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NSW Agriculture

Field lettuce production

Agfact H8.1.40, First edition May 2004
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INTRODUCTION

Lettuce, (*Lactuca sativa* L.), is an annual of the Asteraceae family and native to the Mediterranean. It is thought to have originated in Europe and Asia and has been cultivated for at least 2500 years. The cultivated lettuce *Lactuca sativa* is a popular salad vegetable and is grown on all continents throughout the world including Australia.

PRODUCTION

Approximately 6000 hectares are grown each year throughout Australia, producing 135,000 tonnes for both the fresh and processing markets. The Australian lettuce industry is estimated to be worth approximately $100 million with $8 million going to export. NSW is the third largest producing state with about 27,000 tonnes produced annually from around 1100 hectares.

ORDER NO. H8.1.40

AGDEX 268/11

Australian lettuce production by state (2002)

State	Area (Hectares)	Production (Tonnes)
Victoria	2188	32,970
Queensland	1805	52,552
New South Wales	1011	27,188
Western Australia	538	14,136
South Australia	277	6234
Tasmania	151	1923
Australia	5970	135,015

Source: ABS 2002

Lettuce is grown in most districts of NSW with the bulk of field production centred in the three main growing areas of Sydney Basin, Murrumbidgee and Central West.

Sydney Basin

Lettuce is sown and harvested all year round using both field and hydroponic systems. Production declines through summer due to the warm conditions. About 520 hectares are sown each year by direct seeding and by transplants.

Murrumbidgee

Approximately 320 hectares is sown from early February through to late July for harvesting from April to the end of October. Production through summer is not possible due to high temperatures. Most crops are direct seeded with no hydroponic production.

Central West

Lettuce is only scheduled for harvesting during spring and autumn. Production outside these times is difficult due to harsh climatic conditions. Most crops are sown by transplants with no hydroponic production. Approximately 180 hectares are grown each year.

LETTUCE TYPES

There are four main types of lettuce.

Crisphead

More commonly known as iceberg which forms a tight firm head of crisp leaves. At maturity most varieties are mid green in colour and about 1 kg in weight. Crisphead lettuce is the major type grown in Australia and also the most difficult to grow.

Butterhead

A heading type like the crisphead but with the leaves more loosely folded on top of one another. Head sizes range from 0.3–0.5 kg for hydroponically grown cultivars to 0.5–0.7 kg for field grown cultivars. The inside leaves, because of their lack of light, are cream or butter coloured. The outer leaves are brownish or a darker green than the crisphead and tend to bruise and tear more easily.

Romaine

Also known as Cos, this lettuce is upright in form and grows up to 30 cm tall. The tightly folded leaves are greenish white in the centre and medium green on the outside. Their flavour is sweeter than the other types of lettuce.

Looseleaf

Also known as leaf, speciality, fancy or European lettuce. Looseleaf lettuce is marketed as either a whole product or as an ingredient of ready-made salad mixes. This type does not form hearts and comes in a range of colours with various types of mottling or patterns. Looseleaf lettuce is generally grown in hydroponic systems and is considered the easiest type of lettuce to grow.

HYDROPONIC LETTUCE

Coastal areas of NSW have seen a large increase in production of hydroponically grown lettuce over the past few decades. Looseleaf and Butterhead are the main types of lettuce grown in these systems. Hydroponically grown looseleaf lettuce offers the advantage of producing a saleable product in half the time it takes to produce a Crisphead type. This Agfact does not cover issues of hydroponically grown lettuce but only the issues of field grown lettuce.

FIELD LETTUCE

Two different methods are used to produce lettuce under field conditions in NSW. One method uses transplants and overhead irrigation while the other is by direct seeding and furrow irrigation. In the Murrumbidgee district most growers prefer to direct seed and furrow irrigate due to a heavier soil type. In the Sydney Basin and the Central West where the soil type is lighter, most growers prefer to use transplants and overhead irrigation.

SEEDBED PREPARATION

Bed size width varies with soil type and irrigation

method. In the Murrumbidgee district where furrow irrigation is used the bed width ranges from 1.4 to 1.6 m from centre to centre. In other districts where overhead irrigation is used the bed width ranges from 1.6 to 1.8 m from centre to centre.

Field lettuce needs to be sown on raised beds to aid water infiltration and retention and allow adequate soil aeration and drainage. Beds should be cultivated and formed to produce a fine soil tilth in which the seed can germinate readily without being affected by soil crusting. Lettuce is a shallow-rooted crop, and a fine seedbed is needed to allow the roots to establish and grow.

SOWING

Lettuce crops are seeded or transplanted with 2 to 4 rows per bed. The most common method for direct seeding is establishing 2 rows per bed under furrow irrigation. When direct sowing, the seed can be pelleted or unpelleted depending on the grower's preference and type of seeding equipment used. Unpelleted seed is sown at high rates of about 0.3 kg/ha resulting in seed intervals of about 60 mm. The crop is later thinned to about 300 mm per row when the plants reach about the 6 leaf stage. Where bed centers are 1.5 m apart with two rows per bed you can expect a maximum plant population of about 45,000 per hectare. Pelleting individual lettuce seeds permits the use of precision planters when seeding. This allows for lower seeding rates, more evenly spaced plants and less labour costs to thin the crop.

