

NO-TILL, PERMANENT BED, VEGETABLE PRODUCTION SYSTEMS

BEST PRACTICE MANUAL

Horticulture Australia
Project Number: VX01033



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Introduction

This section of the report outlines some practical guidelines for the implementation of a permanent bed system for vegetable production. The guidelines presented have been developed during the research undertaken as part of projects VG98050 and VX01033 and through contact with other growers utilising similar vegetable production systems in Australia and the United States.

The project was initiated in response to increasing concerns over the use and disposal of agricultural plastic and declining soil structure in vegetable production systems through cultivation and loss of soil organic matter in the Bowen district of Queensland. Trial sites, however, were located throughout the Northern Territory, Queensland, New South Wales and Victoria. Conclusions drawn from this work and general principles can be extrapolated to a range of locations and crop types.

It is essential that before you undertake any actions outlined in this section of the report on a commercial scale, a small trial should be first be conducted to fine-tune practices, choose appropriate cover crops that will suit your soil type, climate and farming practices. In conducting small scale trials, ensure that you leave an area to be managed under conventional practice in the same or similar soil type as a comparison.

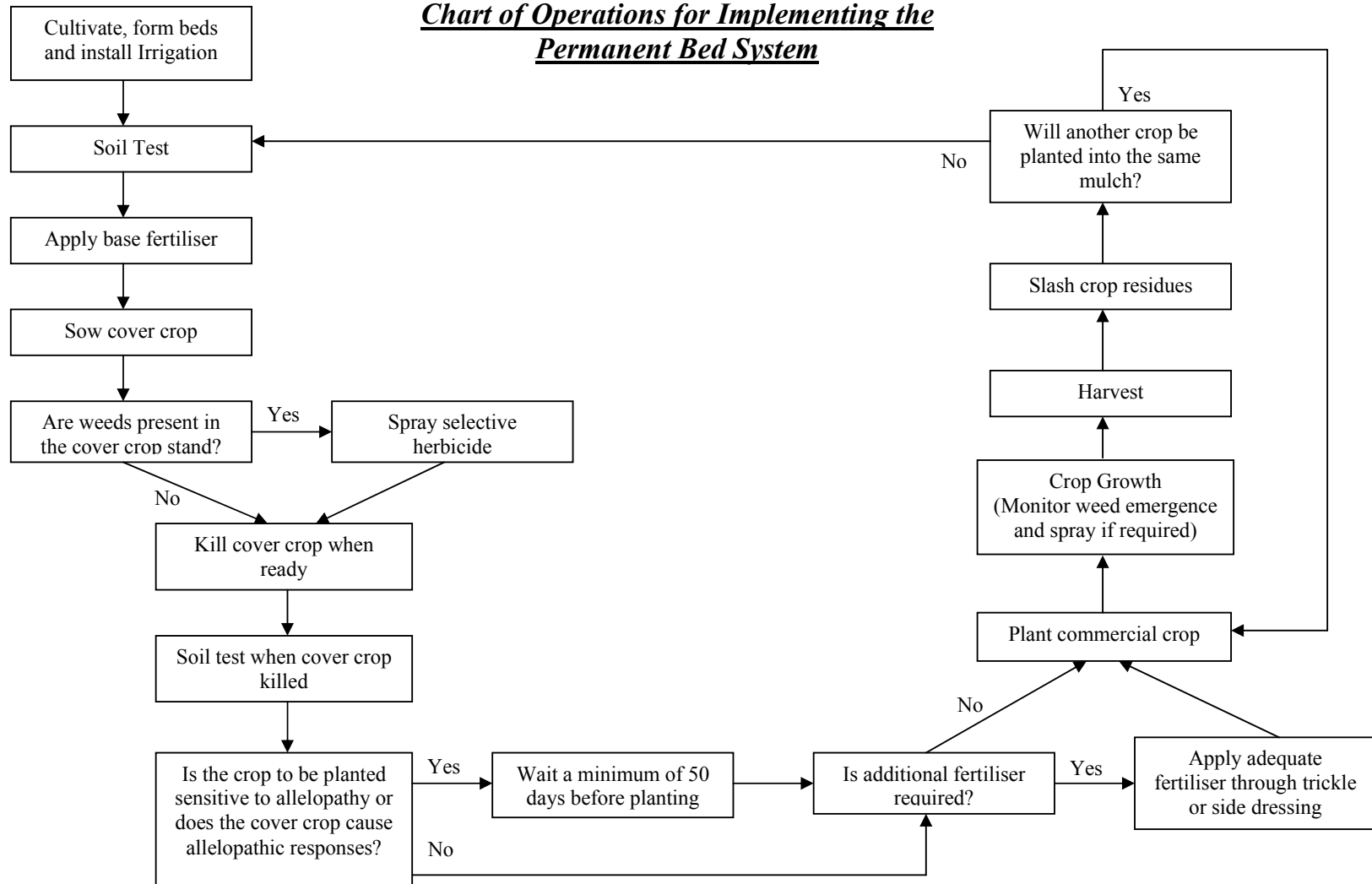
Methods for evaluating changes in soil infiltration and aggregate stability can be obtained from your state department for agriculture, primary industries, or land and water. Levels of weed suppression or soil cover can be determined using visual estimates of percent ground cover and plant vigour or crop quality evaluated using a 1-5 rating system. When making comparisons make 5-10 observations for each treatment and compare the averages, excluding areas or values that are not consistent with the rest of the trial area.

