DEVELOPMENT & EVALUATION OF PRECISION BOOMSPRAY APPLICATION

Research topic 3: Pre and post initiation nutrition management
Trial number 03-WB-05

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INTRODUCTION

Fertilisers and pesticides contribute significantly to the cost of pineapple production. With growing concerns about their potential environmental impact and increasing costs, using these products efficiently and effectively has never been more important.

Traditionally, hauled trailers with large tanks and extended booms fitted with hydraulic nozzles are used to apply fertiliser and pesticide.

Figure 1. Traditional boom spray equipment

The key to efficient boom spray operations is to maximize application to the target area and minimize application to non-target areas.

The design and calibration of the sprayer needs to consider crop parameters such as type and area of the plant canopy, area of plant leaf, height of the crop and the product being applied.

Precision agriculture seeks to use new technologies to increase crop yields and profitability while lowering the levels of traditional inputs needed to grow them. Precision spraying can be defined as targeted spraying using specific crop information and efficiently applying pesticides and fertilisers to the target area.

This demonstration trial compared boom spray operations using precision application methods against more traditional non-precision application methods. It includes economic and agronomics analysis.

HYPOTHESIS

The amount of chemical and fertiliser applied to young plants can be reduced without negatively affecting yield and fruit quality. This can be achieved by carrying out relatively low-cost modifications to a traditional boom sprayer enabling more direct product application to the crop and less to non-target areas of the field.

OBJECTIVE

To develop and evaluate precision spraying in pineapples to improve fertiliser and pesticide efficiency and reduce off-farm deposition of these chemicals.

Specifically:

- Improve the application efficiency of foliar fertilisers and pesticides particularly during early growth stages when traditional broadacre boom spray equipment wastes product on non-target areas such as the inter-row and sides of the bed.
- Direct product to the target areas by only applying it over the plant rows.

- Show how traditional boom sprayers can be modified for a relatively low cost to reduce the amount of chemicals and fertilisers needed.
- Reduce the amount of fertilisers and chemicals applied to non-crop areas such as headlands and drains by giving the spray operator the ability to independently control different sections of the boom.

METHOD

Location and grower

Amaryllys Farming Pty Ltd located on Goomburrum Road, Bundaberg was chosen as the project collaborator for their engineering capabilities and history of precision farming in their sugar cane operations including their established GPS capacities. Farm owner Mr Jay Hubert was the principal collaborator.

Subsequently a second project collaborator, Piñata Farms located on Scurr Rd near Wamuran, has become involved to further develop and adapt precision spraying to a traditional two row bed.

Dates

Planning at Amaryllys commenced March 2019. After 18 months of planning and construction, initial field testing began in September 2020. After numerous pilot runs and modifications, the precision boom spray was ready for commercial field testing. The commercial testing was undertaken in multiple locations over a 12-month period.

Planning at Piñata commenced in November 2021. A cost analysis was conducted in February 2022 then construction began in April 2022.

Crop details

The equipment was developed and tested at Amaryllys Farming on pineapples planted at a density of 58,000 plants per hectare on a staggered four row bed with a 1.8 metre bed centre, with two rows on each side of the bed at 0.3 metre plant centres across and down the rows (this is illustrated in Figure 6).

Further development has commenced with Piñata Farms on standard bed geometries with 1.3 metre bed centres, 0.5 metre between rows and 0.25 metres between plants down the row.

Directed sprays were applied to the crop from the age of two months until nine months when canopy closure was reached.

Description

The precision boom sprayer was developed from traditional pineapple equipment with the following enhancements.

Sectional control output and GPS guidance

The 18-metre spray delivery boom was split into four independently operated sections (each 4.5m in length) across the boom to provide sectional control output and variable rate. Each of the four sections can be manually turned on or off independently. The supporting tractor was fitted with GPS guidance and each block mapped within the GPS operating system. The sectional controlled output enables more accurate spraying operations across the block that includes minimising waste when spraying over headlands, drain ways and fields with angled ends. GPS guidance is not essential to achieve savings, but more reliance is placed on the skill of the operator to engage and disengage each of the four sections as required.

Figures 2 & 3. Sectional control with variable rate

Figures 4 & 5. Traditional nozzle set up (left). Precision nozzle set up (right) showing the five nozzle options with the dropper option selected so the spray targets the plants only.

Figures 6. Droppers directing spray only onto the rows of young plants. The spray nozzle manifold in between these two can be engaged when broad acre spraying is required.