Lettuce germinates best at low temperatures between 0ºC to 10ºC, and depending on variety, germination is inhibited when temperatures reach 25ºC to 35ºC. This is known as thermo-inhibition, with the seed germinating when returned to more suitable temperatures. Unfortunately, continued exposure to high temperatures may induce a secondary dormancy, called thermo-dormancy which means the seed will not germinate even when returned to non-inhibiting temperatures. Thermo-inhibition and thermo-dormancy is a common cause of germination failure during summer. Germination of lettuce is also promoted by light and inhibited by dark; which is known as photo-dormancy. As light is essential, the seeds need to be planted very shallow to allow good germination.

Transplanting overcomes many establishment problems including germination failure and the cost of thinning. The cost of transplants varies from $20

Transplanting four rows of lettuce to a bed.

to $40 per 1000 with some growers producing their own. Transplants are planted on beds, usually with 3 or 4 rows per bed, depending on bed width. The plants are spaced about 300 mm apart along the rows, giving a plant population of about 60,000/ha

NUTRITION

Lettuce is a rapid growing plant that needs a well-balanced nutritional program to produce a high quality, high yielding crop. Field lettuce grows best on well-drained fertile soils with a pH between 6.0 and 7.0. Where soil pH is too low (too acid), the application of lime or dolomite is necessary to allow better uptake of nutrients. For optimum results incorporate the lime or dolomite into the soil at least 6 weeks before planting.

A soil test will help determine the soil nutrient status and should be the basis of any fertiliser program. A full soil test costs around $100 per sample and analysis results will be received a few weeks after sending. The following recommendations are based on the nutrient requirements to produce a 50 t/ha lettuce crop.

Nitrogen (N)

A soil test measures nitrate nitrogen and where levels are very low a maximum fertiliser rate of 200 kg/ha of N is recommended. As soil nitrate levels increase the fertiliser rate should be reduced. When soil nitrate levels are high (50 ppm or more), fertiliser applications should be no more than 50 kg/ha of N. Nitrogen is easily leached from the soil by irrigation and rain and is not recommended for all nitrogen to be applied as a base application. As a general guide, apply one third as a base application and apply the remainder in even ammounts during the crop's life. Monitoring sap nitrate throughout the season may help with this decision making. Side dressing of nitrogen should be drilled in when cultivating for weeds or spun over the top and irrigated. The number of side dressings required varies from one in soils with high nitrate levels to three or four evenly split over regular intervals where a high amount of nitrogen is required. When high inputs of nitrogen are required it is recommended that the fertiliser be in the nitrate form rather than the ammonium form to reduce the chance of ammonium toxicity (jelly butt). Care needs to be taken not to apply excess nitrogen to minimise the incidence of jelly butt, excessive growth and outer leaf burn.

Phosphorus (P)

Where a soil test shows very low phosphorus levels, a maximum fertiliser rate of 100 kg/ha of P is recommended. As soil phosphorus levels increase, the fertiliser rate should be reduced. A rate of only 20 kg/ha of P is required when soil tests show high levels of phosphorus. Phosphorus is stable in the soil and does not move much after it has been applied; therefore it can be applied weeks before the crop is planted. The entire recommended rate should be applied as a base dressing. Broadcasting phosphorus fertilisers is common but banding it below the seed line is preferable, allowing roots to quickly find it. There is of little value in applying phosphorus fertilisers as a side dressing after a crop has already been established.

Potassium (K)

Where a soil test shows very low potassium levels, a maximum fertiliser rate of 150 kg/ha of K is recommended. As soil potassium levels increase, the fertiliser rate should be reduced. A rate of only 20 kg/ha is required when soil tests indicate high levels of potassium. Potassium is more stable in the soil than nitrogen but can be leached over the season. Application recommendations are the same as nitrogen with one third as a base application and the remainder applied evenly over the crop's life.

Other

Calcium, magnesium and molybdenum become less available to lettuce as soil pH decreases. The amount of lime needed to correct pH varies with soil type. Soil testing will help with this decision making. Heavier soil types will need higher rates of lime to increase pH than lighter soils.

Animal Manure

Animal manure can be used for growing lettuce and should be incorporated into the soil at least 4 to 6 weeks before sowing. This is important, especially with fowl manure to avoid ammonium toxicity (jelly butt). It is recommended that fresh manure be cured (dried) before use to avoid plant burn and Bottom rot (*Rhizoctonia*) problems. Animal manures help increase the soil's organic matter, improving soil structure and water and nutrient holding capacity. Animal manures are generally low in N:P:K content, with fowl manure generally the highest at approximately 2.1% N, 1.6% P and 1.0% K. An application rate of about 7 t/ha (approximately 20 m^3) makes a useful base dressing for lettuce crops.

