Crop Profile for Spinach Seed in Washington

Production Facts\(^{(1)}\)

- 75% of United States production.
- 50% of world production.
- 3000-4000 acres grown annually in Washington.
- Value of market seed sold to commercial growers is $20 million.
- Grower production costs average $900/acre.

Production Regions

Major spinach seed-producing areas are Skagit and Snohomish counties in northwest Washington.\(^{(1)}\)
General Information

There is no open market (non-contracted) small seeded vegetable seed production in Washington. Commercial vegetable seed production is under bailment contracts, where the seed companies (bailors) provide growers (bailees) with the seed necessary to produce a crop. The seed company retains ownership of the seed, growing crop, and resulting harvested seed. Growers produce and harvest the crop and are then paid the contract price for the resulting seed if it meets quality criteria stated in bailment contracts, typically an 85% germination rate and a 99% purity. Weed seeds which are the same or nearly the same size/shape as the vegetable seed are difficult to remove at the conditioning plant and can cause seed companies to reject a seed crop.\(^{(10)}\) Federal regulations for moving seed into interstate commerce require that seed must be completely free of all noxious weeds.

Small seeded vegetable seed production takes place on approximately 6,000 acres in western Washington contracted by approximately 25 seed companies. The average field size for spinach seed production is 20-30 acres. Fields are scheduled for long (6-15 year) rotation periods depending upon whether inbred parent lines used in production have *Fusarium* tolerance. Companies control the location of seed crop fields in order to prevent cross-pollination of different varieties of the same crops (spinach open pollinated seed vs. spinach hybrid seed) and of cross-compatible crops (e.g. beet and Swiss chard). Isolation distances vary depending on whether the crops are wind or insect pollinated, are grown for market or stock seed, and can range from one-quarter mile to 3 miles or more. Market seed is produced and used for vegetable production. Stock seed is grown specifically for use in planting seed crops.

Company representatives meet with county agents at the WSU Cooperative Extension Office in Mount Vernon each spring in a “pinning” meeting to plot map locations of seed crops planned for that year. It is worth mentioning that with the increased urbanization of the Skagit Valley, and the presence of hobby farmers, it is more difficult to control pollen flow and ensure the isolation necessary for hybrid seed production.

Spinach seed.

Gravity separator.
In Washington State, small seeded vegetable seed crops are considered non-food and nonfeed sites for pesticide use. 

**Cultural Practices**

Spinach (*Spinacia oleracea*) seed is an annual, wind-pollinated crop and is direct-seeded between late March and mid-May. Only 10% of the spinach seed grown in Washington are open-pollinated; the remaining acreage is hybrid seed. In hybrid seed, fields are rogued prior to and during the bloom period to remove male plants and plants not displaying true varietal characteristics. Spinach seed is harvested in July and August. At harvest, the crop is cut and dried in the field for 10 to 14 days. During this period, the crop may require hand turning, as seeds shatter easily, to facilitate drying. After the seed is threshed, it is sent to a conditioning plant, where it is cleaned to 99% purity. Spinach is the most economically important small-seeded vegetable seed crop grown in western Washington. 

Any damage to seeds that affects yield, germination rate, purity of type (weed contaminants), or purity from disease will cost the grower money and/or affect his ability to do future business with seed companies.

**Weeds**

Weeds are considered the most important pests in spinach seed production. Two factors are primarily responsible for this, the first is that spinach is not competitive against weeds during its early growth, and second, is that spinach is sensitive to most herbicides. Spinach is closely related to the weed lambsquarter, which is used as a target weed in herbicide screening trials to identify useful herbicides.

Weed competition can reduce the yield in seed crops. Competition from weeds can result in 100% yield loss if weeds are not controlled. Weeds present at harvest interfere with threshing, reduce harvest efficiency, and increase mechanical damage to the seed. Many weed species can also serve as hosts for diseases and insects that affect crop plants. Weed seeds can also be contaminants of harvested spinach seed. This can either affect marketability of the seed, or result in higher cost to...
the grower if several conditioning runs must be made to decrease the contamination to acceptable contract levels.

