Agriculture Notes

Organic Farming: Vineyard Weed Management

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Introduction

Organic viticulture, like other organic industries, entails the production of high quality food products from agricultural systems that rely upon more natural approaches to crop nutrition, pest and disease control, and management of natural resources such as soil.

The principles of organic viticulture include:

- the development and maintenance of good soil structure, fertility and biological activity, and
- the exclusion of most viticultural chemicals.

Weed management is one of the most challenging issues faced by grape growers adhering to these principles. Managers of organic vineyards need to achieve effective control of weeds without using synthetic herbicides and ideally with minimal disruption to the soil.

They meet this challenge by selecting from a wide range of acceptable techniques to develop weed management programs appropriate to their particular situation.

Figure 1. Like most farmers, organic grape growers devote considerable resources to managing weeds.

This publication provides a general introduction to weed management and weed control techniques suitable for organic vineyards.

Weeds in viticulture

What is a weed?

There are many reasons why certain plants are, or become, weeds in vineyards. Plants are commonly defined as weeds if they exhibit one or more of the following characteristics:

- compete with vines for water (most plants);
- compete with vines for nutrients (most plants, especially non-legumes);
- interfere with water distribution from low-level sprinklers (most plants);
- harbour grape pests (most broadleaf plants host lightbrown apple moth);
- produce spiky seeds that may injure workers or contaminate produce (eg. caltrop or puncture vine: *Tribulus terrestris*);
- interfere with harvest or other vineyard operations (any tall plants);
- compete with more desirable cover crops (eg suppression of clover by capeweed: *Arctotheca calendula*);
- contaminate export tablegrape bunches with quarantinable seeds (eg. some thistles);
- affect vineyard aesthetics.
- have the potential to invade neighbouring properties where they can exert their undesirable qualities

Classify weeds thoughtfully

Before developing a weed management program, it is important that organic viticulturists consider their definition of weeds carefully. In many situations, considerable time, energy, money and other resources are spent combating ‘weeds’ that are in fact causing no physical or economic harm to the vineyard enterprise. As with the management of any pest, the use of resources to control vineyard weeds is only warranted when those weeds cause, or are very likely to cause, economic or other loss to the vineyard or neighbouring properties.

Volunteer plants in vineyards are often defined as ‘weeds’ simply because they were not deliberately planted as part of the grapevine/cover crop system. However, that definition alone does not justify efforts to control those plants. To determine their real weed status, the

characteristics of volunteer species need to be considered, in relation to the management objectives of the vineyard and those of your neighbours. When these volunteer species are divided into 'real weeds' and 'other plants', the grape grower's job becomes easier.

Figure 2. Weed management needs to be focussed on 'real' weeds such as Gentle Annie (Cenchrus longispinus).

Weeds are not always weeds

The real and perceived status of plants as 'weeds' can vary significantly between vineyards and regions because of differences in soil, climate, vineyard age, management practices, end use of the crop and the philosophy of individual grape growers. For example, grasses are often encouraged in cool climate vineyards on fertile soils where their competition for nitrogen is used to reduce excess vine vigour. On naturally poor soils of some hot, dry regions however, summer grasses tend to be discouraged, because they compete for water and nutrients – major issues for some regions. Summer ground cover does however help reduce vineyard temperatures and dust. Many agricultural weeds have been defined as such because of their negative impact in pasture and grain cropping systems, the dominant form of agriculture in Australia. Their impact, or role, in vineyards can be quite different.

Because of these differences, it is important that grape growers assess the weed status of plants in their own particular situation. However, consideration of potential weed spread to neighbouring properties should always be taken into account. Your weed management should be prioritised by: 1. Impacts on your vineyard, and 2. Potential impacts on your neighbours.

