Horticulture Innovation Australia

Final Report

The development and manufacture of a semi-automatic transplanter for a range of cell grown plants into plastic mulch

Morgan Upton
Agcom International

Project Number: VG10088

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FINAL REPORT FOR HAL
PROJECT VG10088

(May 2012)

THE DEVELOPMENT AND MANUFACTURE OF A SEMI-AUTOMATIC TRANSPLANTER FOR A RANGE OF CELL GROWN PLANTS INTO PLASTIC MULCH

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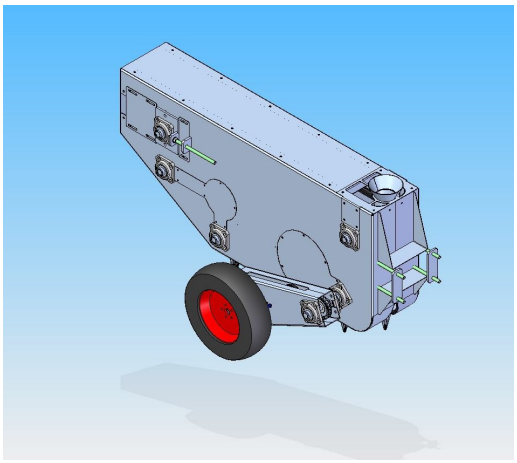

Agcom International

Horticulture Australia

HAL Project Number: VG 10088

Project Leader

Morgan Upton

The aim of this project was to develop a semi-automatic transplanter which could efficiently plant through plastic mulch. Mechanisation of planting substantially reduces costs of production.

Morgan Upton	**Owner, Agcom International**
Michael Weisenberger	**General Manager of KW Automation Pty Ltd (Palmwoods, Queensland)**
Warrick Chudleigh	**Project Consultant**

This is a final report for R&D work conducted for the Australian vegetable industry from 2010-2012.

"This project has been funded by HAL using voluntary contributions from Agcom International and matched funds from the Australian Government."

Agcom International

Horticulture Australia

Date of report: May 2012

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1.0 MEDIA SUMMARY

MEDIA SUMMARY

The aim of this project was to develop a semi-automatic transplanter for the Australian vegetable industry. The project was successful in designing and building a new transplanter which could efficiently plant through plastic mulch. Over 3,000 vegetable growers in Australia could benefit from the new technology. Transplanting is a laborious task when performed by hand.

The project was instigated based on the visionary concepts of Morgan Upton, director of Agcom International. In conjunction with KW Automation Pty Ltd, Morgan designed, built and tested the new transplanter on commercial farms. The transplanter cuts the plastic, punches a hole into the soil bed and deposits the seedling and a supply of water in the hole in the bed. About 2,500 plants can be transplanted per hour with a 30% reduction in costs compared with traditional transplanters. Successful construction of the transplanter can be attributed to the engineering skills of KW Automation Pty Ltd who are based at Palmwoods, Queensland. KW Automation Pty Ltd has had a long association with designing horticultural equipment.

The transplanter will be manufactured and made available to the market within 12 months. Agcom International expects to have a 10% per annum adoption rate for the first three years once the unit is commercially available.

2.0 TECHNICAL SUMMARY

TECHNICAL SUMMARY

- This project has successfully designed, built and tested a new transplanter for vegetables. The machine has been specifically designed to plant through plastic mulch which is widely used throughout the vegetable industry.
- The project was instigated based on the visionary concepts of Morgan Upton, director of Agcom International. In conjunction with KW Automation Pty, Morgan designed, built and tested the new transplanter on commercial farms.
- Successful construction and modification of the transplanter can be attributed to the engineering skills of KW Automation Pty Ltd who are based at Palmwoods, Queensland. This company has had a long history with designing horticultural equipment.
- Compared with other transplanters that use a 'wheel' drive mechanism, the Agcom transplanter uses a unique track drive system. This track system allows greater time to apply fertilizer, water and other additives.
- Vegetable growers who will benefit most from the new technology will be those using plastic mulch. Over 3,000 vegetable growers in Australia could benefit from the new technology. Priority crops are listed below:
    - Peppers (Hot & Sweet)
    - Tomatoes
    - Melons (Water, Honeydew & Rock)
    - Zucchinis & Squash
    - Pumpkins
    - Egg Plants
- The transplanter cuts the plastic, punches a hole into the soil bed and deposits the seedling and can supply water in the hole in the bed.
- Planting costs were reduced by 33% over traditional transplanting methods.
- About 2,500 plants can be transplanted per hour.
- The transplanter will be manufactured and made available to the market within 12 months.
- Agcom International expects to have a 10% per annum adoption rate for the first three years once the unit is commercially available.

3.0 REVIEW OF LITERATURE

3.1 Vegetable crops grown on plastic

Australia has a large and vibrant vegetable growing industry ($3.36 billion in 2007-2008, Ausveg). Some specific species of vegetable crops are grown on 'plastic mulch' in Australia (Table 1). Nearly all plantings of vegetable seedlings on plastic mulch is currently by hand. The crops frequently grown on 'plastic mulch' include the following:

- tomatoes
- peppers (both sweet & hot)
- melons (water, honeydew & rock melons)
- zucchinis &squash
- pumpkins
- eggplants

The percentage of specific crops grown on plastic mulch varies from region to region and the time of the year (i.e. peppers in Bundaberg are grown on plastic mulch over the cooler winter months only).

TABLE 1.
*Size of Australian vegetable industries which may benefit from use of a mulch transplanter. *Source Ausveg 2008 Industry Report.*
**Note - growers may grow multiple crops.*

Crop	Hectares	Number of growers
Tomato	7000	540
Melons	7000	640
Pumpkins	5000	915
Peppers	2500	486
Zucchinis	2000	552
Egg Plants	700	217
TOTALS	24200	3350

There are many advantages growing vegetable crops on plastic which include;

1. less water usage
2. less tillage and cultivation
3. better fertilizer utilisation
4. reduction of weeds
5. higher plant/crop yields
6. lower management input requirements

3.2 Transplants in non-plastic applications

There are currently two types of transplanters for "non plastic" applications

- Semi automatic (where an operator places a plant into a drop tube)
- Fully automatic (the unit extracts the plant from the tray and places it into the soil).

There two major manufacturers of these units in Australia;

- Williames Pty. Ltd
- Transplant Systems Pty. Ltd.

