

Sustainable horticulture

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Introduction

Sustainable farming applies agricultural systems and practices which aim to maintain or enhance the health of the natural resource base within the constraints of the market based production system. In this framework this publication examines some of the benefits and challenges of sustainable horticulture in NSW.

The horticultural industries in NSW provide consumers with a variety of products, including fresh fruit and vegetables, wine, nuts, flowers and other ornamental and nursery products. Horticulture is a significant sector of the NSW economy, with a farm gate value exceeding

\$1 billion per annum, and it provides significant numbers of jobs in regional NSW.

Horticultural activities inevitably have some impact on the natural resources harnessed for the production of fruit, vegetables and other products. As awareness of sustainability issues increases, horticultural industries are becoming increasingly concerned with maintaining and protecting their resource base and the wider environment.

Some past and some current production systems have failed to address the impact they have on the environment resulting in the degradation of the natural resource base on both a local and landscape scale. Estimates suggest environmental degradation throughout the state costs \$700m a year in lost production (Policy on Sustainable Agriculture in New South Wales, 1998).

The challenges facing current and future generations of horticultural producers are to increase sustainability by minimising their impact on the environment and to repair the effects of past practices now known to be inappropriate to the Australian landscape. It is first necessary to have an economically viable production system if



Our horticultural industries provide fruit and vegetables to local and export markets.



the costs of these investments in environmental enhancement are to be carried by the current generation of farmers.

Impacts that need addressing include salinity, raised water tables, soil erosion and degradation, residues of persistent pesticides and off-site impacts of nutrients. Positive action is needed now to protect, restore and enhance the natural resources our agriculture and horticulture industries depend upon.

As horticultural industries develop a better understanding of their production systems, growers are increasingly adopting best practice management approaches that aim to market a regular supply of safe, quality foodstuffs at reasonable cost to consumers whilst preserving the productivity of the landscape.

To ensure the horticultural industries are sustainable, management strategies need to encapsulate practices that minimise impacts on the environment. Approaches such as Environmental Management Systems are being developed to facilitate the adoption of sustainable practices into the farm management system.

Some of the key elements of farm management and the sustainability issues relating to them are discussed in the following pages.

Planning for sustainability

A key principle for sustainable agriculture is to take a holistic view of the industry at every level, from the individual plant/environment interaction through to the orchard and landscape level. The effects of an enterprise's interactions with the wider environment are assessed on a generational timeframe to ensure the long-term health of the farming system. Short-term and problem focussed approaches that fail to recognise and account for the complexity of interrelations between activities on and off the farm will not increase an enterprise's sustainability. Planning needs to be considered at regional, local and individual enterprise levels.

Regional planning

About 75% of the NSW landscape is used for some form of agriculture. Horticultural production is mostly limited to land where soil depth, structure and fertility are suitable for cultivation of horticultural crops and a reliable source of irrigation water is available.

In recognition of the importance of natural resource management, the NSW government has recently established regional Catchment



Productive river flats need protecting by local government planners.

Management Authorities and the Department of Natural Resources to direct community and government efforts in managing and enhancing the resource base. These reforms aim to keep our river systems in a healthy state whilst giving irrigators greater certainty in their access to water, and to conserve and enhance the natural vegetation of the state. New and existing horticultural enterprises will need to consult with the Department of Natural Resources for guidance on water harvesting and irrigation licences and with the Catchment Management Authorities before any clearing of native vegetation takes place.

The NSW Department of Planning has recently embarked on projects to identify land that has regionally significant agricultural potential and to protect this land from development which reduces the productive potential of the region.

Local planning

Local councils have a responsibility to protect the future productivity of their local government areas for economic, social and aesthetic reasons. In some parts of the state productive horticultural land needs to be protected from competing demands from an increasing population (rural vs residential vs recreational land use).

Where settlement encroaches on horticultural areas, there may be conflict with neighbours if farming operations generate excessive noise, odours or dust. Frost control equipment as pumps operated at night, bird and fruit bat scaring guns, hail netting, pesticides and use of pesticide application equipment, processing sheds and composting operations have all caused neighbourhood conflict.