The retention of an organic mulch on the soil surface and a reduction in cultivation results in an increase in organic matter within the soil. This increase in organic matter promotes improvements in soil physical and biological properties that can in turn be of benefit to crop productivity. Watch for changes in worm populations, soil colour and smell, improvement in soil aggregation and stability resulting in a more friable, less compacted soil. In high rainfall events note the extent of water ponding on the soil surface and the colour and cloudiness of any water running off the trial site.

Improvements in soil structure mean more air and moisture can be held within the soil; crop roots can move through the soil and establish faster; high levels of rainfall are rapidly drained away allowing earlier vehicular access to production areas; and soils are less prone to erosion in all conditions. A healthy well-structured soil is vital to the continued productivity of horticultural systems.

Note: The practices described in this document are experimental. Applied Horticultural Research Pty Ltd or Horticulture Australia Ltd therefore do not accept liability for any loss which may occur as a result of implementing any of the practices or techniques described herein and any such implementation by any person or organisation is entirely at their own risk.

Chart of Operations for Implementing the Permanent Bed System



Initial Setup

- **Bed Forming**
- **Irrigation Installation & Flushing Manifold Setup**

Bed Forming

Beds are formed in the first instance using practices similar to conventional production. Bed dimensions are based on common practice and irrigation can be permanent trickle, or overhead depending upon the cropping system.

Irrigation Installation & Flushing Manifold Setup

Where trickle irrigation is installed, trickle tube is buried, typically 150mm below the soil surface. The tubes are then connected to sub mains and flushing manifolds which are also buried to avoid damage. The manifold system installed in Bowen consisted of lengths of 2-inch pipe into which the trickle tubes drain. The trickle tube is flushed by opening taps on the lower end of each length of pipe and allowing the pressure in the system to eject any soil, sand or other rubbish.

Where sub main lines or any above-ground components of the irrigation system are located within a block, difficulties in the maintenance of a permanent bed system have been encountered. It is preferable to situate such equipment on headlands.

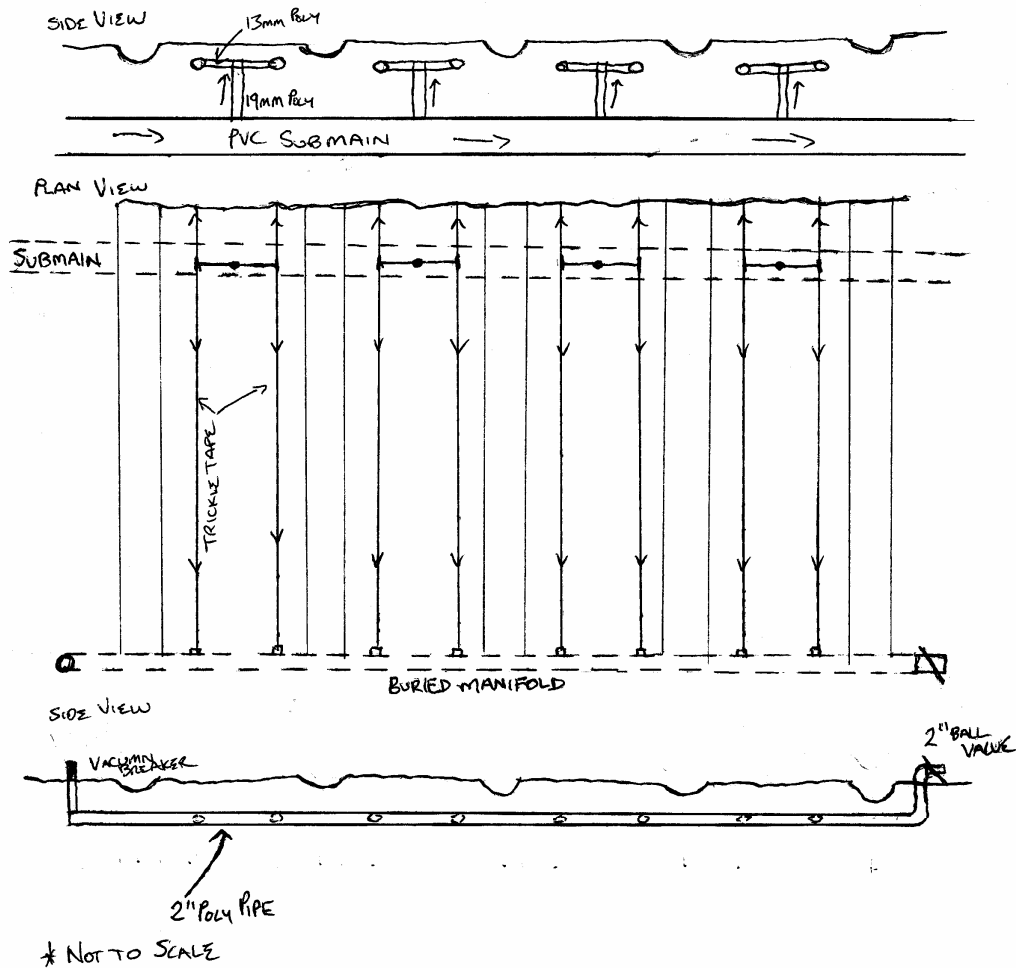


Diagram of the irrigation and manifold layout at Euri-Gold Farms, Bowen.

The choice of trickle tube is critical as it is buried with the aim that it not be touched for a number of years (at least 5-10 years). Critical factors are a combination of good filtration and trickle tube wall strength to ensure uniformity of the irrigation system over time.

Trials conducted in Bowen used two tubes of trickle tape per bed, approximately 300mm apart. The purpose of the two tubes was to ensure a uniform germination of the cover crop seed, however the use of two tubes uses significantly more water,



Flushing Manifold prior to burial.

particularly in the early stages of commercial crop growth, as water is not delivered directly into the root zone of the plant in single row crops.