Williames Pty Ltd. was founded by Geoff Williames in 1976. The business is based in Warragul approximately 100km south east of Melbourne in Victoria. The company premises house a research and development facility together with a manufacturing plant. The Williames Transplanter (Plate 1) leads the world in high speed selective automatic transplanting. Each head automatically selects seedlings from a tray, transfers it to the drop tube and plants it into the ground.

Plate 1. The Williames transplanter for non-plastic situations.

Transplant Systems Pty Ltd, Berwick, Victoria is an Australian owned and registered company. They sell the TEA XP608M which is an excellent transplanter. Typical production is about 1700 plants per hour per head so with 4 heads expect around 6 800 plants per hour at full speed, with 6 heads expect about 10 000 plants per hour production.

Plate 2. The Transplant Systems transplanter (for non-plastic situations.)

There are also a number of imported units from Spain, Italy, China, & USA for "non' PM applications. A full list of the manufacturers and models is available however as these units are not in direct competition with the proposed Agcom unit they are not considered relevant.

3.3 Transplants in plastic applications

The most common planting technique is the waterwheel type.
The waterwheel mechanism utilizes a rotating drum or drums with spikes at set intervals which punches a hole in the plastic and creates a cavity which is filled with water. A plant is hand planted into this hole in a subsequent operation.

Worldwide, there are few manufacturers of transplanters that can plant through plastic mulch. Two companies based in the USA have developed transplanters that can plant through plastic mulch (Plate 2). These companies are:

- Mechanical Transplanter Company, Michigan State
- Renaldo Company, New York State

Their transplanters can plant either single or double rows. Their units can be viewed at their web sites (see references). The Renaldo transplanter uses a gas burner to burn a hole through the plastic. The unit carries a gas tank and the flame is always alight. They have been trialled in Australia with limited uptake.

Plate 3. Top: Michigan Model 948T Mulch Transplanter. Bottom: Renaldo mulch transplanter showing gas burner.

The only other relevant unit, that the authors are aware of, is owned, developed and operated by Charlie De Dominico at Double D Farms in Ingham, North Queensland. This unit also operates on the "single wheel" principle. It is attached to a Williames* automatic transplanter head. There is currently no plan for "commercialisation" of this device.

3.4 Agcom transplanter

The Agcom transplanter unit, developed through this project, is a semi-automatic unit but may be integrated with a fully automatic system if required. This can be achieved by adding a commercially available delivery system; usually referred to as a transplanting head. The operation of the Agcom unit differs from the Mechanical Transplanter Company. This unit operates on a "single wheel" principle whereas the Agcom unit is more closely identified to a conveyor or track system. The Agcom unit will not use a gas burner to burn holes through the plastic mulch but will punch the holes with specially designed pointed delivery cups.

Advantages of Agcom transplanters

The Agcom unit has a number of other discernible differences from units/systems currently available. Compared with other transplanters that use a ‘wheel’ drive mechanism, the Agcom transplanter uses a unique track drive system. This track system allows greater time to apply fertilizer, water and other additives.

The planting heads have been designed on narrow spaces to cater for double rows to be planted per bed simultaneously.

Because of its unique design features, the Agcom unit will significantly reduce costs to the vegetable grower in two (2) main areas:

1. labour
2. fuel

The unit will eliminate the need for the current practice of two tractor passes (1 with the "water wheel" and 1 to plant the seedlings) in the “traditional” water wheel planting

Supplementary benefits of the unit include:

- decreased physical effort required by workers
- cleaner, better working environment for employees (as they are no longer required to place the plant directly into the hole)
- reduced ground compaction (with fewer tractor passes)
- be locally made (with the added bonus of probable exports)

Reference websites

- http://www.williames.com/
- http://www.transplantsystems.com.au/
- http://www.mechanicaltransplanter.com/plastic.html.
- www.renaldo.org/renaldo_sales/agricultural/rtme.html
- http://www.kwengineering.com.au/

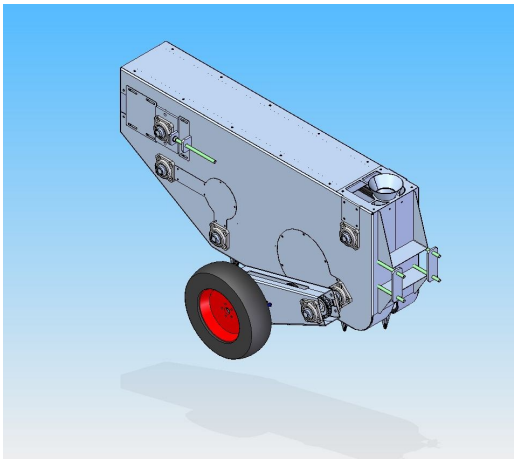

Plate 4 “concept” drawing

4.0 TECHNICAL REPORTS

4.1 OUTLINE OF THE DEVELOPMENT STRATEGY FOR THE AGCOM TRANSPLANTER

Resource Allocation and methodology

- Before starting the project a detailed action plan was developed. This action plan has been successfully implemented (see Table 1).
- The original design has been modified several times and refined based on field testing.
- The final prototype tested in May 2012 meets commercial performance standards and is ready for manufacture.

TABLE 1.

Action plan for development of the Agcom transplanter.

Action Step	Responsible person/s for work detail	Completion date
Design Unit	KW Automation & Agcom	7/3/11
Generate BOM	KW Automation & Agcom	7/3/11
Source Components	KW Automation & Agcom	29/5/11
Assembly	KW Automation & Agcom	6/6/11
Field Trials	Agcom	8/8/11
Modify Drawings	KW Automation & Agcom	17/10/11
Modify Unit	KW Automation & Agcom	12/12/11
Field Test (Second round)	Agcom	9/1/12
Develop appropriate manufacture plan	KW Automation & Agcom	30/3/12
Develop appropriate Marketing & Sales plans	Warrick Chudleigh & Agcom	30/3/12

Note: Although not listed individually a number of appropriate people advised throughout the project

Outcome & Outputs

1. Demonstrated and proved the underlying concepts of the unit
2. Designed and built a successful prototype
3. Refined prototype to be commercially acceptable
4. Produced bill of materials and drawings of the units in anticipation of commercial sales
5. Gained confidence of the consumer group to purchase (when available)

4.2 DESIGN OF THE AGCOM TRANSPLANTER

Design options and considerations

The Agcom transplanter was specifically designed to plant through plastic mulch. There are two operations involved in current methods of planting into plastic mulch.