Beneficial 'weeds'

Some 'weeds' provide benefits of value to organic vineyard systems, and these benefits need to be weighed against any negative characteristics of the weeds. Some benefits of weeds are listed below:

- *Soil protection* - Most plants protect otherwise bare soil from the effects of sun, wind and rain.
- *Food source for beneficial insects* - Many flowering plants produce pollen or nectar that is a useful food source for beneficial insects such as *Trichogramma* (a wasp parasite of lightbrown apple moth), hover flies and lacewing insects (predators of mealybugs, scales and other vine pests) and predatory mites (predators of pest mites on grapevines). Other plants, like thistles, support aphids which provide a food source for beneficial insects and help maintain populations of those beneficial species in the vineyard.
- *Nutrient recycling* - Deep-rooted plants play a useful role in nutrient recycling by absorbing nutrients from lower in the soil profile and redistributing them when the plants decompose.
- *Weed suppression* - heavy growth of some 'weeds' like grasses, can suppress the establishment and growth of less desirable weeds such as the spiky-seeded three-cornered jack.

Pre-planting weed management

Managing weeds before vines are planted, helps to reduce the weeds' competitive pressure during the establishment phase of the new vines. It also helps to reduce the risk of vine damage resulting from post-planting weed control practices such as cultivation.

Pre-planting weed control is especially important where the ground is infested with perennial weeds like couch grass (*Cynodon spp*), Johnson grass (*Sorghum halepense*) and nutgrass (*Cyperus rotundus*). Weeds such as these, established amongst vines, are much more difficult to manage than those growing in open ground.

Weeds in new vs established vineyards

Good weed management is critical for newly planted vineyards, because of the relative inability of new vines to compete for light, water and nutrients. Vines are most susceptible to competition from weeds during their first three to four years of growth (Elmore & Donaldson 1999).

Inadequate weed management during this period can significantly delay the early growth and profitability of new vineyards. After this time, the vines' larger root systems permit them to compete with weeds more strongly. Shade from the vine canopy also helps suppress weed growth under established vines.

Figure 3. Effective weed management helps give these new organic vines a good start.

Integrated weed management

Integrated weed management (IWM) is an approach to weed management that helps growers achieve the most effective weed management outcomes in the short and long-term. Like IPM (integrated pest management), successful IWM relies upon some basic principles that include:

- correct identification of weeds
  - know what you are dealing with;
- some understanding of weed ecology
  - know why the weeds grow where they do, and how they get there;
- appropriate vineyard design
  - eg: choice of irrigation system can influence weed development and weed management approaches;
- choice of appropriate management methods
  - use effective techniques that minimise negative impacts on the vineyard environment (eg. soil);
- monitoring
  - know where weeds are a problem and how effective the control strategies have been.

Rather than relying upon one or two methods of weed control, IWM makes use of any appropriate methods to deliver the best outcome. One reason to integrate several weed control methods into a weed management program is that generally, no one method can control all weeds, cost-effectively, all the time. This is because, for example,

- some weeds are easier to control than others;
- some weeds are annual and some perennial;
- some are spread by cultivation, others by wind;
- some are avoided by grazing animals;
- some are very competitive against cover crops.

By combining weed control methods, grape growers can reduce the risk of particular weeds dominating the vineyard and causing major problems.

Total property weed management

IWM programs should take the whole property into account. This helps minimise the risk of the actual vineyard area being continually reinfested by weeds carried by wind or on machinery from less-intensively managed areas such as roadsides, headlands, irrigation channels and habitat reserves.

Also, weed management needs to be integrated with overall vineyard management. Weeds, pests, diseases, soil, water and vines are all interrelated aspects of the vineyard system. Good planning and timely implementation are required for grape growers to maximise the benefits from their IWM programs.

Figure 4. Non-vineyard areas like irrigation channels need to be included in the weed management program.

Keep weed management objectives realistic

Weed management objectives need to be realistic and achievable if the programs are to have any chance of implementation, let alone success. For example, where curled dock (*Rumex crispus*) is considered undesirable, an objective to eradicate it from a vineyard within the short to medium term may be unrealistic, given that dock seed can remain viable in the soil for up to 80 years (Telewski and Zeevaart 2002). A more realistic objective would be to prevent further seed set of that weed.

