Weed Management

Rick A. Boydston, Bernard H. Zandstra, and Robert Parker

Weeds in hop yards can interfere with production by impacting the growth and yield of hops (direct interference) or by interfering with field operations (indirect interference). Weeds compete with hop plants for nutrients, water, and—to a lesser extent—light. (Hop by nature grows tall and is trained to grow on an upright trellis system, therefore competition for light is not the problem it can be with other crops.) Some weeds also provide a favorable environment for certain pathogens or insects, including promoting the survival of detrimental pests during the period when hop plants are not actively growing. A heavy density of weeds in the hop yard can interfere with spraying, training, and harvesting, reducing both the efficacy and efficiency of various practices. Therefore, weed management must be considered in an integrated hop pest management program.

Weeds can present problems throughout the year in hop yards. Summer annual weeds are those germinating in the spring or summer, producing seed in late summer, and then dying. These weeds can interfere with spraying operations, distort sprinkler patterns, and interfere with harvest. Winter annual weeds typically germinate in the late summer or fall, overwinter, flower and produce seed in the spring, and die in early summer. These weeds typically have little direct impact on hop growth but can deplete stored soil moisture, interfere with hop yard maintenance, slow spring field operations, and host insect pests and pathogens. Perennial weeds live more than two years and often reproduce and spread from vegetative stolons or rhizomes. These weeds can create problems similar to those posed by annual weeds and are often much more difficult to control with herbicides and cultivation. Perennial weeds can be spread with tillage operations.

A few representative annual and perennial weeds are pictured in Figures 186 to 192. The pages that follow contain basic information on planning and executing an integrated weed management program in hop, as well as photos of many of the weeds that can be problematic in hop yards.

Representative Annual Weeds

Figure 186. Prickly lettuce. (R. Parker)

Figure 187. Lambsquarters. (R. Parker)

Figure 188. Kochia. (R. Parker)

Figure 189. Pigweed. (R.A. Boydston)

Representative Perennial Weeds

FROM TOP:
Figure 190. Canada thistle.
Figure 191. Field bindweed.
Figure 192. Blackberry.
(R. Parker)

Figure 193. Canada thistle seedling. (R.A. Boydston)

Figure 194. Common groundsel seedlings. (R. Parker)

Figure 195. Russian thistle seedlings. (R.A. Boydston)

Figure 196. Green foxtail seedling. (R.A. Boydston)

Figure 197. Kochia seedlings. (R.A. Boydston)

Figure 198. Shepherd's purse seedling. (R.A. Boydston)

Figure 199. Common lambsquarters seedling. (R.A. Boydston)

Figure 200. Puncturevine seedlings. (R. Parker)

Planning a Weed Management Program

Several factors should be considered when planning a weed management program in a hop yard. Weed species, tillage, row spacing, irrigation, cover crops, duration of crop (rotation), and herbicides all need to be integrated to develop an effective weed management strategy. A brief overview of some of these factors is presented in this section.

The first step in managing weeds in a cropping system is to identify the weed species present (See Weed Seedling Identification sidebar, opposite). The photos presented in this section are intended to aid in the identification of weeds at various growth stages. Weed seedlings are shown first, with other stages on the pages following.

Prevention

The first line of defense in hop yard weed control is to prevent weeds from becoming established. It is very difficult to prevent weed seed from infesting a hop yard, as weed seed and reproductive propagules are easily transported from outside areas into a yard via animals, birds, wind, equipment, irrigation water, and many other means.

Weed seed, stolons, and rhizomes can be brought in on soil and plant material when planting new hop yards. Cleaning equipment before moving it from one field to another, planting hop free of weed seed and vegetative propagules, screening irrigation water, and controlling weeds around field borders will help mitigate the establishment of weeds within the yard. Cultivating or mowing weed growth around the field border not only reduces the potential for weed seed movement into the field, but also improves air circulation and helps eliminate refuge areas for insect pests.

As weeds arise, further spread can be discouraged through diligence and immediate control of new weeds before they are allowed to produce seed.

Weed seed germination is triggered by optimum temperature, adequate moisture, and field operations that expose seed to light. Not all weed seeds located in the soil will emerge each year because most weed seeds have an inherent dormancy factor. For example, approximately 26% of kochia and 3% of common lambsquarters seed will germinate each year. With certain summer annual weeds, secondary dormancy will occur and seed germination stops when the temperature reaches a critical point. Winter annual weeds generally will not germinate until soil temperatures and/or day length begin to decrease. Perennial herbaceous weeds (e.g., Canada thistle, field bindweed, quackgrass) begin to grow when soil temperatures reach a certain point and will continue to grow until they either set seed or temperatures drop to a critical point.