Nutritional Disorders

Tipburn

Tipburn is considered a problem of calcium deficiency. Most vegetable growing soils have enough calcium with the problem usually being associated with water stress. Tipburn is the breakdown of leaf

margins, particularly on the inner heart leaves and is difficult to see during harvest. Where this disorder is a problem, it is common practice to apply weekly foliar sprays of calcium nitrate. However, using less susceptible varieties and good soil moisture management will give better tipburn control than using foliar supplements later on.

Ammonium toxicity (Jelly Butt)

Jelly Butt can be a problem when high inputs of nitrogen are used in the ammonium form. The ammonia released in the soil becomes toxic and causes poor emergence of seedlings, followed by wilting and death. Symptoms in older lettuce are seen in the central root tissue with browning and tissue breakdown. Jelly Butt is common where heavy applications of fowl manure are applied on wet soils. Fowl manure needs to be incorporated into the soil at least 4 to 6 weeks before sowing.

Suggested Fertiliser Program

The base fertiliser application will depend on soil fertility with between 300 and 900 kg/ha of 8:11:10 compound (or similar) usually being required. If applying fowl manure at 20 m^3/ha the base fertiliser application rate can be reduced by one third. Ensure that the total phosphorus requirements are applied at this stage. Banding the base application under the seed or transplant line will give the best results. If broadcasting prior to hilling-up, you will need to increase the base application by 50 to 75%.

Side dressing of nitrogen should start at about the 6 leaf stage and can be timed with weed cultivation. A rate of about 100 kg/ha of ammonium nitrate (nitram) should be applied at each application with the number of applications depending on total nitrogen requirements. Intervals of at least 2 weeks are needed between each application. Yellowing of the older leaves is a good indication of nitrogen deficiency. If extra potassium is required then the first side dressing of nitram can be substituted with nitrate of potash. Muriate of potash is also used, as it is one of the cheapest forms of potassium available.

CLIMATE AND VARIETAL SELECTION

Lettuce is a cool season crop with optimal growing temperatures from 23ºC during the day to around 7ºC at night. Temperature and day length experienced throughout the growing period has the greatest influence on how a variety performs. Lettuce grown over the hotter months matures much quicker than in the colder months. Long periods of high light intensities can also affect lettuce as it has an internal counter that keeps track of the number of daylight hours the plant receives. Once a critical number of hours are received, the plant will bolt. Bolting is the term used for the initiation and development of the flower stalk. The exact number of hours varies from cultivar to cultivar. Lettuce varieties can be classified as either hot or cold weather varieties (or somewhere in between) depending on what temperature and time of the year best suits them. Lettuce varieties are adapted to specific planting periods to help overcome the range of climatic conditions therefore planting a variety in its correct slot will help reduce these symptoms.

Disease resistance is an important consideration when selecting varieties. Some varieties are more susceptible to certain diseases than others; e.g. Salinas types tend to be more susceptible to dry leaf spot, a bacterial disease prevalent in wet weather or with overhead irrigation. Varietal resistance to downy mildew, corky root, black root and big vein are available. Different varieties can show reduced or increased disease levels due to some physical characteristic of the lettuce. Cos type lettuce can be more prone to Botrytis infection as it is a more upright lettuce than an iceberg type lettuce. In windy conditions the taller varieties are more likely to be damaged at the base of the stem which allows entry of the fungus. Some iceberg lettuce varieties have more leaves hanging very close to the ground, which can create a warm moist environment allowing fungi such as Botrytis and Sclerotinia to invade the leaves.

Choosing a variety is difficult and it is hard for growers to keep abreast of all the new varieties released each year. Lettuce varieties are adapted to specific planting periods and planting them out of their time slot will result in a less than desirable product. Whether growing for the fresh market or for processing will also have an influence on what variety is grown. When considering a new variety, trial it alongside your standards so you can assess its performance against your current varieties.

WEED CONTROL

Weeds reduce available light, moisture and nutrition to the crop. Lettuce does not compete well and poor weed control will result in reduced quality and yield. Hand hoeing, inter-row cultivation and herbicides are all used to help control weeds.

Weed management starts with planting into a weed-free seedbed. This can be achieved by planting into a

Cultivating and renovating furrows.

bed that has been freshly cultivated and bed formed. If the paddock has a high weed seed load then it is recommended you pre-irrigate to germinate an initial flush of weeds. These weeds can then be controlled by a shallow cultivation or the use of a knockdown herbicide.

The use of pre-emergent herbicides is the standard method for controlling broadleaf weeds in lettuce when sowing by transplants. There are only a few registered herbicides in NSW that control broadleaf weeds in lettuce. These chemicals will only work if applied before the weeds have emerged and are ineffective against established weeds. It is best to minimise the time between the final cultivation (or knockdown herbicide) and the application of these pre-emergent herbicides. A delay of more than a few days could mean no control on newly germinated weeds. There are no selective herbicides that will control emerged broadleaf weeds in lettuce.

If broadleaf weeds germinate after sowing then a shallow inter-row cultivation or hand hoeing are the only control options. Avoid cultivating the soil too early, as disturbing the soil will stimulate more weed germination and prematurely upset the pre-emergent chemical barrier. Timing it with the first fertiliser side dressing should work. Be careful not to leave the cultivation too late or there may be insufficient space between rows and plant damage could occur. Care also needs to be taken as lettuce is a shallow-rooted crop and cultivation may cause damage to feeder roots close to the surface.