Like the actual definition of weeds, a grower's objectives and motivation in weed management should be considered carefully.

Weed management techniques

Quarantine

Quarantine is used to minimise the introduction of weeds into the vineyard, and their spread between vineyard blocks. As a preventative measure, quarantine is very cost-effective, compared to the resource input required to suppress introduced weeds over the long-term.

Figure 5. Ensure mulch and other materials obtained off-site are free of noxious weeds.

This approach also reduces the risk of undesirable chemical residues entering organic vineyards. When using the quarantine approach, vineyard managers:

- restrict the movement of machinery, people and livestock onto and across the property, especially those coming from high-risk, weed-infested sites;
- clean machinery/equipment before it enters the vineyard, to remove weed seeds, bulbs, roots etc;
- take care in selecting clean sources of potted vines, mulch, raw materials for compost, or other materials that may be weed-infested;
- develop buffers such as windbreaks and surface water diversion, against wind and water-borne seed from adjacent properties.

Hygiene

Hygiene is a component of quarantine, and involves additional elements that reduce the spread of weeds within a vineyard. As well as the points listed above, vineyard managers should:

- prevent weed seed set wherever possible;
- avoid activity that spreads weeds vegetatively, eg. avoid cultivating through areas infested with nutgrass, couch grass or other perennial weeds;

- destroy seed of noxious weeds by burning, deep burial etc. Grazing is not always a reliable technique, as the seed of many weeds germinates after passing through grazing animals (Govt. British Columbia 2002).

Figure 6. Weeds are spread easily on vineyard equipment.

Monitoring

Monitoring is an important aspect of weed management. It helps grape growers to identify a site's major weed issues and hotspots, select appropriate management techniques, and determine the best timing of treatments (eg. soon after germination to prevent weed establishment or at the start of flowering to prevent seed set). Monitoring also reveals the effectiveness of weed control techniques. This is necessary for fine-tuning of weed management programs.

For monitoring to be of value, it is important that weeds are identified correctly. Guides are available to help with this. Weed surveys and mapping are also a useful way to document a vineyard's weed status for future reference.

Surveys should be carried out at times appropriate to the particular vineyard situation, eg. on drip-irrigated sites a week or two after significant rainfall events, to detect widespread germination of summer weeds, or after autumn breaking rains for winter weed germination.

Figure 7. A new flush of caltrop seedlings two weeks after summer rain.

Competition

Weed growth can be suppressed by competition from other plants for water, light, nutrients and space. A simple weed risk formula applies to organic vineyards like most other agricultural systems:

Bare soil = Weed problem!

In most ecosystems with adequate water resources, bare soil is unnatural, a sign of imbalance or disturbance. To counter this, many plants are adapted to colonise and cover bare soil very effectively. The result is that grape growers who attempt to maintain their system in a state of imbalance, ie. keep their vineyard soil bare, generally find themselves battling constantly against these colonising plants, or 'weeds'.

In contrast, many weeds are poor competitors, and their establishment, growth or seed production can be greatly reduced by a reasonable level of competition from more desirable plants. Wherever possible, growers should design bare soil out of their vineyard management system.

Cover crops and green manures are commonly used in organic viticulture to improve soil structure and fertility, and out-compete weeds in the inter-row area. Weed pressure is also reduced by the cultivation used to prepare seed-beds for these crops. The choice of appropriate crops will depend upon local climate, soil conditions and water availability. Mixtures of cereals and legumes are often the most competitive cover/green manure crop, but local expertise and experience should be used in choosing the right crop for each situation.

For effective weed suppression, green manure and cover crops need to be managed well so they cover the soil as quickly as possible to smother emerging weeds. Particular attention should be given to irrigation, nutrition and pre- and post-planting weed management, with such an implement as the Striegel, a flexible-tined finger harrow.

Figure 8. Inter-row weeds are suppressed by a white clover-based cover crop in this organic vineyard.