The use of CRZI irrigation tape in a permanent bed system has merit, in particular the wide wetting pattern produced by the CRZI would provide sufficient moisture for even germination of the cover crop without requiring as much water usage. CRZI tape is constructed in such a way, that damage to the tube by insects, rocks, and plant roots is near zero, thus increasing the potential life span of the trickle tape significantly when compared to standard tube.

Consistent wetting pattern produced by CRZI.

Step 1: Commencing the Cycle

Soil Test & Base Fertiliser Application

A soil test should be taken at this stage to determine the nutrient status of the soil and the rates of nutrients that need to be applied to ensure adequate growth of both the cover crop and the subsequent commercial crop. Base fertiliser must be applied at this stage, as it is the only point in the cycle when the soil surface is readily accessible allowing easier application of solid fertilisers. Soluble fertilisers can be applied just prior to the commercial crop through trickle irrigation or applied as a side dressing and watered in using overhead irrigation.



Base fertilisers are applied when the soil surface is easily accessed.

Nitrogen is a key nutrient in the permanent bed system; Nitrogen is lost to nutrient drawdown of decomposing mulch crops and is also used readily by grass and cereal cover crops. Legume cover crops can be used to supply additional nitrogen, however much of the nitrogen produced by a cover

crop of Centro is either used by the decomposing mulch, or lost to leaching during the wet season. Because of the solubility of nitrogen, it is recommended that nitrogen be added before sowing the cover crop. This will typically only be sufficient for the growth of the cover crop and will require further applications before planting the commercial crop.

Without significant results from the research conducted, it is only possible to estimate the levels of fertiliser required to satisfy both the cover crop and commercial crops needs. Using the soil test, determine the needs of the commercial crop, then add 10-15% more fertiliser for the cover crop. If a grass or cereal cover crop is to be grown, be prepared to add further nitrogen and potassium through the trickle before planting the commercial crop.

Step 2: Sowing the Cover Crop

- Choosing a cover crop
- Sowing the cover crop

Choosing a cover crop

AHR has trialled a range of cover crops for growing in summer and winter in both the tropics and temperate cropping areas. Ideal cover crops establish rapidly, and produce high levels of biomass which when killed off, decompose slowly to provide adequate soil cover for the length of the commercial crop.

Ideal cover crops for the summer period in the dry tropics are the Indian Bluegrass varieties 'Hatch' and 'Keppel' and a tropical legume *Centrosema*



A Wheat cover crop at maturity.

pubescens cv. Cavalcade, also known as "Centro." These cover crops form dense and stable mulches, however they are slow to establish and are poor competitors to weeds in the early stages of growth.

Nutrifeed is a forage crop developed and sold by Pacific Seeds, with potential as a summer cover crop in the dry tropics. It is a hybrid *Pennisetum* with a very late flowering habit and narrow stems. Nutrifeed has performed well in trials at Giru in North Queensland. It is easier to manage than sorghum and when chopped with a flail mulcher and left un-irrigated did not ratoon.

Millet has proven valuable in northern sites such as the Lockyer Valley in Queensland, where a limited window of opportunity exists

between winter and summer crops. White French millet, sown at 40kg/ha, has been used in this region to quickly produce a mulch crop in spring, in preparation for a summer tomato crop. Millet has also provided a good mulch cover for winter crops in the tropics, such as melons.

In crops where ground rot is a potential problem, such as tomatoes, the ground cover provided by millet may prove insufficient. In such cases, a mixture of the fast growing millet with a forage sorghum or cereal with greater biomass, may produce a thicker and hardier mulch.

Cereals have been trialled as winter cover crops in northern Australia. Performance at subtropical sites, such as the Lockyer Valley, has been satisfactory, with no allelopathic effects detected between oats and commonly grown summer crops such as zucchini, rockmelon, watermelon and green cucumber. In the tropics, winter cereals were not as successful, as growth was considerably slower and competition with weeds was poor.

Trials conducted in New South Wales and Victoria focussed primarily on annual cover crops. Best cover crops for winter/spring were the cereals Wheat and Oats, which are sprayed and then rolled using a crimping roller. Other cover crops to show potential include ryegrass and barley.

The thick mulch generated by a winter cereal has proven beneficial in rockmelon production, affording some protection from ground moisture. Potential gains for the quality of smooth-skinned fruits such as watermelon requires further evaluation. Cereal rye has performed particularly well in southern region trials. When sown at relatively high density, the fine stems form a good quality mulch.

For summer cover in the temperate regions, millet provides good mulch and can be killed by spraying and rolling. Forage sorghum also provides excellent cover in the summer in most areas, however it is too thick to be rolled effectively and the resulting mulch is coarse and difficult to manage.

Legumes can potentially add value to a no till system by fixing nitrogen in the soil and alleviating the effects of nutrient drawdown (refer to Step 5). Legume crops have been trialled alone and in combination with other cover crops.

White lupins have been shown to improve the uptake of phosphorus by the following crop, as well as providing organic nitrogen. This is due to the formation of proteoid root clusters which secrete citrate and other organic acids into the rhizosphere.

White lupins, however, have failed to control weed growth in winter legume trials and they provide a poor quality mulch due to watery stems and low plant density per unit area. Field peas have also been evaluated but also failed to prevent weed germination, as plants tend to lodge. When grown in combination with barley, legume growth was suppressed.

Caloona cowpea has achieved some success as a legume in the dry tropics, although growth rate is poor if conditions are relatively cool. Soybeans



Cover produced by Indian Bluegrass "Keppel"

require further testing as a summer legume cover crop for northern areas.