Folding arm boom

The next generation boom sprayer was modified so it could be folded to improve mobility across the farm and between different farming locations. The traditional fixed boom spray frame was fitted with a central pivot which enables the boom to fold in two and be secured against the side of the spray tank when in transit.

Figure 7. Central pivot to enable all boom to fold in half for ease of transport

Figure 8. Boom folded and ready for transit

Height control

It is critical that the spray boom can be raised or lowered to achieve the desired width of the spray band applied to the crop. The height of spray boom above the bed is necessary to cater for the growth in plant size from freshly planted crowns or slips to established plants up to six

months of age. In this way the spray boom can then apply fertiliser and some pesticide as a spray band directly over the plant to minimises spray onto the ground in the inter-row and the open space on top of the bed. Each plant still receives the same amount of fertiliser and pesticide as it would from a broadacre application, the difference being that materials are not wasted on non-crop areas such as the interow. About half the sprayers in the industry can lift and lower the boom whilst keeping it parallel to the ground. The others would need to be retrofitted by an engineer to be able to do this.

Figure 9. Height control mechanism

A comparison was made between the precision boom sprayer and a standard industry boom sprayer. Traditional industry practices involve broadacre applications covering both the crop and non-target areas such as the inter-row and sides of beds. Precision boom spraying applies product directly over the plants with minimal coverage of the non-target areas. Note the foliar applications include all post plant fertiliser and *some* pesticide applications.

The focus of the comparison was from the initial boom spray activities at two months after planting to canopy closure at nine months after planting. In this window the percentage of ground cover would be the lowest.

Treatments

1. Application of post plant fertiliser and pesticide from 2 – 9 months of growth using precision boom spray application methods.
2. Application of post plant fertiliser and pesticide from 2 – 9 months of growth using standard boom spray application methods.

RESULTS

The treatments were applied across multiple sites on the farm. A number of assessments were undertaken. The key data collected consisted of:

- Comparative spray output / unit area
- Crop yield assessment – plant crop harvest
- Cost analysis – fertiliser and pesticide inputs, operating labour and capital outlay.

Comparative spray output

The number of hectares sprayed per tank is a key factor in the comparison and constitutes the main financial saving in this evaluation. The demonstration was replicated at Amaryllys over three sites on two separate farms:

Farm 1: Vecellios Rd, block 45 and 47

Farm 2: Goomburrum Rd, block 27

The results of the comparison between the standard and precision spraying are presented in Table 1 below. The data is an average of the three sites.

Table 1. Average area covered and time taken to apply one tank (Amaryllys Farming).

Parameter	Industry standard	Precision application
Ground covered per tank	1.51 ha	4.02 ha
Application time per tank	21 minutes	55 minutes

This data collected at Amaryllys Farming, which has non-standard four row beds, showed that the precision boom sprayer covered 2.7 times more crop with the same amount of fertiliser and pesticides compared with the traditional broadacre application.

Evaluation of precision spraying at Piñata Farms, which has standard two row beds, has shown 2.0 times more coverage.

Plant crop yield

An assessment of yield at Amaryllys was undertaken across the three sites comparing precision boom spray treatment to standard industry broadacre boom spray application. At eight randomly selected sites within each treatment, fruit were collected from each of 12 plants in a row and their size was recorded as the tray count size (the number of fruit that fit in a 14 kg standard tray, e.g. fruit in count 8 are larger than fruit in count 12).

Tables 2 & 3. Fruit weights from precision sprayed and broadacre sprayed blocks at Amaryllys

1 of 3 Data Sets: Amaryllys Farming - Vecellios Rd, Block 45

Farm 1 - site Blk 45

Pineapple Size Profile: Treatment

	Fruit 1	Fruit 2	Fruit 3	Fruit 4	Fruit 5	Fruit 6	Fruit 7	Fruit 8	Fruit 9	Fruit 10	Fruit 11	Fruit 12
Site 1	11	10	12	9	10	12	9	10	12	9	10	12
Site 2	11	11	10	11	10	14	10	10	14	10	12	10
Site 3	11	10	10	11	9	11	12	14	12	12	9	12
Site 4	11	11	11	11	10	10	11	12	14	11	9	12
Site 5	10	10	9	9	9	9	9	14	9	12	12	10
Site 6	12	11	9	11	10	12	11	12	11	12	9	14
Site 7	12	10	11	9	11	10	9	11	9	12	14	12
Site 8	14	10	9	10	11	9	11	10	11	11	10	11
											Average	10.81