A) A device (often referred to as a water wheel) is passed over the bed.

This unit;

1. Cuts the plastic creating a hole (with an appropriate size & shape to allow plant root ball access)
2. Drills/punches a hole into the soil bed (sufficient depth and size to accommodate the plant root ball)
3. Deposits a supply of water in the hole in the bed (as created in point 2) - this addition of water aides in plant establishment.

- This device is like a road construction roller or compactor with blunt end spikes over it at appropriate points.
- The device is filled with water to deposit water into the holes it creates and to increase the unit's weight (creating a hole to place the plant)

B) A person deposits a plant into each hole

- A person deposits/plants a plant into the hole created - this person is normally on a trailed platform, at the appropriate height and distance pulled behind a tractor.
- One (1) person normally plants one (1) row at a time (or per pass)
- The process is labour intensive and costly for the grower and repetitive for the worker

Agcom unique design features

To develop a unit which will accomplish all planting procedures in one pass whilst reducing the labour and cost component of the operation.

The unit will:

1. Cut the appropriate hole in the plastic
2. Make a crevice/hole in the bed sufficient to plant the root ball
3. Deposit a plant in the crevice at the appropriate depth
4. Back fill the hole leaving the plant in place as required
5. Water the plant in place

Compared with other transplanters that use a ‘wheel’ drive mechanism, the Agcom transplanter uses a unique track drive system. This track system allows greater time to apply fertilizer, water and other additives if required.

The planting heads are very narrowly spaced which allows for double rows to be planted per bed simultaneously.

Design concept

The transplanter was designed by Morgan Upton of Agcom International and fabrication was done by KW Automation Pty Ltd, based at Palmwoods, Queensland. KW Automation Pty Ltd has had a long association with designing horticultural equipment.

A design/plan of the unit was created through computer 3D modelling programs. A bill of materials (BOM) was subsequently developed and components were sourced from appropriate suppliers.

Technical Drawings

A contract draftsman was engaged to produce "concept" drawings of the unit which were passed on to KW Automation to refine into the "finished" plans and blueprints for construction/build purposes of the "prototype". The initial drawings were produced by ACCO.

Details of the plans are presented in Plates 5 - 7.

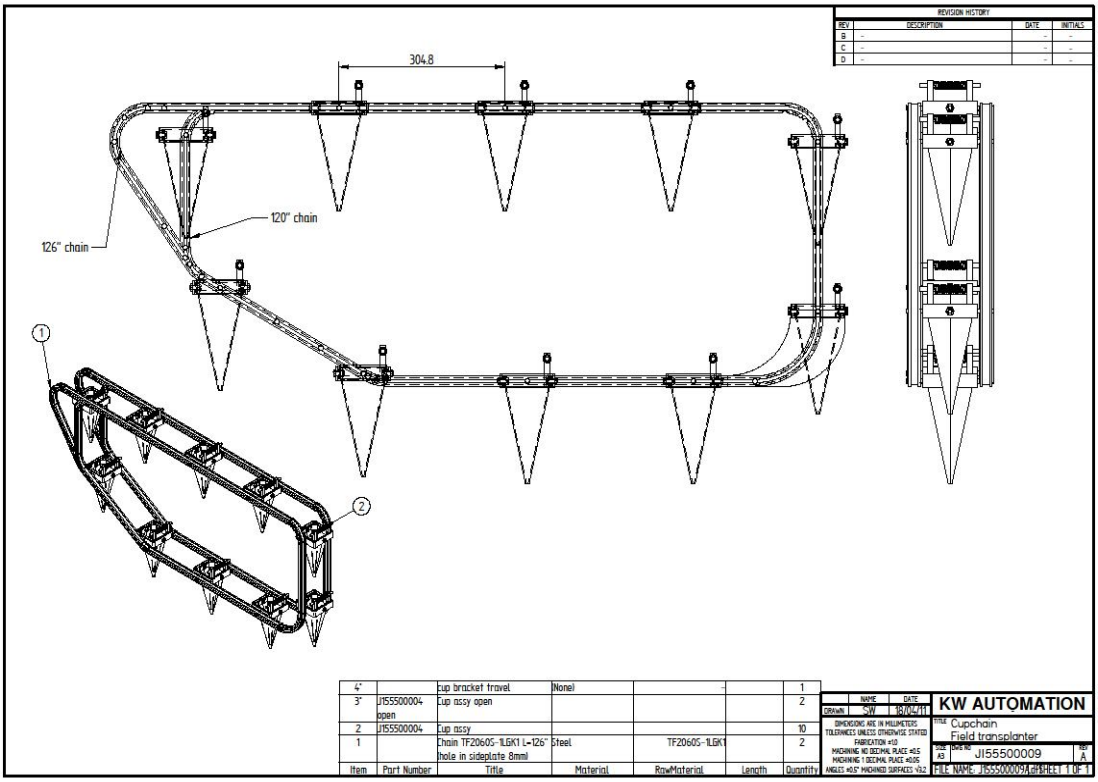

Plate 5. Detailed drawings of the body of the Agcom transplanter.

