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Weeds

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Weeds are often the most common and costly pests in vegetable production. Weeds that germinate during cover cropping and produce seed increase the weed seed bank and may increase production costs. The effects of cover crops on weeds are relatively easy to monitor. For example, the size of individual weeds and weed biomass during cover cropping are excellent indicators of weed suppression by the cover crop (fig. 6.1). The choice of cover crop variety, seeding rate, planting date, and other management factors influence the growth of cover crops and their ability to suppress weed growth and weed seed production.

This chapter focuses primarily on how growers can minimize and control weeds during cover cropping periods in the tillage-intensive vegetable systems most common in California. Careful attention to weed management during the cover cropping period is critical because many important weed species occur year-round and vegetable production can occur throughout the year in many regions. The potential biofumigation effects of soil-incorporated cover crop residue in subsequent vegetables, the use of cover crop mulch in reduced-tillage systems, and cover crops as weeds are also briefly addressed.

Weed Control in the Cover Crop

Weed control in cover crops is influenced by several factors (table 6.1). Many of these factors (also discussed in chapter 10) impact other important benefits of cover crops, such as total biomass production. Many weeds that grow during cover cropping mature much faster than the cover crop and can produce viable seed before cover crop termination. The critical period for weed suppression by the cover crop is typically during the first 30 days of cover crop growth. A cover crop's ability to suppress weeds is generally correlated with the cover crop's early-season biomass production rather than with cover crop biomass at maturity. Cover crops such as mustards and cereal rye that maximize light interception with a dense canopy early in the season are often the best at suppressing weed growth and weed seed production.

Table 6.1. Effect of selected factors on weed suppression during cover crop production

Factor	Effect on weed suppression in the cover crop
cover crop variety or mixture	Varieties and mixtures that rapidly develop a canopy are more weed suppressive.
seeding rate	Up to a certain point, higher seeding rates are more weed suppressive than lower rates.
planting date	Earlier fall planting dates allow winter cover crops to germinate quickly and rapidly cover the soil and improves weed suppression.
row spacing	Narrow spacing (6 inches between rows) minimizes competition between cover crop plants and maximizes weed suppression.
irrigation	Irrigation hastens cover crop germination and early canopy development and can increase weed suppression.
planting method	Drilling versus broadcasting a cover crop results in more uniform planting depth, even plant spacing, and an even stand that is more weed suppressive.

Figure 6.1. Burning nettle *(Urtica urens)* weeds that grew under cover crops with increasing weed suppressive abilities: from left to right, legume-oat mixture, oat, cereal rye, and mustard. These plants were harvested 84 days after cover crop planting. Emergence of weeds in the cover crops was not affected by cover crops.
E. Brennan

Figure 6.2. Burning nettle growth in a mixture of 90% legumes and 10% rye planted at 375 pounds per acre (A) versus 125 pounds per acre (B). These photographs were taken at 55 days after planting in a long-term organic systems trial in Salinas, California, that has shown that weed densities in vegetable crops are several times lower where the winter cover crop was grown at the higher seeding rate for several seasons. E. Brennan

The factors in table 6.1 affect each other and can be manipulated to improve the competitive ability of a given cover crop variety or mixture. This is illustrated in a cover crop mixture of 35% bell bean, 25% pea, 15% common vetch, 15% purple vetch, and 10% oat (percentages by seed weight). Mixtures like this are common on organic vegetable farms in the Central Coast region. At a typical seeding rate of 100 pounds per acre, this mixture results in a density of 14 plants per square foot. This mix has poor weed suppressive ability at this seeding rate because the plant density is relatively low. Doubling the seeding rate increases weed suppression, but the increased weed suppression would be more likely to occur if the cover crop were planted with a drill using narrow (6-inch) versus wide (12-inch) spacing between the rows. Narrow spacing increases cover crop competition with weeds earlier in the season because the weeds and cover crops are closer to each other. Adding more oat to the mixture also improves its weed suppression, but it is also likely to suppress the growth of the legume. More research is needed to determine the optimal seeding rates and plant densities that maximize weed suppression by sole and mixed cover crops. With sole cover crops (e.g., rye, mustard, oat, etc.), seeding rates necessary to give good weed control will likely be at least 25 to 50% higher than rates recommended when these crops are grown for seed production. Recent research on the Central Coast found that seeding rates of at least 200 pounds per acre may be necessary to achieve weed suppression by common mixes such as the 90% legume and 10% cereal mix described above (Brennan, unpublished data). A long-term organic trial in Salinas has recorded excellent weed suppression with a cover crop mixture of 90% legume and 10% rye when it was planted at 375 pounds per acre compared with a standard seeding rate of 125 pounds per acre (fig. 6.2); furthermore, weed densities in subsequent vegetables were several times lower where the higher cover crop seeding rate was used (Brennan, unpublished data). Areas of a field that are often more weedy, such as the field edges, should be planted at higher seeding rates by making double passes with the planting equipment.