A summary of cover crops trialled during the research is shown in table 1. The list of cover crops is not exhaustive and experimentation with other varieties or species is encouraged (in small areas), however key characteristics of suitable cover crops include:

- Competes well with weeds,
- Produces a suitable mulch,
- Is readily killed using herbicides or mechanical methods,
- Is cost effective, and
- Is easily established.

Cover Crop	Establishment		Cover		Killing Method	Mulch Quality	Comment
	Summer	Winter	Summer	Winter			
Grasses							
Indian Bluegrass - Hatch	Good	Nil	Good		Spray	Good	Can be mown. Very high biomass.
Indian Bluegrass - Keppel	Good	Nil	Good		Spray	Good	Expensive seed.
Sorghum	Good		Good		Spray	Coarse	Cheap alternative but coarse mulch.
Shirohoe Millet	Good	Good	Early Seed	Good	Spray & Roll*	Good	Good winter cover crop.
Rye Grass	Good	Good	Moderate	Good	Spray & Roll*	Good	Good winter cover crop.
Japanese Millet	Good		Early Seed				Seeds too early for thick cover.
Cereals							
Wheat/Triticale	Poor	Good		Good	Spray & Roll*	Good	Excellent winter cover crop.
Barley		Good		Good	Spray & Roll*	Good	Good winter cover crop.
Oats	Poor	Good		Good	Spray & Roll*	Good	Excellent winter cover crop.
Legumes							
Clovers	Poor	Good	Poor	Moderate	Spray	Poor	Poor competition with weeds.
Centrosema (Centro)	Slow	Nil	Good		Spray	Good	Excellent cover, hard to kill.
Lucerne	Poor	Good	Poor	Good	Spray	No Kill	Hard to kill.
Verano Stylo	Poor		Poor				Poor establishment
Sunn Hemp	Good		Moderate		Spray & Roll	Poor	Thin stalks, poor seed availability.
White Lupin	Poor	Good		Poor	Spray & Roll	Poor	Incorporate into a mixture with cereals.
Villosa mixes	Poor		Poor				Poor establishment
Biofumigants							
BQ Mulch	Good	Good	Good	Good	Spray	Poor	Tissue too watery for good mulch.
Rangi Rape	Good	Good	Good	Good	Spray	Poor	Tissue too watery for good mulch.
Other <i>Brassica napus</i> vars.	Good	Good	Good	Good	Spray	Poor	Tissue too watery for good mulch.
Fumus (Mustard)	Good	Good	Early Seed	Early Seed	Spray	Poor	Tissue too watery for good mulch.
Skymustard	Good	Good	Early Seed	Early Seed	Spray	Poor	Tissue too watery for good mulch.
Muscon (Mustard)	Good	Good	Early Seed	Early Seed	Spray	Poor	Tissue too watery for good mulch.
Yellow Mustard	Good	Good	Early Seed	Early Seed	Spray	Poor	Tissue too watery for good mulch.

*Note: Rolling alone may be effective if plant well into reproductive phase, but rolling alone must be tested before use commercially.

Sowing the cover crop

Cover crops are best sown using minimum tillage planters capable of dealing with mulch residues. The minimum tillage planter shown in the figure below was developed as part of this research for planting the tropical legume *Centro* cavalcade in 6 rows per bed.

The planter consists of a crinkled coulter disc that cuts through the residues and the soil surface, the disc is followed immediately by a seed tube which drops the seed directly into the open cut which is then closed with rubber tyre press wheels. Other minimum tillage technology could also be adapted from broadacre systems or conventional equipment modified to enable cover crops to be planted through mulch residues.



The no-till cover crop planter.

Sowing density varies with cover crop. Typically most cover crops can be sown in rows using modified planters, however it is important to ensure that the plant density is sufficient to provide soil coverage when the cover crop is living and when killed off.



Centro 3 weeks after planting.



Centro 12 weeks after planting.

Cover crops that spread laterally such as *Centro* are planted using only six rows per bed, however cereals and grasses need to be sown in as many rows as is possible per bed to ensure a sufficiently thick cover crop stand.

Grasses and cereals have been broadcast sown during research trials. A cone spreader with shielding to direct seed onto beds has been used and the seed lightly incorporated using rolling cultivators followed by a roller. However this requires any residual mulch to be thoroughly broken up before the cover crop can be sown.

Step 3: Managing the Cover Crop

- **Irrigation requirements**
- **Controlling weeds in the cover crop stand**

Typically it is best for efficiency that cover crops are maintained with minimal inputs of water, fertilisers and chemicals. However, as the quality of the mulch produced by the cover crop is so vital to commercial crop productivity, some management is required to ensure maximum biomass is produced.

Irrigation Requirements

During dry periods, particularly as the cover crop nears maturity, some irrigation can help to further boost cover crop biomass. It is also best to keep the soil profile moist to encourage organic activity, this may only require a few hours of irrigation every few weeks during the dry period.



A lush, thick, weed free Centro cover

Where insufficient distribution of moisture across the bed has been provided by sub-surface irrigation, a minimum till system has been employed. A limited amount of cultivation allows better lateral movement of moisture across the bed.

For example, in Katherine, in the Northern Territory, Pearl millet has been established on cultivated beds during the wet season. After conditions dry out and the cover crop matures, the millet is rolled, which snaps the stalks and kills the plants. The lack of moisture prevents rationing. A flail type mulcher is then used to break up the dry and tough residue before a commercial crop is planted into the mulch in a no till fashion. A forage harvester could potentially streamline this process by chopping up the standing millet crop.