Grass weeds alone do not pose much of a problem as most are controlled at sowing by the pre-emergent herbicides and then by the inter-row cultivation used to control the broadleaf weeds. If grass weeds need controlling, there are post emergent herbicides registered in NSW.

Hand cultivation is still an option for smaller direct seeded plantings.

Soil fumigation is also an option to control weeds and should be applied at least two to three weeks prior to planting. If soils are heavy (i.e. high in clay content), very high in organic matter or remain below 15^0C following application, the plant-back period will need to be longer. Fumigating also controls nematodes, fungi and soil borne insects. Care is needed with fumigation as overuse can lead to soil biodegradation and reduced pest control.

When direct seeding, registered pre-emergent herbicides are available, but many growers elect not to use them. Crops are direct seeded into a weed free seedbed at a high sowing rate. When the crop reaches about the 6 leaf stage it needs to be thinned and inter-row cultivated. Hand hoeing to thin the lettuce crop and weed along the plant line takes about 60 man hours per hectare where 2 rows of lettuce are sown on 1.5 m beds. Use of precision seeding can speed the thinning operation and help reduce labour costs.

Good weed control and irrigation is needed for even yields.

Fitting a conventional boom with droppers and extra nozzles can improve spray coverage.

IRRIGATION

To achieve a consistent maximum yield of high quality lettuce, growers will need to irrigate their crops. Lettuce is a shallow rooted crop that has difficulty in extracting water from depth. Furrow and overhead irrigation of lettuce are the two preferred options with growers in NSW. Drip irrigation is not widely used for lettuce in NSW but would be very suitable. The most critical stage for lettuce is during germination, seedling establishment and the last few weeks before harvest. Growers should use moisture monitoring equipment (e.g. tensiometers) to help schedule irrigation requirements.

A lettuce crop requires about 3 to 4 megalitres of irrigation water from sowing to harvest. The crop is sensitive to salinity and plant growth may be affected if levels are too high. The recommended threshold to avoid yield loss is when the conductivity of the irrigation water reaches 900 μS/cm. When levels increase to 1400 μS/cm, a yield loss of 10% may be expected and when levels reach 2100 μS/cm, a yield loss of 25% may be expected. These values are a guide only and vary with soil type, leaching potential, irrigation method and age of plant.

SPRAY APPLICATION

To control weeds, insect pests and diseases, growers often need to apply the appropriate spray treatments. Factors influencing the biological efficacy of these spray treatments include the dosage rate, spray coverage, timing and product efficacy. Timing and spray coverage are the factors which growers have the most control over. Timely spray application can only be achieved with regular and thorough crop scouting. Crop scouting involves close inspection of some twenty to forty individual lettuce plants throughout the crop and recording the incidence of pests and diseases. This way the grower can be better informed and able to apply sprays when the pest is most vulnerable and before a problem gets worse. (i.e. target heliothis when at early instar stages)

To achieve the maximum spray coverage growers should use the most suitable boom types. Control Droplet Application sprayers and air-shear sprayers have given better droplet penetration and spray coverage than conventional booms. Their superior spray coverage is due to the air stream causing agitation of plant foliage increasing droplet penetration. Modifying a conventional boom with inter-row droppers can greatly improve spray coverage and penetration on lettuce. Nozzles should be aimed in towards the base of lettuce plants helping to increase spray coverage in and under lower leaves.

All spray equipment needs to be regularly calibrated and checked for wear. Poorly maintained equipment is often the cause of spray failures. Only with correctly calibrated equipment can growers achieve good results.

DISEASE CONTROL

More detailed information on disease control can be found in the 'Integrated Pest Management in Lettuce: Information Guide' (see references on page 15).

Disease reduces both the yield and quality of lettuce. The three main types of disease in lettuce are fungal, bacterial and viral.

Downy mildew

Cause: Caused by the fungus *Bremia lactucae*.

Symptoms: Light green patches develop on leaves, which eventually turn yellow then brown. A fluffy growth can often be seen on the underside of the leaves associated with the patches.

Source of infection: The primary source of infection is from the seed, spores in debris, spores from wild lettuce weeds and from nearby fields. Once

Downy mildew showing the browning of the leaf and white coloured fungal growth.

established, spores from diseased lettuce within the crop spread the disease further, helping carry the fungus from season to season.

Control: Using resistant varieties is the best method of controlling this disease. If growing a variety that is susceptible to Downy mildew then a strategy of using appropriate fungicides is the best option. Both protective and curative (systemic) fungicides are available.

Sclerotinia

Cause: Caused by the soil borne fungi *Sclerotinia minor* and *S. sclerotiorum*.

Symptoms: This disease is often called lettuce drop. The early signs of the disease are wilting and browning of leaves followed by eventual death. In NSW, *S. minor* is the most common type of sclerotinia.

