Weed Control and Vineyard Floor Management

Weed control is an important practice in vineyard management. Traditionally, the primary objectives for controlling weeds are to conserve soil moisture and reduce the competition for essential mineral nutrients required by the grapevines. Other benefits for weed control are improving air circulation to reduce the incidence of diseases, reducing cover for voles and other rodents, reducing competition for sunlight in low trellis systems, and improving harvest labor efficiency and satisfaction. For young vineyards, effective weed control is essential to reduce weed competition for water, nutrients, and light during critical periods of active growth to establish the vines and get them producing some fruit by the third growing season. Once the vineyard is well-established, it may continue to be essential to maintain a rigorous weed control program, or it could be cut back depending on the site characteristics. Factors that need to be considered in developing a vineyard weed control program include:

- The available moisture supply from precipitation and irrigation if available.
- The soil's ability to store moisture based on its texture, potential rooting depth and infiltration rate.
- The slope of the field as it affects surface runoff and potential for erosion.
- The soil's fertility [organic matter (OM) content] as it affects vine vigor.
- Inherent vigor of the grape cultivar.
- Sustainability in conserving soil organic matter and maintaining good soil structure.
- Other vineyard practices.
- Labor requirements and costs.

Weed control in vineyards can be separated into practices performed between the vine rows (alleys) and under the vines.

Weed control between the rows:

Weed control alternatives between the rows are cultivation or the use of sod in combination with mowing. Each practice has its advantages and disadvantages.

Cultivated alleys: In smaller plantings, weeds can be controlled easily by regular tilling with a rototiller. In larger plantings, tractor cultivation is generally required and may need to be need to be done 4 to 6 times per year. In the spring, weighted discs or tractor driven rototillers seem to be the best method for breaking up vine trimmings and vegetation. Later, a spring-tooth harrow may be used for regular cultivation.

Depending on the frequency of cultivation and timing based on the height of the weeds, cultivating the alleys can conserve soil moisture and minimizes competition for essential mineral nutrients. Also, there is less risk of spring frosts in vineyard with cultivated alleys than those with vegetation because there is nothing to intercept sunlight that warms the soil. However, cultivating the soil increases the risk of erosion and is not recommended for vineyards on steeper slopes. There is the risk of injuring the roots if the cultivation is too deep, and cultivation will lead to soil compaction below the till zone, particularly when the soil is too moist. In addition, you may not be able to get into a cultivated field in a timely manner following a rain, and cultivation does not conserve soil organic matter.

Whenever, cultivation of the alleys is practiced, growing winter cover crops is recommended. Winter cover crops should be sowed sometime in late July or early August. This will provide some competition for the vines and help them harden off for the winter. During the winter, a cover crop reduces soil erosion due to wind and water, insulates the soil and catches snow, both of which will help to protect the vine's roots from the winter cold. The most common annual cover crops are oats, cereal rye, and winter wheat. Oats are preferred because they typically will be killed over the winter, whereas wheat and rye tend to persist into the spring. Cereal rye does have allelopathic (weed suppressing) properties that will aid in controlling weeds in the spring when left on the soil surface as a mulch.

You need to consider these advantages and disadvantages when considering cultivated alleys as related to your specific

site conditions. One place where cultivated alleys has potential is where precipitation is very limited and trickle irrigation is practiced under the vines. Also, cultivated alleys are better suited for cultivars that require winter protection when soil is mounded over the vines.

Sod alleys: In Minnesota and other northern climate vineyards, the use of a permanent vineyard ground cover is a good alternative to clean cultivation. A permanent sod provides excellent insulation of the vine's roots against the winter cold and through its insulation effect tends to delay bud break in the spring. The sod will compete for soil moisture and nutrients, but it can also take up any excesses. The timing and frequency of mowing can be used to minimize these disadvantages and can aid in controlling vine vigor. Sod alleys aid in controlling erosion, improve the water infiltration rate, conserve soil organic matter, and allow equipment to travel through the vineyard under adverse conditions. However, vineyard with sod alleys are more prone to spring frosts than vineyards with cultivated alleys.