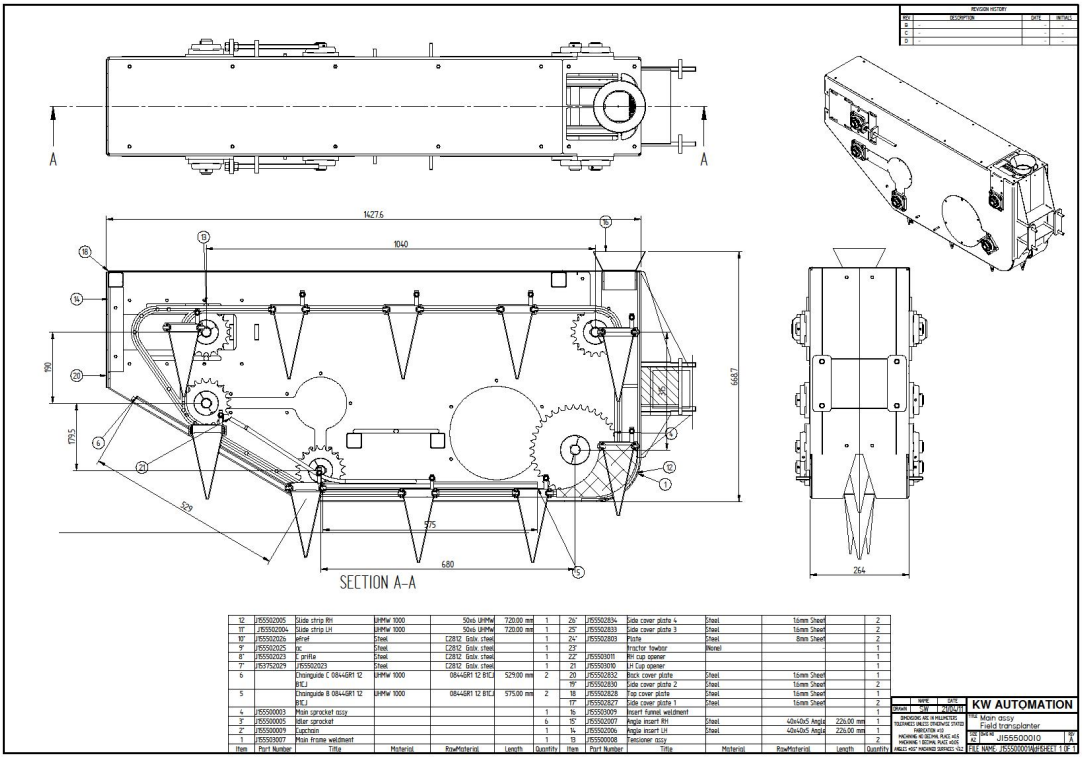

Plate 6. Detailed drawings of the track drive mechanism of the transplanter.

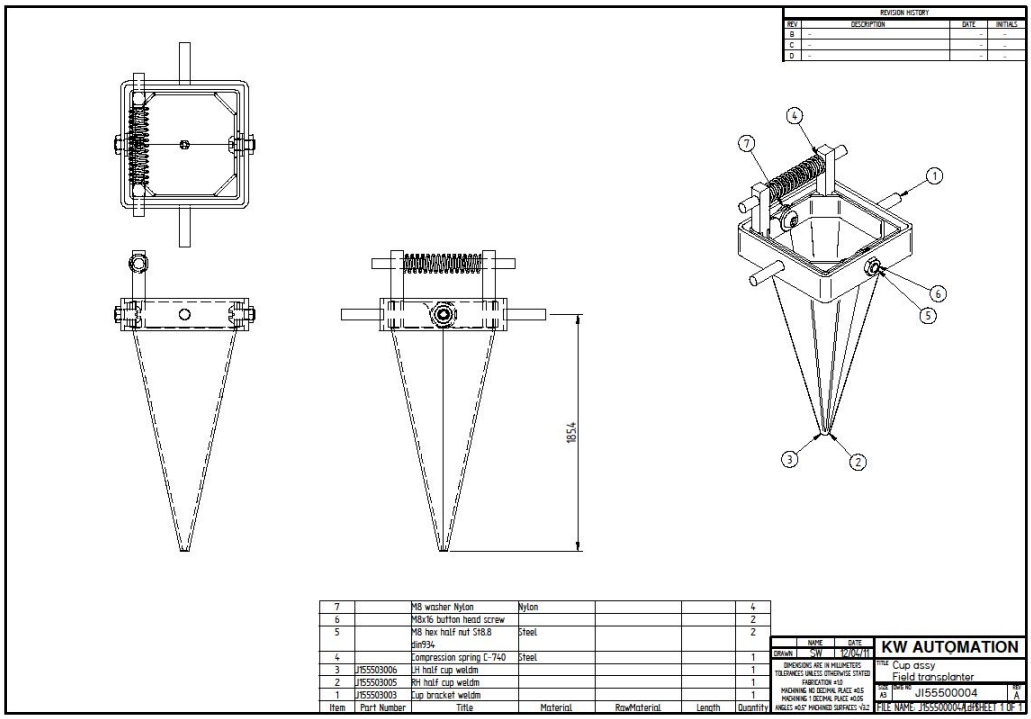

Plate 7. Detailed drawings of the transplanter cups.

4.3 CONSTRUCTION OF THE AGCOM TRANSPLANTER

Construction materials

The Agcom transplanter was built at KW Automation Pty Ltd., Palmwoods, Queensland. The transplanter chassis was built mainly from 1.6mm mild steel. A list of construction components is presented in Table 1.

Modifications

Based on field testing, a series of modifications were made to the original design. Most modifications/revisions were identified as being needed to facilitate the units field performance.

- The force generated by the small points (cups) which are in contact with the soil was found to be insufficient to "drive" the chain mechanism.
    - A ground wheel was fitted to ease the tension on the drive chain.
    - This wheel was synchronised with the ground speed of the unit.
    - It was mounted on a "floating" frame adjacent to the transplanter unit - connected by universal joint
- A small "lip" was put on the cup to stop it being able to move sideways.
- The cup design was altered (less of a point, shallower and smaller
- Cups had UMPE added to the inside surface to aid plant removal
- The "opening" bar/mechanism was modified to work correctly.
- Strategically placed bars, UMPE and brushes to help with cup alignment
- Modifications to the tool bar to allow two units
- Addition of new anchoring pins on the tool bar to allow the unit to be offset

Additions (to be added)

Additions were made which made the transplanter more "user" friendly and versatile. The additions did not change the operation of the unit. The additions do not alter the overall project premise and are to be viewed as auxiliary rather than core achievement criteria/s. These additions included:

- Carousel for plant delivery to cups (Which will give the operator more flexibility in timing of the plant delivery)
- Planter wheels to aide in back filling of the plant "hole"
- Water delivery mechanism into plant "hole" (to help back filling and to enable the plant to have water at planting to relieve stress)
- Fitting and positioning of an appropriate seat and platform for operator.
- Fabrication, fitting & positioning of a plant tray storage rack (to enable longer periods before the operator requires "restocking".)
- Independent adjustment mechanism for height on front of unit for operating in uneven terrain and when units are "in tandem" on the one tool bar (this will be a modified "plate" where the unit attaches to the tool bar.

Additions (completed)

These additions have already been completed;

- A dedicated tool bar for attachment to the tractor via the 3 point linkage
- Wheels for height adjustment of unit (jockey wheels have been added to each end of the tool bar).
- Carousel for placing the plants into the cups
- Planter wheels to aide in back filling of the plant “hole”
- Fitting and positioning of an appropriate seat and platform for operator.