Figure 201. Horseweed seedling.
(R.A. Boydston)

Figure 204. Curly dock seedling.
(M.A. Goll)

Figure 202. Pigweed seedling.
(R.A. Boydston)

Figure 205. Flixweed seedling.
(R.A. Boydston)

Figure 203. Barnyardgrass seedlings.
(R.A. Boydston)

Figure 206. Prickly lettuce seedling.
(R.A. Boydston)

Weed Seedling Identification

◆ Accurate weed identification should be the first step in any weed management program.

◆ Many weeds (e.g., hairy nightshade, common lambsquarters, and pigweed) look similar in the seedling stage, however their susceptibility to control measures can be quite different.

◆ To aid in proper seedling identification, a series of common weed seedlings affecting hops are presented in Figures 193 to 206.

◆ Proper weed identification is important for selecting the most effective and economical treatment in the hop yard.

Figure 207. Redroot pigweed. (R. Parker)

Figure 208. Aptly named redroot pigweed root. (R. Parker)

Figure 209. Powell amaranth is a pigweed species distinguished by its longer, slimmer inflorescence. (R. Parker)

Cultural (Non-chemical) Tactics

Tillage has a major impact on weed spectrum and population. Weed seed response to burial and exposure to light varies by species. Disking in the spring stimulates certain seeds to break dormancy and germinate. Tillage or cultivation practiced for annual weed control should be done as shallow as possible to avoid bringing new weed seed to the soil surface. Most annual weeds germinate from the upper 2 inches of the soil profile and can be controlled with shallow tillage without bringing deeper weed seed to the upper soil profile where it can readily germinate. Repeated tillage can weaken perennial weeds and exhaust reserves stored in rhizomes and stolons. However, tillage can spread small pieces of rhizomes and stolons to new areas not previously infested and create new or larger patches of perennial weeds.

The use of a fall-planted cover crop can reduce winter annual weed emergence and reduce weed emergence the following spring. Fall tillage may stimulate germination of certain summer annual weed seeds, which are then killed by freezing fall temperatures. This has the effect of reducing the soil seed bank. Summer annual weed populations will be lower in fall-tilled areas planted to a fall-planted cover crop. Fall-planted cover crops and weeds can then be killed with glyphosate (Roundup) before hop shoots emerge.

Tillage can be used to incorporate certain soil-active herbicides, such as trifluralin (Treflan). Again, shallow incorporation in the upper 2 to 3 inches of the soil profile will place the herbicide in the zone of annual weed seed germination where is it the most effective. Poorly timed tillage and traffic in the hop yard can also disturb preemergence herbicide barriers and expose untreated soil, allowing weeds to germinate and establish.

Organic mulches have been utilized in some organic hop yards to suppress weeds. Growing a cover crop and then mowing it and blowing the residues onto the hop crowns can suppress annual weeds. However, use of organic mulches can also have impacts—both positive and negative—on insect pests, voles, or plant pathogens. Synthetic mulches may also be useful in certain situations to suppress weeds, but are not widely used in conventionally grown hop yards.

Figure 210. Prickly lettuce leaves. (R. Parker)

Figure 211. Mature prickly lettuce plant. See also Figures 185 and 206. (R. Parker)

Figure 212. Puncturevine fruit. (R. Parker)

Figure 213. Puncturevine plant. (R. Parker)

New Hop Yards

Managing weeds during planting of a new hop yard is critical for the successful establishment of the newly planted hops. Planting schemes that allow for repeated and close cultivation to the hop plants reduce expensive hand weeding costs. Shallow, rather than deep, cultivation should be practiced to reduce the amount of new weed seed brought into the germination zone (upper 2 inches of soil).

Glyphosate (Roundup) can be used prior to hop emergence, but should be avoided once hop plants have emerged. Norflurazon (Solicam) is labeled for use as a preemergence herbicide in new plantings and can reduce the number of cultivations or hand weeding required. Pendimethalin (Prowl H_2O) is not restricted to established plantings, so this control can also be applied to new plantings. Clethodim (Select Max) can be applied to control emerged grass weeds that have escaped cultivation or pre-emergence herbicide treatments.

Once new hop plants have been strung and are approximately 6 feet tall, weeds can be suppressed with contact herbicides such as paraquat (Gramoxone) or carfentrazone (Aim).

