Best weed management practices for organic snap beans in western Oregon

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Weeds in snap beans drag down yield and contaminate products sent to processors or markets. They may even make it impossible to harvest the crop mechanically. It is worth the effort to be proactive when managing weeds in row crops. Proactive rather than reactive approaches are essential to successful management of weeds in row crops.

Crop Rotation

Crop rotation is the cornerstone of a successful weed management system. Alternating winter and summer crops, competitive and uncompetitive, high-fertility crops and low-fertility crops, or irrigated and nonirrigated crops will select for different weed species. Winter annual crops such as winter wheat host an entirely different suite of weeds than do irrigated summer annuals. Summer annual weed seeds remain in the soil ungerminated during the wheat crop but lose viability over time. Broadleaf weeds last longer in the soil than most grass weed seeds. A three-year break in a rotation will substantially reduce summer annual broadleaf seed survival. Crop rotations are the key to long-term successful weed management because a well-constructed rotation will prevent a shift to one or a few dominant weed species.

Prevention and Eradication

Another key to success is keeping new weeds off the farm and keeping weeds from moving from one field to another. Prevention and eradication are a priority. This takes a proactive strategy that must be followed throughout the year.

A particularly important time to destroy weeds is after harvest. Weeds standing after crops are harvested are often allowed to continue to produce and ripen seeds. The fall season is particularly important for weeds such as hairy nightshade. This indeterminate plant will continue to produce berries as long as the stems are allowed to grow, and the longer the season, the more seeds are produced.

If you are using animal manures to fertilize crops, find out where or how the forage was produced, and whether weed seeds may be present. Many weed seeds go straight through ruminants undamaged. If you are using compost, make sure that compost temperatures exceeded 60°C for at least 48 hours so that weed seeds were killed. If the compost was extremely clean, this high temperature may not be needed to kill targeted disease organisms.

A good case study in prevention is the increase of puncturevine here in the valley (figure 1). Seeds are continually transported from the east side of the mountains on equipment and in hay and end up in staging areas in vegetable production sites or along roadsides. If puncturevine is sighted, it is best to dig up the plant and destroy it by burning. Seed dormancy is long in puncturevine. In fact, Rick Boydston of United States Department of Agriculture in Prosser, Washington, demonstrated that maximum emergence after seed was produced occurred 3 years after the initial seeding event.

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Managing Weed Seeds in the Soil

Leaving weed seeds on the soil surface in the fall will reduce winter survival of many weed seeds. This exposes weed seeds to seed predators such as mice, ground beetles, and birds, more extreme temperature variation, and wetting and drying. Weed seeds usually lose viability in this setting more quickly than if buried. Soil disturbance or tillage in the fall that buries weed seeds may enhance weed seed survival. For instance, in a recent study at OSU, we demonstrated that the tillage incurred during direct drilling of a cover crop in the fall actually enhanced wild proso millet emergence the following year, mainly because the drill caused enough soil disturbance to bury and protect seeds during the winter.

A number of organisms eat weed seeds. Carabid beetles are ubiquitous in most cropping systems and consume a reasonable amount of weed seeds that range in size from very small pigweed seeds to large seeds like wild proso millet. Mice, voles, and birds consume weed and crop seeds, but tend to focus on larger seeds like wild proso millet. These seed predators are not often welcome, however.

_Pterostichus melanarius_ is the most common carabid beetle in Willamette Valley, and this carabid is an important consumer of weed seeds and other pests (figure 2). In ongoing research, we are attempting to determine the factors that enhance the abundance of these carabids. Spring tillage appears to be important. Strip tillage in the spring has increased the activity and density of these carabids compared to conventional tillage. Research is also examining the use of beetle banks (uncropped areas within a field) to promote carabid beetle populations.