Ground cover species used for sod alleys are separated into legumes and non-legumes. Perennial legumes are not recommended for most northern vineyards because they fix nitrogen that stimulates vine vigor, delays the hardening off of vines in the fall, and increased the risk of winter injury. However, if a soil has a very low organic matter content and a sandy texture, a low growing moderate nitrogen fixing perennial legume such as Dutch white clover or Korean lespedeza may be beneficial.

Perennial grasses are the preferred groundcover in the alleys of northern vineyards. They grow low to the ground, can withstand traffic, are not too competitive for moisture and nutrients, go dormant during periods of drought, and can take up excess soil moisture and nutrients. Species recommended for northern vineyards include common Kentucky bluegrass, perennial ryegrass, creeping red fescue and other non-competitive fescues. For arid sites such as western Nebraska and the Dakotas, blue gramma, and buffalo grass can be used. Avoid K-31 tall fescue unless the site is very fertile, particularly in combination with a very vigorous cultivar. Under most conditions, K-31 tall fescue is just too competitive to be used in a vineyard.

The competition between perennial sod and grapevines intensifies with each additional year the sod is allowed to grow. Vine vigor and production can begin to drop after a few years of sod competition, and the availability of other nutrients may be reduced. This is particularly true for potassium because the sod takes it up and deposits it near the soil surface. Sod that covers two-thirds of the vineyard floor will require annual applications of about 30 lbs. of actual N/acre, and depending on the soil's OM content, additional N may be needed to maintain the sod.

Weed control under the vines:

Weed control practices under the vines can be achieved through cultural or chemical practices or a combination or the two methods. Cultural methods for controlling weeds include cultivation, mowing, mulching, burning and biological, while chemical methods include the use of pre- and post-emergence herbicides. Typically weed control under the vines focuses on the area 18" from either side of the vines for single curtain training systems when sod alleys are used. However, the width of weed-controlled area can be narrowed to cope with excess vine vigor.

Cultivation: In smaller plantings, weeds can be controlled by hand hoeing under the trellis. In larger vineyards, specialized tools such as a "grape hoe" or Weed Badger™ have been useful for controlling these hard-to-reach weeds. The mechanical hoe also is useful for hilling up soil over the vines for winter protection. The one main drawback of mechanical cultivators is that occasional damage to vines can occur. Cultivation has a short term effect of improving the water infiltration rate, but on a long term basis, it leads to crusting of the soil surface and greater runoff of precipitation. Cultivation increases the risk of erosion, can injure the roots near the soil surface, and leads to compaction of the soil below the till zone, particularly when practiced when the soil is too moist.

Mowing: Mowing under the vines is an alternative mechanical method of weed control, but requires specialized

equipment that could injure the vines when not properly adjusted. The mowed off ground cover will control erosion, but does compete some for soil moisture and nutrients so it is best practiced in combination with an irrigation system. It is not recommended for young vines because competition for water and nutrients should be kept to a minimum to promote good vine growth. For well-established vineyards, it can be used to control excessive vine vigor. The ground cover serves to control erosion, improves the infiltration rate and soil organic matter content. However, the ground cover increases the risk of spring frosts and can harbor voles and other pests.

Mulches: The use of mulches under the vines conserves soil moisture, improves the infiltration rate and controls erosion. However, the mulch increased the risk of spring frosts and can harbor voles and other pests. Both organic and man-make fabric mulches can be used in a vineyard.

Organic mulches that can be used include wood chips, leaves, straw and corn stalks. These materials will initially tie up available nitrogen and reduce growth, so additional nitrogen fertilizer may be required. They do increase the availability of potassium and phosphorous. Organic mulches improve the soil organic matter content, but can aggravate wet soil conditions, and some straws can introduce new weeds. Thick layers of mulch delay the warming of the soil and thereby delay the release of nitrogen held by the soil organic matter. This can lead to prolonged vine growth in the fall and delayed hardening off of the vines. Grass clippings directed off sodded alleys onto the area under the vines does act as a mulch, but is generally too thin to control weeds. These clippings do serve to improve undesirable characteristics associated with practice that create a bare area under the vines.

Man-made fabric mulches do not compete for nutrient, and can promote an earlier harvest when the fabric has reflective properties. The greatest disadvantages of using fabrics is that they can get caught up in a mower, and create an environment favorable for voles.