Source of infection: Both species produce hard, black reproductive survival structures called sclerotia. These can be seen on the lower leaves and at the base of the lettuce when infected by *S. minor* and towards the top of the lettuce when infected by *S. sclerotiorum*. The sclerotia survive from season to season in the soil. The sclerotia of *S. minor* germinate in the soil and infect the lower leaves of the lettuce. *S. sclerotiorum* infects the lettuce in two ways. Sclerotia germinate in the soil and infect the lower leaves (similar to *S. minor*) or the germinating sclerotia eject spores into the air. These spores may then infect the top of the lettuce, usually where some previous damage has occurred (i.e. damage from frost or insects). Excess rainfall or irrigation can predispose lettuce to sclerotinia.

Control: Rotation with non-host crops helps in controlling both types of fungi but fungicide applications are also generally required. To control *S. minor*, dipping the trays in fungicide followed by spraying at the base of the plant will give good

Lettuce paddock with plant losses due to sclerotinia.

protection. If *S. sclerotiorum* is a problem then further applications are necessary to cover the foliage and protect the leaves from infection.

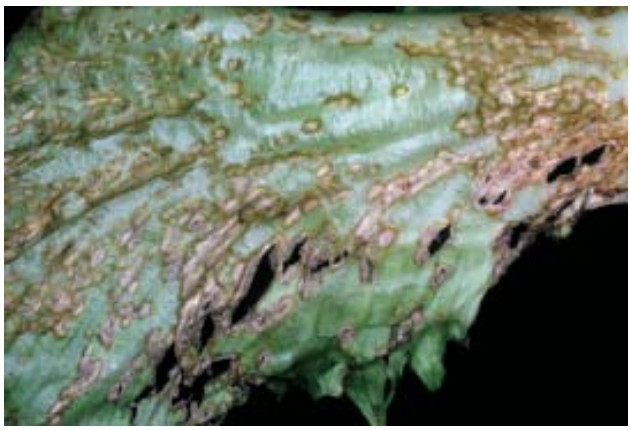
Grey Mould

Cause: Caused by the fungi *Botrytis cinerea.*

Symptoms: The symptoms are similar to Sclerotinia with the lower leaves wilting and eventually the whole plant dies. The fungal growth (hyphae) of Botrytis looks grey whereas the hyphae of Sclerotinia are white.

Source of infection: The small black sclerotia and spores produced from this disease are the initial sources of infection. The sclerotia is long lived and found in crop trash and in the soil. Grey mould is favoured by cool damp conditions.

Botrytis is similar to sclerotinia but produces grey to brown coloured fungal growth.



Anthracnose produces brown spots, often along the midrib of the lettuce.

Control: The fungicides used for the control of sclerotinia also control Botrytis.

Anthracnose

Cause: Caused by the fungi *Microdochium panattonianum*.

Symptoms: The symptoms are leaf spotting, often along the midrib of the lettuce. First seen as tiny water soaked spots which enlarge to brown circular to angular spots with a reddish edge about 4 mm in diameter.

Source of infection: The fungus survives as sclerotia in soil and as hyphae in infected crop debris. This disease needs free moisture for its spores to germinate. The spread of the disease is favoured by cool-wet conditions.

Control: Controlling this disease is assisted by crop rotation and ploughing in debris as soon as possible after harvest. Removal of weed hosts is also important. Avoiding overhead irrigation in the late evening may assist in control.

Septoria Spot

Cause: Caused by the fungi *Septoria lactucae*.

Symptoms: The symptoms are first seen on the older leaves as brown spotting.

Septoria symptoms are similar to downy mildew but without the white coloured fungal growth.

Source of infection: The fungus is initially seed borne and can be carried from lettuce to lettuce by spores. This disease establishes best in wet conditions. Infected lettuce debris and weeds such as prickly lettuce (*Lactuca serriola*) may also harbour the disease.

Control: Planting disease-free seed or seed that has been hot water treated will aid in reducing this disease. Using crop rotations is very important. Rapid breakdown of crop debris to reduce the carry-over of diseased trash is also necessary.

Bacterial Leaf Spot

Cause: Caused by the bacterium *Xanthomonas campestris* pv. *Vitians*.

Bacterial leaf spot lesions look dark and greasy.

Symptoms: Seen as large brown to black circular areas that start as small translucent spots. When the lesions coalesce the leaf blade collapses. Bacterial leaf spot may be confused with Septoria and Anthracnose.

Source of infection: This disease can be seed-borne and spread from infected plants by wind and rain or overhead irrigation.

Control: Using disease free seeds and variety resistance are the best control methods for this disease.

Varnish Spot

Cause: Caused by the bacterium Pseudomonas.

Symptoms: Symptoms include shiny brown discolouration, often along the midrib of inner leaves. Not always visible from the outside of the lettuce but when the outer leaves are removed, the rotting can be seen.

Source of infection: The bacteria survive in crop debris, other hosts and in the soil. They are spread by rain and wind. Insects can cause injuries through which the bacteria may enter the plant.

Varnish spot causing rotting on the midrib of inner leaves.