All these potential conflicts need to be considered when developing local planning instruments. Consultation and cooperation between industry,

local authorities and the community will ensure local planning instruments recognise and protect prime agricultural land and avoid conflicts that may render some of our limited horticultural land unproductive.

Individual farm planning

Recognition that each property is part of a greater landscape will assist farmers to develop property plans that will better enable their crops and cropping practices to coexist with the surrounding environment.

By applying whole farm planning farmers are able to better define the limitations of their soils, landscape and climate and locate each farming system on the most suitable parts of their properties whilst retaining native vegetation on the parts best suited for conservation. In this process key areas of sustainable vegetation, water, soil and crop management can be considered in a total farm picture. The location of farm dams and drainage systems and areas suitable for irrigation are determined as part of this process.

Once a whole-of-farm plan is worked out sustainable management of the enterprise can be developed. While there are many ways of viewing the whole farm picture, this can be done by considering four major areas, as below.

Sustainable vegetation management

Vegetation management is a critical component of sustainable horticultural management, particularly in its contribution to biodiversity, protection of soils and management of water tables.

Vegetation management should be considered on a whole farm scale when planning the layout of the farm and on a paddock scale when planning which crops to grow. Opportunities to retain stands of native vegetation should be taken as they have a positive effect on farm and over the wider landscape. Benefits include the provision of habitat for birds and other pest control agents, wind protection for crops, and associated reduction in irrigation demand.

Farmers also need to consider how the property fits into the surrounding landscape when designing the farm layout. A well thought out farm plan will incorporate wind breaks, retain or replant vegetation corridors, and have buffer zones between different cropping areas and adjacent to waterways, to limit the off-site impact farming operations will have.

Trees also have a positive hydrological effect on a landscape scale by drawing water up from the subsoil and/or water table which will help protect arable land from the disastrous effect of rising water tables and increased salinity.



Stonefruit protected by a windbreak. Windbreaks increase biodiversity and reduce water use.

NSW DPI has Trees on Farms coordinators who can advise on establishment and management of trees for shade and shelter, nature conservation and soil and water conservation

Sustainable water management

A healthy river system is essential for a healthy environment and a productive agricultural sector. The health of most Australian rivers has been declining as demands for water have increased over recent decades. This has necessitated the introduction of a range of water reform regulations over recent years. It is recognised that rivers need to have sufficient flow for the ecological processes in the catchment and to provide water of suitable quality for domestic use and irrigators.

Horticulture must compete for water with other needs such as town water supplies, industrial uses, environmental flows and recreational uses. Supplies are limited and efficient use of allocations is essential for the sustainability of NSW horticultural industries into the future.

As well as efficiency and cost issues there are important environmental issues at stake. Over-irrigation and poor management of drainage water leads to major changes to the hydrological characteristics of the catchment and can have detrimental effects on other producers and the environment many miles downstream. The loss of previously productive land to raised water tables and the associated salinisation of soils is occurring on a serious scale.

A well planned and managed irrigation and drainage system should achieve a healthy vigorous crop with very little run-off above the natural level, only small losses to the water table and minimum discharge of salt, fertiliser, pesticides and organic matter into the river system. All aspects of water management have to be considered at the design stage, including system design, irrigation scheduling, water quality, fertigation options, and drainage management.

Horticultural producers can improve their use of water by developing a better understanding of the interaction between the crops and the soils in which they grow and an increased knowledge of the fate of water applied. Once crop demands and soil water holding capacity are determined, irrigation can be scheduled and applied more precisely with a much reduced effect on the environment.

Irrigation scheduling at its simplest uses evaporation figures from meteorological stations, and crop factors, to predict how much water

demand is likely in a crop, and how much irrigation needs to be applied. Far more accurate scheduling can be obtained by using various soil moisture monitoring systems. These accurately measure moisture levels in the root zone, and allow very accurate application of water to meet crop demands while avoiding either excesses or deficits. Real time monitoring and computerised systems can supply a crop's irrigation needs with a high degree of precision.

