EVALUATE THE EFFICACY OF VARIOUS PRODUCTS AND METHODS TO STABILISE THE SOIL SURFACE AND MITIGATE EROSION AT THE SOURCE

Research Topic 5: Management of Erosion and Sedimentation

Trial number: 05-SEQ-01

CONTENTS

INTRODUCTION

In agriculture and horticulture soil erosion removes valuable top soil which is the most valuable asset for farmers. The loss of this top soil results in lower yields and higher production costs. When top soil is gone, erosion can cause rills and gullies that make the cultivation of paddocks impossible. It also sends soil-laden water downstream, which can create heavy layers of sediment that prevent streams and rivers from flowing smoothly and can eventually lead to flooding.

Soil stabilisers are an important tool in mitigating soil erosion. Soil stabilisers function by binding soil particles together and improving resistance to water flow. Stabilisation can increase the shear strength and 'shrink-swell' properties of a soil, thus improving the soil's ability to withstand the influences of wind, rainfall and water flow. Geopolymers bind dust particles and particulate matter through their strong binding properties and flexibility.

The geopolymers tested in this trial are suitable for low to moderately trafficked areas and their non-hazardous formulation make them easy to apply, usually curing within a few hours, they will not remobilise into the surrounding environment.

HYPOTHESIS
The integration of a range of different methods to reduce soil erosion is likely to have the best chance of success.

OBJECTIVE
This demonstration trial set out to evaluate practices to stabilise the soil surface at the source of soil erosion. The practices were:

- Establishing a 'living mulch' into a field with a standard industry herbicide program.
- Retrofit a standard industry headland sprayer into a precision application inter-row sprayer.
- Examine the potential for stabilising herbicides on the soil surface by combining them with geopolymers.

METHOD
Location and grower
Phase one and two of this demonstration was undertaken in collaboration with Piñata Farms located in Wamuran, South East Queensland. The farm owners Stephen and Gavin Scurr and their family have been growing and packing pineapples and other crops in the area for eighty years.

Phase three of this demonstration was undertaken in collaboration with Sandy Creek Pineapple Company located in Glasshouse Mountains, South East Queensland. The farm owner and manager Sam Pike and his family have been growing pineapples in the region for over one hundred years.

There were three phases to this trial:

1. Phase One: Establish a 'living mulch' crop into a standard industry herbicide program. This was undertaken at Piñata Farms on their Pates Rd farm in Wamuran.
2. Phase Two: Modify a standard industry headland sprayer into a precision application inter-row sprayer. This was undertaken at Piñata Farms on their O'Shea Rd farm in Wamuran.
3. Phase Three: Evaluate the ability to stabilise standard industry herbicides on the seedbed using geopolymers. This was undertaken at Sandy Creek Pineapple Company on their Pikes Rd Farm Glasshouse Mountains.

Dates
<u>Phase One – evaluation of 'living mulch' into a standard industry herbicide program</u>

- February 2019 - Grower identified, site selected and trial planned.
- March 2019 - block cultivated, pre-plant pesticide and nutrition applied.
- April 2019 - bed-formed, site planted and treatments applied.
- July 2019 - erosion data collected and assessed.

<u>Phase Two – development of a precision inter-row sprayer</u>

- January 2020 - modify standard industry headland sprayer planned.
- December 2020 - modifications to the standard industry headland sprayer complete.

Phase Three – evaluate the ability of geopolymers to stabilise herbicides on the seedbed

- January 2023 – establish screening trial, apply geopolymer treatments and evaluate.

Crop details

All demonstration sites were planted with 73-50 pineapple following a previous crop of 73-50 taken to plant crop harvest only. The soil was prepared to a good tilth, soil moisture was good and there were no crop residues present. The average slope of the blocks was 2 - 3%. The weather leading up to phases one and two included limited rainfall and temperatures ranging from 15 – 25°C. Phase three screening was undertaken in the summer months of 2023 with consistent rainfall and warmer temperatures ranging from 18 - 30°C. Thus, phases one and two were established in 'drought like' conditions receiving well below average annual rainfall, whereas phase three was established during La Niña with consistent rainfall events.