Another aspect of competition is that of allelopathy, which involves the suppression of seed germination or plant growth by chemical substances produced by another plant. These substances may be leached from the foliage or secreted from the roots of the growing plant, or released from the plant when it dies and decomposes. Many plants produce allelopathic substances (Rice 1984). Of the potential cover/green manure crops for use in organic vineyards, barley and cereal rye are known to suppress numerous weed species and are considered to have the greatest allelopathic potential.

Mowing

Mowing is often used by organic grape growers to keep cover crops and weeds to a manageable height. It is a relatively fast operation that causes minimal soil disturbance, although soil compaction may become an issue where mowing is frequent.

Figure 9. Lighter alternatives to tractor-driven mowers can be used to reduce vineyard soil compaction.

The timing and height of mowing are important and can be manipulated to suit the grape grower's objectives. Mowing during or before flowering of weeds will prevent seed production. High mowing (eg. 20cm) will reduce or prevent seed set in medium to tall weeds while allowing useful species, including non-grasses, to regenerate. Low mowing tends to favour grasses over many other desirable plants, because the regeneration point for grasses is low. For the same reason, low mowing is not effective against weeds with very low crowns, like capeweed and caltrop.

Mowing of cover crops or resident vegetation can be used to produce mulch material for weed suppression in the inter-row or vine-row areas. If mulch is desired, slasher mowers are preferable to mulchers (eg. flail mowers). The coarser material produced by slashers will break down more slowly and have a longer effective life as a mulch.

Growers should consider a program of slashing alternate rows, allowing the uncut rows to provide habitat and food sources for beneficial insects in the vineyard.

Grazing

Grazing has considerable potential for weed management in vineyards, and is in keeping with organic certification standards which encourage the incorporation of livestock into organic farming systems. In vineyards, sheep and geese are the most likely candidates because of their size and relative ease of management. A side benefit of grazing is that useful nutrient recycling occurs through conversion of weeds into manure. Well-managed grazing livestock can also provide a useful income source.

Grazing needs to be managed to avoid damage to vine shoots. In well-established Australian organic vineyards that use winter grazing for weed control, the sheep are removed from the vineyard before budburst to prevent them from eating the new vine shoots.

Figure 10. Sheep performed a useful weed management function in this Victorian organic vineyard.

Grape growers using grazing for weed control need to address several management issues including:

- a need for temporary fencing or a suitable alternative to control stock movement and avoid over-concentration in specific areas;
- protection from predators (eg. dogs, foxes & eagles);
- selective grazing (eg. geese prefer grass) that can lead to dominance of specific weeds.

Heat

Thermal weeding uses heat in various forms (radiant, flame, steam, hot water) to kill plant tissue. This technique has been researched and used for weed control for many years, but is generally economically effective only against small seedlings. For this reason, thermal weeding is most commonly used on row-crop seedbeds, to kill the new flush of weed seedlings before the crop germinates. It has however also been used in vineyards and orchards.

Figure 11. Trialing vineyard weed control with super-heated steam from a new Vaporjet® thermal weeder.

A benefit of thermal weeding is that it does not disturb the soil. Organisms below the soil surface are generally not affected, as the heat does not penetrate far into the soil. A disadvantage of thermal weeding is its high energy cost - it is usually based on fossil fuel such as diesel or bottled gas. It is also a relatively slow operation to achieve a good weed kill. Also, flame weeders may create a fire risk, especially where there is dry ground cover or mulch.

Research into thermal weeding continues, and new advances in technology will help make it a more

economical and practical weed management option for organic grape growers.

Rolling

Weeds and cover crops may be flattened with a roller instead of being mown. Rolling leaves the plants largely intact, so they break down more slowly and create a longer-lasting mulch layer. The experimental roller pictured below is cheap to manufacture and maintain, and can be towed by a four-wheel ATV.

Figure 12. The ribbed roller shows promise for vineyard weed management.