Burning: Burning with a flame is another form of weed control, but requires specialized equipment, and requires trunk guards for young vines or any vine with green shoots near the ground that are being saved to replace a trunk. Burning is only effective in controlling weeds that have emerged and are still succulent. Speed of travel is critical when using burning as a weed control strategy. Too slow you can burn the trunks and wooden posts, and waste fuel. Too fast and you get poor weed control.

Biological: Biological forms of weed control include smother crops as used before planting the vineyard, and cover crops in the alleys where cultivation is practiced. Winter cover crops, such as cereal rye could be used under the vines to take advantage of its allelopathic (weed suppressing) properties, but this requires special equipment to seed the rye, and it must be killed either with a contact herbicide or by crushing the stems before the rye tillers in the spring.

Another form of biological weed control is a living mulch. This can be achieved by seeding creeping red fescue under the vines. This grass species lays over and does not require mowing. A living mulch will control erosion, but as with mowing, it does compete some for water and nutrients. Therefore, it is not recommended for young vineyards and irrigation should be considered.

Grazing is another form of biological weed control that is being tried in some vineyards. Most notably this has been with sheep, caged chickens and weeder geese have been tried. For grazing to work, either the cordons need to be set high enough the that the sheep or birds cannot reach the crop, be isolated from the grapevines, or the grapevines need to be treated with a repellent that animals object to.

Chemical Control: Herbicides have proven to be particularly useful for controlling weeds under the vines and can be dramatically save on labor. Both pre-emergence and post-emergence herbicides are commonly used in vineyards. However, due to the sensitivity of the vine to certain herbicides, care must be exercised by the grower both in selecting an appropriate herbicide and in applying it at the proper rate. **Table 31** presents a list of

herbicides labelled for use in vineyards and restrictions on their usage. Grape growers are urged to identify the problematic weed species in their vineyard before selecting an herbicide. Your university extension office is also available to assist in weed identification.

Table 31. Pre-emergence and post-emergence herbicides registered for use in vineyards with restrictions on usage.

Pre-emergence		Post-emergence
Alion (5-yr AP)	**Princep** (3-yr AP)	**Aim** (3 day PHI)
Casoron (1-yr AP)	**Prowl**	**Fusilade** (50 day PHI)
Chateau (2-yr AP)	**Snapshot** (NB only)	**Gramoxone Inteon** (R)
Devrinol (70 day PHI)	**Solicam** (2-yr AP)	**Poast** (50 day PHI)
Goal (3-yr AP)	**Surflan** (oryzalin)	**Reglone** (NB only)
Karmex (3-yr AP)	**Treflan**	**Rely 280** (Cheetah) (14 day PHI)
Kerb (R)	**Trellis** (165 day PHI)	**Roundup** (glyphosate) (14 day PHI)
Matrix (1-yr AP, 14d PHI)	**Zeus Primel** (2-yr AP)	**Scythe**
	Zeus XC (3-yr AP)	**Select Max** (NB only)
		Venue (pre-bloom)
Restriction abbreviations: AP=after planting; NB=non-bearing; R= restricted use pesticide; PHI=pre-harvest interval.		

* *From*: Midwest Small Fruit and Grape Spray Guide.

Herbicide resistance: When using herbicides to control weeds a concerning issue is the development of "herbicide resistance". This is most evident with pre-emergence herbicides, but can occur with post-emergence herbicides. It occurs when a particular weed can no longer be controlled with a particular herbicide or herbicides with similar modes-of-action. To reduce the risk for developing herbicide resistance, the Herbicide Action Resistance Committee (HRAC) (http://www.hracglobal.com/) developed a code based on mechanism of action for an herbicide and the Weed Science Society of America (WSSA) developed a code based on the herbicide's mode-of-action for both Pre-emergence herbicides (**Table 32**) and post-emergence herbicides (**Table 33**). To avoid developing herbicide resistance when using herbicides:

1. DO NOT USE the same herbicide from year to year.
2. DO NOT USE herbicides that are of the same chemical group.
3. DO NOT USE herbicides that have the same modes-of-action.

Table 32. Classification of pre-emergence vineyard herbicides based on Herbicide Resistance Action Committee (HRAC) and Weed Science Society of America (WSSA) codes.