The soil type at Piñata Farms was a grey, sandy loam and at Sandy Creek Pineapple Company it was a light brown loam. Both are highly erodible soil types and typical of pineapple farms in the Wamuran and Glasshouse Mountains area.

Description

The treatments are as follows:

Phase One

Phase one consisted of two treatments and a standard practice. The two 'living-mulch' treatments were rye grass planted at 25kg seed/hectare (equivalent) and oats planted at 25kg seed/hectare (equivalent). The standard practice had no living mulch. The two 'living-mulch' treatments were planted four weeks after pineapple planting.

Living mulch has been trialled in the past for soil stabilisation, this trial evaluated the potential to establish a living mulch after a full industry standard pre- and post-plant herbicide program using a pre-plant incorporation of Bromacil and post-plant foliar application of Bromacil and Diuron.

Planting of the living mulch involved first pulling a tine down the inter-row to a depth of ten centimetres to open a furrow, seed was then sown by hand, this was followed by another pass with the tine in order to close the inter-row furrow and compact the soil using the tractor tyre by driving down the walkways (see Figures 1 and 2).

The treated rows were one hundred metres in length and nine beds wide. The 'living mulch' treatments were compared with standard practice (no living mulch) of a full 18 beds adjacent to the living mulch treatment.

Figure 1: Opening the furrow for before planting seed (left), Implement used to open furrow (middle) and opening the furrow (right).

Figure 2: Open furrow (left), seeding the inter-row (middle), and (right) the seed buried by another pass with the tine and at the same time compacted with the tractor tyre.

<u>Phase Two</u>

Phase two consisted of the retrofit of a standard industry headland sprayer into a precision application inter-row sprayer. These modifications consisted of the addition of the small frame at the rear and base of the headland sprayer. Attached to the frame at both ends are retractable arms that can be adjusted to varying widths to change spray width. In addition, the arms can be angled forward or backwards and extended towards the ground to adjust spray height and angle to ensure accurate location of the spray band in the inter-row.

Figure 3: Current industry headland sprayer (left and right).

Phase Three

This was undertaken to evaluate the application of geopolymers in the inter-row mixed with and applied over standard industry herbicides. The combination of geopolymers and herbicides was to determine if the geopolymers have the capacity to hold the herbicides to the soil surface to minimise off-farm deposition. The geopolymer used in the demonstration was Stonewall™. The standard industry herbicide was Bromacil applied at 2.2kg per hectare and Diuron applied at 1.0kg/ha. The first treatments had Bromacil and Diuron mixed with Stonewall™ in the tank and applied broadacre with the boomspray. The second treatments applied Bromacil and Diuron broadacre over the ground followed by a broadacre Stonewall™ application using the boomsprayer.

Trial 1 - The initial trial demonstration was established at Piñata Farms located on Harrison Rd in Wamuran. Conditions at the time of application consisted of good soil moisture following light showers and cool air temperatures of 18 – 24°C. Treatments were applied within a few days of bed forming and planting. Seedbed conditions consisted of a rough and coarse surface texture. The first seventy-two hours after application is critical for Stonewall™ to cure and harden on the seedbed. After application the demonstration received 15 millimetres of rainfall over three days. Unfortunately, the Stonewall™ did not cure and failed to harden. The site was abandoned and the trial was replicated on Sandy Creek Pineapple Company in Glasshouse Mountains.

Trial 2 - The demonstration was relocated to Sandy Creek Pineapple Company on Steve Irwin Way, Beerwah. The site was planted over summer 2022 and 2023 with hybrid pineapple. Immediately after planting numerous rainfall events created heavy soil erosion with the loss of considerable amounts of soil from the site. The Beerwah site was abandoned and the demonstration relocated to Pikes Road, Glasshouse Mountains. The new site was planted in April 2023 after the grower completed his harvesting. The application of treatments is planned for May 2023. The treatments will be as follows:

Table 1: Geopolymer and herbicide treatments.