Another major factor in efficient water use is the delivery system. A wide range of irrigation technologies are used in horticultural crops. These include furrow irrigation, overhead irrigation, drip and trickle systems and low-pressure under-tree systems. Irrigation efficiency increases with increasing precision of water delivery. Flood irrigation is generally least efficient. High pressure, high volume sprinkler systems covering wide areas are considerably less efficient than micro sprinklers or dripper systems which target the root zone of the crop.

The delivery system is an important investment and cost should not be the deciding issue in selection. Generally the higher technology systems are more expensive but give growers the ability to apply water with a high degree of precision, which not only benefits the crop, but also allows for very efficient use of water and avoids losses and associated off-site impacts.

Another major benefit is the use of the irrigation system for fertigation. In these systems dissolved fertiliser is supplied to the crop through an irrigation system. This facilitates frequent small applications of fertiliser that supply nutrients to the root zone as needed and reduce the risk of nutrients being transported off-site by run-off. Labour input and compaction by machinery delivering fertiliser to the plants is also reduced. In this way both water and fertiliser use can be managed to obtain optimal yields of high quality



A trickle irrigation system delivers water to a young vineyard.



A tensiometer measures soil moisture for precise irrigation management.

product, while minimising the impact on the wider environment.

The NSW Government is investing in education strategies to help irrigators develop 'land and water management plans' which aim to increase efficiency and minimise off-farm impacts of irrigated horticulture. The increasing cost of irrigation water is also driving a move to more efficient irrigation systems.

Sustainable soil management

A primary goal of sustainable horticulture is to protect and enhance soil health. No farming system can be sustained unless the soil has suitable fertility, structure, water holding capacity, drainage capacity and sufficient depth. Topsoil forms very slowly and is, in terms of the human life cycle, irreplaceable.

It is important to increase awareness of the causes, symptoms and consequences of soil degradation. Growers should protect their land from soil loss due to erosion by wind or water and to more closely monitor the chemical and physical condition of the soil so that tillage and fertiliser practices can be better managed.

Erosion controls

Erosion control begins at the farm planning level. Some areas are simply too erosion prone to sustain horticultural activity. An obvious example is very steep slopes. These should be either left uncleared (land clearing regulations specifically prohibit general clearing of steep slopes) or if they are

already cleared, cover crops and trees should be planted to stabilise them.

Incorporation of windbreaks into farm plans will slow wind velocity, and reduce soil loss due to wind erosion. When planting windbreaks the mature size and shape of the windbreak needs to be considered. A combination of tall and low growing species may be needed. Information on suitable species for different areas and needs is available from a number of sources, and checking local experience is a good indicator.

Well-designed and managed farm irrigation and drainage systems will reduce soil loss due to run-off by minimising the quantity and speed of water flowing through the crop. Well-designed drainage systems are particularly important, as they can slow the movement of water during rainfall and direct run-off into suitable areas. Maintaining cover crops on these drainage systems is essential to preventing erosion.

Most perennial horticulture industries grow inter-row cover crops between the trees which, among other benefits, protect soils from erosion by wind or water. Incorporating strip cropping and green manure crops in vegetable production systems also protects soil from wind and water erosion. While contributing to soil protection cover crops also assist in weed management and enhance the biodiversity of the soil, which benefits soil health.

Mulching under tree crops can also be used to protect soil against erosion by water or wind, as well as adding valuable organic matter to the soil.

The use of permanent beds or tram tracks in crops with frequent vehicle movements, such as vegetables, restricts compaction to a small percentage of the field, increases the infiltration rate of the soil, and therefore reduces run-off and associated soil loss. Restricting vehicle movements when the soil is wet also reduces the likelihood of soil compaction.