HRAC code	WSSA code	Mode-of-Action	Pre-emergence Herbicide
B	2	Inhibits enzyme action	Matrix
C 1	5	Inhibits photosynthesis	Princep
C 2	7	Inhibits photosynthesis	Karmex
E	14	Membrane disruption in light	Chateau, Goal, Zeus Primel, Zeus XC
F 1	12	Inhibits carotene synthesis	Solicam
K 1	3	Inhibits cell division	Kerb, Prowl, Surflan, Treflan, (Snapshot)
K 3	15	Inhibits cell division	Devrinol
L	20, 21, 29	Inhibits cell wall biosynthesis	Casoron, Trellis, (Snapshot), Alion

Table 33. Classification of post-emergence vineyard herbicides based on Herbicide Resistance Action Committee (HRAC) and Weed Science Society of America (WSSA) codes.

HRAC code	WSSA code	Mode-of-Action	Pre-emergence Herbicide
A	1	Inhibits lipid biosynthesis	Fusilade, Poast, Select
D	22	Rapidly disrupts cell membranes in light	Gramoxone Inteon, Reglone
E	14	Disrupts cell membranes in light	Aim, Venue
G	9	Inhibits amino acid synthesis	Glyphosate (Roundup, touchdown, Hancho, Ritter, etc.)
H	10	Inhibits amino acid synthesis	Rely 280, Cheetah
Z	27	Unknown, differ from others	Scythe

Pre-emergence herbicides are sprayed or applied to the soil in the fall or spring before weed seeds germinate. They control weeds by killing the germinating weed seedlings and must be moved into that germination zone by rainfall, irrigation, or shallow cultivation to be effective. Thus, most have absolutely no effect on weed foliage and often need to be tank mixed with a post-emergence herbicide in the spring to control weeds that have already germinated. They pose little threat the vines unless they are leached down into the root zone of the vines by excessive precipitation. Strict adherence to recommended application rates is essential, since many of these compounds can potentially cause damage to the vine's roots. The application rates for these herbicides is given in rate per acre, but only applies to the treated area under the vines and not the field acres the vineyard occupies. For example, if a vineyard rows that are 10 feet wide and the herbicide is being applied under the vines to strip that is 3 feet wide, then the treated area for a field acres would be 0.3 acre, or 3.33 field acres would be equivalent to one treaded acre. Further, the activity of these pre-emergence herbicides is closely related to the type of soil on which they are applied. Lighter, sandy soils will require a lesser rate of application. Heavier clay or organic soils will require higher rates to achieve the same level of weed control. These pre-emergence herbicides differ in their ability to control various weed types and species (**Table 34**). The grower must know his vineyard soil type and be able to select an appropriate application rate from the range of rates recommended on the label. Translating the rate into the appropriate sprayer tank mix also is critical to avoid over application and vine damage. The grower is advised to seek out information on sprayer calibration and tank mixing prior to proceeding.

Table 34. Effectiveness of pre-emergence herbicides registered for use in vineyard for controlling various types of weeds.

Herbicide	HRAC (WSSA)	Risk of resistance	Broadleaf		Grasses	
			Annual	Perennial	Annual	Perennial
Alion, Casoron	L (20)	Med.	Most	Some	Most	Some
Chateau	R (14)	Med.	Most		Some	
Devrinol	K3 (15)	Low	Some		Most	
Goal	E (14)	Med.	Most			
Karmex	C2 (7)	Med.	Most		Most	
Matrix	B (2)	Low	Some		Some	
Princep	C1 (5)	Med.	Most		Some	
Prowl	K1 (3)	Low	Some		Most	
Snapshot	K1 (3), L (21)	Med.	Most		Some	
Solicam	F1 (12)	Med.	Some		Most	
Surflan	K1 (3)	Low	Some		Most	
Treflan	K1 (3)	Low	Many		Most	
Trellis	L (21)	Med.	Most		Some	
Zeus	E (14)	Med.	Most	Some	Most	Some

Post-emergence herbicides are used to control weeds after they emerge from the soil. They can be applied as a band under the vines, or on a spot treatment basis using a hand-held applicator. They vary in their mode-of-action with some killing on contact, others must be absorbed, and others must be absorbed and translocated to the roots (**Table 33**). Many of these herbicides require a surfactant or other spray additive to be most effective. They can be selective or non-selective regarding the types of weeds they control. For some, the stage of weed development can be critical, while others can be effective in controlling established perennial weeds (**Table 35**). They can cause injury to the vines, so avoid contact with foliage, shoots and clusters when applying. This particularly evident with glyphosate which is absorbed and translocated to the roots. Symptoms often appear the following growing season (**Figures 35-38**). Suckers and water sprouts near the ground are the first shoots to emerge, so be careful with early applications of these herbicides. When using grow tubes, make sure the bottoms are buried in the soil to avoid a "chimney-effect" drawing in the glyphosate (**Figure 36**).

