil surface where weeds have emerged.

REI: 12 hours.

PHI: Pre-plant application only.

Efficacy: Good for some broadleaf weeds under 4 inches tall. Must be mixed with other herbicide(s) for control some broadleaves and grasses.

Post-seeding, pre-emergence (crop) application:

Bensulide (Prefar 4E)

Target weeds: Annual grasses and some broadleaf weeds.

Percent acres treated: 30%

Active ingredient used (lbs.): 348

Average rate and frequency of application: 5-6 qt. of Prefar 4E/A one time.

Method of application: Pre-plant incorporated 1-2 inches deep before planting OR apply pre-emergence and overhead irrigate with ½ inch of water within 36 hrs.

REI: 12 hours.

PHI: Pre-emergence application only.

Efficacy: Good for annual grasses. Fair on lambsquarters, pigweed and shepherd's purse. No control of other broadleaves (including purslane) or sedges.

Note: Available as 24c in NJ, EPA SLN #NJ-070001. The higher rate is recommended for broadleaf weed suppression. Worker exposure is unlikely as it is applied to soil at or prior to seeding. Bensulide is an organophosphate (OP) pesticide, and is highly toxic to bees, although contact is unlikely due to method of application.

DCPA (Dacthal Flowable)

Target weeds: Annual grasses and some broadleaf weeds.

Percent acres treated: 68%

Active ingredient used (lbs.): 1088

Average rate and frequency of application: 6-14 pt. of Dacthal Flowable/A one time.

Method of application: At planting, over row. Must be activated with 1/3-1/2 inch of rain or irrigation within 36 hrs.

REI: 12 hours.

PHI: Pre-emergence application only.

Efficacy: Fair to good on annual grasses, lambsquarters, purslane and pigweed. Poor to no control of sedges, cocklebur, galinsoga, ragweed, and velvetleaf.

Note: EPA classification group C (possible carcinogen). DCPA is slightly toxic to bees, although contact is unlikely as it is applied to soil prior to plant emergence. A breakdown product of DCPA has been found in groundwater as a result of agricultural use. Applications on sand or loamy sand soils where groundwater is close to the soil surface should be avoided. Worker contact is unlikely as it is applied to soil prior to plant emergence.

Post-emergence (crop and weed):**Sethoxydim (Poast)**

Target weeds: grasses.

Percent acres treated: 0%

Active ingredient used (lbs.): 0

Average rate and frequency of application: .75 pt. of Poast/A one time over crop after grass weeds have emerged.

Method of application: Foliar spray after grass weeds have emerged.

REI: 12 hours.

PHI: 15 days.

Efficacy: Good for some annual and perennial grass weeds, particularly when small. No control of sedges or broadleaf weeds.

Note: This material is not used, as indicated by grower surveys. This is due to the short duration of the crop and long PHI on the material.

Worker Activities in Arugula Production in New Jersey

IPM scouts and others may visit arugula fields 1-2 times a week starting at plant emergence and make recommendations for pest control until harvest. Field workers generally do not enter arugula fields until harvest. Arugula production in New Jersey offers little opportunity for field worker exposure to agrichemicals. The crop is seeded mechanically, and weed control is obtained with herbicides or mechanical cultivation.

Re-entry intervals (REIs) for all utilized insecticides and fungicides and herbicides are 12 hours or less, and are not inhibitory to field scout or field worker activities.

Pre-harvest intervals (PHIs) for foliar applied insecticides are generally one day, with neonicotinoid materials such as imidacloprid (Provado), dinotefuran (Venom), and acetamiprid (Assail) having PHIs of 7 days. Additionally, malathion (Cythion 8), and pymetrozine (Fulfill) have 7-day PHIs. Growers indicate that none of these materials are used due to long PHIs, the short duration of the crop, and the possibility that flea beetles and aphid pests may need treatment fairly close to harvest to avoid contamination (by insects) in the saleable product.

Soil applied imidacloprid (Admire) has a 21 day PHI, and is used by growers. Because this material is applied at the time seeds are sown, the long PHI is not an issue.

Foliar materials used for disease management also have REIs of 12 hours or less. All have PHIs of zero days with the exception of phosetyl-Al (Alliette) with a PHI of 3-days. This fungicide is not used by growers because other effective materials are available with shorter PHIs. Fungicides with efficacy against downy mildew, particularly having short PHIs are important because treatments close to harvest are sometimes necessary to limit post-harvest decay caused by the live downy mildew organism present in the bunched or bagged product. It should be noted, however, that FRAC Code 11 materials (pyraclostrobin [Cabrio] and azoxystrobin [Quadris and Heritage]), which are effective against downy mildew, are known to incite resistance in some fungi. For this reason, Alliette is a useful resistance management tool for downy mildew.