Mulching

Mulch inhibits weed growth and germination of weed seeds by blocking sunlight and light rainfall from reaching the soil surface. It also forms a physical barrier to weed growth. Almost any organic material can be used as mulch, with straw being commonly used in vineyards. Grape marc and composted green municipal waste is also used. Other materials include shredded paper, wet paper pulp (sprayed on) and jute matting.

Figure 13. Straw mulch used for in-row weed suppression.

The correct depth of mulch is important. Weeds will not be suppressed effectively if the mulch is too thin, and overly thick mulch can shed sprinkler water and rainfall away from the vine row. Some local experimentation may be required to determine the best mulch depth for each situation, but as a general guide, approximately 20cm of straw mulch is recommended, while only 7.5cm – 10cm of composted green waste mulch is required (Buckerfield personal communication).

Mulching is commonly used for weed control in the vine row and is particularly useful on stony soils where under-vine cultivation is difficult or impossible. Good reasons for managing in-row weeds with organic mulch include:

- some mulches (eg. partly composted green waste) are a useful source of nutrients;
- the mulch adds organic matter to the soil;
- vine roots concentrated directly under the vine are protected from excessive heat;
- mulch greatly reduces evaporation, thus conserving soil moisture;
- mulching helps avoid vine damage from cultivation;
- vine trunks, sprinklers and irrigation tubing make cultivation and mowing difficult in the vine row.

Mulches do have some disadvantages that include:

- partly decomposed mulch may create an ideal seedbed for weeds;
- mulch may harbour pests such as snails;
- it can be difficult to manage weeds at the mulch/inter-row interface without disturbing the mulch (steam weeding is an option).

The need for reapplication of organic mulches, possibly annually, has to be considered when costing this method of weed management. Also, as most organic mulch material is bulky, the cost of transport and handling needs to be considered.

Another consideration relating to mulch materials is their influence on soil microbial communities. 'Soft' materials such as straw or slashed cover crops are likely to favour bacterial decomposers, while fungi are more likely to be encouraged by 'hard' materials such as chipped wood. Growers who aim to fine-tune their soil management may need to take this into account.

Mulch costs may be reduced by growing mulch material on-site as inter-row green manures or cover crops. The mowing/mulching operation may be performed in a single pass with a side-throw mower that delivers the material directly to the under-vine bank. This is a good approach for organic vineyards, as it reduces the need for external inputs. It also reduces the risk of bringing unwanted weeds into the vineyard, in contaminated mulch material.

Synthetic weed mat effectively suppresses some weeds, and a temporary mulch of black plastic may be used to kill patches of difficult weeds including couch grass, by starving them of water and sunlight.

This technique does not need the hot conditions required for solarisation (see below), but has to be applied over months rather than weeks. Disposal of these materials is an environmental issue that organic growers would need to consider. Also, their use may be restricted by organic certification organisations.

Biological control

Like most plants, weeds are subject to attack by their natural enemies including root, stem and seed-eating insects, mites and diseases. In some cases these organisms are officially imported, and, after considerable research, released for the control of introduced noxious weeds. There have been some spectacular successes in the biological control of major weeds in Australia, but most common vineyard weeds have not warranted this level of

attention. Weeds that are, or have been, the target of biological control in Victoria are listed in Table 1.

Table 1. Weeds targeted for biological control in Victoria.

Blackberry	*Rubus fruticosus* agg.
Boneseed	*Chrysanthemoides monilifera*
Bridal creeper	*Asparagus asparagoides*
Cape broom*	*Genista monspessulana*
Chilean needle-grass*	*Nassella neesiana*
Common heliotrope	*Heliotropium europaeum*
Cord grass*	*Spartina* spp.
Dock	*Rumex* spp.
English broom	*Cytisus scoparius*
Flax leafed broom*	*Genista linifolia*
Gorse	*Ulex europaeus*
Horehound	*Marrubium vulgare*
Illyrian and Scotch thistles	*Onopordum illyricum & O. acanthium*
Paterson's curse	*Echium plantagineum*
Prickly pear	*Opuntia stricta*
Ragwort	*Senecio jacobaea*
Serrated tussock*	*Nassella trichotoma*
Skeleton weed	*Chondrilla juncea*
Slender thistle	*Carduus pycnocephalus* & *Carduus tenuiflorus*
Spear thistle	*Cirsium vulgare*
Spiny emex	*Emex australis* & *Emex spinosa*
St John's wort	*Hypericum perforatum*
Tiger pear	*Opuntia aurantiaca*
Tutsan	*Hypericum androsaemum*
Variegated thistle	*Silybum marianum*
* weeds earmarked for biological control research	