Soft rot causes hearts to turn brown and slimy.

Control: Knowledge about this disease is limited, hence control recommendations are difficult.

Bacterial Soft Rot

Cause: Caused by the bacterium Erwinia.

Symptoms: Symptoms include soft rotting and slime on the head. Infection starts as translucent spots which turn to a dark brown colour.

Source of infection: Erwinia bacteria survive in lettuce debris and infection can occur through damaged plant tissue. The damage may be caused mechanically, by insects or by frosts. An ideal condition for infection is hot, wet weather. The disease is often transferred from lettuce to lettuce by contaminated cutting knives or spread by contaminated washing water.

Control: Reducing injury to the lettuce will assist in controlling this disease.

Big Vein

Cause: Big Vein Virus

Symptoms: The lettuce develops leaves with large veins that appear stiff with ruffled margins. Depending on the severity of infection, some hearts will make it through to harvest, whereas other plants remain stunted, or often don't form hearts. Cooler weather and low light levels favour lettuce big vein development.

Big vein symptoms are unmistakable with the characteristic large veins.

Source of infection: The soil borne fungus, *Olpidium brassicae* spreads this virus. The fungus itself causes no problems to the lettuce crop and can survive in the soil for many years.

Control: There is no chemical control available for lettuce big vein. Irrigation management to reduce waterlogging will help reduce the likelihood of this disease. Where possible, growers should use varieties that show a useful degree of resistance.

Lettuce Necrotic Yellows Virus

Cause: Lettuce Necrotic Yellows Virus

Symptoms: This disease causes yellowing of the lettuce accompanied by stunting of infected plants. Older plants may develop the yellowing on one side only. Plants infected when young may turn brown and die.

Source of infection: The sowthistle aphid (*Hyperomyzus lactucae*) transmits this disease from the sowthistle (*Sonchus oleraceus*) to the lettuce plants. This aphid normally prefers to feed on sowthistle weeds but occasionally feeds on lettuce plants. The aphid transmits the virus while feeding on the lettuce plant.

Lettuce necrotic yellows causes yellowing and dark markings on leaves associated with stunting of the plant.

Control: Insecticides are available but the aphids are very difficult to control because they tend to only visit the crop for a short period before moving on to neighbouring sowthistles. The best method of control is to remove all sowthistles in the vicinity of lettuce crops.

Tomato Spotted Wilt Virus

Cause: Caused by the Tomato Spotted Wilt Virus (TSWV)

Symptoms: The main symptoms on lettuce are yellowing, often associated with brown spotting and a distinct russetting on the leaves. The central leaves may be distorted. Plants do not recover once infected and heart formation is often incomplete. Seedlings can be infected with the virus and not show symptoms till the plants mature.

Source of infection: Tomato Spotted Wilt Virus has numerous hosts and can be transmitted from plant to plant by thrips. The main thrips species that transmit TSWV are tomato thrips, onion thrips and western flower thrips. The spread of TSWV occurs when juvenile thrips feed on TSWV infected plants, and fly into lettuce crops as adults. Secondary spread occurs by adult thrips moving within the crop.

TSWV symptoms show leaf spotting with some dwarfing of lettuce.

Control: Controlling thrips numbers is the only way of reducing the incidence of the disease. If using an IPM program, beneficial insects may keep their numbers down. When their numbers increase, and/or high levels of the virus are present, insecticides are needed for control.

Lettuce Mosaic Virus

Cause: Caused by the Lettuce Mosaic Virus

Symptoms: This virus causes mottling and mosaic symptoms on leaves. Growth is restricted if the plant is infected when young. When older plants are infected, the symptoms can be very similar to necrotic yellows, producing a yellow mottling on the leaves.

Mosaic infected lettuce have mottled leaves with ruffled edges.

However leaves may have a downward curling symptom as well.

Source of infection: The main source of this virus is through contaminated seed. Lettuce mosaic virus can also be transmitted by numerous types of aphids. Aphids can transmit the disease from an alternate host outside the crop or from an infected lettuce within the crop.

Control: Because lettuce mosaic virus is predominantly a seed-borne disease, seed companies grow their seed crops away from normal growing areas to reduce the chance of mosaic virus developing in their crops. Controlling aphids with registered insecticides will help to reduce the spread of the disease. Narrow spectrum chemicals are recommended to preserve beneficial insect activity

INSECT PEST CONTROL

More detailed information on insect pest control can be found in the 'Integrated Pest Management in Lettuce: Information Guide' (see references page 15).

Most pests of lettuce are common pests of other vegetable and field crops. The insects either damage the lettuce plants by physical damage or by transmitting diseases. Pests are typically managed by calendar spraying, strategic spraying or integrated pest management.

Calendar spraying

Calendar spraying is the term used for a set program of sprays, usually using older cheaper broad spectrum chemicals. Unfortunately resistance has developed to many of the older insecticides by some insect pests. Although calendar spraying has the advantage of

being predictable, it often means sprays are applied when either not necessary or not at the optimal time. This strategy is not recommended.