In some cases, spring primary tillage (tillage before crop planting in the spring) can be used to manage the number of weeds that emerge in the spring. This is especially the case if weeds were allowed to produce seeds in a field last year that previously had few weeds. Weed seeds can be plowed under with inversion (moldboard) plows so they cannot emerge in the spring. Few weed seeds produce seedlings if buried more than 2 inches deep; the zone of optimum emergence for most small-seeded summer annuals is ¾ inch. Tillage following spring plowing must be relegated to the near surface soil layer to make this strategy work. This strategy can backfire if good records are not maintained. Seeds that are moved to 6 inches or below in the soil typically survive much longer than seeds that are buried near the soil surface, and deep plowing to bury crop residues may bring these same seeds to the surface 7 to 10 years later.

Cover Crops

Proactive approaches also may include the use of winter or summer cover crops. Keeping the soil covered during the winter will help prevent winter weeds such as shepherds purse, deadnettle, speedwell, and annual bluegrass from establishing themselves and interfering with other crops in the rotation. Competitive spring and summer cover crops will even keep patches of perennial weeds such as nutsedge from expanding in the area. It is important to seed at rates high enough to establish a solid stand of cover crop. For cereals, 45 seeds/sq ft is usually adequate, or about 1.5 times more than when seeding for grain.
Controlling Weeds in the Crop
False and Stale Seedbeds

Stale and false seedbeds can be used with great effect to reduce weed density. False seedbeds are developed by tilling the soil well ahead of snap bean planting, and tillage or other techniques are used to destroy emerged weeds before the crop is planted. This technique may be applied several times in succession to exhaust the soil of germinable weed seeds.

Stale seedbeds are developed by tilling the soil before crop planting to stimulate weed emergence, but the tools used to remove the weeds are applied after the crop is planted.

The tillage event used to stimulate weed emergence must be planned to coincide with normal times of emergence. Hairy nightshade is reluctant to emerge before May 20 in most years; black nightshade will start 1–2 weeks earlier. Tillage before weeds are ready to germinate just brings a fresh set of seeds to the soil surface, where they may germinate after the false or stale seed bed is completed.

The success of stale and false seedbeds depends on careful timing. They work best when weeds are most likely to germinate, and this does not occur at the same time for all species. Knowledge of which weeds are present and when they will have the greatest germination potential is essential. Data from weed emergence models developed by Dr. F. Forcella indicate that the sequence of weed emergence following seedbed preparation on May 1, 2009 and 2010, would be wild mustard first, followed by common lambsquarters, then black nightshade and barnyard grass (figure 3). As noted this year, and predicted by the WeedCast software, even though weed emergence was delayed this year for the species shown, emergence of common summer annuals such as lambsquarters, black nightshade, and barnyard grass was predicted to be much greater in 2010. Most would concur that this was in fact the case in 2010. Of course, the results shown in figure 3 are mathematical estimates, but they do indicate potential differences in emergence that are evident among species and years. These differences should be kept in focus when attempting to kill weeds in stale seedbeds or when cultivating.

Techniques used to kill weeds in stale seedbeds range from propane flame weeding to blind tillage (cultivating after seeding but before the crop emerges). If blind tillage is used, the soil surface must be level and uniform. A bar is run over the seed row with an accurate depth control. It may be best to use independent gangs that target only the area over the row and have a gauge wheel attached to ensure a precise depth of cultivation. Blind tillage is particularly suited to large-seeded crops like snap beans, which can be planted deep. Planting depth may need to be adjusted to accommodate blind tillage.

Flame weeding can be used in stale seedbed systems before the beans have emerged or when the first hypocotyl crooks are visible (figure 4). The hypocotyl is moderately tolerant to flame intensities that will kill very small weeds. Flame that is banded over the row to catch that first flush of weeds can be very cost effective ($5–$10/acre), but it all depends on the timing of weed emergence. If snap beans emerge before the weed seedlings, flaming will obviously damage the crop rather than the weeds.