Typical weeds affecting spinach grown for seed include annual grasses (including annual blue-grass, *Poa annua* and others), seedling perennial grasses (such as quackgrass, *Elytrigia repens* and perennial ryegrass, *Lolium perenne*), pale smart-weed (*Polygonum lapathifolium*), corn spurry (*Spergula arvensis*), shepherdspurse (*Capsella bursapastoris*), common groundsel (*Senecio vulgaris*), chickweed (*Stellaria media*), pigweed (*Amaranthus* spp.), henbit (*Lamium amplexicaule*), pineapple-weed (*Matricaria matricariodes*), nightshade (*Solanum* spp.), wild buckwheat (*Polygonum convolvulus*), mustard (*Brassica* spp.), lambsquarters (*Chenopodium* spp.), and volunteer grains such as barley (*Hordeum vulgare*), and wheat (*Triticum aestivum*).\(^{(1, 4, 5)}\)

**Cultural Controls**

Crop rotation and mechanical cultivation are practiced by 100% of the industry. Weather factors in western Washington do not permit delayed seeding dates. Hand hoeing, up to several times a season, is practiced in the female rows of hybrid spinach seed.

**Chemical Controls**

**Diquat** (*Diquat at 0.5 lbs. AI/acre*). (24c, WA-930013). Applied at 1 1/2 - 2 pt/A three to ten days before harvest. Plants stop growth and cure better with application of a desiccant. Weeds that make harvest difficult are also killed with this treatment, resulting in a more uniform harvest. Wet weather in western Washington necessitates quick drying times for seed crops. This is the only desiccant available, thus is a critical use to the industry.

**Cycloate** (*Ro-Neet 6E at 2 lbs. AI/acre*). (24c, WA-960011). It is applied at planting to 35% (ca. 1225 acres) of area planted to spinach seed to control hairy nightshade, henbit, pigweed, shepherdspurse, annual grasses, lambsquarters, and volunteer barley. It is for use only in western Washington. This herbicide is a critical use to the industry.

**Phenmedipham** (*Spin-Aid at 0.5 to 1.0 lbs. AI/acre*). 40-day PHI. It is applied when plants have developed 4 to 6 true leaves. Temporary crop damage may occur.\(^{(7)}\) It is applied to 95% (ca. 3325 acres) of spinach seed crops to control lambsquarters, mustard, pigweed, chickweed, shepherdspurse, wild buckwheat, and nightshade.\(^{(1)}\) This is a critical use herbicide as it is the only post-emergence herbicide available to the industry.

**Ethofumesate** (*Nortron SC at 0.75 lbs. - 1 lbs. AI/acre*). (24c, WA-930011). Restricted to use in western Washington only. Ethofumesate is applied at planting to 10% (ca. 350 acres) of area planted to spinach seed to control lambsquarters, pigweed, shepherdspurse, and volunteer grains. Crop damage may occur.

**Fluazifop-P-butyl** (*Fusilade DX at 0.19 - 0.25 lbs. AI/acre*). (24c, WA-950029). It is applied to 5% (ca. 175 acres) of spinach seed crops from seedling to fresh market stage to control annual grasses and seedling perennial grasses.\(^{(1)}\) (Note: the term fresh market stage refers to a growth stage of the crop; spinach seed crop is not grown as “fresh market” spinach.)