Organic matter

Organic matter and the humus it breaks down to are vital to sustaining the productive life of the soil. Humus helps bind soil particles into aggregates and improves soil structure. In turn this improves aeration and drainage, as well-structured soils allow water and air to pass through the soil more easily. Organic matter and humus also improve the moisture holding capacity of the soil.

Organic matter can also provide a slow release form of nutrients, and even more importantly, humus can attract and hold large amounts of nutrients in the soil so that applied fertilisers are better protected against leaching.



Tomatoes fertilised through the trickle irrigation system.

Organic matter levels can be maintained or increased through a number of practices. Cover crops make a valuable contribution, particularly through the contribution of dead roots. Generally crops with dense fibrous roots are more useful than those which have fewer fleshier deep roots. Inter-row cover crops in orchards can also be mown and put into the crop row to supply leaf matter to the crop row litter.

Incorporation of green manure crops can provide short-term increases in organic matter as well as protection for the soil during a fallow.

Bulky organic manures can increase organic matter but frequent and heavy applications are needed. Where this activity is a fundamental part of the enterprise (such as with organic production) it can be worthwhile but applications are generally energy intensive. Cover crops may be a simpler way to produce bulk organic matter.

Crop residues can be another good source of organic matter, provided their retention is compatible with the good crop hygiene essential for disease management. Pest and disease guides will indicate where crop hygiene is an issue.

As well as adding organic matter to the system, minimising cultivation, which breaks down organic matter and exposes humus, will prolong the life of existing organic matter.

Nutrient management

The challenge in managing crop nutrition is to supply the nutrient levels required at the right time to meet crop demands whilst preventing on-site soil degradation and minimising off-site movement of nutrients.

The most basic approach is to use indicative fertiliser programs that can be obtained for most crops. Some have been derived from experimentation on crop responses whilst others are derived by calculating the amount of nutrients expected to be exported from the field in the form of product, pruning and leaching.

These indicative fertiliser recommendations are only a guideline to the likely use for the season and fail to account for differences in soil/crop interactions. They lack precision and may result in crop reduction and/or off-site nutrient losses. More timely feedback is needed to develop a more precise nutrition strategy.

A widely used source of such feedback is the regular use of soil and leaf tests which allow growers to balance nutrient use and fine tune their fertilising choices. Typically, soil and tissue tests are made once or twice a year. In some crops growers gain further information by using sap testing which provides a very immediate picture of the plant's nutrient status.

Once the nutrient status of the soil and plant are known, this information is combined with knowledge of the crop cycle to apply the amounts of fertiliser needed. Applications need to be made in small amounts at the right times in the crop cycle. Crop calendars provide this information for most horticultural crops.

A thorough understanding of the fate of the range of fertiliser products will enable producers to choose products that will best achieve their aims without any detrimental after effects. For example some forms of nitrogen fertiliser are much less acidifying than others and should be the preferred

choices. Growers need also be aware that some fertilisers contain certain heavy metals that can accumulate in some soils to levels where crops may become unsafe for consumption and the land becomes less useful.

For the producer, the most immediate benefit of a good nutrient management strategy is optimum productivity and quality at a minimum cost. At the same time these activities can ensure good outcomes for sustainable production, by avoiding soil degradation through acidification or salting, and ensuring the areas outside the crop, the farm, and ultimately the catchment area, are protected from the adverse effects of nutrient run-off.

Sustainable pest management

Having achieved sustainable production by maintaining water and soil health, the challenge then is to protect this production from the threat of various pests. To do this sustainably requires a balanced approach that maximises the use of natural control agents and minimises pesticide use when controlling insects, diseases and weeds. Integrated pest management programs are available to achieve this aim, and are under constant development for a wide range of cropping situations.

Integrated pest management (IPM) uses a combination of biological, physical, cultural, genetic and chemical control methods to manage weeds, insects and diseases. IPM requires growers to have a thorough understanding of crop growth stages, the lifecycle of pests and the conditions most favourable to the development of pest populations.

Monitoring of crops and pests, either by direct observation, trapping with pheromones or other baits, or monitoring of seasonal conditions allows growers to predict the arrival of a harmful pest population or event and take action to prevent economic effects on crops.