The timing and amount of heat needed to kill weeds is critical to the success of flame weeding. Weeds with only cotyledons or one or two true leaves are much easier to kill than larger weeds, particularly if they are grasses. Inexperienced flamers often apply too much heat. You need to apply only enough heat to rupture the cells, not fry the plant. A simple test can be done by squeezing a leaf after flaming between thumb and finger. If your thumbprint remains, the leaf turns a dark watery green, or it is easily smashed, you have applied enough heat. The best time to flame weeds is usually late afternoon, but this is also a time that is very difficult to see the flame. For safety, a consistently repeating spark should be applied to keep the flame lit at all times.

As with all weed control practices, some weeds are resistant to flame weeding, and weed shifts (changes in the abundance of species) can be expected with continual use. Grasses are difficult to control with flame weeding because their growing point is below ground and well protected. Broadleaves are more susceptible because their growing point is above ground, but even then, if the weed is too large, it may regenerate from latent buds low on the stem that are not damaged. Common purslane is completely tolerant of flame weeding because of its fleshy leaves.
Figure 3. Predicted emergence timing (as the percentage of seeds in the soil that will produce seedlings) of common summer annuals at Corvallis in (a) 2009 and (b) 2010 following final seedbed preparation on May 1 on a silt loam soil. Yellow = mustard. Green = lambsquarters. Blue = black nightshade. Red = barnyardgrass. Predictions are from the output of the WeedCast software program, Agricultural Research Service, United States Department of Agriculture (http://www.ars.usda.gov/services/software/download.htm?softwareid=112#downloadForm).

Figure 4. Flamer weeders come in all shapes and sizes. This is a two-row experimental flamer for high-residue, strip-tillage systems (design courtesy of C. Merfield). (Photo by Ed Peachey, © Oregon State University.)
Cultivation

A number of strategies can be used, but effective strategies usually move soil away from the row very early, and then move it back toward the row later. Ridges left during cultivation must be compatible with harvesting equipment. Withholding irrigation immediately before and after cultivation will improve the effectiveness of cultivation. Also, less frequent irrigations tend to favor large-seeded crops over small-seeded, shallow-rooted weeds.

The video and print resources Weed ’Em and Reap (Stone 2006) and Vegetable Growers and Their Weed Control Machines (Grubinger and Else 1996) are recommended for more information on the wide diversity of cultivation equipment.

The weed-free period for snap beans is typically assumed to be 3 to 4 weeks, depending on the weed species present. The critical weed-free period is the minimum length of time a crop should be nearly weed-free to avoid a yield reduction. The weed-free period must be 4 weeks in many cases to accommodate mechanical harvesting. The weed-free concept can be extended to weeds such as hairy nightshade that not only compete with the crop for water, light, and nutrients, but also produce berries that will contaminate the harvest. Research in 2003–2004 indicated that removal of hairy nightshade was needed for up to 3 weeks in 2004 and 4 weeks in 2003 to prevent plants from producing berries greater in size than sieve size 2. Nearly the same result was obtained over four planting dates from May 4 through June 20 (figure 5).

Care should be taken to avoid bringing new weed seeds to the surface during cultivation. Most weed seedlings emerge from seeds that are buried less than 1 inch deep. Larger seeds such as wild proso millet and barnyard grass may emerge from as deep as 2 inches. As much as 30%–40% of that zone may be depleted if tillage and weather conditions coincide to produce favorable weed seed germination conditions in the spring. Cultivation that moves soil from below 2 inches may bring new soil to the surface with a new set of weed seeds. This is less of a concern as the season progresses.

The first cultivation should occur when weeds are in the white thread stage or just beginning to poke through the soil. This is a precarious time to cultivate but can be very effective. If the soil is crusted slightly, many seedling cotyledons may be sheared off during slight shifting of the soil. Some cultivation equipment is designed to do this, such as torsion weeders. Check the stability of snap bean plants in the row during cultivation by gently tugging on them to make sure that the radical was not disconnected from the soil.