**Diseases**

Diseases are the second most important pests of spinach seed production. These pests drive the long (8-10 year) rotation periods used to prevent disease build up. These rotation periods are necessary even when using resistant plant varieties. Several of the fungal organisms are soil inhabitants with a wide host range, making it difficult to rotate from one seed crop to another (such as a spinach seed to beet seed rotation).
Fusarium Wilt
*Fusarium oxysporum f. sp. spinaciae*

Fusarium wilt is a fungal disease that causes wilting and death of seedlings, and is the most serious disease of spinach seed. Infected older plants exhibit chlorotic older leaves, early maturity, low seed production, and premature death. The pathogen can persist for several years in the soil in the absence of a host crop and can also survive on seed, causing disease in fields previously free of spinach wilt. Table and fodder beets, Swiss chard and *Lychnis* species (campion) are also susceptible to this pathogen. The disease is favored by warm, acidic soils. The disease may devastate a planting and result in 100% crop loss if not controlled in a field where the pathogen has a high inoculum level.

**Cultural Control**

Growers carefully select planting sites where Fusarium wilt has not been a problem. Crop rotation is practiced on a 6- to 7-year rotation cycle for parent lines with *Fusarium* tolerance, and a 12- to 15-year rotation cycle for parent lines with no *Fusarium* tolerance. Rotations include peas, cereals, and processing vegetables. Tolerant or resistant varieties are planted. Early planting may allow seedlings to develop prior to soil temperatures becoming conducive for the pathogen.

**Chemical Control**

Benomyl (Benlate). Seeds are treated with a slurry at 16-32 oz. product/100 lbs. seed in 0.5 to 2 pts. water. All of the spinach seed planted for seed production is treated with benomyl. This is a critical use as it is the only product available to the industry.

Downy Mildew
*Peronospora farinosa f. sp. spinaciae*

Downy mildew and leaf spot complex are tied for the second most important disease in spinach seed production. Downy mildew is a fungal disease that causes leaf damage and creates open wounds for leaf spot complex. Plant stunting and death may occur in severely infected plants. Infection is systemic and the disease can be carried mixed with the seed as oospores or as mycelium in the seed. The pathogen overwinters in plant debris, dead spinach plants, and volunteer spinach plants. Oospores produced in diseased plants may be plowed under in the field and survive in soil for up to one year. Oospores mixed with the seed may survive for up to two years. This disease has the potential to cause a yield loss of 20% if not controlled.

**Cultural Control**

Crop rotation out of spinach for several years is practiced to reduce disease inoculum. Volunteer spinach is controlled in adjacent fields. Infected seed can be hot water treated at 122°F for 25 minutes.

**Chemical Control**

Cymoxanil (Curzate 60 DF at 0.12 lbs. AI/A). Must be used in combination with products containing mancozeb or chlorothalonil. Initial application of 3.2 ounces of product/acre begins when conditions indicate downy mildew infection is imminent. Additional applications can be made at 5 to 7 day intervals.

Mefenoxam (Ridomil Gold EC at 0.5 lbs. AI/A), 21-day PHI. One application is made as a preplant incorporation or as a surface application at planting at 1 to 2 pints/acre in sufficient water or liquid fertilizer to cover. This fungicide is not applied as a foliar application to minimize the
potential for development of resistant fungi. Approximately 350 acres (10%) of the spinach seed crop are treated annually.\(^{(1)}\)

**Chlorothalonil (Bravo Weatherstik at 2.25 lbs. AI/A), (24c, WA-950036b)** Preventative applications are made when conditions favor disease from bolting to early bloom. Usually more than one application is made at a rate of 3 pints/acre on a 7- to 14-day schedule. Chlorothalonil is used to treat 35% of the spinach seed acreage (ca. 1225 acres).\(^{(1)}\) The applications also provide control of Cladosporium leaf spot.