Another minimum till technique was developed in Northern Queensland, where a coulter has been used to cut the soil surface, 150mm either side of the trickle tape. The cover crop is then sown in two drills, directly over the coulter tillage. The coulter operation serves to direct water to where the seed is sown on the bed.

Controlling weeds in the cover crop stand

Selective herbicides can be used in the system to clean up cover crop stands and prohibit weeds that have germinated from setting seed.



Grass weeds present within a Centro cover crop.

Trials in Bowen have successfully used Fusilade® to control grass weeds in Centro stands, and Kamba® to control broadleaf weeds in grass cover crops. Jaguar® has also been used to remove certain broadleaf weeds from legume cover crops, however damage to the legume can occur, check the label to ensure cover crop suitability before use.

Step 4: Killing the Cover Crop

- **Choosing herbicides**
- **Mechanical killing**

Cover crops must be killed to enable the commercial crop to establish successfully. This currently involves the use of herbicides to kill or assist in the killing of all cover crops currently recommended.

Choosing Herbicides

The tropical grasses and legumes grown in commercial trials in Bowen were successfully killed using glyphosate (Indian Bluegrass varieties) and Basta® (Centro) at maximum label rates using an air assisted spray boom to ensure full coverage and penetration.



Spraying a cover crop with the air-assisted boom.

Winter cereal cover crops like wheat, oats, millet, etc. are first sprayed with glyphosate at label rates, allowed to stand for a couple of days and then rolled using a crimping roller.

Where a cover crop has produced a low yield, it may be sprayed as late as the milky seed stage to gain maximum biomass. It is important to roll the cover crop while still green (no more than 7 days after spraying) as a crimping roller will not flatten a cover crop properly, once completely dry.

Selective herbicides were trialed in instances where nearby crops were sensitive to glyphosate damage. However, herbicides which specifically target monocotyledonous plants were found to be ineffective in killing cereal cover crops. A tank mix of glyphosate and dicamba can be used for killing cover crops where legumes are present.

Care needs to be taken that herbicide residues on the mulch cover do not impact on subsequent commercial crop production. In some trials, it was suspected that glyphosate residue had a detrimental affect on plant growth. Poor crop performance was also observed after using Touchdown® to kill a cover crop

Organic Interceptor® is a herbicide certified for use in organic production systems. This has been found effective in controlling a range of weeds when combined with a flaming treatment. This combination may be a useful tool for killing cover crops in production systems certified by the BFA or NAASA.

The crimping roller is based on the design of Dr Abdul-Baki (USDA) was constructed during the project and used to roll cereals and grasses. The roller is filled with water to increase weight and improve usability. There are 40mm high ridges on the drum that help to crush the cover crop. Currently the roller attaches to the tractor drawbar, however this can be modified to add a 3-point linkage to improve transportability between sites.

Mechanical Killing



The Crimping roller in action.

There is a potential to use only the crimping roller to kill off cover crops of wheat, oats, barley, and millet providing the plants are near the end of the life cycle (i.e. have formed seed heads) although this has not yet been tested.

The use of flail mulchers, slashers and forage harvesters at maturity may also kill cover crops without requiring the use of herbicides. The use of these



Corn Stalk Chopper used in the USA to kill cover crops in preparation for planting

implements will significantly reduce the amount of mulch produced, which may in turn reduce the extent and longevity of weed suppression. In short crops such as zucchinis and beans however, the mulch cover may be sufficient to produce a crop before weed emergence becomes significant.

Undercutting with a scissor bar has been evaluated, with moderate success on Hatch.

Undercutting the cover crops with a Blade Plough can also be used to kill the cover crop by severing roots. In the US, some growers are using a corn stalk chopper (pictured above) to kill the cover crop and prepare for planting.

Step 5: Transplanting the Crop

- **Allelopathy & nutrient drawdown**
- **Soil Test & Additional Fertiliser**
- **Planting transplants**
- **Direct Seeding**

Allelopathy & Nutrient Drawdown

Nutrient drawdown occurs when soil fungi and bacteria utilise nutrients present in the soil to fuel the breakdown of organic material, resulting in lower levels of soluble nutrients within the soil. Allelopathy occurs when one species of plant releases compounds to suppress competition from other plant species.

Allelopathy is only a problem with certain species of cover crops. Of the cover crops tested in this project, only sorghum and *Bothriochloa* sp. (Indian Bluegrasses), caused significant allelopathic effects on subsequent crops. None of the cereals including wheat, oats, rye, barley or the legumes including barley and Centro caused any allelopathic effects in vegetable crops planted in their residue.

Centro, avoided by allowing the dead cover crop a period of 50 days after spraying to allow allelopathic chemicals to breakdown in the soil. Allelopathy can also be avoided by selecting cover crop / commercial crop rotations that do not combine allelopathic producing cover crops (such as sorghum) with sensitive commercial crops such as Capsicums. Nutrient drawdown is avoided by supplying additional fertiliser through subsurface trickle just prior to establishment of the commercial crop (see below).

Soil Test & Additional Fertiliser

Following the cover crop it is recommended that another soil test be taken to determine levels of nutrients remaining in the soil following the cover crop stage. This soil test can then be used to determine what rates of fertiliser may need to be applied through trickle irrigation before the commercial crop is established. Consistent sampling over the years will give an indication of nutrient use by various cover crops, enabling base fertiliser rates to be refined for future reference.

Planting transplants

Transplanting seedlings through organic mulches has required adaptation of existing technology to ensure a good and consistent establishment of the commercial crop.

The use of conventional water wheel planters resulted in seedlings that struggled to establish due to mulch being pushed down into the seedling hole preventing good seed-soil contact.



Planting out tomatoes using a water wheel planter.

