Sugar Research Australia

SRA Grower Group Innovation Project Final Report

(Please note: The report must be submitted as a Word document)

SRA Project Code	**GGP071 (=2013/071)**		
Project Title	Strategies to limit the impact of nematode pressure on sugarcane productivity in the Isis		
Group Name	ISIS PRODUCTIVITY LIMITED (IPL)		
Chief Investigator(s)	Andrew Jakins and Bruce Quinn (IPL), Neil Halpin and Stephen Ginns (QDAFF)		
Project Objectives	• Evaluate sugarcane variety tolerance to Plant Parasitic Nematodes (PPN) populations to reduce the production losses cause by nematode damage in the cane crop following various fallow cropping strategies. • Comparing sugarcane varietal performance in a range of strip trials to gauge the degree of response to high PPN populations to assist in establishing the sugarcane varieties that advisors can confidently recommend to growers. • Train and build capacity of growers & land managers understanding of the impacts on the sugarcane crop following the various fallow cropping regimes adopted in the farming system and the influence that choosing the right sugarcane variety has on PPN damage. • This project is a pilot scheme for Isis Productivity Limited to gauge if, and to what degree certain sugarcane varieties can help to address productivity losses caused by high PPN populations in the farming system practices adopted by growers and land managers.		
Milestone Number	Final Report		
Milestone Due Date	12 June 2015	**Date submitted**	11 June 2015
Milestone Payment	$7,000		
Milestone Title	Final Report		
Success in achieving the objectives	☒ Completely Achieved ☐ Partially Achieved ☐ Not Achieved		

PART A
To be completed by the Chief Investigator

Section 1: Executive Summary

Two trials were done in this project.

One was a continuation of work started under a previous GRDC/SRDC-funded activity, 'Strategies to improve the integration of legumes into cane based farming systems'. This trial aimed to assess the impact of trash and tillage management options and nematicide application on nematodes and crop performance. Methods and results are contained in the following publication:

> Halpin NV, Stirling GR, Rehbein WE, Quinn B, Jakins A, Ginns SP. The impact of trash and tillage management options and nematicide application on crop performance and plant-parasitic nematode populations in a sugarcane/peanut farming system. *Proc. Aust. Soc. Sugar Cane Technol.* **37**, 192-203.

Nematicide application in the plant crop significantly reduced total numbers of plant parasitic nematodes (PPN) but there was no impact on yield. Application of nematicide to the ratoon crop significantly reduced sugar yield. The study confirmed other work demonstrating that implementation of strategies like reduced tillage reduced populations of total PPN, suggesting that the soil was more suppressive to PPN in those treatments.

The second trial, a variety trial, demonstrated the limited value of nematicide application in sugarcane farming systems. This study has highlighted that growers shouldn't view nematicides as a 'cure all' for paddocks that have historically had high PPN numbers. Nematicides have high mammalian toxicity, have the potential to contaminate ground water (Kookana *et al.* 1995) and are costly. The cost of nematicide used in R1 was approx. \$320 - \$350/ha, adding \$3.50/t of cane in a 100 t/ha crop. Also, our study demonstrated that a single nematicide treatment at the application rate registered for sugarcane is not very effective in reducing populations of nematode pests.

There appears to be some levels of resistance to nematodes within the current suite of varieties available to the southern canelands. For example the soil in plots that were growing Q183 had 560% more root knot nematodes / 200mL soil compared to plots that grew Q245. The authors see great value in investment into a nematode screening program that could rate varieties into groups of susceptibility to both major sugarcane nematode pests. Such a rating could then be built into a decision support 'tree' or tool to better enable producers to select varieties on a paddock by paddock basis.

Section 2: Background

Plant-parasitic nematodes (PPN) are a significant constraint to the productive capacity of sugarcane soils and cost the Australian industry 3.29M tonnes of cane annually (Blair and Stirling 2007). Historically, nematodes were only thought to be an issue on sandy soils of

Bundaberg (Bull 1981), but nematode survey work identified PPN in all soils growing sugarcane in the southern region (Blair *et al.* 1999). Lesion nematode (*Pratylenchus zeae*) and root-knot nematodes (*Meloidogyne spp*) were considered the most important pest species based on abundance and density in the field (Blair *et al.* 1999).

Root knot nematodes (RKN) are confined to sandy soils (<20% clay) and well-structured clay loams; whereas lesion nematodes were found in 100% of cane paddocks sampled (Blair *et al.* 1999). *Meloidogyne javanica* accounted for 76% of the *Meloidogyne spp* isolated from southern sugarcane soils. PPN have been implicated as part of the biotic constraint of yield decline (Chandler 1984; Pankhurst *et al.* 2001). Yield decline is defined as the loss of the productive capacity of soils under long-term sugarcane production (Garside *et al.* 1997).

The traditional method of controlling nematodes in sugarcane farming systems has been through the application of nematicide. Bull (1981) demonstrated productivity responses of 20% - 60% when nematicides were applied in the Bundaberg district. However responses were variable, as nematicide application only controlled nematodes for a short time (49-77 days).