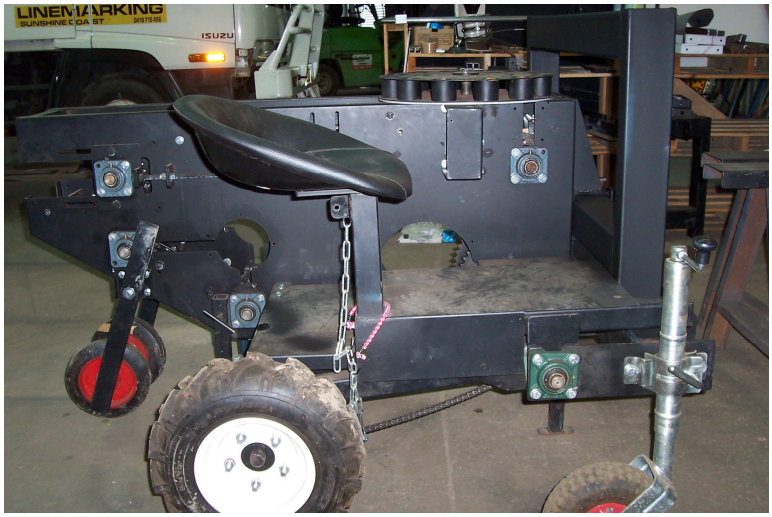

Plate 8 Side view illustrating some of the “additions”

Plate 9 & 10. Constructing the Agcom transplanter. Side view.

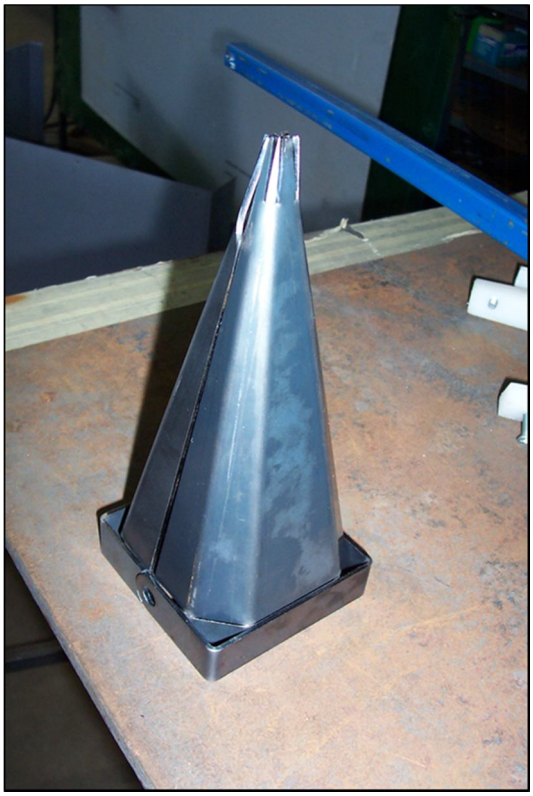

Plate 11 Individual cup

TABLE 2.

Bill of materials used in the construction of the Agcom transplanter.

x 1 J155502828 Top cover plate Field transplanter A Steel 1.6mm Sheet 1
x 1 J155503009 Insert funnel weldment Field transplanter A 1
x 2 J155502011 drop pipe Field transplanter A Steel 88.9x3.2 pipe 50.00 mm 1
x 2 J155502829 In feed funnel Field transplanter A Steel 1.6mm Sheet 1
x 2 J155502826 In feed section top plate Field transplanter A Steel 2mm Sheet 1
x 1 J155502830 Side cover plate 2 Field transplanter A Steel 1.6mm Sheet 2
x 1 J155502006 Angle insert LH Field transplanter A Steel 40x40x5 Angle 226.00 mm 1
x 1 J155502007 Angle insert RH Field transplanter A Steel 40x40x5 Angle 226.00 mm 1
x 1 J155502827 Side cover plate 1 Field transplanter A Steel 1.6mm Sheet 2
x 1 J155502832 Back cover plate Field transplanter A Steel 1.6mm Sheet 1
x 1 J155502803 Plate Field transplanter A Steel 8mm Sheet 2
x 1 J155502833 Side cover plate 3 Field transplanter A Steel 1.6mm Sheet 2
x 1 J155502834 Side cover plate 4 Field transplanter A Steel 1.6mm Sheet 2
1 J155503010 LH Cup opener Field transplanter A 1
2 J155502031 M8 threaded stud Field transplanter A Steel 8.8 M8 treaded stud 100.00 mm 3
2 J155502029 Cup opener bar LH Field transplanter A Steel 10 RMS 650.00 mm 1
1 J155503011 RH cup opener Field transplanter A 1
2 J155502030 Cup opener bar RH Field transplanter A Steel 10 RMS 1
2 J155502031 M8 threaded stud Field transplanter A Steel 8.8 M8 treaded stud 100.00 mm 3
DNU tractor towbar - (None) - 1
x 1 Chain guide C 0844GR1 12 B1CJ Washer - UHMW 1000 0844GR1 12 B1CJ 529.00 mm 2
DNU 1 J155502023 C profile 2812 Grader A Steel C2812 Galv. steel 1
DNU 1 J155502023 C profile 2812 Grader A Steel C2812 Galv. steel 1
x 1 J155500003 Main sprocket assy Field transplanter A 1
x 2 F205 Flanged bearing housing 2
x 2 UC205 Bearing insert - Dia 25 Bearing Unit Steel - 2
x 2 TL2517 bore25 2
x 2 J155504001 Main shaft Field transplanter A Steel 25 RMS 342.00 mm 1
x 2 12B38 TL2517 Steel 2
x 2 8x7x50Key - Steel - 2
x 1 J155500005 Idler sprocket Field transplanter A 6
x 2 F205 Flanged bearing housing 2
x 2 UC205 Bearing insert - Dia 25 Bearing Unit Steel - 1
x 2 CS205LLU bearing insert - Steel - 1
x 2 TL2012 bore25 1
x 2 J155504003 Idler shaft Field transplanter A Steel 25 RMS 112.00 mm 1
x 2 12B20 TL2012 Steel 1
x 2 8x7x30Key - Steel - 1
x 1 Chain guide B 0844GR1 12 B1CJ Washer - UHMW 1000 0844GR1 12 B1CJ 575.00 mm 2
DNU 1 J155502025 C profile 2812 Grader A Steel C2812 Galv. steel 1
x 1 J155502004 Slide strip LH Field transplanter A UHMW 1000 50x6 UHMW 720.00 mm 1
x 1 J155502005 Slide strip RH Field transplanter A UHMW 1000 50x6 UHMW 720.00 mm 1
x 1 J155500008 Tensioner assy Field transplanter A 2
x 2 8x7x30Key - Steel - 1
x 2 TL2012 bore25 1
x 2 M12 washer 8.8 ZP DIN125 Steel 4
x 2 M12x250threaded stud Fastener - Steel Galv. - 250.00 mm 1