Extending and sharpening the spikes on the water wheel planter produced good results but was abandoned due to the depth of the seedling hole produced and the risk of water draining into the hole providing an ideal environment for fungi to attack the seedling.

Cup planters are currently used which enter the soil then open to deposit the

seedling in a hole that does not contain mulch residues, the soil is then pressed against the seedling using press wheels. A modification of this design

used in 2001 used a large cutting disc which cut through the mulch in the centre of the bed as well as cutting through the soil to a depth of around 15cm. Following behind the disc was a small boot which opened a furrow approximately 5cm wide and 5cm deep. This was followed up by the cup planter, which planted the seedlings into the open furrow. The success of this technique in planting seedlings was good, however the cutting of the mulch and exposure of bare soil encouraged weed germination within the plant row leading to competition and crop damage.



A no-till transplanter developed by RJ Engineering, Canada.

Technology used in US no-till vegetable production systems shows the greatest potential. As part of this project, the Canadian manufactured RJV-600 no till transplanter was trialled in Australia. This technology was found to be pivotal in the future development of no till vegetable production in Australia.

It has demonstrated an exceptional ability to transplant melon seedlings into cover crop residue, including sorghum mulch which is particularly difficult to manage. This machine works best when the mulch is dry but the soil is still slightly damp.



The RJV-600 no-till transplanter developed by RJ Engineering, Canada.

Direct Seeding

Direct seeding crops into mulch residues also requires modified equipment. Rockmelons have been planted through mulch residues by slightly lengthening the cups on a conventional seeder used to plant through plastic. By lengthening the cups the seed is buried in the soil rather than in the mulch or at the boundary between the mulch and the soil. This method resulted in an 85% strike.



A planter with lengthened cups for direct-seeding rockmelons into mulch (left) and a seeder used for planting zucchini seed directly into cereal residue

It is expected that further modifications to equipment would primarily be the addition of a coulter disc to slice through the mulch in front of the planting mechanism. Monosem produce a vacuum seeder that is suitable for planting large seeded vegetable crops such as melons and watermelons through mulch residues.



*A no-till seeder produced by Monosem TM.
Note: coulter disc to slice through surface mulch.*

Step 6: Growing the Crop

- **Crop nutrition**
- **Pre-emergent herbicides & weed control**
- **Irrigation**
- **Crop Performance**
- **Crop residues**
- **Next crop**

Crop growth following transplant follows a similar pattern to conventional agronomy, with careful management of weed emergence, irrigation and nutrition.

Crop Nutrition

Crop nutrition should be monitored using leaf tests, particularly in early stages of crop growth, where nutrient drawdown of nitrogen can occur as the mulch decomposes.

Pre-emergent herbicides & weed control

There is some scope in the system for the use of pre-emergent herbicides although the organic mulch layer prevents much of the chemical from entering the soil, reducing their effectiveness. Knockdown herbicides such as Basta or Spray Seed can also be used in the system to control any weeds that do emerge through the mulch layer, particularly when a low-yielding cover crop has resulted in poor bed coverage.



Weed free mulch 6 weeks after planting tomatoes.

However controlling weeds prior to transplanting an area using glyphosate herbicides can lead to problems. During the project a commercial area was sprayed with glyphosate to control a heavy infestation of nutgrass 2 weeks before planting with tomatoes. The tomato seedlings once transplanted, showed symptoms of herbicide damage and stunted growth the result of residual herbicide on the Centro mulch, which had come into contact with the young seedlings. Use of gramoxone based herbicides prior to crop transplanting did not result in damage to crop seedlings.

Irrigation

Irrigation management requires a change of irrigation scheduling in comparison to crops grown in plastic mulch. In conventional practice, irrigation schedules can be spaced out due to the plastic mulch preventing any evaporation of the soil moisture. However with organic mulches moisture can be lost more easily to the atmosphere particularly from the soil surface. This requires more frequent but shorter irrigations to maintain adequate soil moisture, particularly near the soil surface. This frequency can be lowered to some degree, when a canopy has developed, in crops such as melons.

In cropping situations where no soil cover is used, organic mulch helps to retain moisture, particularly in the soil surface.

Crop Performance

With lower soil temperatures under the organic mulch relative to soil under plastic, the use of the permanent bed system in cooler climates where plastic mulch is currently used to increase soil temperature may require the grower to consider a slightly earlier planting date or a later harvest due to the slower growth under cool conditions, relative to plastic mulch. For watermelon crops grown in Mataranka, in the Northern Territory, organic mulch extended the harvest date by 7-10 days, relative to plastic mulch.