Breaking the sugarcane monoculture with legumes significantly reduces PPN populations and, at the same time, increases the population of beneficial free living nematodes (FLN) (Stirling *et al.* 2002). In a monoculture, the FLN/PPN ratio is about 2:1 whereas following a legume break the ratio is 20:1. This ratio can be used as a measure of soil health. However this change in PPN populations is short lived and there is no residual effect of cropping history by the ratoon phase (Blair and Stirling 2007; Stirling *et al.* 2002). Stirling *et al.* (2003) suggested that cultural and biological control should form the basis of nematode management strategies.

These experiments were implemented to determine the following:
1. the impact of trash and tillage management options and nematicide application on nematodes and crop performance;
2. if different sugarcane varieties had differences in resistance to PPN in a field situation, so productivity officers could provide better varietal recommendations to growers known to have paddocks with high PPN populations.

Section 3: Outputs and Achievement of Project Objectives

1. Impact of trash and tillage management options and nematicide application (Russo trial)

This project continued a nematode field trial that had been set up under a previous GRDC/SRDC-funded activity, 'Strategies to improve the integration of legumes into cane based farming systems'. Methods and results were presented at the 2015 conference of the ASSCT (see attached):
Halpin NV, Stirling GR, Rehbein WE, Quinn B, Jakins A, Ginns SP. The impact of trash and tillage management options and nematicide application on crop performance and plant-

parasitic nematode populations in a sugarcane/peanut farming system. *Proc. Aust. Soc. Sugar Cane Technol.* **37**, 192-203.

2. Varietal resistance to nematodes

Materials and methods

The site was planted to peanuts (variety Holt) in October 2011. Nematode sampling at the end of the peanut crop demonstrated no root knot or lesion nematodes and TPPN count of 10 spiral nematodes/200mL soil. The peanut crop was harvested in April 2012 and the paddock was maintained as a clean bare fallow, via cultivation, until the sugarcane trial was planted on 29th August 2012.

The main treatments consisted of four different varieties (KQ228, Q183, Q242, and Q245) planted in plots ~ 400m long and three rows wide, in a randomized complete block design with three replicates. Row width was 1.83m. Varieties were randomly allocated in each replicate. On 17th of October, 49 days after planting, all plots were split to +/- nematicide. 'Rugby®' 100G (100 g/kg Cadusafos) ' was applied at 82kg/ha through a micro-feed granular applicator that was equipped with finger rakes to immediately incorporate the nematicide. Irrigation was applied that evening.

The site was kept weed free by both mechanical cultivation and application of knock-down and residual herbicides. The site was irrigated via a high pressure travelling irrigator, on a 7-10 day cycle when required. Both the plant cane and ratoon crop was fertilized with 140kgN/ha 120kgK/ha and phosphorus (20kgP/ha) was supplied at planting.

The site was sampled for nematode populations in February and May during the plant and ratoon crop. 20 soil sample cores (12mm diameter) were taken from each treatment to a depth of 150mm. These cores were bulked and mixed, placed in a plastic bag and samples kept at less than 12^{o}C. The samples were sent to DAF Eco sciences precinct and nematodes extracted from the soil by placing soil on a Baermann tray for 96 h (Whitehead and Hemming 1965). Nematodes were recovered by sieving twice over a 38 µm sieve.

Cane yields were determine by harvesting 100m of the center row of the plots via commercial harvester (John Deere® 3520) and weighed into SRA weigh truck.

CCS was determined via a 6 stalk sub-sample immediately prior to harvest that was analyzed at the Isis Central Sugar Mill.

Data was analyzed using Genstat (release 16.1, VSN International) as a split plot design with varieties as the main plots and nematicide application as the sub-plots. Nematode numbers were Log (x+1) transformed prior to statistical analysis. Pair-wise test of means were conducted at P = 0.05 using Fischer's Protected LSD. This report will focus on root knot, lesion and total plant parasitic nematodes (TPPN). TPPN = root knot + lesion + stubby + spiral + reinform + stunt + ring nematodes.

Harvesting Isis Productivity GGIP Nematode Trial Site (Peter McLennan Farm Wallaville). Harvested by Central Harvesting and weighed into SRA weigh truck.

Results and Discussion

Nematicide application significantly reduced the populations of root knot and lesion nematodes by 86.5% and 81% respectively four months after application (Table 1).

Table 1: Effect of nematicide application on root knot, lesion and TPPN populations (per 200mL soil) in February and May 2013. Values are log (x+1) transformed (values in parenthesis are back-transformed means). Values followed by the same letter are not statistically different (P=0.05).

	February 2013			May 2013		
Nematicide	Root Knot	Lesion	TPPN	Root Knot	Lesion	TPPN
Yes	1.39[b] (25)	1.04[b] (11)	2.40 (249)	2.41 (255)	1.71[b] (51)	2.80 (636)
No	2.26[a] (182)	1.77[a] (58)	2.71 (502)	2.45 (278)	2.05[a] (113)	2.75 (571)
P value	0.031	0.002	0.088	0.690	0.007	0.385
LSD	0.33	0.15	n.s.	n.s.	0.22	n.s.

100 mtr harvest strips for trial yield assessment

However, by the May 2013 sample there was no difference in root knot or TPPN populations between the + and – nematicide treatments, but there was a reduction in lesion nematodes in the nematicide treated plots. There were no differences in the +/- nematicide treatments in the 2014 and 2015 samplings (Figure 1).