The equipment available for cultivation in row crops is numerous and beyond the scope of this publication. Figures 6a and 6b show two types of cultivation equipment that might be considered for use.
The rotary hoe is a “preemergence” weeder and typically used over the entire field just before or during crop emergence. Large-seeded crops or cereals are most tolerant to this type of weeding, while small-seeded weeds are kicked out of the soil by the rotating tines. Proper timing is critical, as is soil moisture. The Bezzerides weeder is a “postemergent” cultivator that is confined to areas between rows and applied after crops emerge. The fingers of the “spiders” are positioned very close to the crop plants and reach into the row to loosen soil next to crop plants, while blades or sweeps follow the spiders and uproot small weed seedlings next to the row. The spiders can be positioned so that soil is moved into or away from the row, depending on the size of the crop. (Use of the Bezzerides cultivator can be viewed in the following video: http://www.extension.org/pages/Video_Clip_Bezzerides_Cultivator_on_Applefield_Farm_from_Vegetable_Farmers_and_Their_Weed_Control_Machines.) The third category of weeder (broadcast, postemergent) applies cultivation over the entire field after the crop has emerged; the differential size between crop and weed determines effectiveness. Soil texture, soil moisture, weed seedling size, and the differential between weed and crop size are the main factors that determine efficacy of cultivation equipment. The use of precision guidance systems such as Real Time Kinematic (RTK) or inline row sensors can greatly improve cultivation accuracy and allow faster cultivation speeds.

**Cultural Practices**

Fertilize the beans, not the weeds, when possible. Most summer annual weeds are extremely well adapted to high-nitrogen soils, and do much better than beans under comparatively high fertility conditions.

Wider row spacings mean less in-row area to manage weeds, higher plant densities in the row that are more competitive with weeds in the row, and less white mold.

A competitive crop is essential. Planting beans when soil temperatures are optimum ensures quick emergence and good competition with emerging weeds.

**Organic Herbicides**

Several organic herbicides are available for use in organic production, and as of printing, only one is registered by the United States Environmental Protection Agency and approved by the Organic Materials Review Institute for use in vegetable crop production. Most organic herbicides are approved only for use in areas where crops are not grown, such as fencerows, or for burndown before the crop is planted. These herbicides are all nonselective contact herbicides; they damage any plant tissue that they contact, and they will not prevent weeds from emerging from the soil like conventional soil-active herbicides. These herbicides are either extracted from plants such as cloves, citrus rinds, or lemon grass, or they are produced by fermentation (acetic acid or vinegar) and are used at relatively high rates (2–7 gallons/acre) and cost ($/acre). An example of the broadcast efficacy of these herbicides for control of summer annual broadleaves is provided in the photo below. One advantage to these herbicides is their generally very short reentry interval. The main disadvantage to using these herbicides is cost and lack of control of grasses and perennial weeds (figure 7).

The one herbicide approved for in-crop use is made from extracts of lemon grass and must be applied with shielded sprayers to prevent damage to the crop or must be used before the crop emerges. One possible use of these herbicides is in stale seedbed systems where the herbicide would be banded over the row just before the snap beans emerge. Inrow weed control is a challenge in snap beans, and limiting the herbicide to a band over the over the row would greatly reduce the cost. This strategy has not been tested in Oregon.

**Summary**

Managing weeds in organic snap beans is no easy task, but it will determine whether a crop is actually harvested and sent to the processing plant. Crop rotations are the anchor to successful management, followed by steps to prevent weed seed production or new introductions to the farm. Cultivation will be the cornerstone of management once the crop is seeded, but overall efficacy can be enhanced by using stale and false seedbeds shortly after planting.
Figure 7. (a) Desiccation of weeds with an organic herbicide made from extracts of citrus rinds. Total application volume of water and herbicide was 170 gallons/acre, with a ratio of herbicide to water at 1:3 (foreground plot) and 1:6 (plot at the top of the photo). (b) Close-up of the treated area 8 days after the herbicide was applied, showing weed size when the herbicide was applied, some of the species present at the site, and the efficacy of the herbicide. (Photos by Ed Peachey, © Oregon State University.)

References