**Copper hydroxide (Kocide DF at 1.84 lbs. AI/A).** The first application is made at early bloom or at the first appearance of disease. The recommended rate is 2-3 lbs. product/acre. More than one application may be made at 7- to 10-day intervals when conditions are favorable for disease. Copper fungicides are applied to approximately 700 acres (20%) of the spinach crop grown for seed production.\(^{(1)}\) Copper products are not as effective in controlling downy mildew as are other fungicides. Leaf burning often occurs under western Washington conditions.\(^{(10)}\)

**Copper oxychloride and basic copper sulfate (C-O-C-S WDG at 0.89 - 2.67 lbs. AI/A).** Usually more than one application (7- to 10-day intervals) is made at a rate of 1-3 lbs. product/acre when conditions are favorable for disease. Copper products may cause leaf flecking under certain environmental conditions. Copper fungicides are applied to approximately 700 acres (20%) of the spinach crop grown for seed production.\(^{(1)}\) Copper products are not as effective in controlling downy mildew as are other fungicides. Leaf burning often occurs under western Washington conditions.\(^{(10)}\)

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**Leaf Spot Complex**

*Cladosporium variable* and others

Tied with downy mildew for the second most serious disease of spinach seed production, this disease is associated with a complex of several fungi of which *Cladosporium variable* is believed to be a primary pathogen. Foliar damage from downy mildew infections can create sites for leaf spot infection. The disease causes spotting and death primarily of older leaves, but in severe cases can kill all leaves and affect seed. Infected volunteer spinach can serve as a source of inoculum. If not controlled, this disease can result in a 50% loss of the spinach seed crop.\(^{(1)}\)

**Cultural Control**

Tolerant or resistant varieties are planted. Volunteer spinach is controlled prior to planting spring crops. Crop rotation is practiced.

**Chemical Control**

Chlorothalonil (Bravo Weatherstik at 2.25 lbs. AI/A), (24c, WA-950036b). Preventative applications are made from bolting to early bloom when conditions favor disease. Usually more than one application is made at a rate of 3 pints/acre on a 7- to 14-day schedule. Twenty percent of the spinach seed acreage is treated with chlorothalonil.\(^{(1)}\) The applications are also effective in controlling downy mildew.
DAMPING-OFF

Pythium spp. and Rhizoctonia solani

Pythium spp. and Rhizoctonia solani are soil-borne fungi that attack germinating spinach seedlings as well as many other plant species. They can survive in soil indefinitely. Infection can occur prior to seedling emergence, thereby preventing emergence, or young plants can be attacked during emergence resulting in plant loss. Cool weather, high humidity, and saturated or compacted soils\(^{10}\) favor development of damping-off. Under favorable conditions such as a wet spring, seedling death may reach 100% if non-treated seed is planted in soils where these fungi are established.\(^{1}\)

**Cultural Controls**

Sites are selected with good drainage to promote rapid, vigorous seedling growth. Plants are spaced to aid airflow throughout the subsequent canopy. Scrupulous sanitation, including removal or decomposition of plant debris, is practiced along with crop rotation with cereals to reduce inoculum levels.

**Chemical Controls**

Metalaxyl (Apron XL LS). All of the spinach seed planted for seed production is treated with metalaxyl at 0.32 to 0.64 fl. oz. product/100 lbs. of seed. This fungicide is effective in controlling Pythium spp., but does not control damping-off caused by R. solani.

Mefenoxam (Ridomil Gold EC at 0.5 lbs. AI/A). 21-day PHI. One application is made as a preplant incorporation or as a surface application at planting. The application rate is 1 to 2 pints/A in sufficient water or liquid fertilizer to cover. This fungicide is not applied as a foliar application to minimize the potential for development of resistant fungi. Approximately 350 acres (10%) of the spinach seed crop are treated annually.\(^{1}\)

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**Insect Pests**

Insect pests do not damage the seed directly, but affect seed quality and yield through damage to the plant during early growth.