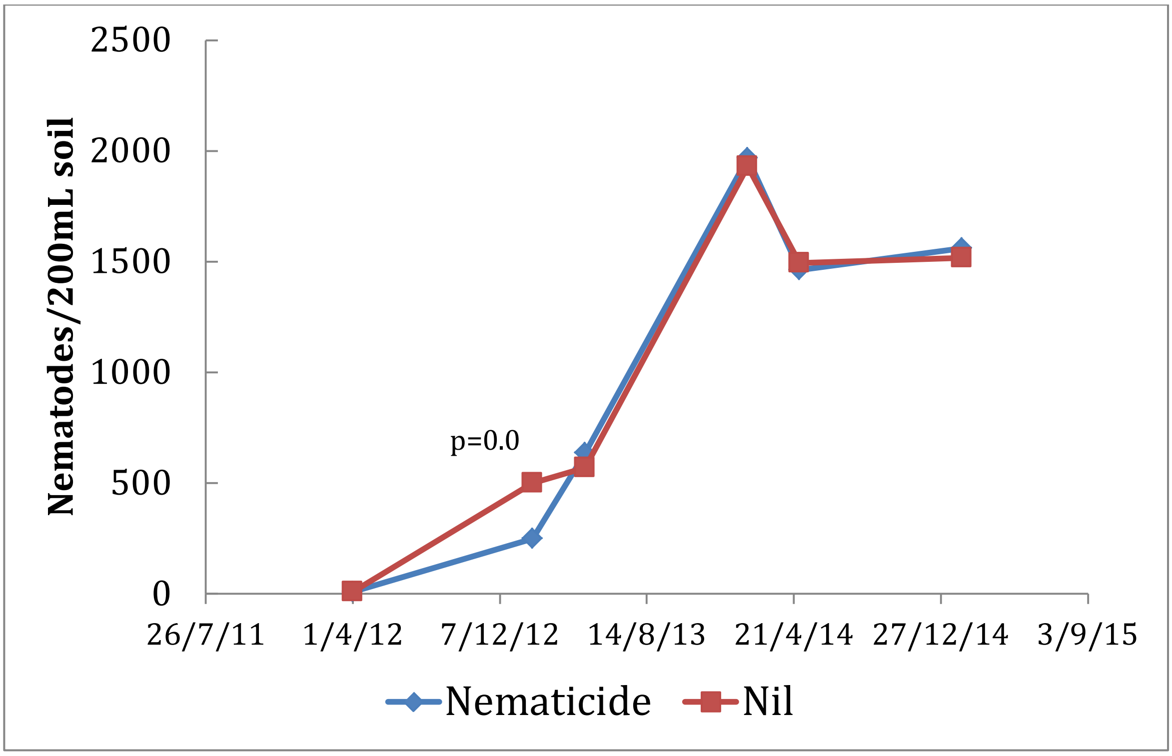

Figure 1: Effect of nematicide application on TPPN populations. (Values and back-transformed treatment means)

Nematicide application incorporated with rakes and followed up with irrigation

Variety selection had a significant effect on nematode populations. There was very little varietal difference on root knot populations in the February sampling during the plant cane crop. However by the May sampling there were very clear differences between the varieties in terms of the number of root knot nematode present in the soil; $Q183^{a}$>$Q242^{b}$>$KQ228^{c}$>$Q245^{d}$ (Table 2). Both KQ228 and Q245 hosted significantly fewer lesion nematodes than Q242 and Q183. Overall there were far fewer lesions than root knot nematodes.

Table 2: Effect of variety selection on root knot, lesion and TPPN populations (per 200mL soil) in February and May 2013. Values are log (x+1) transformed (values in parenthesis are back-transformed means). Values followed by the same letter are not statistically different (P=0.05).

	February 2013			May 2013		
Variety	Root Knot	Lesion	TPPN	Root Knot	Lesion	TPPN
KQ228	2.03 (107)	0.78 (6)	2.37^{bc} (233)	2.07^{c} (118)	1.42^{b} (26)	2.38^{c} (239)
Q183	2.03 (107)	1.60 (39)	2.71^{ab} (509)	3.29^{a} (1992)	2.18^{a} (150)	3.37^{a} (2331)
Q242	2.07 (117)	1.84 (69)	2.81^{a} (650)	2.82^{b} (662)	2.30^{a} (201)	3.03^{b} (1081)
Q245	1.17 (15)	1.40 (25)	2.31^{c} (202)	1.51^{d} (33)	1.62^{b} (42)	2.34^{c} (219)
P value	0.190	0.125	0.044	<0.001	0.013	<0.001
LSD	n.s	n.s.	0.38	0.37	0.499	0.198

Plant cane yields

Nematicide application had no effect on sugarcane productivity, despite significantly reducing root knot nematode populations until February, Figure 2. This is similar result to that reported by Halpin *et. al.* (2015); where nematicide application failed to deliver a productivity response, despite reducing nematode populations for a short period of time during the plant cane crop.