Figure 214. Henbit plant. (R.A. Boydston)

Figure 215. Small kochia plant. See also mature plant, Figure 188. (R. Parker)

Figure 216. Common groundsel. (R. Parker)

Figure 217. Green foxtail stem with leaf. (R.A. Boydston)

Figure 218. Green foxtail inflorescence. (R.A. Boydston)

Figure 219. Henbit flower. (R.A. Boydston)

Figure 220. Field bindweed flowers. See also plant, Figure 191. (R. Parker)

Figure 221. Horseweed plant. (R. Parker)

Figure 222. Mature horseweed plants. (R. Parker)

Figure 223. Horseweed inflorescence. (R. Parker)

Figure 224. Horseweed buds. (R. Parker)

Figure 225. Curly dock inflorescence. It is a perennial broadleaf weed. (M.A. Goll)

Figure 226. Barnyardgrass is an annual grass weed. (R.A. Boydston)

Figure 227. Bermudagrass is a perennial grass weed. (R.A. Boydston)

Herbicides

Herbicides are becoming more widely used for controlling weeds in hop, but the number of herbicides available in hop production is limited. Herbicide selection should be based on the weed spectrum in each yard. It is extremely helpful for hop producers to keep records of previous weed infestations. Perennial weeds such as Canada thistle, field bindweed (wild morning glory), quackgrass, and Bermudagrass usually occur in patches initially. Scattered patches and individual weeds can be spot-treated with an herbicide, rogued, or cultivated. Soil-active herbicides applied during the dormant period may not provide adequate weed control because of inadequate incorporation (via rainfall, irrigation, or mechanical means) after application. Tools such as disking and postemergence herbicide application can help control weed escapes. Disadvantages of disking are that soil disturbance can stimulate weed seed germination and can deposit dust on hop foliage, which could enhance the buildup of spider mites. Field scouting immediately after weeds emerge is important to identify weeds and provide the information needed to choose a postemergence herbicide that matches the weed spectrum.

Several herbicides are registered for use in hop production: pendimethalin (Prowl H_2O), trifluralin (Treflan and several other trade names), norflurazon (Solicam), clopyralid (Stinger), 2,4-D amine (various trade names), glyphosate (Roundup), clethodim (Select), carfentrazone (Aim), flumioxazin (Chateau), paraquat (Gramoxone), and pelargonic acid (Scythe).

Pendimethalin, trifluralin, and norflurazon are primarily soil-applied and are applied prior to annual weed emergence. Trifluralin must be mechanically incorporated into the soil, whereas pendimethalin and norflurazon may be mechanically incorporated or incorporated into the soil by sufficient overhead moisture. Norflurazon can persist in the soil and injure rotation crops or cover crops, so proper planning is needed to avoid potential problems with this herbicide. Clopyralid, glyphosate, and 2,4-D are postemergence herbicides applied to actively growing weeds. Clopyralid is selective on some broadleaf weeds, particularly those in the sunflower, nightshade, pea, and smartweed families, and is particularly useful for control of perennial weeds in those plant families. 2,4-D controls a wider spectrum of annual broadleaf weeds and suppresses or controls many perennial broadleaf weeds found in hop yards. Glyphosate is non-selective and will control both annual and perennial broadleaf and grass weeds, but also will kill or seriously injure hop plants if allowed to contact hop foliage. Clethodim is selective in controlling most annual and perennial grass weeds found in hop yards and is applied after emergence of these weeds. Pelargonic acid, while registered, is not widely used.

Paraquat effectively controls emerged weeds and is sometimes tank-mixed with norflurazon. Carfentrazone and paraquat are used as desiccants to "burn back" basal leaves and suckers, aiding in air circulation and the removal of inoculum of the powdery and downy mildew pathogens. Carfentrazone is the most active product in burning back or desiccating hop foliage and will also control some annual broadleaf weeds as well as burning back field bindweed. It should be used with care, exactly as directed; damage has been reported in young hop yards when contact occurs on stems with underdeveloped bark. Paraquat, although not as active as a desiccant, will control both annual grass and broadleaf weeds and provide top kill of some perennial weeds. Paraquat can be used to control broadleaf weeds prior to bine training.

Table 5 presents a summary of the effectiveness of herbicides and cultural control practices for several common weeds in hop yards.

Specific herbicide use guidelines for Washington, Oregon, and Idaho can be found in the annually updated *Pacific Northwest Weed Management Handbook,* available from the Washington State University, Oregon State University, and University of Idaho extension services and online at http://pnwhandbooks.org/weed/

Table 5. Efficacy Ratings for Weed Management Tools in Hop

RATING SCALE: E = Excellent (90-100% control); G = Good (80-90% control); F = Fair (70-80% control); P = Poor (<70% control); ? = Efficacy unknown, more research needed; - = Not used for this pest; U = Used but not a standalone management tool, NU = Not Used.