Although sounding complex, this approach is achievable and has changed the course of pest control in horticulture. Routine spraying programs using any available pesticides have given way to minimal treatments with softer chemicals that are less disruptive to biological control by beneficial organisms.

IPM strategies provide the community with safer food and greater biodiversity. The grower may obtain additional benefit from lower costs, improved market access and a more sustainable system with less threat of losses caused by development of resistance to pesticides.

Many IPM programs are available. Pest management guides and similar publications are designed to help growers use these systems.

Weed management

Weeds impact on productivity and on biodiversity. Good weed management benefits both agricultural production and the conservation and enhancement of natural resources.

Integrated weed management combines management strategies such as fertiliser use, groundcover retention, cultivation, biological control and herbicide use. Such an approach can dramatically reduce the reliance on herbicide use, limit weed establishment and simultaneously encourage desirable plant species.

In perennial horticulture, weed management, once a matter of routine spraying or ploughing, is now part of total orchard floor management. In general growers can use a combination of non-tillage methods such as mowing, selective herbicide application, cover crops and mulching for a healthy and protected orchard floor.

Most perennial crops now have beneficial inter-row cover crops that compete with weeds and are managed by mechanical means to out compete weeds and further reduce the need for herbicide use. Ground with a cover crop is less prone to weed establishment. Herbicides are still necessary along the rows but the range of herbicides now available provides plenty of options and have minimal adverse effect on the environment.

Perennial weeds are often serious competitors for water and nutrients. Spot treatment of these weeds while they are young can be very cost effective and a far better option for sustainable management than later heavy herbicide treatment regimes over the entire planting.

Timeliness is the key to minimising herbicide use. For example timely mowing of weeds in the inter-row areas reduces the competition for water and nutrients. Where mowing alone is insufficient, especially close to the crop, there are choices of contact, pre-emergence and translocated herbicides to give added management options. Timely preparation of orchards for harvesting, especially in nut orchards, is another important strategy. In other words the intensity of management of weeds and cover crops can be varied through the year to suit the needs of overall orchard management.



Apple orchard with inter-row covercrop.

Cover crops

The benefits of cover crops for erosion control and as part of the weed management plan in sustainable agriculture have already been discussed. Cover crops can also improve the habitat for beneficial insects by providing shelter and nectar for food. Leguminous cover crops can increase fixation of atmospheric nitrogen.

Cover crops should be selected with overall crop management in mind. For example tall growing vigorous cover crops may be well suited to inter-row plantings in annual vegetable crops while low growing, shade tolerant species are often most suitable for orchards of trees.

Insect management

Integrated pest management has replaced older approaches to pest control based on routine calendar spraying or spraying pests on sight.

Biological control agents are important components of modern pest management systems. These are predators, parasites or disease agents which help control key pest insects. If too much spraying of the pest kills these biological control agents, then the key pest may rebound in even higher numbers, leading to a treadmill of spraying.

Biological agents also often control a range of other minor pests to the extent they are not a problem. If inappropriate spraying kills them, the minor pests may become major problems. Mites and scales are good examples of this induced pest syndrome.

Some biological control agents are available commercially so they can be introduced to crops at strategic times. Their use is often much more effective if applied in response to specific stages in the pest life cycle and changes in the season. Wasp parasites for control of some scale insects and mealy bugs and predatory mite for control of spider mites are examples of commercially available biological control agents.

Protecting and encouraging the fauna of beneficial organisms is a major aim of IPM. For that reason the choice of 'soft' insecticides, which have minimal effect on beneficial insects, and minimal use of sprays generally, is an important part of sustainable pest management.

To achieve minimal spraying of insect pests it is essential to monitor insect populations to know when a serious problem is developing. Economic thresholds for pests indicate what numbers are likely to be more costly in damage than the treatment costs.

By monitoring pest numbers and considering thresholds it is possible to greatly reduce insecticide usage compared to the 'calendar' approach. Pest scouts operating in many industries can monitor insect populations in a range of crops and give specific advice to growers about the best pest control strategies to follow.