Pineapple Size Profile: Standard

	Fruit 1	Fruit 2	Fruit 3	Fruit 4	Fruit 5	Fruit 6	Fruit 7	Fruit 8	Fruit 9	Fruit 10	Fruit 11	Fruit 12
Site 1	12	10	10	11	12	10	11	10	12	12	11	11
Site 2	10	11	10	9	10	14	10	11	12	11	11	14
Site 3	12	11	12	10	10	10	12	10	10	9	12	14
Site 4	9	11	12	11	9	11	11	11	12	12	14	10
Site 5	10	10	9	9	10	10	11	10	12	14	12	9
Site 6	12	11	12	9	12	12	9	12	12	12	14	10
Site 7	11	12	9	10	14	10	11	12	11	14	11	9
Site 8	10	10	10	11	12	11	10	11	12	10	9	10
											Average	10.97

Table 4. Fruit size profiles from precision sprayed and broadacre sprayed blocks at Amaryllys

	Fruit size percentage in each tray						
Treatment	**8**	**9**	**10**	**11**	**12**	**Juice**	**Av. Size**
Precision Boomspray	0%	20%	25%	26%	21%	8%	10.99
Standard Boomspray	0%	13%	29%	24%	26%	8%	11.03

Thus, there was little difference in fruit size between treatments, either in premium sizes (8s, 9s and 10s), smaller sizes (11s and 12s) or 'juice' size.

ECONOMICS

The general principle of the demonstration sites was to keep new practices and machinery simple, easy to replicate, adaptable to current machinery on the farm and cost-effective.

The construction of the precision boom spray consisted of three distinct parts:

- The folding arm retractable boom (Note: the retractable boom is not essential for precision spraying)
- Sectional rate control
- Precision output manifolds.

The total cost to retrofit a standard industry boom spray was approximately $10,600 of which $5,000 was for parts and $5,600 for labour. This does not include the cost of a folding arm boom spray or the cost of retro-fitting the boom with height control if not already present.

The key components were the 15 precision output manifolds (for the 13.5-metre-long boom) costing $95 each complete with droppers, jets, caps, filters, etc, a total of $1,425. The remaining cost was for the plumbing and modifications to the spray boom frame.

The ability to retrofit these components remains simple and well within the capabilities of individual growers and their on-farm resources.

The cost of equipping the tractor with GPS is not considered in this costing. GPS mapping is not considered essential to operate a precision sprayer as long as the operator is moderately skilled.

Fertiliser and pesticide inputs

Investigations in Southeast Queensland using standard two row beds showed that substantial savings in fertiliser and pesticide per hectare could be made using the precision boom sprayer. These figures in table 4 (below) are for a hybrid pineapple variety sprayed with fertiliser and pesticide with a standard broadacre boom applications as per industry best practice.

Table 4. Monthly cost of spray materials for a standard broadacre spray programme on a traditional two row bed (Note: costed as per prices during February 2022).

Fertiliser and pesticide inputs	**Cost / hectare / month**	
	Broadacre spraying	**Precision spraying**
Urea	$153.79	$76.90
Potash	$277.77	$138.89
Magnesium Sulphate	$85.75	$42.88
Mono Ammonium Phosphate	$44.00	$22
Iron	$32.00	$16
Zinc	$23.00	$11.50
Agri-phos (phosphorous acid)*	$14.40	$7.20
Ridomil (metalaxyl)*	$22.08	$11.04
Astral (bifenthrin)*	$7.86	$3.93
Dimethoate*	$28.40	$14.20
Total ($/ha/month)	**$689. 05**	**$344.53**

** These pesticides are not sprayed every month (e.g. dimethoate is sprayed 4 times in 6 weeks) but for the purpose of this analysis, costs are averaged out on a per month basis.*

With precision boom spraying, the target area for the spray is the top of the bed which represents 50% of the total area of the field. This resulted in 50% savings on fertiliser and pesticide inputs per hectare. When extrapolated over five months of post plant foliar applications, the comparative costs of inputs are:

- Broadacre boom spray application (1st 5 months) $3,447.78 / ha
- Precision boom spray application (1st 5 months) $1,723.89 / ha

These costs exclude fuel and machinery running costs.

For a large producer who plants say 30 ha per year, these savings would equate to over $50,000/year based on February 2022 material prices.

Note: a number of critical applications, such as herbicide application, should remain as broadacre applications. A broadacre seal of herbicide on the entire planted area of the field remains important for good weed management.