The one post emergence herbicide labeled for use in arugula is the grass herbicide, sethoxydim (Poast). This material has a 15 day PHI, and surveyed growers indicate that it is not used in New Jersey.

References

1. Bull, C.T., Goldman, P.H., Morris, N.C., Koike, S.T., and D. Y. Kobayashi. 2004. Expanded host and geographic range of *Pseudomonas syringae* pv. *alisalensis*. *Phytopathology*. 94:S12.
2. Bull, C.T., Goldman, P., and S.T. Koike. 2004. Bacterial Blight on Arugula, a New Disease Caused by *Pseudomonas syringae* pv. *alisalensis* in California. *Plant Dis*. 88:1384.
3. Crop Management Data Systems 2007. Product Search. www.cdms.net/LabelsMsds/LMDefault.aspx
4. Dimson, E.V. 2001. Crop Profile for Arugula in Arizona. www.ipmcenters.org/cropprofiles/docs/AZarugula.html
5. Fungicide Resistance Action Committee. 2007. www.frac.info/frac/index.htm
6. Hazzard, R., Andersen, C., Van Driesche, R., and F. Mangan. 2005. Univ. of Massachusetts. www.umassvegetable.org/soil_crop_pest_mgt/insect_mgt/documents/PAOrganicPresentationJune05.pdf
7. Holmstrom, K.E. 2007. Survey of Arugula Growers of New Jersey 2006-2007. Attached at the end of this document.
8. Morales, M. and J. Janick. 2002. Arugula: A promising specialty leaf vegetable. p. 418–423. In: J. Janick and A. Whipkey (eds.), *Trends in new crops and new uses*. ASHS Press, Alexandria, VA. www.hort.purdue.edu/newcrop/ncnu02/v5-418.html
9. Padulosi, S. and D. Pignone, editors. 1997. *Rocket: a Mediterranean crop for the world*. Report of a workshop, 13-14 December 1996, Legnaro (Padova), Italy. International Plant Genetic Resources Institute, Rome, Italy. www.bioversityinternational.org/Publications/Pdf/234.pdf
10. Stephens, J.M. 1994. *Arrugula – Eruca sativa* (Mill.). Fla. Coop. Ext. Publication HS534. http://edis.ifas.ufl.edu/BODY_MV010
11. Weed Identification Guide. Virginia Cooperative Extension. www.ppws.vt.edu/weedindex.htm
12. Weed Photo Gallery. 2007. Statewide IPM Program, Agriculture and Natural Resources, University of California. www.ipm.ucdavis.edu/PMG/WEEDS/_common.html

Arugula photograph provided by permission of *Southern Exposure Seed Exchange*
www.southernexposure.com

Key Contacts

Primary Contact:

Kristian E. Holmstrom

Project Coordinator II
Rutgers New Jersey Agricultural Experiment Station
Cooperative Extension
Vegetable IPM Program
Blake Hall Rm. 243; 93 Lipman Dr.
New Brunswick, NJ 08901-8524
Holmstrom@njaes.rutgers.edu
732-932-9802

Reviewers and Contributors:

Entomology

Dr. Gerald M. Ghidui; Specialist in Vegetable Entomology
Rutgers Agricultural Research and Extension Center
121 Northville Rd.; Bridgeton, NJ 08302-5919
Ghidui@njaes.rutgers.edu
732-932-4000 X-4116

Pathology

Dr. Christian A. Wyenandt; Specialist in Vegetable Pathology
Rutgers Agricultural Research and Extension Center
121 Northville Rd.; Bridgeton, NJ 08302-5919
Wyenandt@njaes.rutgers.edu
732-932-4000 X-3133

Weed Science

Dr. Bradley A. Majek; Specialist in Weed Science
Rutgers Agricultural Research and Extension Center
121 Northville Rd.; Bridgeton, NJ 08302-5919
Majek@njaes.rutgers.edu
732-932-4000 X-4122

SURVEY OF NEW JERSEY GROWERS OF ARUGULA: 2006 - 2007

Information on arugula production is not as readily available as for many of the larger vegetable crops. In order to develop information for this crop profile, seven New Jersey arugula growers were surveyed over the winter of 2006/2007 regarding varieties, cultural and pest management practices, and marketing strategies.