GGIP grower group member's discussion at trial site

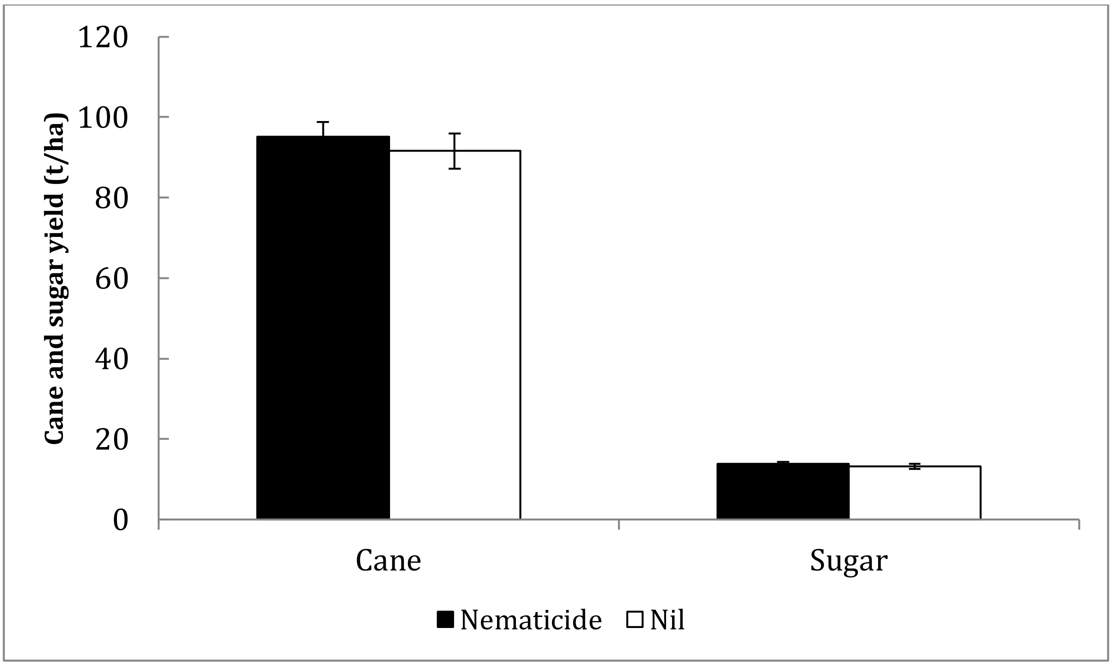

Figure 2: The effect of nematicide application on plant cane productivity

There was no variety by nematicide application interaction despite the range of nematode populations hosted by the different varieties. This would suggest no differences in varietal tolerance of nematode numbers Figure 3.

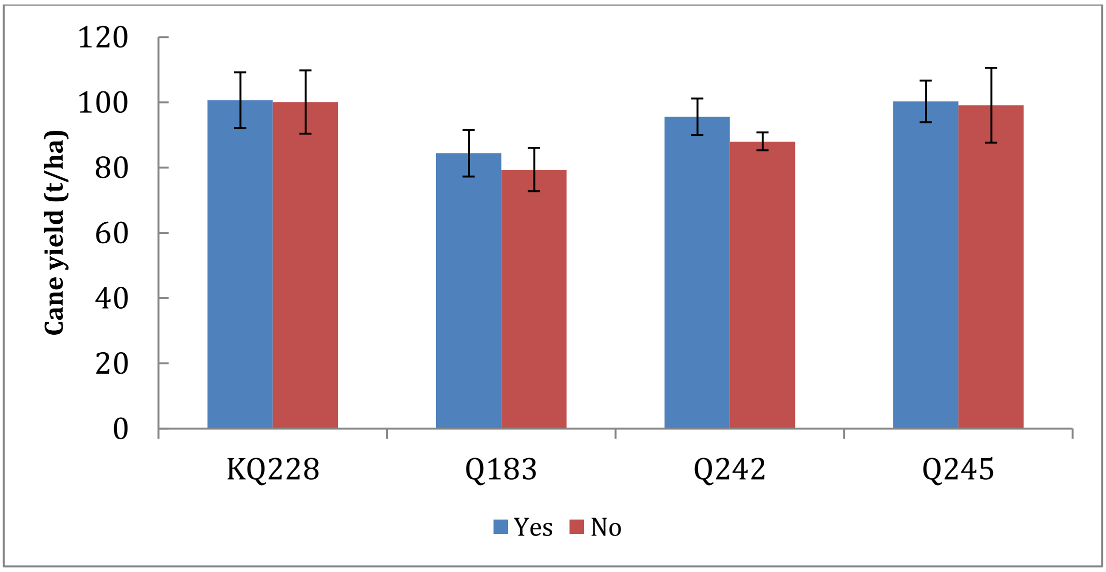

Figure 3: Variety productivity response to nematicide application (tonnes cane/ha) in the plant cane crop.

There was a significant varietal effect on cane productivity with Q245, which hosted the lowest number of root knot nematodes, yielding 21.8% more cane than Q183 that hosted the highest number of root knot nematodes. However Q245 had the lowest sucrose content that reduced its sugar yield relative to KQ228[A] (Table 3).

Table 3: Varietal effect on CCS, cane and sugar yield (t/ha) for the plant cane crop. Values in columns followed by the same letter are not statistically different (p=0.05).

Variety	Cane yield (t/ha)	CCS	Sugar yield (t/ha)
KQ228	100.3[a]	15[a]	15.03[a]
Q183	81.8[b]	14.26[b]	11.66[b]
Q242	91.7[ab]	14.59[ab]	13.38[ab]
Q245	99.6[a]	13.84[c]	13.75[a]
P value	0.028	0.002	0.020
LSD	11.92	0.41	1.79

There was a significant correlation (p=0.026) between populations of root knot nematodes in May and cane productivity of the plant cane crop, with crop productivity reducing as nematode numbers increased. However the r^2 was low at 0.186 (Figure 4).