Cultivation is seldom used to control weeds in cover crops, but it may be an effective and practical option when competition alone is not adequate, and when weather conditions permit cultivation. Row crop cultivators can be used to cultivate between rows of cover crops that are planted on beds, and blind tillage (shallow cultivation over an entire field without regard to row position) implements can be used in cover crops planted in solid stands. This technique selectively uproots weed seedlings at the white thread stage that are below the soil surface and are smaller and more shallowly rooted than the larger-seeded cover crops. Rotary hoes (fig. 6.3) or flex-tine weeders are examples of implements used for blind tillage. With blind tillage, relatively fast (8 to 10 mph) multiple passes can be made to uproot and kill weeds with surprisingly little damage to the young cover crop. Weed seed production by some species in a mixed cover crop can be reduced by up to 80% with the rotary hoe (fig. 6.4).

Figure 6.3. Rotary hoe implement used for blind cultivation.
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Weed Control after Incorporation of Cover Crops

When brassica cover crops are incorporated into the soil, biologically active compounds are released from the residue that can affect weed seeds in the soil. There has been interest in this biofumigation potential of brassica cover crops on weeds (Brown and Morra 1995). Brassica residues contain glucosinolates, which are converted to volatile isothiocyanates that can be toxic to some plant

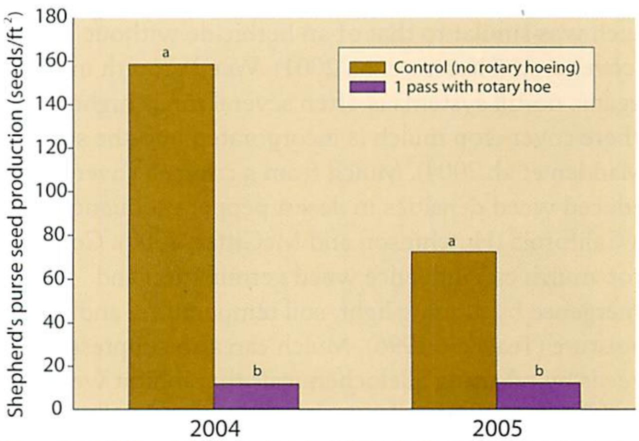

Figure 6.4. Effect of rotary hoeing (blind tillage) on weed seed production by shepherd's purse *(Capsella bursa-pastoris)* in a mixed cover crop (10% cereal rye, 90% legume) grown during the winter in 2 years. Bars topped by different letters within each year are significantly different at an error rate of $P < 0.05$.
Source: Boyd and Brennan 2006

species. The effects of cover crop breakdown products on weeds in field situations are variable, and the mechanisms are poorly understood. For example, in a 2-year study in California, mustard cover crop residue incorporated into the soil reduced weed emergence more than did residue of other cover crops in one year but not in another (Brennan and Smith 2005). It is clear that incorporating residue from a wide range of cover crops can delay seedling emergence and establishment of some weed and crop species: Haramoto and Gallandt (2005) found that the effect of brassica cover crop residue on weed seeds was not different from the effect of residue from a wide range of cover crops.

In addition to the effect of species-specific allelopathic compounds on weeds, adding carbon-rich cover crop biomass to the soil can increase microbial (bacterial and fungal) activity that may influence weed seedling survival and degradation of the weed seed bank, although this is poorly understood (see Kremer 1993; Davis 2007). Soil-incorporated cover crop residue can also alter the amount of available nutrients such as nitrogen that can influence the growth of weeds. For example, highly lignified residues from cereal cover crops can immobilize nitrogen, which may reduce weed growth more than residues from nitrogen-rich legume cover crops that may improve weed growth.

Weed Control by Cover Crop Mulches

Cover crop mulches are seldom used in vegetable production in California, and most of the research on mulches for weed control is from other regions of the United States. In a study of cover crop mulch with processing tomatoes in California, early-season weed control by cover crop mixes of rye-vetch and triticale-vetch was similar to that of an herbicide without a cover crop (Herrero et al. 2001). Weed growth in organic no-till systems is often several times higher than where cover crop mulch is incorporated into the soil (Madden et al. 2004). Mulch from a cowpea cover crop reduced weed densities in desert pepper production in California (Hutchinson and McGiffen 2000). Cover crop mulch can influence weed germination and emergence by altering light, soil temperature, and soil moisture (Teasdale 1996). Mulch can also suppress weeds by releasing allelochemicals that inhibit weed establishment, and if the mulch is dense enough it may physically obstruct weed seedling emergence. Weed control by cover crop mulch depends on weed species and the type and amount of mulch; control generally increases with increasing amounts of mulch. Several times more mulch than would naturally be produced on a given area of land may be required to reduce weed emergence by more than 90% for many weeds. The use of cover crop mulch or surface residue to control weeds may work with direct-seeded vegetables with large seeds, but it is most practical where vegetables are transplanted by hand or with mechanical transplanters that can operate in high-residue situations.

Cover Crops as Weeds

Cover crops can become weeds in subsequent vegetable crops if they mature and set viable seed prior to termination. This is more likely with winter cover crops where wet spring conditions can postpone the cover crop termination and incorporation dates. Growers can minimize the risk of cover crops becoming weeds by monitoring flowering and seed development, selecting cover crop varieties that mature late, avoiding species with hard seed that may persist for many years, and adjusting the planting date to prolong the vegetative growth phase. Mowing the cover crop may prevent or minimize cover crop seed production even when soil conditions are too wet to incorporate the residue.

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