Strategic Spraying

Strategic spraying involves scouting the crop on a regular basis to determine the level of pest activity. When pests are detected and their numbers reach a level that will cause damage, insecticides are used for control. Broad spectrum insecticides are also more commonly used due to their cheaper price.

Integrated Pest Management (IPM)

This option is a pest management system where all the pest and beneficial insects are considered in management decisions. Crops are scouted on a regular basis to determine the number of both pests and beneficial insects. While trying to reduce insect pest numbers, every effort is made to try and preserve beneficial insects as they eat and kill the pest insects. All available tools for managing pests are considered including, cultural practices, beneficial insects, biological insecticides, new generation narrow spectrum insecticides and broad-spectrum insecticides. Where possible, new generation narrow spectrum insecticides are preferred over broad-spectrum insecticides to encourage beneficial insect activity.

Heliothis

Heliothis is the most common caterpillar pest of lettuce with two species found in Australia

Helicoverpa armigera

Probably the most difficult caterpillar to control as it has developed resistance to a range of insecticides. *H. armigera* are usually locally bred pests that emerge as moths in late spring from over-wintering pupae. There are usually 3 or 4 generations each year with each successive generation larger in number than the previous. *H. armigera* populations decrease in autumn as more of the mature larvae delay their development into a pupa over the winter months.

Heliothis caterpillars feed on leaves and often burrow into the heart.

Helicoverpa punctigera

This native budworm is also prevalent on lettuce and has tended not to develop resistance to insecticides. *H. punctigera* is the dominant species in spring but generally numbers diminish in summer. *H. punctigera* are believed to over-winter in the arid regions, flying in early spring (usually during September), often with spring storm fronts.

In temperate areas both *H. armigera* and *H. punctigera* moths have usually finished laying eggs by the end of April with only very low numbers of larvae seen by the end of May. In sub-tropical areas, Heliothis may continue breeding throughout the winter months.

A female moth may deposit a thousand eggs, usually laid singly, on different leaves or plants. When the eggs hatch, small larvae emerge, about 1.5 mm long. The larvae begin feeding almost immediately and usually burrow into the heart. After 6 moults, the mature larvae finish eating, descend the plant and burrow into the soil to pupate.

Spraying for control should be timed when grubs are just hatching and before they burrow into the heart. Even though *H. armigera* have developed resistance to a number of chemicals, they are still susceptible at the 1st and 2nd instar stage. Timing sprays for egg hatch will mean that sprays can be less frequent during the spring and autumn compared to the hotter months of summer.

After harvest, cultivate paddocks to a depth of 10 cm ('Pupae Busting') to kill any pupating larvae. Do this as soon as possible after harvest for maximum benefit.

Other caterpillars

Other caterpillar pests of lettuce include cutworms (*Agrotis* spp), loopers (*Chripodeixis* spp) and cluster caterpillars (*Spodoptera* spp). These can also be destructive pests in lettuce but are not usually seen in as high numbers as heliothis. Control measures for heliothis will usually also control loopers and cluster caterpillars. Cutworms are more of a problem at establishment and can be controlled by cultural methods and insecticides.

Aphids

A number of aphid species infest lettuce including the Green peach aphid (*Myzus persicae*), Brown sowthistle aphid (*Vroleucon sonchi*), Potato aphid (*Macrosiphum euphorbiae*), Rose aphid (*Macrosiphum rosae*), and Sowthistle aphid (*Hyperomyzus lactucae*). These aphids are all vectors of the Lettuce Mosaic virus while only the sowthistle aphid is a known vector of the Necrotic Yellows virus. Cool dry weather favours aphids. Aphids have a wide range of natural enemies,

Winged and wingless sowthistle aphids.

Typical damage caused by thrips.

and if narrow spectrum insecticides are used to control other pests, then aphid populations are usually kept below levels that cause damage from direct feeding.

Aphids can be in either the winged or non-winged form. When in the winged form they are on the move and when they are in the non-winged form they are colonising and rapidly increasing in number. Aphids mostly reproduce asexually and are well adapted to rapidly increase in number.

Damage from direct feeding results in leaf curling and wilting. Lettuce will tolerate a moderate level of damage depending at the growth stage. Aphids generally tend to feed on the lower side of outer leaves, which are mostly removed at harvest. Beneficial insects usually keep aphids in control. When aphid levels increase to damaging numbers use only narrow spectrum chemicals for control.

A new and highly invasive aphid is soon expected to arrive in Australia. The Lettuce Aphid (*Nasonovia ribisnigri*) is presently found in Europe, North America, South Asia, and New Zealand. Unlike other aphids that colonize on the outer leaves, the lettuce aphid prefers to feed in the centre of lettuce hearts and is therefore difficult to control.

Thrips

A number of thrips species infest lettuce including Western Flower thrips (*Frankliniella occidentalis*), Onion thrips (*Thrips tabaci*), Plague thrips (*Thrips imaginis*) and Tomato thrips (*Frankliniella schultzei*).