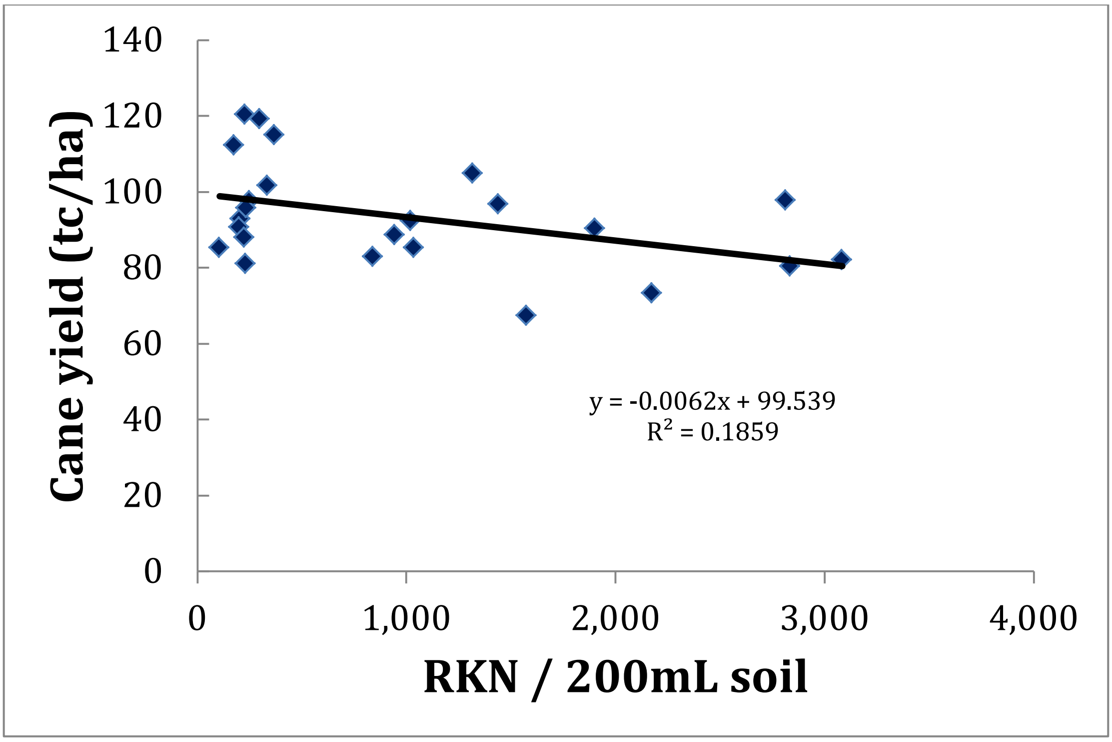

Figure 4: Effect of root knot nematode (RKN) population on sugarcane productivity in the plant cane crop.

Ratoon phase

There was no evidence of any residual effect of the nematicide application in the plant cane crop (Oct 2012) on nematode populations in the R1 crop Table 4. This result is unsurprising as Bull (1981) had previously demonstrated the short-term effect of nematicide applications on PPN populations.

Table 4: Effect of nematicide application on root knot, lesion and TPPN populations (per 200mL soil) in February and May 2014. Values are log (x+1) transformed (values in parenthesis are back-transformed means).

	February 2014			May 2014		
Nematicide	Root Knot	Lesion	TPPN	Root Knot	Lesion	TPPN
Yes	3.19 (1546)	2.01 (103)	3.29 (1967)	2.96 (914)	2.37 (232)	3.17 (1462)
No	3.21 (1602)	2.10 (126)	3.29 (1930)	2.97 (930)	2.36 (230)	3.17 (1494)
P value	0.861	0.551	0.905	0.934	0.970	0.898
LSD	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Variety Q245 hosted significantly less root knot nematodes in both the February and May (2014) samplings during the R1 crop phase, Table 5. For example there was an 82% and 68% reduction in root knot and TPPN nematodes respectively in the soil of plots growing Q245 compared to Q183, at the time of the May sampling.

Table 5: Effect of variety selection on root knot, lesion and TPPN populations (per 200mL soil) in February and May 2014. Values are log (x+1) transformed (values in parenthesis are back-transformed means). Values followed by the same letter are not statistically different (P=0.05).

	February 2014			May 2014		
Variety	Root Knot	Lesion	TPPN	Root Knot	Lesion	TPPN
KQ228	3.18[a] (1529)	1.95 (90)	3.25 (1725)	3.05[a] (1108)	2.27 (188)	3.21[a] (1627)
Q183	3.57[a] (3718)	1.92 (83)	3.62 (4123)	3.27[a] (1845)	2.34 (217)	3.38[a] (2420)
Q242	3.47[a] (2942)	2.19 (156)	3.51 (3206)	3.03[a] (1082)	2.36 (229)	3.19[a] (1561)
Q245	2.56[b] (367)	2.15 (143)	2.79 (611)	2.51[b] (327)	2.49 (307)	2.89[b] (777)
P value	0.026	0.873	0.051	0.008	0.561	0.030
LSD	0.617	n.s.	n.s.	0.136	n.s.	0.287

The R1 crop performance/yield variability was heavily influenced by frost damage (Figure 5).