Labour

A comparative cost analysis for labour was undertaken by Piñata Farms in south-east Queensland for a standard industry two row bed. The key data is (a) hectares covered per tank, (b) time to refill the tank and (c) time taken to spray.

With the precision boom, the time taken to cover the same area of field does not change (because the sprayer travels at the same speed), however double the area of field is now covered with one tankful of spray so it does not have to be re-filled as often. This results in a small saving in labour.

Table 5. Labour costs at Piñata for spraying with the precision spray boom compared with the standard broadacre spray boom

Measurement	Precision Boom Spray	Broadacre Boom Spray
Time taken to spray one tank (hrs)	2	1
Time taken to fill one tank (hrs)	0.5	0.5
Total time to fill up and spray out each tank	2.5	1.5
Tanks sprayed per day*	7.5 ÷ 2.5 = 3	7.5 ÷ 1.5 = 5
Area sprayed per tankful (ha)	5.6	2.8
Area sprayed/day	3 x 5.6 = **16.8 ha**	5 x 2.8 = **14 ha**
Labour cost/day	$45 x 8 = $360	same
Labour cost/ha	$360 ÷ 16.8 ha = **$21.43**	$360 ÷ 14 ha = **$25.71**
Saving ($ / ha)	**$4.28 / ha**	-

** Assume a standard workday of 8 hours with 0.5 hours for breaks leaves 7.5 hours spraying time.*

Table 6. Total fertiliser, pesticide and labour savings from using a precision boom sprayer on standard two row beds

Cost saving per hectare, based on 10 fortnightly sprays over 5 months	
Fertiliser and pesticide	$1,724 / ha
Labour	$43 / ha
Total savings	**$1,767 / ha**

DISCUSSION

The comparative analysis between precision boom spray application and standard industry broadacre application has indicated many economic, environmental and operational benefits for precision spraying.

The key factor in the design and construction of the precision boom sprayer is to ensure that each individual plant still receives the same amount of nutrition and pesticide as it would using the standard industry broadacre application. The difference is that with the broadacre boom about half the chemical is applied to non-target areas. The fact that fruit size (which equates to yield in pineapple) was very similar in both treatments suggest that the chemicals applied to non-target areas (mainly the walkways) was of little or no benefit.

The economic benefit is mainly derived from a 50% saving in fertiliser and chemical inputs plus a small labour saving. In addition, more ground is covered in a day (more time spraying and less time filling up, see table 5), and fuel and machinery running costs are slightly less. Also, there are potentially large benefits for the environment.

Payback of the cost to modify the current industry boom spray will of course depend on the size of the farm area but for an area of five to six hectares of pineapples can be achieved within the first 12 months of operations based on the findings of this trial.

ADOPTION AND IMPACT

The farm manager at Amaryllys Farming has continued to use the precision boom sprayer across the entire farming operation. Furthermore, he has extended the spraying window from the first nine months to the entire cropping cycle.

The concept of sectional control output and variable rate boom had, by April 2022, been adopted by seven large growers across the industry. The degree of complexity varies amongst growers from complete GPS guided systems to manual operating systems.

Piñata Farming has continued the evaluation on standard industry two-row beds and will develop additional capabilities with inter-row spraying.

CONCLUSIONS

1. The use of a precision boom caused no apparent reduction in crop growth or yield. Each plant received approximately the same amount of fertiliser and chemical when applied as a precision band compared with a broadacre application.
2. By almost eliminating the application of fertilisers and pesticides to non-target areas about half the materials were applied and therefore a much greater efficiency of use was achieved.
3. Halving the amount of foliar fertilisers and pesticides applied resulted in savings of $1,724/ha (February 2022 prices) based on 10 fortnightly sprays over five months.
4. The labour cost was reduced by $43/ha (also based on 10 fortnightly sprays over five months) because the spray tank didn't have to be refilled as often and 20% more ground was covered per day.
5. The risk of off-farm deposition of chemicals and fertilisers is substantially reduced, not only because less material is applied, but also because little is applied to bare ground where chemicals and fertilisers are more prone to erosion and leaching. This is a substantial gain for environmental sustainability.
6. The cost of converting a standard spray boom to the precision boom described in this document is approximately $10,000 and can be carried out by growers in their sheds. Payback can be achieved within 12 months on a sprayed area of five to six hectares.
7. Some pesticides, e.g. pre-emergent herbicides still need to be applied on a broadacre basis.
8. The concept of the precision boom has been adopted by seven growers to date.

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