TYPE: Pre = Soil-active against preemerged weeds, Post = Foliar-active against emerged weeds. Note that weed size or stage of growth is an important consideration with most postemergence herbicides.

		ANNUAL BROADLEAVES							PERENNIAL BROADLEAVES						
MANAGEMENT TOOLS	**Type**	**Kochia**	**Lambsquarters**	**Prickly Lettuce**	**Mallow**	**Mustards**	**Pigweed**	**Puncturevine**	**Bindweed**	**Blackberry**	**Curly Dock**	**Canada Thistle**	**Perennial Grasses**	**Annual Grasses**	**COMMENTS**
REGISTERED CHEMISTRIES															
2,4-D (Weedar & others)	Post	F-G	E	G-E	P	E	E	E	F-G	F	G	F-G	- -	- -	
carfentrazone (Aim)	Post	G	F	G	P	F	G	G	P	P	P	P	- -	- -	Broadleaf weeds need to be small and spray coverage must be good. Perennial weeds will regrow. Follow label directions carefully to avoid hop damage, especially early in the season and in young yards.
clethodim (Select Max)	Post	-	-	-	-	-	-	-	-	-	-	-	G	G-E	Repeat applications may be needed for perennial grasses.
clopyralid (Stinger)	Post	P	P	E	P	P	P	P	P	P	G	G-E	- -	- -	
flumioxazin (Chateau)	Pre	E	E	E	F	G	G	G	P	P	P	P	P	F-G	If small weeds are emerged, use in combination with a postemergence herbicide.
glyphosate (Roundup & others)	Post	E	E	E	P	E	E	E	F	E	?	E	F-E	E	Rating based on weeds not being dusty. Correct timing important on perennials. Repeat applications may be needed for Canada thistle and perennial grasses; timing and rates are critical for these weeds.
norflurazon (Solicam)	Pre	G	P-F	E	F	G	G	E	P	P	P	P	F	G	
paraquat (Gramoxone & others)	Post	E	E	E	F	E	E	E	P	P	P	P	P	F-G	Rating based on weeds being small and not dusty.
pendimethalin (Prowl H_2O)	Pre	G	E	F	P-F	F	E	G	G	P	P	P	P-F	E	
trifluralin (Treflan & others)	Pre	G	E	F	P	F	E	G	F	P	P	P	P	G	Requires mechanical incorporation for best results.
CULTURAL (NON-CHEMICAL)															
Cover crop between rows		U	U	U	U	U	U	U	F	F	F	F	P	U	Efficacy depends on cover type and stand quality.
Crowning (mechanical)		F	F	F	F	F	F	F	P	P	P	P	P	?	
Cultivation between rows		E	E	E	E	E	E	E	see comments				P-E	E	Good to excellent on perennials if very persistent and done correctly.
Equipment sanitation		Not a standalone management tool, but cleaning equipment before moving from infested to uninfested fields is always a good practice													
Hand hoeing/pulling		G-E	G-E	G-E	G-E	NU	G-E	G-E	P	P	P	P	P	G-E	Can be good to excellent if very persistent in efforts.

weed photographs continue next page...

Figure 228. Common mallow. (R.A. Boydston)

Figure 232. Blue mustard plant. (R.A. Boydston)

Figure 229. Common purslane plants. (R. Parker)

Figure 233. Blue mustard seed pods. (R. Parker)

Figure 230. Common purslane flowers. (R. Parker)

Figure 234. Severe blue mustard infestation. (R. Parker)

Figure 231. Individual purslane plant.
(S. Dewey, Utah State University, Bugwood.org)

Figure 235. Curly dock. See also mature plant's inflorescence, Fig. 225. (M.A. Goll)

Calculating Treated Acres versus Sprayed Acres

Herbicide rates on an herbicide label are usually given in pounds, pints, or quarts per acre. An acre is equal to 43,560 square feet. Herbicides in hop yards, particularly foliage desiccant control products, frequently are applied in bands over the row. Confusion commonly occurs in interpreting how much herbicide should be applied when the herbicide is used to treat only a portion of each field. To illustrate this, if a 4-foot band is applied only over the row, 10,890 feet, or 3,630 yards, of row would have to be treated to equal one treated or broadcast-sprayed acre. If hop plants were in rows spaced 14 feet apart and the herbicide label indicates the herbicide is to be applied at 2 pints per acre, then 2 pints of herbicide is enough to treat 3.5 field acres of hop plants. Since 2 pints equal 32 fluid ounces, each planted acre of hop will receive only 9.14 fluid ounces of herbicide.