A further problem addressed by minimal spraying is the capacity of many pests to develop resistance to pesticides. This process is accelerated by frequent treatments, especially if only one type of insecticide is used. Using a range of insecticides of different classes will assist. Further advice on resistance management strategies is available in many pest and disease guides.

A special class of biocontrol organisms known as biocides, includes insect killing bacteria, fungi and nematodes, that can be used as a spray in place of conventional insecticides for some pests. They generally have limited application but can be very effective in the right situations. Because they are often host specific and very low in mammalian toxicity they make an excellent choice where appropriate.

Where available, crops with resistance or tolerance to important insect pests also reduce dependence on conventional insecticides.

The use of insecticides in horticulture has reduced considerably over the last several years as a result of industry funded research, much of which is improving IPM strategies.

Disease control

A good starting point for sustainable disease control is the use of plant varieties that are resistant or tolerant to troublesome diseases such as Fusarium in tomatoes, canker in stonefruit, and Panama disease in bananas.

Many horticultural tree crops utilise rootstocks that are resistant to key soil borne diseases or pests. In cases such as citrus and avocados the budwood can potentially be infected with diseases and accreditation schemes are available to ensure the grafting material is free of disease. Ensuring planting material is from accredited nurseries utilising good quality resistant rootstocks is an important fundamental step to sustainable production. Vegetable breeders are constantly developing new varieties with disease resistance.

Minimising pesticide applications for disease control is another element of sustainable disease management. Timely and targeted applications of the appropriate treatment can save on pesticide applications in the longer term by giving more efficient control.



Weather data is used for disease forecasting.

One of the best ways to ensure timely treatment is by using predictive systems. Disease control strategies have been developed in a range of crops that use weather data to predict high-risk conditions and allow growers to apply fungicides when and where they are most effective.

Another essential aspect of sustainable disease management is to avoid resistance to the pesticides used. Modern disease programs clearly spell out rotation strategies using different groups of pesticides to reduce the risk of resistance developing.

Finally cultural control by good crop hygiene (the removal of crop residues which can be a disease reservoir) is another essential element of sustainable disease management.

Increased skill levels in using pesticides

Over 100 000 farmers in Australia have completed a farm chemical user course. Farmers find this course very beneficial in increasing their understanding of pest management strategies and become more confident when deciding on which pest management method to apply to specific situations.

The course also teaches farmers how to choose the most effective equipment for the task and keep it operating correctly so that any pesticides applied remain on target and off-site impacts are minimised.

Conclusion

Sustainable horticulture builds on the long-standing desire of farmers to ensure their land remains productive into the future. It also addresses the community's expectations and concerns for safe food and for environmental protection.

Sustainable horticultural systems can be achieved by appropriate planning and by building on the general Best Practice Management approach increasingly employed by modern horticultural enterprises to achieve a holistic approach to their farming system.

The issues for a sustainable horticultural system, outlined in the preceding pages are to:

- Protect and enhance existing native vegetation for greater biodiversity and security of the rural environment at large;
- Manage the use of scarce water resources to ensure greatest efficiency, productivity and protection of surrounding catchments and waterways from salt, soil, fertilisers and chemicals carried in run-off water;
- Manage for healthy soils through protection from degradation and loss by erosion, organic matter depletion and unbalanced and inappropriate fertiliser usage;
- Manage the impact of pest and diseases while minimising the usage of chemicals and maximising profitability over the short and long term.

Increasingly, systematic management plans such as Environmental Management Systems are being developed to assist horticultural enterprises to be sustainable, integrated into the overall rural

environment, and profitable by producing the range of premium products required by the market place.

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Acknowledgments

Several members of Agriculture and Fisheries division of NSW DPI contributed to the development of this Primefact.

Published by NSW Department of Primary Industries
© The State of New South Wales 2006

ISSN 1832-6668

Job No. 6396

Updates of this Primefact are available at
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