Figure 5: Picture of frost affected cane at the trial site.

The productivity trend of the R1 crop mirrored that of the plant cane crop where Q183 produced the lowest cane yield and Q245 produced one of the highest yields. However, there was no statistical difference in cane or sugar yield (Figure 6) or CCS (data not shown).

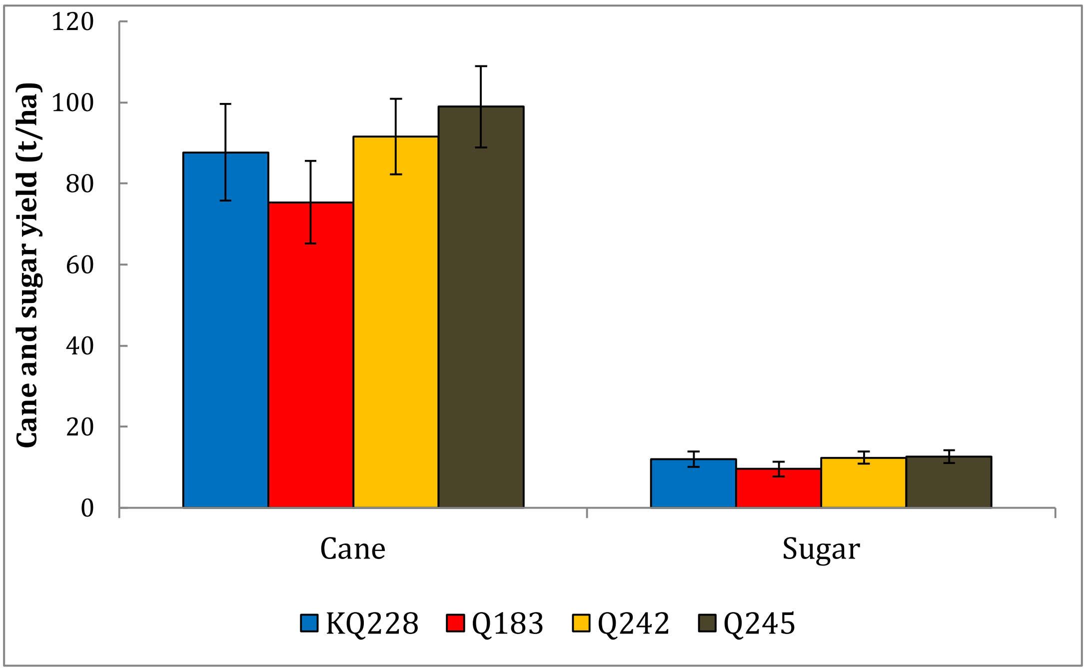

Figure 6: R1 cane and sugar yield (t/ha)

R2 crop phase

Soil sampling for PPN populations in the R2 crop phase demonstrated that nematicide application in Oct 2012 had no impact in R2 (data not shown). However the varietal impact was still evident. For example Q245 hosted 82% less root knot nematode as Q183. Similarly Q245 hosted 76% less TPPN than Q183 (Table 6). This sampling also demonstrated that there were significantly fewer lesion nematode hosted on KQ228 than any other variety tested.

Table 6: Effect of variety selection on root knot, lesion and TPPN populations (per 200mL soil) in February 2015. Values are log (x+1) transformed (values in parenthesis are back-transformed means). Values followed by the same letter are not statistically different (P=0.05).

	February 2015		
Variety	Root Knot	Lesion	TPPN
KQ228	3.06[ab] (1154)	1.26[b] (18)	3.10[b] (1257)
Q183	3.44[a] (2758)	2.17[a] (149)	3.51[a] (3209)
Q242	3.11[ab] (1275)	2.35[a] (224)	3.25[ab] (1772)
Q245	2.68[b] (482)	2.28[a] (189)	2.90[b] (784)
P value	0.031	0.010	0.051
LSD	0.440	0.561	n.s.

Sampling R2 crop phase

Acknowledgements

This project wouldn't be possible without the input of Peter McLennan who implemented and maintained the trial site. We thank Jenny Cobon from DAF Ecosciences precinct for processing nematode samples. Wayne Stanley and Ian Putt from Isis Canegrowers contribution for compiling annual reports is also acknowledged.

This project was funded as a Grower Group Innovation Project under the Sugar Research and Development Corporation and later Sugar Research Australia.

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Section 4: Intellectual Property (IP) and Confidentiality

None

Section 5: Industry Communication and Adoption of Outputs

A round of grower group shed meetings were held on 26th and 27th May with a total of 54 members attending. Mr Philip Patane (SRA PEC Unit) attended all meetings. Neil Halpin (DAFF) presented most final results of the trial. A roving field day bus trip has been undertaken to the trial site which involved approximately 50 members.

No information is currently available on adoption of project outputs. Some recent variety discussions for spring plant 2015 with growers has highlighted the benefits of Q245 in nematode prone soils.

Information is available on the Isis Productivity Limited website regarding variety performance in the presence of nematodes.

We intend to present a paper at the next ASSCT conference in Mackay in 2016 and hope to be able to present the same paper at the next GIVE conference.