The survey was conducted by Kristian Holmstrom of the Rutgers New Jersey Agricultural Experiment Station (NJAES) Vegetable IPM Program. Participants represented growers of arugula for bunched sale and for baby (bagged) production. Wholesale and retail growers were represented. Surveyed participants were from Cumberland, Gloucester, Hunterdon and Warren counties.

SUMMARY OF SURVEY RESULTS

1. County?

Surveyed growers were from Cumberland, Gloucester, Hunterdon and Warren counties.

2. How much arugula do you grow per season?

Acreage ranged from .25 to 50 acres.

3. What varieties of arugula do you grow?

Varieties included Astro, AstroII, Selvetica, Rocket, Surrey, and Johnny's wild type.

4. Is crop direct seeded or set out as transplants?

One surveyed grower used transplants. All others direct seed the crop.

5. When/how often do you seed/plant?

The larger growers (8 acres – 50 acres) seed 1-2 times a week throughout the season.

The smaller acreage growers (<1 acre) generally seed 2-3 times each in the spring and/or fall.

6. Describe field culture, i.e. bed configuration, irrigation, mulch.

Only one (<1 acre) grower used plastic mulch with trickle irrigation. One grower (<1 acre) prepared outdoor boxed beds filled with soil-less mix with overhead irrigation. All others prepared bare ground, raised beds and used overhead irrigation. Rows/bed ranged from 3 to 22.

7. Fertility program.

Four surveyed growers broadcast a fertilizer prior to bed-making. Materials included balanced (i.e. 13-13-13) fertilizers, calcium nitrate, and organic fertilizers. Three growers only applied fertilizer as side-dress or top-dress applications. A total of six growers applied fertilizer as side-dress or top-dress applications. Materials included balanced (i.e. 10-10-10) materials, 9-5-9, calcium nitrate, and urea.

8. Herbicide/weeding program?

Two surveyed growers used Prefar and 3 used Dacthal prior to emergence of the crop. Two of the Dacthal users only did so occasionally, with cultivation the more common method of weed control. Two growers exclusively cultivated to manage weeds.

9. What insect pests do you have?

All growers identified crucifer flea beetle as the worst insect pest problem. One grower also noted that diamondback moth larvae were an occasional problem.

10. How do you control them?

One grower (50 acres) uses Admire at seeding, followed by Mustang as necessary for flea beetle control. Four growers use permethrin as necessary. Two growers do not attempt to control flea beetle, other than harvesting earlier if damage is occurring.

11. What diseases do you encounter?

Three growers identified downy mildew as a primary disease problem, and three indicated that bacterial leaf spot (bacterial blight) were primary problems. Three growers did not encounter disease problems on this crop.

12. How do you manage them?

Growers experiencing disease problems generally use chemical methods to manage them. Oxidate (hydrogen dioxide) is used by larger acreage growers for management of

bacterial blight, while strobilurin-type fungicides (Quadris, Amistar, Cabrio) as well as phosphorus acid (Phostrol), and potassium phosphite (Prophyt) based materials are used for downy mildew management.

13. How and when is crop harvested?

Arugula is generally hand pulled and bunched with the roots on when leaves have reached 8-10". Some of the northern (very small acreage) growers will cut the plants, but generally roots are left on, and bunches are sold by weight. Arugula grown for the baby (arugula) market is cut with a steel band harvester similar to that used in spinach production. Baby arugula is cut when leaves are approximately 4". Daily harvests of baby arugula are conducted, and wild-type varieties may be cut 2-3 times, although leaf quality declines with repeated harvests. Strap-leafed varieties are harvested one time only.

14. How is crop marketed?

Bunched arugula is sold directly at farm markets, particularly in the case of the small acreage (<1acre) growers. Larger growers of bunched arugula typically wholesale by the 24 bunch box or crate at a local produce auction. Baby arugula is sold directly to a large buyer, i.e. supermarket by the 4 lb. box.

15. What is a typical price for your arugula?

Small acreage growers (<1acre) generally retail arugula for \$1.25-4.00/quarter pound bunch. The larger acreage growers of bunched arugula sell retail at the farm for \$7-12 for a 24 bunch crate, and wholesale at auction for \$5-7 for a 24 bunch crate. Baby arugula is sold directly to food service organizations, restaurants and food markets for \$9-10 for a 4 lb. box.