x 2 M12 hex nut St8 zpl din934 4
x 2 12B20 TL2012 Steel 1
x 2 F205 Flanged bearing housing 2
x 2 J155503004 Tensioner plate weldm Field transplanter A 1
x 3 J155502831 Adjuster plate Field transplanter A Steel 10mm Sheet 1
x 3 J155502823 Spacer Field transplanter A Steel 8mm Sheet 4
x 3 J155502808 Tensioner main plate Field transplanter A Steel 8mm Sheet 1
x 2 UC205 Bearing insert - Dia 25 Bearing Unit Steel - 1
x 2 J155504004 Idler shaft tension unit Field transplanter A Steel 25 RMS 122.00 mm 1
x 2 CS205LLU bearing insert - Steel - 1
DNU 1 J153752029 C profile 2812 Grader A Steel C2812 Galv. steel 1
ASSY 1 J155500009 Cup chain Field transplanter A 1
x 2 Chain TF2060S-1LGK1 L=126" (hole in side plate 8mm) - Steel TF2060S-1LGK1 2
ASSY 2 cup bracket travel - (None) - 1
x 2 J155500004 Cup assy Field transplanter A 10
x 3 M8x16 button head screw 2
x 3 M8 washer Nylon Nylon 4
x 3 M8 hex half nut St8.8 din934 Steel 2
x 3 J155503003 Cup bracket weldm Field transplanter A 1
x 4 J155502027 Pivotting pin Field transplanter A Steel 8 RMS 160.00 mm 1
x 4 J155502014 cup bracket Field transplanter A Steel 100x100x3 RHS 25.00 mm 1
x 3 J155503005 RH half cup weldm Field transplanter A 1
x 4 J155502806 Cup top 1 Field transplanter A Steel 2mm Sheet 1
x 4 J155502816 Cup bracket Field transplanter A Steel 2mm Sheet 1
x 4 J155502804 Cup Transplanter A Steel 2mm Sheet 1
x 4 J155502022 Cup tracker Field transplanter A Steel 10x10 FMS 60.00 mm 1
x 4 J155502028 tracker pin Field transplanter A Steel 8 MRS 40.00 mm 1
x 3 J155503006 LH half cup weldm Field transplanter A 1
x 4 J155502804 Cup Transplanter A Steel 2mm Sheet 1
x 4 J155502807 Cup top 2 Field transplanter A Steel 2mm Sheet 1
x 4 J155502028 tracker pin Field transplanter A Steel 8 MRS 40.00 mm 1
x 4 J155502811 Cup tipper bracket Field transplanter A Steel 2mm Sheet 1
x 4 J155502022 Cup trackers Field transplanter A Steel 10x10 FMS 60.00 mm 1
x 3 Compression spring C-740 Steel 1
x 1 J155503007 Main frame weldment Field transplanter A 1
x 2 J155502012 C profile 2812 Field transplanter A Steel C2812 Galv. steel 575.00 mm 2
x 2 J155502818 RH side Field transplanter A Steel 3mm Sheet 1
x 2 J155502825 Thickener plate Field transplanter A Steel 5mm Sheet 8
x 2 J155502013 C profile 2812 Grader A Steel C2812 Galv. steel 529.00 mm 2
x 2 J155502802 Lower Gusset Field transplanter A Steel 3mm Sheet 1
x 2 J155502801 Top gusset Field transplanter A Steel 3mm Sheet 1
x 2 J155502015 M12x150threaded stud Field transplanter A Steel 8.8 M12 treaded stud 150.00 mm 4
x 2 J155502002 RHS Field transplanter A Steel 40x40x2 RHS 258.00 mm 4
x 2 J155502817 LH side Field transplanter A Steel 3mm Sheet 1
x 2 J155502001 Angle Field transplanter A Steel 75x50x6 Angle 575.00 mm 2
x 2 J155502003 Cross bar Field transplanter A Steel 10 RMS 340.00 mm 2
x 2 J155502824 Adjuster plate Field transplanter A Steel 10mm Sheet 2
x 2 J155502010 End flat Field transplanter A Steel 40x6 FMS 252.00 mm 1
x 2 J155502820 Brace Field transplanter A Steel 8mm Sheet 2

4.4 TESTING THE AGCOM TRANSPLANTER

Field Testing Sites

Field testing was conducted at Austchilli Pty Ltd. Goodwood Road, Bundaberg, Queensland.
Austchilli is the largest chilli company in Australia and are leaders in food manufacturing. Founder of the company is David De Paoli who is a qualified mechanical engineer and has a passion for innovation.
A series of test were also held at Robert Bernhagen's property at Thomas Road, Bli Bli, Queensland

Efficiency Benchmarks

We have set benchmarks which will define efficiency of the transplanter. The most important efficiency benchmark will be defined as follows:
The unit will transplant over 95% of plants correctly (in line with normal commercial practices) in the bed/row in one pass. Other researchers have used 95±3% as the benchmark (Tsuga, 2000; Wang, 2011).

The 95% benchmark was further defined as;

- Verified by suitably qualified vegetable grower/s, &/or HAL stakeholders and Agcom team member/s on site.
- For verification and replication of results trials will be replicated a number of times
- Trials to be conducted under "normal" field transplanting conditions.

A number of field tests were conducted throughout the development of the unit over a 12 month period as set out in the project timetable and in benchmark reports. These trials were conducted at the two properties as listed above. Field trials for the project milestones concluded in late May 2012.

A successful transplant efficiency level of over 96% was achieved in a range of planting conditions. The unit achieved the benchmark criteria as listed in the project submission.

The unit has been left with Austchilli, Bundaberg, Queensland to undertake ongoing tests in a commercial environment.