IPL Board has approved financial costs to cover further yield assessment for the second ratoon crop and to sample nematode numbers in February 2016. There is also a consideration to harvest the third ratoon crop also. These activities are considered important by the district to achieve better information on varietal tolerance.

Section 6: Environmental Impact

This trial has again highlighted that the use of nematicides in sugar cane do not appear to provide long term control of various nematode species. The reduction in use of highly toxic chemicals where variety resistance can achieve similar or better results can only be beneficial to the environment.

Section 7: Recommendations and Future Industry Needs

The authors see great value in investment into a nematode screening program that could rate varieties into groups of susceptibility to both major sugarcane nematode pests. Such a rating could then be built into a decision support 'tree' or tool to better enable producers to select varieties on a paddock by paddock basis.

Section 8: Publications

A paper presented at the 2015 conference of the Australian Society of Sugar Cane Technologists and two grower group presentations are embedded as PDFs or PowerPoint presentations on the following pages.

See below 2015 ASSCT paper for Russo Trial Information

THE IMPACT OF TRASH AND TILLAGE MANAGEMENT OPTIONS AND NEMATICIDE APPLICATION ON CROP PERFORMANCE AND PLANT-PARASITIC NEMATODE POPULATIONS IN A SUGARCANE/PEANUT FARMING SYSTEM

By

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KEYWORDS: Plant-parasitic Nematodes, Soil Suppression, Tillage, Farming Systems, Nematicides.

Abstract

PLANT-PARASITIC NEMATODES (PPN) are a significant productivity constraint in the sugarcane farming systems of the Bundaberg/Childers region. This experiment was established to examine the impact of strategies like trash retention and reduced tillage on nematode populations and crop performance. A sugarcane field that was due for plough-out had two trash managements, green cane trash blanket (GCTB) retained or residues removed by burning (Burnt), split for two tillage treatments, conventional tillage (Conv.) and direct drill (DD). The site was sown to peanuts in August 2010. Following the peanut crop, the tillage treatments were re-instituted and sown to sugarcane (KQ228Ⓐ) in September 2011 using a double-disc opener planter. When the established cane crop was at the four leaf stage all plots were split for +/– nematicide. Nematicide was applied to see if this option would retard the reinfestation of PPN during the plant cane phase. Treatments were split again for +/– nematicide in the ratoon phase. Trash management had no impact on peanut productivity whereas tillage did. The Conv. treatment produced 39% greater peanut yield than the DD treatment. Early plant cane development was retarded in the DD plots, a trend that continued through to the harvest of the plant cane crop where the Conv. treatment improved productivity by 36% compared to DD plots. However, there was no tillage effect on cane productivity in the R1 crop. While nematicide application in the plant cane crop significantly reduced total PPN numbers, there was no impact on yield. Application of nematicide to the ratoon crop significantly reduced sugar yield. This study confirmed other work demonstrating implementation of strategies like reduced tillage reduced populations of total plant-parasitic nematodes (TPPN) in the ratoon phase; suggesting that the soil was more suppressive to PPN in those treatments. Further work is required to over-come the lack of crop performance when the DD treatment is implemented for the peanut break crop and in the plant cane phase.

Introduction

Plant-parasitic nematodes (PPN) are a significant constraint to the productive capacity of sugarcane soils and cost the Australian industry 3.29M tonnes of cane annually (Blair and Stirling 2007). Historically, nematodes were only thought to be an issue on sandy soils of Bundaberg (Bull 1981), but nematode survey work identified PPN in all soils growing sugarcane in the southern region (Blair *et al.*, 1999). Lesion nematode (*Pratylenchus zeae*) and root-knot nematodes (*Meloidogyne spp*) were considered the most important pest species based on abundance and density in the field (Blair *et al.*, 1999).