Table 35. Effectiveness of post-emergence herbicides registered for use in vineyard for controlling various types of weeds.

Herbicide	HRAC (WSSA)	Risk of resistance	Broadleaf		Grasses	
			Annual	Perennial	Annual	Perennial
Fusilade	A (1)	High			Most	Most
Poast	A (1)	High			Most	Most
Select	A (1)	High			most	most
Scythe	Z (27)	Low			Most	Most
Aim	E (14)	Med.	Most	Some		
Venue	E (14)	Med.	Most	Most		
Gramoxone Inteon	D (22)	Med.	Most	Suppress	Most	Suppress
Glyphosate (Roundup, etc.)	G (9)	Low	Most	Some	Most	Many
Reglone	D (22)	Med.	Most	Suppress	Most	Suppress
Rely280 (Cheetah)	H (10)	Low	Most	Some	Many	Many

For banded applications of both pre- and post-emergences herbicides should be applied with fan-type nozzles at or less than 30 psi pressure to produce larger droplets and minimize drift. These nozzles produce a fan-shaped, elliptical pattern so it is important to overlap spray pattern when spraying under the vines from each side of the row. Sprayers should be calibrated to deliver 10-40 gallons of solution per acre unless otherwise stated on the label.

Figure 35. Glyphosate injury on a young vine where the bottom of a grow tube was not buried.

Figure 36. Glyphosate injury from an application made the previous season.

Figure 37. Severe glyphosate injury from an application made the previous season.

Figure 38. Severe glyphosate injury from an application made the previous season affecting just a portion of the vine.

Additional information on herbicides registered for usage on grapes is available in regional Extension Publications:

- Midwest Small Fruit and Grape Spray Guide https://ag.purdue.edu/hla/Hort/Documents/ID-169.pdf
- New York and Pennsylvania Pest Management Guidelines for Grapes
- Michigan Grape Pest Management Guide
- NE Small Fruit Management Guide http://ag.umass.edu/fruit/ne-small-fruit-management-guide
- Guide to Fruit Production, *Ontario Ministry of Agriculture* http://www.omafra.gov.on.ca/english/crops/pub360/p360toc.htm
- CDMS Pesticide Label Database http://www.cdms.net/Label-Database.

Sucker management with herbicides: Some post-emergence herbicides are labelled for controlling suckers with some restrictions.

Rely 280, Cheetah: Apply when suckers are less than 12-inches tall. Do not allow contact with desirable fruit, foliage or green bark.

Aim: Apply when suckers are green. Do not allow contact with desirable fruit, foliage or green bark.

Gramoxone Inteon: Apple when suckers are less than 8-inches tall. Do not allow contact with desirable fruit, foliage or green bark. A RESTRICTED USE PESTICIDE.

Preventing Herbicide Drift and Injury to Grapes*

Grapes are especially sensitive to growth regulator herbicides such as 2,4-D and dicamba. When applied to nearby areas, these herbicides can drift to vineyards and cause significant injury to grapevines. Herbicide concentrations of 100x below the recommended label rate have been reported to cause injury to grapes. Field observations indicate drift from growth regulator herbicides can injure grapes ½ mile or more from the application site.

Herbicide drift can injure foliage, shoots and flowers. If injury is severe enough or occurs repeatedly, it can reduce yields and fruit quality, and occasionally cause vine death. Drift injury can result in substantial economic loss. In addition, drift to grapes from misapplication of pesticides can result in illegal residues on the exposed crop. Herbicide injury to grapevines can last several years after the occurrence of the drift. It may reduce vigor, increase susceptibility to diseases, decrease yield and fruit quality and shorten the life of the vineyard.