Figure 14. Caltrop seed damaged by seed-eating weevils.

Biological control programs are generally operated by the Government rather than by individual land holders. Anyone seeking information on these programs in Victoria should contact the Victorian Department of Primary Industries Frankston (see 'Useful information sources').

Figure 15. Larvae of the Paterson's curse weevil, Mogulones larvatus *damaging a rosette.*

Soil modification

Different plants are adapted to different soil conditions like high or low pH, salinity, fertility, moisture content, compaction and so on. Because of this, the presence, dominance or quality of growth of particular plants, including weeds, may indicate to some degree, the underlying soil conditions.

*Figure 16. A predominance of wireweed or knotweed (*Polygonum aviculare*) is indicative of compacted soil, and is commonly found on vineyard headlands.*

Awareness of this relationship between weeds and soil gives vineyard managers some opportunity to address their weed issues by modifying their soil conditions. In the long-term, this may be more cost-effective than tackling the weeds directly.

Weeds are not always 100% reliable as indicators of specific soil conditions because, for example:

- some weed species are tolerant of a wide range of soil conditions;
- some are sensitive to a number of environmental conditions;
- some species develop localised 'ecotypes' that differ in their adaptation to specific conditions.

For this reason, care should be exercised when using weeds as soil indicators. Communities of weeds, rather than individual species, are likely to give more reliable indications of soil conditions.

Numerous sources exist for information on 'indicator plants' but not all are reliable. Growers should compare several information sources and combine them with their

own observations as a basis for interpretation of the soil conditions indicated by their weed communities.

Mechanical cultivation

Cultivation destroys or buries weeds, disrupting their growth and preventing seed set. Most forms of cultivation are very disruptive to soil structure and to soil organisms. Cultivation can also spread seeds, tubers and rhizomes of noxious weeds, is relatively energy-expensive and increases the risk of soil compaction. Despite these costs, cultivation is common practice in organic viticulture.

Figure 17. Vine rows are often cultivated for weed control in organic vineyards.

Standard tools such as disc or chisel/tine ploughs are generally used to cultivate the vineyard inter-row area. The undervine area is cultivated with specialised equipment - some examples are shown in Figure 18.

These tools are mounted on manually or automatically-operated retractable arms, so they can be moved around vines and irrigation risers. With this equipment, experienced operators can clean vine rows of weeds relatively quickly, with little if any damage to the vines.

Some growers use these or other tools to control annual weeds with the scrape-off/throw-on strategy. Soil is repeatedly shuffled on and off the under-vine area to destroy weeds where the soil is removed, and smother those where the soil is dumped.

In hot dry climates, under bare soil, grapevine roots usually avoid the top 100mm or so of soil, so the root system will be largely unaffected by shallow cultivation. In cooler regions, or where mulch has been applied, shallow roots will develop and these will be destroyed by undervine cultivation.

Undervine knife

Mac Rotary Weeder

Weed Badger®

Rinieri disc cultivator

Pellenc Tournesol®

Spedo® Underviner

Figure 18. Cultivation implements.

Solarisation

Solarisation involves the destruction of plants and seeds by the solar heat trapped when soil is covered by clear plastic sheeting during hot weather. While this technique is more commonly used to kill disease organisms in the soil, it is also effective against many weeds and their seeds. However, it is generally not effective against weeds with deep tubers or rhizomes, like Johnson grass.