Treatment No.	Treatment
1	Control 1 (nil)
2	2.2kg / ha Bromacil and 1.0kg/ha Diuron broadacre applied + Stonewall at 10% concentration broadacre applied (standard)
3	2.2kg / ha Bromacil and 1.0kg/ha Diuron broadacre applied + Stonewall 5% concentration broadacre applied
4	2.2kg / ha Bromacil and 1.0kg/ha Diuron broadacre applied + Stonewall 2.5% concentration broadacre applied
5	2.2kg / ha Bromacil and 1.0kg/ha Diuron broadacre applied + Stonewall 1% concentration broadacre applied
6	Combined 2.2kg / ha Bromacil and 1.0kg/ha Diuron + Stonewall 10% concentration broadacre applied
7	Combined 2.2kg / ha Bromacil and 1.0kg/ha Diuron + Stonewall 5% concentration broadacre applied
8	Combined 2.2kg / ha Bromacil and 1.0kg/ha Diuron + Stonewall 2.5% concentration broadacre applied
9	Combined 2.2kg / ha Bromacil and 1.0kg/ha Diuron + Stonewall 1% concentration broadacre applied
10	Control 2 (nil)

The Stonewall concentrations of 10% (standard rate), 5%, 2.5% and 1% (experimental rates) will be evaluated to understand the capacity of Stonewall at lower rates and cost per hectare.

Although results will not be evaluated by the end of the project, it is encouraged that growers undertake similar demonstrations on their farm for their own interest.

RESULTS

Phase One

The initial results have indicated that living mulch can be planted with moderate success into pineapple fields that have been treated with industry standard herbicide program. Both rye grass and oats were able to successfully establish in a soil with herbicide residue present.

However, growth was limited to 15cm before the living mulch died. This also coincided with the first rainfall event of 20mm when the residual herbicides reactivated approximately six weeks after planting.

The vegetative mass/cover of both living mulch crops was able to stabilise the soil to a moderate degree. In this case, the oats were more successful than the rye grass.

The additional observation of mechanically controlled compaction from the tractor tyres in the inter-row when opening and closing the furrow requires further investigation. This compaction may potentially improve soil stabilisation and minimise erosion.

Figure 4: Living mulch 2 weeks after planting (left and right).

Figure 5: Living mulch 2 weeks after planting - rye grass rows on left and oats rows on right.

Figure 6: Living mulch after 20mm rainfall – Control treatment with high erosion (left) and living mulch with low erosion (right).

The amount of soil eroded from each treatment was measured by laying 10m lengths of plastic at the ends of the rows, wide enough to collect the eroded soil. 10m was enough to collect all the soil that washed out of the ends of the inter-rows. After the first flush, the soil on the plastic was collected and weighed.

Table 2: Soil erosion captured from living mulch treatment.

Treatment	Amount of soil eroded (equivalent tonnes / ha)
Rye grass	6.4
Oats	5.5
Nil	16.0

Figure 7: Living mulch four months after planting (left and right).

Even after the living mulch had died after the activation of the herbicide by the rainfall, the vegetative matter remained and continued to stabilise the inter-row for some time. However, the vegetative matter in the rye grass treatment was minimal. Soil erosion measured in the rye grass area was marginally more than the well-established oats.

In conclusion, the living mulch resulted in less soil erosion than standard practices of no ground cover (i.e. bare soil). The ability to establish living mulch can be restricted by weather and ground conditions.

Phase Two

Retrofit of an industry standard headland sprayer

The spraying of geo-polymers requires precision application onto the inter-row. A standard industry headland sprayer was adapted to have precision inter-row spraying capabilities.

The headland sprayer is standard industry equipment that most pineapple farmers have. The sprayer consists of a spray tank, PTO driven hydraulic pump and extendable hose equipped with a fireman's nozzle. This equipment is used to manually spray weeds on headlands.

Over the course of twelve months, work was undertaken to adapt a headland sprayer for use as an inter-row sprayer. It was retro-fitted with a simple frame located at the rear with spray jets behind each wheel track. The frame allows spray angle, spray height and spray width to be adjusted to different bed geometries to ensure coverage of the bottom of the inter-row and both sides of the seedbed. This is this area that is critical for soil stabilisation and has been identified as the source of most soil erosion.

Figure 8: Upgraded industry headland sprayer: Retrofitted frame with nozzles (left) and adjustable arm with nozzle (right).

The initial operation of the inter-row sprayer achieved the precise spray coverage of the bottom of the inter-row and both sides of the seedbed without spraying the plants.

Figure 9: Field testing of upgraded industry headland sprayer showing precision inter-row spray pattern.