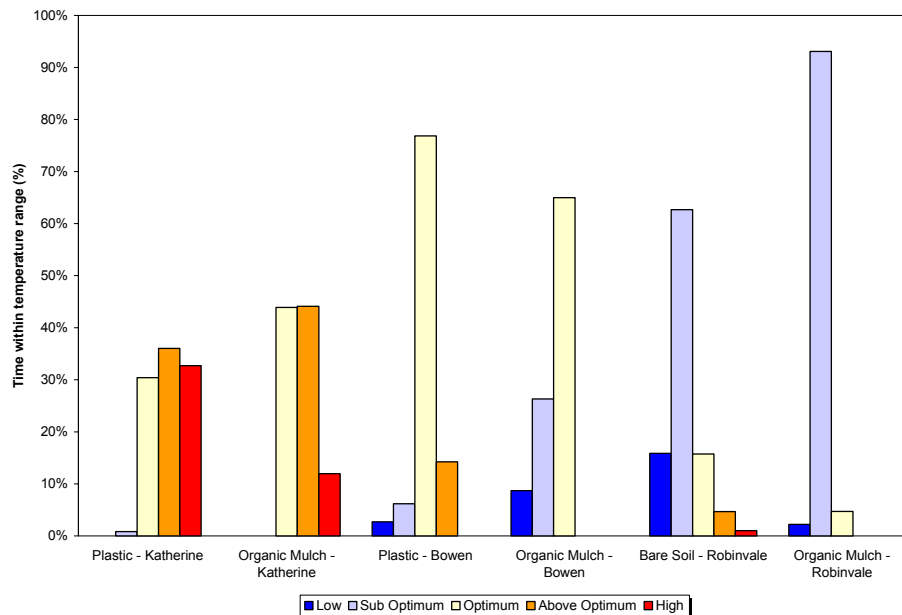


Figure 1: The Effect of Mulch Type on Temperature Regimes in Three Regions

In Figure 1, the effect of organic mulch on the period of optimal temperature experienced by a crop is shown. An understanding of these trends and the temperature requirements of the commercial crop is important in making decisions about the use of an organic mulch.

Organic mulch appears to have a beneficial effect on soil temperature in the Katherine region where temperatures under plastic mulch often exceed 32°C. Soil temperature under organic mulch was below 32° for almost 90 percent of the time compared to 65 percent under plastic mulch. This is seen in the graph as a reduction in the time spent in the high temperature and an increase in the optimum temperature experienced, through the use of organic mulch.

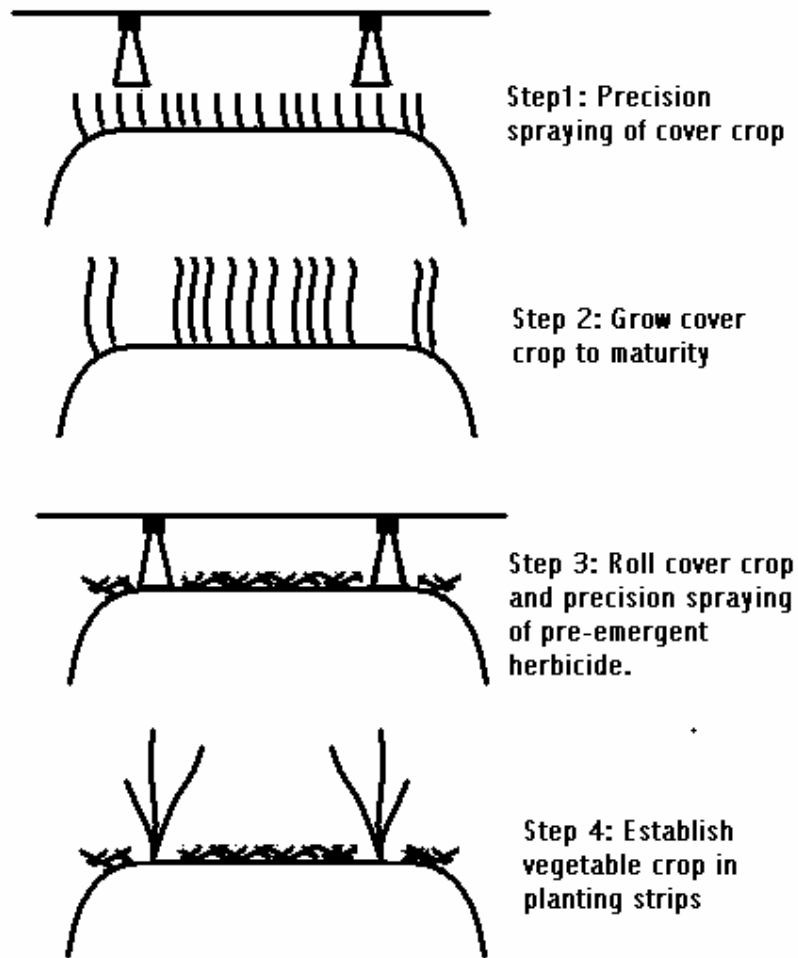
In Bowen, however, organic mulch may hinder plant production as soil temperatures were below the optimum level for plant production for up to 35% of the sampling period. Soil maximum temperature under organic mulch in Bowen was never greater than 25°C whilst soil under black plastic was within the optimum temperature range for 77% of the sampling period. Soil under plastic remained significantly warmer than under organic mulch at all times.

In Robinvale, organic mulch was compared to production on bare soil. The buffering effect of organic mulch on soil temperature was demonstrated at this site. While evening temperatures were an average of 3°C higher under organic mulch, midday temperatures were, on average, 5.5°C lower.

The reduction of day time temperatures by organic mulches has led AHR to investigate the benefits of “planting strips” within the mulch where the soil surface is left free of mulch residues. Seed or seedlings are then planted into these narrow strips of bare soil (Figure 2).

The technique uses precision planting or spraying to leave a strip of soil clear of cover crop residues where the vegetable crop is to be established. Precision spraying using GPS-steer tractors will spray out emerging cover crop seedlings in two 10-12cm strips per bed. Once the cover crop is sprayed and rolled, it is hoped that the two planting strips will provide both improved root zone temperature and improved vegetable crop establishment.

Figure 2: "Planting Strip" technique in No-Till vegetable production (NB: this is yet to be tested in the field)



In research to date, conventional tomato production produced higher yields in the first four picks than production on the permanent beds, whilst the crops on permanent beds had a higher yield after the first four picks. Total yields are similar between the two systems, but are delayed where organic mulch is used instead of black plastic

While seedless watermelon yields have been comparable under both systems, the harvest period and number of harvests has been greater on the crops grown on organic mulch compared to plastic

Other crops have been grown in trial plots using the permanent bed system, all of which were grown to harvest without any growth suppression or disease problems. There is some data to suggest that fungal pathogens have been suppressed in a rockmelon crop grown in a millet residue. Conventional production areas carried infections of fusarium, phytophthora and rhizoctonia.