Effective solarisation requires good movement of heat into the soil. This is aided by high levels of soil moisture, so, if necessary, the soil should be irrigated before the plastic is laid down. Air gaps between the plastic and soil should be minimised as they inhibit heat transfer into the soil. To prevent the plastic being lifted by wind, and to reduce the leakage of heat, the edges of the sheet should be buried.

Solarisation for at least four weeks is likely to be needed for effective weed kill. This will vary according to the quality of plastic sheet used, the prevailing temperatures and weed species present. Winter weeds are likely to be less tolerant of high temperatures than summer weeds, and therefore more strongly affected by solarisation.

Figure 19. Plastic being applied for soil solarisation.

To avoid reinfestation of treated areas with weeds, the soil should be mulched or sown to a green manure/cover crop as soon as possible after removal of the plastic. Avoid bare soil!

Hand cultivation

Organic grape growers often do some hand weeding to remove weeds from around young vines or weeds that are too close to vine trunks to be removed by undervine cultivators or mowers. Although hand weeding is time-consuming, and therefore expensive, it is effective and gives growers an opportunity to observe their soil, vines and vineyard closely.

Figure 20. Young organic vines are hand weeded to avoid damage from undervine cultivators.

Chemical

Organic knock-down herbicides based on plant extracts like pine oil are available commercially. These herbicides disrupt the cuticle of plants and cause them to desiccate.

Even though these herbicides are organic, they still involve the application of chemical substances to the vineyard ecosystem, and should be used with care, as the effects of their long-term use are not yet known. The use of organic herbicides to replace synthetic herbicides also diverges from the spirit of the organic approach, which involves considering and managing the vineyard differently, rather than simply substituting allowed inputs for prohibited inputs.

The organic herbicides currently available need to be applied at relatively high concentrations and seem to work well only against small seedlings. Because of this, their cost-effectiveness should be assessed carefully before organic grape growers incorporate them into weed management programs.

Growers considering the use of organic herbicides should first obtain details of any permitted products from the relevant organic certification organisation.

Figure 21. Mature capeweed lightly damaged by a pine oil-based organic herbicide.

Timing is critical!

In some situations, the timing of weed control treatments in relation to the weeds' developmental stage or weather conditions is critical - a few days can make the difference between success and failure. Weed management actions should be prioritised, scheduled and performed at the optimum timing for best results.

If management of a specific weed relies upon the prevention of seed set, then control treatments must be given adequate priority and applied before, or during flowering. Whenever weeds are allowed to produce a new generation of seed, the problems caused by those weeds will be perpetuated, as will the need for ongoing control. For example, a single plant of blackberry nightshade (*Solanum nigrum*) can produce over 170,000 seeds (Whittet 1968).

Similarly, cultivations to disrupt weed seedlings or to chop the rhizomes of perennial weeds will be more effective if followed by hot, dry weather rather than cool, wet weather. Priority should therefore be given to timing such cultivation according to the prevailing weather conditions.

Try something different!

Ongoing problems with weeds are an indication that the **current approach to weed management is not working**. In this case, vineyard managers should try different techniques or different combinations of techniques in an attempt to find a more cost-effective and long-term solution to those weed problems.

Innovation and perseverance are necessary ingredients for successful weed management.

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Useful information sources

The following list is intended to act as a useful starting point for growers interested in seeking more detailed information on chemical-free weed management.

Weed management

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Contacts

- Australian Quarantine and Inspection Service (AQIS) Organic Program
  For information on certification organisations, the 'National Standard for Organic and Biodynamic Produce' and export requirements for organic produce.
  Tel: (02) 6272 3928
  Email: organic@aqis.gov.au
  Internet: http://www.daff.gov.au/aqis/export/organic-bio-dynamic
- Organic Federation of Australia (OFA)
  Australia's peak organic industry organisation.
  P.O.Box 369, Bellingen NSW 2454
  Tel: 1300 657435
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