Austchilli are very encouraged by the trials undertaken to date and have indicated they will purchase the unit if the large scale commercial trials prove successful

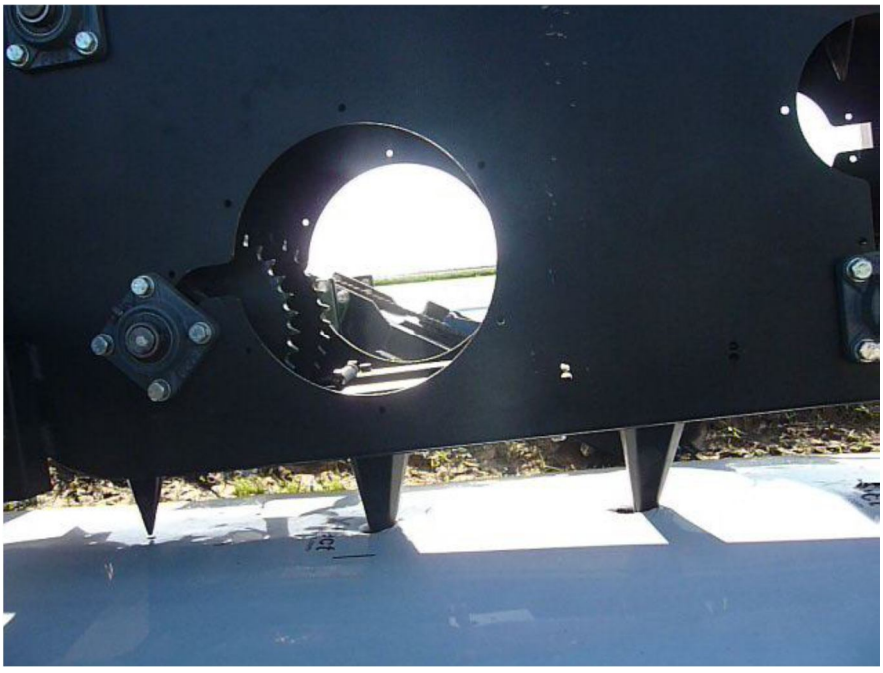

Plate 12 & 13. The Agcom transplanter in the field.

4.5 ECONOMIC PERFORMANCE AND SALES MARKETING

Cost savings

Comparing the Agcom transplanter with traditional transplanting methods, operating costs were reduced by 33% using the Agcom planter (see calculations below).

- Currently traditional transplanters require four staff (2 tractor drivers and 2 "planters" for 2 rows of plants) to plant with traditional methods.
- This number was reduced to three staff (1 tractor driver and 2 "planters") with the Agcom unit.
- One tractor pass was required with the new transplanter rather than the current two (including the "water wheel" tractor pass).

Calculating cost saving

A = Labour (per person involved in the operation including wages, superannuation, work care, etc)
B = Tractor (per tractor including fuel, repairs, maintenance, etc)
C = Operating overheads (set rate incorporating depreciation, capital purchases, amortised running costs, etc)
D = Total hourly rate

Formulas

Traditional transplanting method

A = $22/hour/person
B = $17/hour/vehicle
C = $27/hour
With 4 people involved in the operation the formula will be as follows;
(A x 4) + (B x 2) + c = D Total transplanting operation cost/hour
88 + 34 + 27 = $149 / hour

Agcom method

(A x 3) + B + (C X 0.8 - as reduced overall operation costs) = D
63 + 17 + 21.6 = $101.6 / hour

$$\frac{149 - 101.6}{149} = \mathbf{33\%}$$

Notes:
The cost of Agcom unit purchase, repair and maintenance is not represented in these equations.
A "water wheel" will no longer be required.

Transplant rate

Traditional transplanter

The transplant rate will depend on a number of factors such plant spacing, length of rows etc. On average the traditional planter averages approximately 12,000 plants per hour. With 4 people involved in the operation this equates to 3,000 plants/person per hour.

Agcom transplanter

With 3 people doing the same operation as above this equates to 4,000 plants/person per hour. This equates to an efficiency increase of 33%.

A comparison of the performance of the Agcom transplanter and the traditional transplanter is presented in Table 1.

TABLE 1.

Summary of performance of the the Agcom transplanter compared with a traditional transplanter.

Characteristic	Traditional transplanter	Agcom transplanter
Drive mechanism	wheel	track
Plant into plastic mulch	no	yes
Transplant efficiency rate	90	95
No. of persons needed to operate	4	3
Operating cost per hour	$149	$101.6
Transplant rate per hour (12” spacing, single head)	12 000	12 000
Transplant rate per person per hour (12” spacing, single head)	3 000	4 000
Transplant rate per person per hour (12” spacing, double head)	Not available	8 000

Target Audience

The initial target group for sales will be Australian vegetable growers transplanting cell grown priority crops into plastic mulch. Subsequent priorities will include overseas markets (with particularly emphasis on "mature" markets such as NZ, Europe & North America).
Other cell grown transplants grown on plastic mulch may also benefit from this unit (such as forestry plantations and flowers.)
If the subsequent project on “bare rooted” transplants proves successful the market size will expand enormously.

Specific Priority Crops

Vegetable growers using plastic mulch with priority crops are listed below:

- Peppers (Hot & Sweet)
- Tomatoes
- Melons (Water, Honeydew & Rock)
- Zucchinis & Squash
- Pumpkins
- Egg Plants

Market Potential (Australia only)

Formula
A = Total number of growers of priority crops (refer earlier table)
B = Growers planting multiple crops from priority table
C = Crops NOT grown on plastic mulch
D = Crops grown in more than 1 row per bed
E = Total potential unit sales

Assumptions for total Australian market assessment;
A = Total number of growers of priority crops - from AUSVEG data (2008) = 3350
B = Divide the number of growers by 3 to allow for multiple priority cropping
C = Divide A by 50% to allow for crops NOT grown on plastic
D = Multiply the number of transplanting units per farm by 1.3 to allow for multiple row plantings (Crops such as Peppers & Egg plants are normally sown 2 rows per bed)
E = Total unit sales

The equation A/B/C/D = E
3350 (A) divide by 3 = 1116 (B) divide by 2 = 558 (C) divide
x 1.3 (D) = **715** (E)

Market Uptake

Adoption in the market place should be relatively rapid based on need and cost savings. It is expected to have a 10% per annum adoption rate of the potential market for the first three years once the project is concluded and the unit is commercially available. This will equate to sales of approximately 72 units per year. However we will use a contingency of ±25% to allow your unforeseen circumstances so we expect sales in the first year of about **54** units.