Crops grown include Capsicum, Eggfruit, Rockmelon, Pumpkin, Honeydew, watermelon, Broccoli and ground tomatoes. A range of other crops could be grown using this system including cauliflower and other Brassica crops, beans and peas, corn and other cucurbits.



Eggplant



Butternut Pumpkin



Roma Tomatoes

Crop Residues

Following harvest crop residues are slashed or mulched, the main priority at this point is to destroy crop residues whilst avoiding disturbance to the mulch residues.

Next Crop

In some areas, growers may plant a second crop in the same ground, whilst trials looking into this have not been conducted, provided the mulch cover is sufficient, this should pose no more risk than planting a second crop into areas under plastic mulch.

However if the area is to be planted with the next cover crop, the system returns to Step 1 and the cycle begins again.

Comparative Costs Of The Permanent Bed System Compared To Conventional Trickle, Plastics And Cultivation.

The following section is a comparative analysis of the costs of a conventional vegetable production system and the permanent bed system.

Costs for the conventional system were taken from a commercial vegetable farm and the costs of the permanent bed system were based on actual times taken for operations and actual costs of seed, chemical and other inputs. Where there was no difference in costs between the two system, that was indicated on the analysis.

The total costs presented therefore may be less than actual costs, but the differences in costs between the two systems are valid.

All figures are based on a per hectare basis. Labour was costed at \$12.50 per hour.

Summary of Cost Comparisons

Action	Cost saving or increase over conventional	
Land Prep	\$12.25	Saving
Cover Crop Stage	\$2,104.63	Increase
Pre-Plant	\$2,734.13	Saving
Tomato Crop Stage	\$98.00	Increase
Clean-Up	\$55.25	Saving
Total Saving	\$599.00	Saving

Permanent Bed System Costs

Permanent Bed System				
Action	Man Hours	Tractor Hours	Salary*	Product
Land Prep				
Cover Crop Stage				
Base Fertiliser	1	1	\$ 12.25	\$ 1,500.00
Cover Crop Seed (Average)	3	2	\$ 36.75	\$ 220.00
Selective herbicide	2	1	\$ 24.50	\$ 190.00
Spraying off cover crop	2	1	\$ 24.50	\$ 210.00
Pre-Plant				
Pre-Plant fertigation	2	0	\$ 24.50	\$ 170.00
Tomato Crop Stage				
Planting	Same	Same	Same	Same
Interrow spraying	Same	Same	Same	Same
Trellis	Same	Same	Same	Same
Spraying - fungicides/insecticides	Same	Same	Same	Same
Irrigation	Same	Same	Same	Same
Crop monitoring	Same	Same	Same	Same
Hand weeding	8		\$ 98.00	
Harvest	Same	Same	Same	Same
Clean-Up				
Pull down trellis	Same	Same	Same	Same
Mulching crop residues	Same	Same	Same	Same
Weed spraying	2	1	\$ 24.50	\$ 35.00
Annual Totals	20	6	\$ 245.00	\$ 2,325.00
Total Salary + Products				\$ 2,570.00

Conventional Vegetable Farming Costs

Conventional System				
Action	Man Hours	Tractor Hours	Salary*	Product
Land Prep				
Discing	0.5	0.5	\$6.13	\$ -
Ripping	0.5	0.5	\$6.13	\$ -
Cover Crop Stage				
Cover Crop Seed - Sorghum	0.5	0.5	\$6.13	\$ 95.00
Mulching off Sorghum	1	1	\$12.25	\$ -
Pre-Plant				
Discing	1	1	\$12.25	\$ -
Ripping	1.5	1.5	\$18.38	\$ -
Marking out & Spread base Fertiliser	1	1	\$12.25	\$ 1,500.00
Form beds, lay plastic	6	6	\$73.50	\$ 1,300.00
Set up Irrigation	1	0	\$12.25	\$ -
Tomato Crop Stage				
Planting	Same	Same	Same	Same
Interrow spraying	Same	Same	Same	Same
Trellis	Same	Same	Same	Same
Spraying - fungicides/insecticides	Same	Same	Same	Same
Irrigation	Same	Same	Same	Same
Crop monitoring	Same	Same	Same	Same
Harvest	Same	Same	Same	Same
Clean-Up				
Pull down trellis	Same	Same	Same	Same
Mulching crop residues	Same	Same	Same	Same
Lift plastic & roll trickle	4	4	\$49.00	\$ 65.75
Disposal of Plastic waste				
Annual Totals	17	16	\$208.25	\$ 2,960.75
Total Salary + Products				\$ 3,169.00

Summary of Returns

Comparison of relative returns (from crop yield and quality) for organic mulches vs plastic mulches

The following data was estimated based on grower yields and typical market prices.

Crop	Cultivation Method	Yield (t/ha)	Return (\$/ha)
Seedless watermelons (early crop, Northern Territory)	Plastic mulch	40 - 60	\$28,000 - \$42,000
	Millet mulch	34 - 51	\$23,800 - \$35,700
Seedless watermelons (mid (late season crop, Northern Territory)	Plastic mulch	40 - 60	\$28,000 - \$42,000
	Millet mulch	40 - 60	\$28,000 - \$42,000
Beans	No Mulch	5-8	\$6,500-\$10,400
	Millet/Barley mulch	7-10	\$9,100-\$13,000
Squash	No Mulch	6-9	\$24,000-\$36,000
	Millet/Barley mulch	8-11	\$32,000-\$44,000