Figure 236. Flixweed inflorescence. (R. Parker)

Figure 237. Flixweed plant in flower. (R. Parker)

Figure 238. Quackgrass. (S. Dewey, Utah State University, Bugwood.org)

Figure 239. Mature inflorescence of Canada thistle. See also Figure 190. (R. Parker)

Figure 240. Quackgrass rhizomes. (R.A. Boydston)

Figure 241. Quackgrass plant and rhizome. (S. Dewey, Bugwood.org)

Figure 242. Bermudagrass plants. See also Figure 227. (R. Parker)

Figure 243. Bermudagrass inflorescence. (R. Parker)

Figure 244. Bermudagrass stolon. (R. Parker)

Figure 245. Leaf cupping and stem twisting due to 2,4-D. Notice that upper leaves above the zone of herbicide contact appear healthy. (R. Parker)

Figure 246. Chlorotic (yellow) leaf tissue due to carfentrazone. (D.H. Gent)

Table 6. Common Symptoms of Herbicide Injury on Hop

Herbicide use carries an inherent risk of crop damage. When using herbicides, read and carefully follow label instructions to minimize crop injury and maximize weed control. Table 6 presents herbicide injury symptoms commonly observed on hop. Figures 245 through 256 display typical symptoms associated with herbicides commonly used in hop yards.

Herbicide	Symptoms
2,4-D (Weedar, others)	Leaf cupping usually will be exhibited on sprayed foliage, and developing leaves may be malformed. Some stem twisting may be observed. Symptoms seldom occur above the zone of spray contact (Fig. 245).
carfentrazone (Aim)	Sprayed foliage will exhibit chlorotic (yellow, Fig. 246) and necrotic (brown) stem tissue, with stem cracking reported on some hop varieties (Fig. 247). Sprayed growing points are killed. Chlorotic and/or necrotic spotting will be observed on leaves (Fig. 248) and stems (Fig. 249) if the herbicide drifts. Stem cracking, yellowing of lower leaves, and wilting in late season has been reported in younger hop yards.
clethodim (Select Max)	No symptoms have been observed on hop even at extremely high rates. The young growth of treated grasses will eventually turn yellow or brown, and the leaves in the leaf whorl can be easily separated from the rest of the plant.
clopyralid (Stinger)	Upward leaf cupping and some stem twisting sometimes will be exhibited, particularly on sprayed foliage (Figs. 250 and 251). Leaf cupping is seldom observed above the zone of spray contact.
glyphosate (Roundup)	Leaves may be chlorotic, necrotic, and malformed (Figs. 252 and 253). Leaf veins will often remain green while the areas between the leaf veins are yellow to white. Developing stems have shortened stem internodes. Cones may be malformed. Plants are often severely injured or killed. Symptoms may persist into the next growing season.
norflurazon (Solicam)	Leaf veins may be chlorotic to completely white (Fig. 254). The symptoms are usually temporary.
paraquat (Gramoxone, others)	Sprayed foliage will exhibit chlorotic and necrotic leaf tissue (Fig. 255). Stem cracking may be observed on some varieties. Sprayed growing points are killed. Chlorotic and/or necrotic spotting will be observed on leaves and stems if herbicide drifts (Fig. 256).
pendimethalin (Prowl), trifluralin (Treflan)	Root tips may be club-shaped and stems may emerge slowly if herbicide-treated soil is thrown over the root crowns when incorporating the herbicide. Occasionally stems are thickened where they emerge from the soil.

Figure 247. Stem cracking due to carfentrazone. (D.H. Gent)

Figure 248. Chlorotic spotting of leaves caused by carfentrazone drift. (D.H. Gent)

Figure 249. Necrotic spotting on stems due to carfentrazone. (D.H. Gent)

Figure 250. Severe cupping of leaves due to high rate of clopyralid applied to control Canada thistle. (D.H. Gent)

Figure 251. Slight cupping of leaves exposed to clopyralid. Leaf cupping is seldom observed above the zone of spray contact. (D.H. Gent)

Figure 252. Yellowing and stunting of leaves and shoots caused by a fall application of glyphosate. (M.E. Nelson)

Figure 253. Severe chlorosis of leaves impacted by glyphosate, in which the areas between the leaf veins are bleached to almost white. (D.H. Gent)

Figure 254. Leaf veins bleach yellow to white when injured by norflurazon, but plants generally recover. (D.H. Gent)

Figure 255. Yellowing and death of leaves caused by paraquat applied for spring pruning during cold weather. (D.H. Gent)

Figure 256. Yellow spots on leaves caused by paraquat drift. (R. Parker)