Thrips are very small insects about 1 to 2 mm long. They vary in colour and size depending on species and generally have a wide host range. Thrips can cause mechanical damage to leaves of seedlings, resulting in curled leaves, silvering and wilting. Transmitting disease is usually the biggest concern with thrips. Some species of thrips can transmit Tomato Spotted Wilt virus which causes wilting and a distinct russetting of the leaves.

Yellow sticky traps are a good method of monitoring thrips. If using an IPM program, beneficial insects may keep their numbers down. When their numbers increase, and/or high levels of the virus are present, insecticides are needed for control.

Other sap sucking pests

Other sap sucking pests include leafhoppers and Rutherglen bugs. These are occasional pests and can migrate into lettuce crops when the surrounding crops and weeds dry off. The main concern is their presence causes a contamination problem. When these insects are in very high numbers throughout the hearts, the lettuce becomes undesirable for both fresh and processing markets.

YIELD AND HARVESTING

Iceberg lettuce is ready for harvesting once a firm heart is formed. This can be as quick as 8 weeks over summer, if sown as transplants, and as long as 16 weeks over winter, if sown by seed. The lettuce is cut close to the ground and excess leaves are trimmed off. The heads are washed if needed and packed in the field. Most iceberg lettuce are cut by hand and loaded onto harvest aids for packing in the field. Growers are moving towards mechanising this operation with a number of mechanical harvesters now operating around Australia.

To supply the fresh market, the lettuce is packed into waxed cardboard cartons. A total of 12 heads are packed in each carton with the bottom (butt) facing the top. If supplying a processing market then the lettuce is loosely packed in large bins or crates. Lettuce for processing requires heavier trimming with more of the wrapper leaves removed at harvest.

Yields can vary from 15,000 to 30,000 cartons per hectare with an average of about 2200 cartons per hectare. Lower yields are experienced when the climatic conditions become harsh. Yields in the Murrumbidgee district are higher in the warmer

shoulder seasons than during the very cold winters. Unformed hearts, pest and disease are also reasons for reduced yields and returns. Prices returned to growers vary from season to season and currently range from $5 to $12 per carton.

COST OF PRODUCTION

Cost of lettuce production varies depending on the type of growing system used and the amount of variable inputs needed. The following table gives an approximate cost of production for a direct seeded crop yielding 2200 cartons per hectare. The cost is shown on a 'per carton' and 'per hectare' basis.

These costs are a guide only but give a good indication of which operations are the most expensive. For this example 82% of the cost of production is incurred during and after harvest. This percentage will change depending on the distance from the markets. Transport cost will be much cheaper close to the markets but will increase to over $1.00 per carton if carting long distances. Chemical rates, fertiliser rates, labour costs and irrigation requirements are other examples where costs vary from area to area.

Lettuce production costs

Variable inputs	Cost/ha	Cost/carton
Seed	$225.00	$0.10
Land preparation	$526.75	$0.24
Irrigation	$69.44	$0.03
Fertiliser	$305.35	$0.14
Pest and disease control	$572.96	$0.26
Weed control	$870.00	$0.40
Cartons	$5874.00	$2.67
Harvesting	$2134.00	$0.97
Cooling	$110.00	$0.05
Freight	$1980.00	$0.90
Agent's commission	$2112.00	$0.96
Research levy	$88.00	$0.04
Total	$14,867.50	$6.76

Source: - NSW Agriculture Farm budget handbook for NSW vegetables – 2001

Lettuce being harvested and packed in the field.

Twelve heads of lettuce are packed in each carton with their butts facing the top.

STORAGE AND TRANSPORT

Harvesting is usually conducted in the cool of the morning before the lettuce temperature becomes too warm. Once harvested and packed in the field, the lettuce should be cooled to 1ºC to ensure that it arrives at the market in a fresh condition. Prompt and thorough cooling is necessary to remove any field heat for a longer shelf life. Forced air cooling is preferred to a standard coolroom as it will bring the lettuce temperature down much quicker. Vacuum cooling is also very efficient on leafy products but not as effective on bulky vegetables. Lettuce held between 0ºC and 1ºC and in high relative humidity (95–97%), have a shelf life of 2 to 3 weeks. If harvesting close to markets, unrefrigerated trucks are used for transport. If harvested a long distance from the market then refrigerated trucks are needed. Harvesting over-mature lettuce or storing without cooling will hasten lettuce breakdown and deterioration.

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Acknowledgements
The assistance and input from the following people is gratefully acknowledged

Mr Andrew Watson, Research Pathologist, NSW Agriculture

Dr Sandra McDougall, Technical Specialist, NSW Agriculture

Mr Andrew Creek, Technical Officer, NSW Agriculture

Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (May 2004). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up-to-date and to check currency of the information with the appropriate officer of New South Wales Department of Agriculture or the user's independent adviser.

Always read the label

Users of agricultural (or veterinary) chemical products *must* always read the label and any Permit, before using the product, and strictly comply with the directions on the label and the conditions of any Permit. Users are not absolved from compliance with the directions on the label or the conditions of the permit by reason of any statement made or omitted to be made in this publication.

ISSN 0725-7759

Editing and layout by Bill Noad
Information Delivery Program
Dubbo, May 2004
Job No. 4532