Primary objectives in the planning, design and construction of the inter-row sprayer:

1) Adapt a pre-existing machine currently available on many pineapple farms,

2) Simple construction without the need for external fabrication or engineers,

3) Minimise capital outlay to $500 - $1,000, and

4) Adapt a sprayer for multi-purpose usage.

DISCUSSION

Soil erosion has been a major issue for the Australian pineapple industry throughout its history. Growers have tried many preventative practices with limited success. Trial work across many farms in South East Queensland has indicated that there is no single practice that will totally prevent soil erosion but a program that integrates a number of practices is likely to have the best chance of success. An integrated program will need to focus on the entire soil erosion process from the source (within the block) to the 'edge of farm'.

Establish a 'living mulch' crop into a standard industry herbicide program

Living mulch planted in the inter-row was the least costly option at $120 per hectare for the seed and $250 per hectare for the labour and machinery to plant the seed. This option was limited by the impacts of industry standard herbicide practices and weather events which restricted the longevity of the living mulch in the inter-rows. It is critical to maintain soil stability in the inter-rows for the first six to nine months after planting. In this particular trial living mulch did not have the capability to achieve this outcome. This was due to the 20mm rainfall event six weeks after planting that 'reactivated' the herbicide and killed the living mulch. Although the living mulch died it still resulted in less soil erosion than standard practices of no ground cover (i.e. bare soil).

Evaluate the ability to stabilise standard industry herbicides on the seedbed using geopolymers.

To effectively use geopolymers the environmental conditions at application and post application curing are critical. For example, correct soil moisture content, soil tilth, temperature, humidity and rainfall conditions can greatly influence the performance of the product. The cost of Stonewall™ is $3,500 per hectare when applied broadacre but this cost can be reduced to half when applied through the precision inter-row sprayer. These factors created a degree of risk which restrict grower adoption.

Retrofitting a standard industry headland sprayer

An important consideration when applying soil stabilisers is precision inter-row spraying. The precision application of geopolymers is critical to ensure the target area is sufficiently covered and soil stabilising products are applied in a cost-effective manner. The retrofitting of a standard industry headland sprayer was successful and can support the application of geopolymers. The design allows easy construction by growers for a nominal cost of $1,500. The precision inter-row sprayer can also be used for precision herbicide application.

ADOPTION AND IMPACT

There is potential for inter-row sprayers to become useful tools in growing pineapple. Further trials to test their use for applying geopolymers and precision herbicide application are recommended.

Amaryllis Farming in Bundaberg has further retrofitted the precision inter-row sprayer with shields to undertake herbicide application infield. The shields are designed to target weeds in the inter-row without spraying the crop therefore minimising or eliminating crop damage.

Figure 10: Precision inter-row sprayer with shields in Bundaberg.

Observations were undertaken of a shielded inter-row sprayer applying herbicides in a pineapple crop. The crop was three months of age and had received a full pre- and post-plant herbicide program. The shielded inter-row sprayer applied Glufosinate-ammonium (Basta™) a registered product in pineapple for bluetop. Basta™ when applied over a crop has major phytotoxic effects on the pineapple plants.

The key observations and benefits of precision inter-row herbicide application:

1) Minimal coverage of the pineapple crop with no visual damage,

2) Up to 75% of the bluetop was controlled,

3) Less inputs with 50% of the herbicide used compared to 100% broadacre application,

4) The ability to widen the herbicide options for more registered products for the management of persistent weeds such as bluetop.

5) A wider application window for herbicides in a pineapple crop for example the warmer months of the year.

6) Less potential for off-farm deposition.

Growers have further developed precision inter-row spraying to improve application efficiency and reduce cost.

Figure 11: Precision inter-row sprayer with shields in Maryborough.

CONCLUSIONS

Soil stabilisation is a key area for further research to identify new products and better methods to apply them. Historically, research has focused on capturing soil 'down-stream' in the erosion process. Soil stabilisation focuses at the source where erosion occurs in-field on the seedbeds. Stabilising the seedbed with 'living mulch' or geopolymers is important in mitigating erosion and movement of pesticide or nutrient off-farm. It is important to keep evaluating new products and their application whilst working with relevant companies to make these products commercially available and cost effective for the pineapple industry.

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