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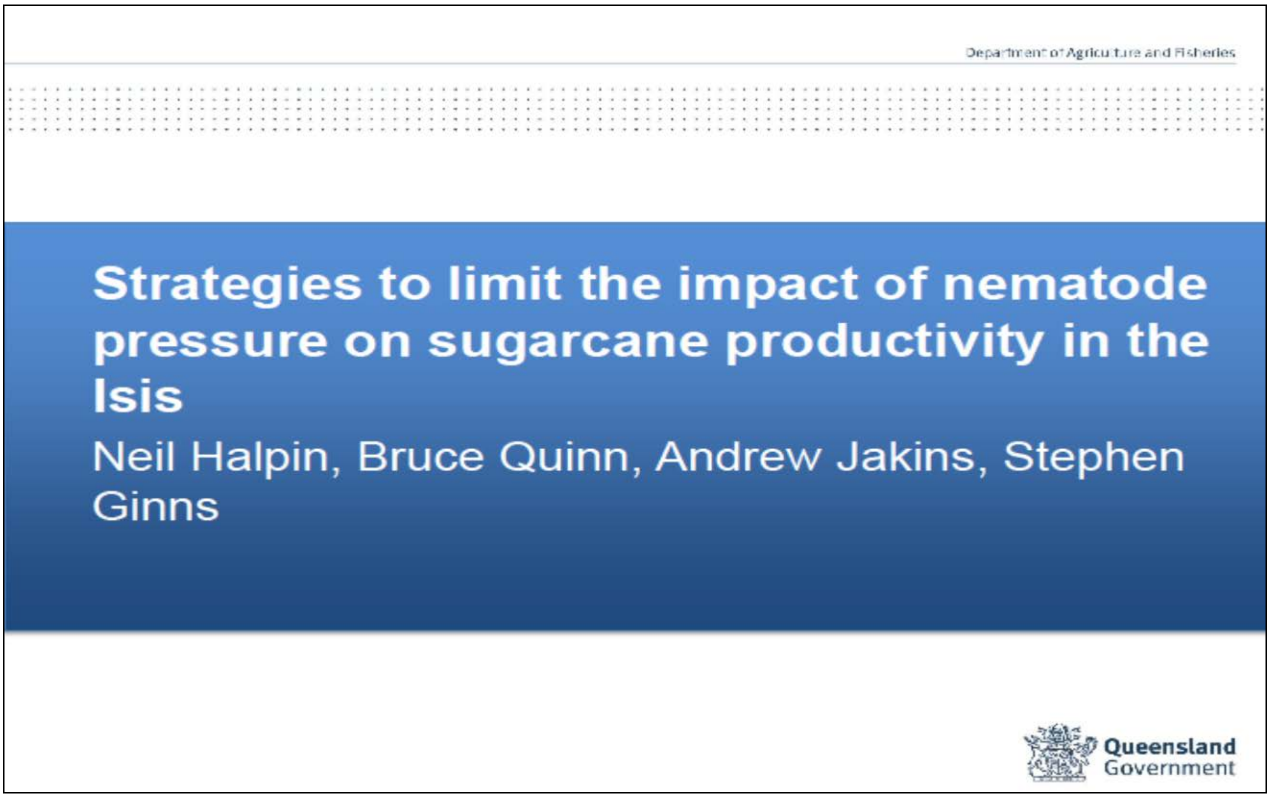
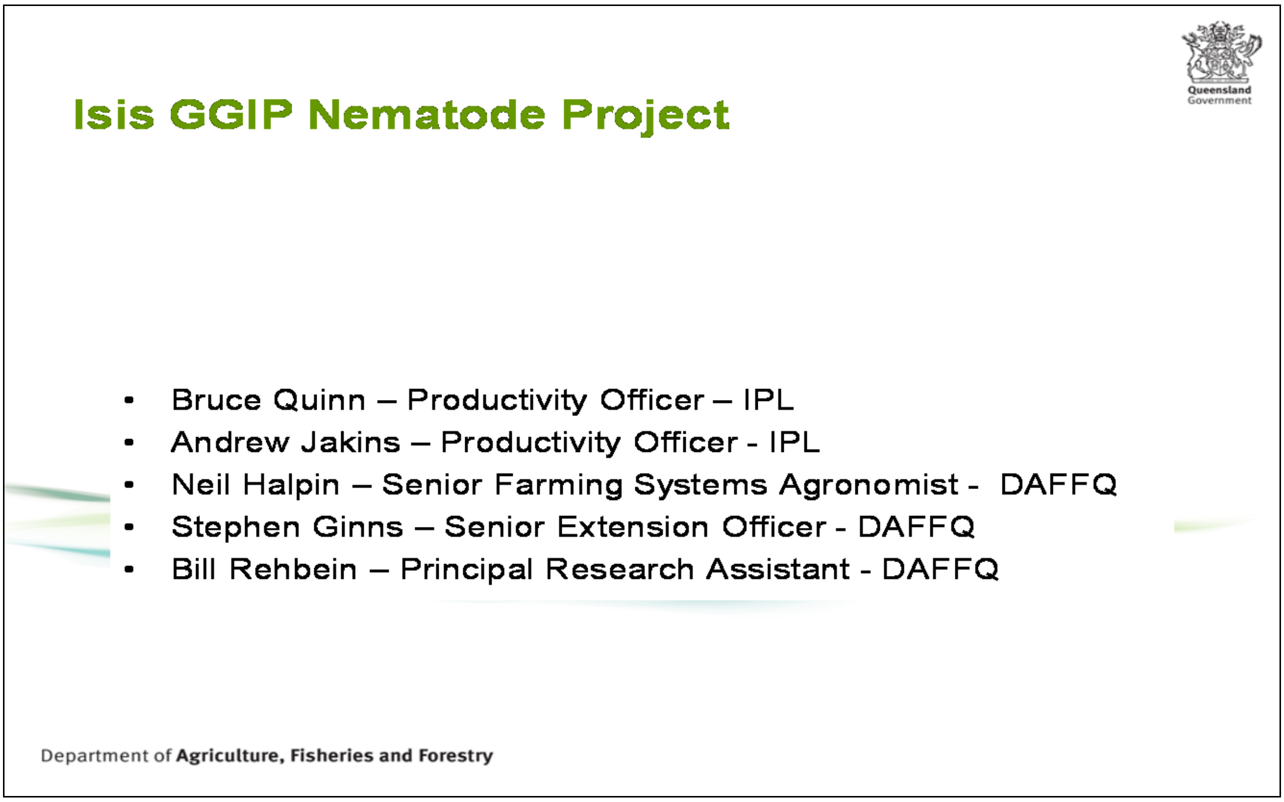
Double click the extract above to open the full ASSCT paper



Double click the heading above to open attachment (Grower Group Presentation)



Double click the heading above to open attachment (Grower Group Presentation)

Grower Group Meetings Trial Update Meetings

Trial Harvesting (Co-operators SRA –Central Harvesting)