Critical Factors

- Refining and perfecting the unit.
- Verifying the costs savings to purchasers.
- Demonstrating the versatility and reliability of the unit.
- Sourcing economical parts, labour & facilities to manufacture the units at an competitive price.
- Implementing an effective Sales & Marketing strategy.

4.6 IP AND PATENTS

Confidentiality is requested on this project to preserve Intellectual Property (IP). Distinct commercial advantages are available for Agcom International and HAL to develop and sell units through maintenance the IP of this project (as opposed to making the IP easily accessible).

It is proposed that HAL will be an equity partner with Agcom International. HAL will be a beneficiary in profits obtained through the commercial sales of transplanting units sold subsequent to the completion of this project (VG10088). It is proposed that the stakeholders equity distribution will be as follows;

Stakeholder:

HAL:	20%
Agcom International:	80%

Patents/Copyrights

Patent applications will be assessed prior to commercial sales. Appropriate patents may be applied for where considered worthwhile and commercially viable by the stakeholders to aid in the preservation of the unique technology and IP integrity. Conditions that will be met include:

- There is no infringement on any existing IP, patents, trademarks or copyrights.
- No permission will be required for this project and no royalties will be liable after completion.
- An Innovation patent is to be instigated on this unit

Market access and availability

At successful conclusion of this project;

- a complete sales and marketing plan will be conducted by Agcom for sales within Australia and possible overseas opportunities
- units will be manufactured and made available to the market under normal commercial trading terms

5.0 TECHNOLOGY TRANSFER

5.1 Industry advisory meetings

Due to the need to protect IP and other issues, only limited meetings have conducted with vegetable industry leader during the development phase of this project

5.2 Field days

Due to the need to protect IP and other issues, only limited meetings have conducted with the vegetable industry. Three leading vegetable growers in the Bundaberg region have attended testing of the Agcom prototype.

In addition, the unit was tested at Austchillli, Bundaberg. Austchilli is the largest chilli grower, marketing and processing company in Australia and are leaders in food manufacturing. Founder of the company is David De Paoli who is a qualified mechanical engineer and has a passion for innovation.

5.3 Workshops and conferences

No field days, workshops or conferences were conducted during this project but will be done at or prior to commercial release with the patent in place

5.4 Publications

None

6.0 RECOMMENDATIONS

Recommendations

- To ensure the unit is refined, corrected or altered as may be identified in the ongoing commercial tests (through Austchilli)
- A marketing and sales plan to be developed as soon as practicable
- Commercial sales to begin as soon as possible
- The Agcom transplanter can be used to plant modified to plants (such as strawberries) in current field conditions. However, the strawberry runner (or other bare rooted seedlings) will need to be modified to have similar properties to a cell grown seedling.
- Agcom submitted a new project to HAL for 2012 - 2014 to develop techniques so that strawberry runners can be planted using the Agcom transplanter.
- By successfully developing techniques to plant strawberry runners (& other “bare rooted”)plants through the Agcom transplanter both Agcom International and HAL will benefit from the subsequent transplanter unit sales.

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Web sites:

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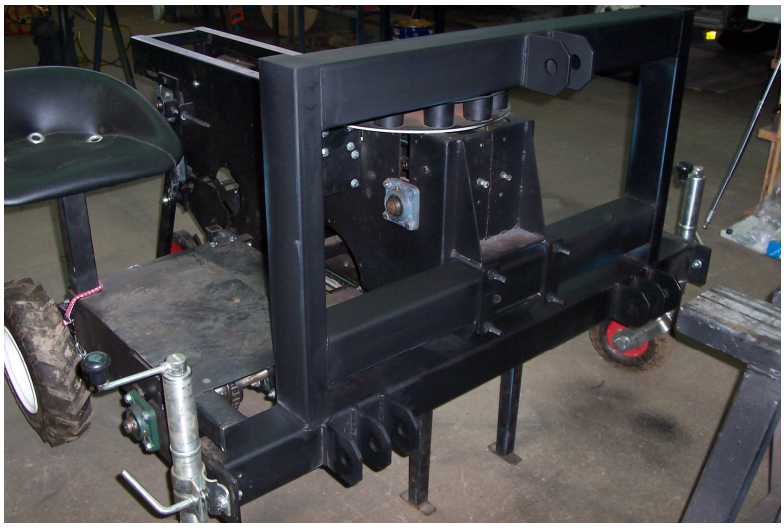
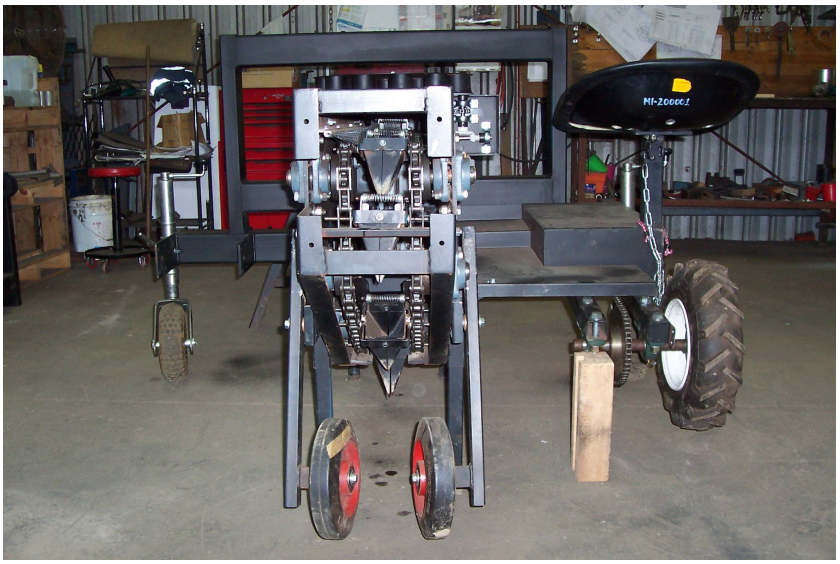


8.0 ACKNOWLEDGEMENTS

We thank the Australian vegetable industry for their guidance and encouragement and the Australian Government and Horticulture Australia Ltd (HAL) for their financial support for the development of the Agcom transplanter.

We would like to thank the vegetable growers who contributed considerable input for this project and allowed Agcom to conduct field tests on their properties and supplied equipment when required

We would also like to thank KW Automation for their diligence, professionalism and outstanding work on this project and acknowledge that their assistance (& guidance) helped make this project not only a reality but ensured it obtained successful outcomes



Agcom International

Horticulture Australia