**Springtail**

(mainly Onychiurus pseudarmatus)

Springtails are small, white, slow-moving, soil-dwelling insects that feed on germinating seeds or on seedling roots. Infestations are primarily localized or occur in irregular spots in fields. Damage causes reduced stands and loss of vigor in surviving plants.\(^{2}\) Although this pest is sporadic, potential yield loss to affected growers is 100% if springtails are not controlled.\(^{1}\)

**Chemical Controls**

Carbofuran (Furadan 15G at 0.03 lbs. AI/1000 linear ft. row). (24c, WA-860012). Seventy-five percent of the spinach seed crop acreage (ca. 2625 acres [assuming average of 3500 acres planted]) is treated at planting as a seed furrow treatment at a rate of 6.7 ounces product per linear foot of row (maximum of 13 pounds per acre). Furadan 15G also controls European cranefly. In tests by WSU researchers, no other insecticide has been found effective against springtails.

**European Cranefly**

Tipula paludosa

The gray-brown, wormlike larvae of cranefly are known as leatherjackets. They feed underground on roots and stems of clover and a number of vegetables and are particularly damaging to seedling vegetables. They are a sporadic but potentially serious pest, particularly in fields planted to
vegetable seed immediately after a pasture rotation. Potential yield loss to growers is 100% in affected areas if craneflies are not controlled.\(^{(1,2)}\)

**Chemical Controls**

Carbofuran (Furadan 15G at 0.03 lbs. AI/1000 linear ft. row). (24c, WA-860012). Seventy-five percent of the area planted to spinach seed crops (ca. 2625 acres) is treated at planting. This product also controls springtails (1).

Methyl parathion (Methyl parathion). It is applied to 20% (ca. 700 acres) of spinach at seed set (1,3). Recommended application rate for control of European cranefly is 0.5 lb. AI/acre. Methyl parathion also controls several species of cutworms, loopers, and related caterpillars (2,3). This active ingredient was voluntarily cancelled in 1999.

**APHIDS**

several species including
- bean aphid, *Aphis fabae*,
- green peach aphid, *Myzus persicae*, and
- melon aphid, *Aphis gossypii*

Aphids feed on the foliage of plants, causing leaf decline or overall plant decline.\(^{(2)}\) Aphids may also serve as vectors for viral diseases such as cucumber mosaic virus.\(^{(9)}\) These aphid species are black, yellowish-pink to pale green, and yellowish to dull green, respectively. Potential yield loss to growers is 30% if aphids are not controlled.\(^{(1)}\)

**Chemical Controls**

Dimethoate (various names at 0.25 lbs. AI/A). 14-day preharvest interval (PHI). Dimethoate is applied at seed set to 80% (ca. 2800 acres) of spinach seed crops.\(^{(1)}\)

**CUTWORMS, ARMYWORMS, LOOPERS**

several species including
- alfalfa looper, *Autographa californica*

Cutworms and loopers are variously colored and patterned moth larvae. They feed primarily on leaves, although cutworms may also completely sever stems of young plants. Several species cause similar damage and are controlled in the same manner. Seed may also be damaged.\(^{(1,2)}\) Potential yield loss to growers is 30% if cutworms and loopers are not controlled.\(^{(1)}\)

**Chemical Controls**

Permethrin (Ambush at 0.05 to 0.1 lbs. AI/A). 1-day PHI. It is used on 80% (ca. 2800 acres) of spinach seed crops and is applied at seed set.

Methyl parathion (Methyl parathion). It is applied to 20% (ca. 700 acres) of spinach at seed set (1,3). Recommended application rate for control of European cranefly is 0.5 lbs. AI/acre. Methyl parathion also controls European cranefly. This active ingredient was voluntarily cancelled in 1999.

Methomyl (Lannate at 0.45 to 0.9 lbs. AI/A). 7-day PHI. It is applied to 5% (ca. 175 acres) of spinach at seed set to control armyworms (1).
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(1) Puget Sound Seed Growers Association. 1998 Spinach Seed Crop Outline, unpublished data.


(3) Washington State University Pesticide Information Center On-Line Label Database (PICOL). http://picol.cahe.wsu.edu


(10) Dr. Debra Inglis, WSU Mount Vernon. Personal communication, December 1998.


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Use pesticides with care. Apply them only to plants, animals, or sites listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

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