Injury from growth regulators (2, 4-D and dicamba) usually appears within 2 days of the drift incident as epinasty of the shoot tips (**Figure 39**). Symptoms of 2,4-D injury include characteristic fan-shaped leaves with sharp points at leaf margins (**Figures 40** and **41A**) while cupping is often associated with dicamba exposure (**Figure 41B**). Leaf strapping with deep sinuses, and leaf puckering with constricted veins that may be slightly chlorotic. Exposure to growth regulator herbicide drift can arrest the development of some berries (**Figure 42**), and affects fruit quality, including fruit color, sugar levels and acid content. Shoot tips seldom resume growth after injury, but laterals continue to grow. The result is a very bushy vine with a shade canopy and poor fruit exposure. Injury is particularly severe when multiple incidents occur to the same grape planting over a period of years.

It would be wise to encourage your neighbors and the local weed control crews (road, rail and utility right-of-ways) to use another herbicide or resist from herbicide use altogether near your vineyard, as it may drift for distances in excess of one mile. The local extension agent, local Ag suppliers of herbicides and aerial applicators should be made aware of your vines and their susceptibility to damage. (*Register your site on a sensitive crops registry. The state of Minnesota participates in DriftWatch™ Specialty Crops Site Registry* (http://driftwatch.org).)

* (Ball, D., R. Parker, J. Colquhoun, and I. Dami. 2004)

Figure 39. Early symptom of growth regulator herbicide drift injury is epinasty of the shoot tips.

Figure 40. Severe early season symptoms of growth regulator herbicide drift injury.

Figure 41. Typical fan-leaf injury symptom caused by 2,4-D (A), and cupping pattern caused by dicamba (B).

Figure 42. Green berries caused by exposure to growth regulator herbicide drift.

On occasion, 2,4-D may be needed to clean up invasive broadleaf weeds such as Dutch white clover or dandelions. If used, apply the 2,4-D when the grapevines are dormant, either in the spring before the buds begin to swell or in the fall after a killing frost. Also, a less volatile amine formulation of 2,4-D, such as Formula 40® should be used. In the spring, suckers and water sprouts developing near the soil surface are first to emerge, so be sure they have not begun to grow when using 2,4-D in a vineyard.

Vineyard Best Management Practices – Care of Established Vineyards

Rate your vineyard establishment practices:

Management Area: **Weed control and vineyard floor management**	**Best Practices**	**Minor Adjustments Needed**	**Concern Exists: Examine Practice**	**Needs Improvements: Prioritize Changes Here**
Development of the between the rows program	Based on the availability of moisture, potential for erosion, soil fertility, vine vigor, sustainability, influence on other practices, and labor & cost requirements.	Based on the availability of moisture, potential for erosion, soil fertility, vine vigor, sustainability, and labor & cost requirements.	Based on the availability of moisture, potential for erosion, soil fertility, and labor & cost requirements.	Based on labor and cost requirements only.
Development of the under the vines program	Based on the availability of moisture, potential for erosion, soil fertility, vine vigor, sustainability, ease & frequency of performing, and labor & cost requirements.	Based on the availability of moisture, potential for erosion, soil fertility, sustainability, ease & frequency of performing, and labor & cost requirements.	Based on the availability of moisture, potential for erosion, ease & frequency of performing, and labor & cost requirements.	Based on labor and cost requirements only.
Selecting herbicides	Aware of restrictions on usage when selecting herbicides to use.			Did not consider restrictions on usage when selecting herbicides to use.
Herbicide effectiveness	Considered the effectiveness for control problem weeds in the vineyard.		Did not considered the effectiveness for control problem weeds in the vineyard.	
Pre-emergence herbicides - herbicide resistance	Did not use the same herbicide, herbicides from same chemical group or mode-of-action from year to year.	Did not use the same herbicide from year to year.		The same pre-emergence herbicide was used year to year.
Post-emergence herbicides	Avoided contact with foliage, shoots and clusters when applying.		Did not take precautions to void contact with foliage, shoots and clusters when applying.	
Herbicide drift	Took measure to alert neighbors, right-of-way crews of the risk to grapevines, and registered on a sensitive crop site.	Registered on a sensitive crop site.	No effort to alert neighbors, right-of-way crews of the risk to grapevines.	