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Evaluating fipronil as a seed dressing for lucerne crown borer (*Zygrita diva*) management in soybeans – 2015/16 and 2016/17

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Key findings

- Soybean yields were reduced by 50% and seed size by 16% on untreated seed compared with seed treated with fipronil (e.g. Legion®), in 2015.
- Where lucerne crown borer (LCB) infestation was heavy, fipronil seed treatment at 100 mL/100 kg of seed reduced infestation levels from 86% to 38%, girdling (stem ring barking) from 70% to 21% and plant lodging from 31% to 5%.
- Fipronil seed dressing had no negative effect on nodulation.
- Crop senescence was hastened where seed was untreated or low concentrations of fipronil were used.
- Crop maturity was delayed by up to eight days in healthier crop protected from LCB by high concentrations of fipronil seed dressing.
- Where LCB pressure was low, the fipronil concentration had no significant effect on yield or quality.

Introduction

The 'Northern pulse agronomy initiative – NSW' (DAN00171) is a joint project between NSW DPI, Queensland Department of Agriculture and Fisheries (QDAF) and Grains Research and Development Corporation (GRDC). The project's broad objectives include identifying management strategies to optimise yields and to develop agronomic recommendations to improve crop reliability.

LCB (Figure 1) is a sporadic soybeans pest capable of causing major yield losses. Infestation levels can be greater than 80% of plants infested.

Figure 1. Adult lucerne crown borer (*Zygrita diva*). Source: K. Hertel, NSW DPI.

Managing LCB in soybeans focuses on cultivation to break up and bury stubble to kill larvae in the lower stem and roots. However, the increased adoption of zero-till has also increased LCB as they survive over winter. Monitoring for emerging larvae and adults is generally undertaken in late spring/

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early summer. Chemical control is generally not effective and not conducive to fostering beneficial insect populations. It also does not comply with Helicoverpa resistance management strategies.

At Breeza, LCB caused significant damage in soybeans in the 2014/15 season. This presented the opportunity for collaboration between NSW DPI and QDAF to evaluate the efficacy of Legion® seed dressing (50 g/L fipronil) to control LCB. At this time, no insecticides were registered or under permit to control LCB in soybean .

Figure 2. Lucerne crown borer (*Zygrita diva*) larva in soybean stem.
Source: K. Hertel, NSW DPI.

Legion® is registered as a seed treatment for redlegged earth mite (*Halotydeus destructor*) in canola, and false wireworm (*Pterohelaeus darlingensis* and *Gononcephalum macleayi*) in sorghum and sunflowers.

A total of six experiments to evaluate Legion® seed dressing in soybeans were conducted in the 2015/16 and 2016/17 summer seasons at four locations: Breeza, Narrabri and Grafton in NSW, and Kingaroy in Queensland. This report shows the results of the experiments conducted at Breeza and Narrabri in 2015/16 and 2016/17, respectively.

Site details

Locations	Breeza 2015/16 – Liverpool Plains Field Station Narrabri 2016/17 – Australian Cotton Research Institute	
Farming system	Irrigated raised beds	
In-crop rainfall	Breeza 2015/16	Sowing date (SD) 1: 295.4 mm SD2: 409.4 mm
	Narrabri 2016/17	207 mm
Mean maximum temperature	Breeza 2015/16	SD1: 32.2°C SD2: 31.8°C
	Narrabri 2016/17	33.6°C
Mean minimum temperature	Breeza 2015/16	SD1: 16.1°C SD2: 16.1°C
	Narrabri 2016/17	18.1°C
Harvest date (days after sowing – DAS)	Breeza 2015/16	SD1: 25 May 2016 (197 DAS) SD2: 25 May 2016 (163 DAS)
	Narrabri 2016/17	2 May 2017 (158 DAS)

Irrigation	Experiments were sown into pre-watered fields with a full soil moisture profile. Each then received in-crop irrigations as required throughout the growing season.
Experiment designs	2015/16: Split plot randomised design with sowing date as the main block and fipronil rates as the sub-plots; three replications. 2016/17: Complete randomised block design; three replications.
Plant population	Target: 30 plants/m^2 (sowing rates adjusted for seed size and germination percentage).

Treatments

Table 1. Fipronil evaluation experiment treatments – 2015/16 and 2016/17.

Experiment	Breeza 2015/16	Narrabri 2016/17
Sowing date/s	SD1: 10 Nov 2015 SD2: 14 Dec 2015	24 Nov 2016
Variety	Moonbi	Moonbi, Richmond, Soya 791
Rate of fipronil (g/kg seed)	Nil 50 100	Nil 100

Assessments

Lucerne crown borer abundance

Plants from SD1 and SD2 were assessed for LCB presence/damage on two and three occasions respectively throughout the season. The most definitive data was obtained when plants were assessed at harvest on 25 May 2016. Immediately before harvest in each plot, plants from a five metre length from two rows (10 m total) were assessed for girdling and lodging, the latter being girdled (ringbarked) plants that had fallen over. Plots were then harvested, which cut the stalks just above ground level. This allowed all stems to be assessed for the presence or absence of LCB.

Infested plants were characterised by the presence of discoloured pith (dark purple or orange) in the severed stalks. In contrast, pith in uninfested plants was pale cream. The external stem colour of infested and uninfested plants was also recorded.

Nodulation

Nodulation was assessed when each SD reached early flowering. Twenty plants were selected at random, dug up and the roots washed. The root system was assessed in two sections: above and below 5 cm soil depth.

Nodulation was scored on a 0–5 scale.

Score 0 = zero nodules present in upper and lower lateral root sections

Score 5 = >10 nodules in upper lateral root system with >10 nodules in the lower root section

Results – Breeza 2015/16

Crop establishment

Crop emergence was rapid and uniform after each SD. Time of sowing and the fipronil application rate had no significant effect on crop establishment (Tables 2 and 3).

Nodulation

Seed was inoculated with peat-based Group H rhizobia prior to sowing. Nodulation scores were assessed 69 DAS and 59 DAS for SD1 and SD2 respectively. Sowing date and the fipronil concentration had no significant effect on root nodulation (Tables 2 and 3). Nodules were all coloured pink inside, indicating nitrogen fixation activity. There was no significant interaction between SD and fipronil application rate (data not shown).

Physiological maturity

Physiological maturity was recorded when 95% of plants had reached their mature pod colour (P95). Time of sowing had a significant effect on the time to physiological maturity (Table 2). The early November planting date, SD1, reached physiological maturity in May, equivalent to 190 days after planting; SD2 reached physiological maturity 155 days after planting.

The fipronil application rate significantly affected crop development by slowing the time to physiological maturity. The physiological maturity of the crop sown with seed treated with 100 g fipronil/kg seed was eight days later than the untreated seed (Table 3). The poor health of untreated plants was the likely cause of early senescence.

There was no significant interaction between sowing date and rate of fipronil on the time to crop maturity (data not shown).

Yield and seed quality

There was no significant interaction between sowing date and fipronil rate on yield or seed size (data not shown).

Time of sowing did not significantly affect the yield or seed size of Moonbi[Φ] (Table 2); however, treatments with fipronil did have a significant effect on both yield and seed size (Figure 1). The yield from soybean treated with fipronil at 100 g/kg seed was double that of untreated seed.

Fipronil-treated (100 g /kg) seed size was 16% larger compared with the untreated seed (Figure 1).

There were marked visual differences in plants with those in plots with the highest fipronil concentration appearing much healthier compared with other treatments, and had noticeably more pods.

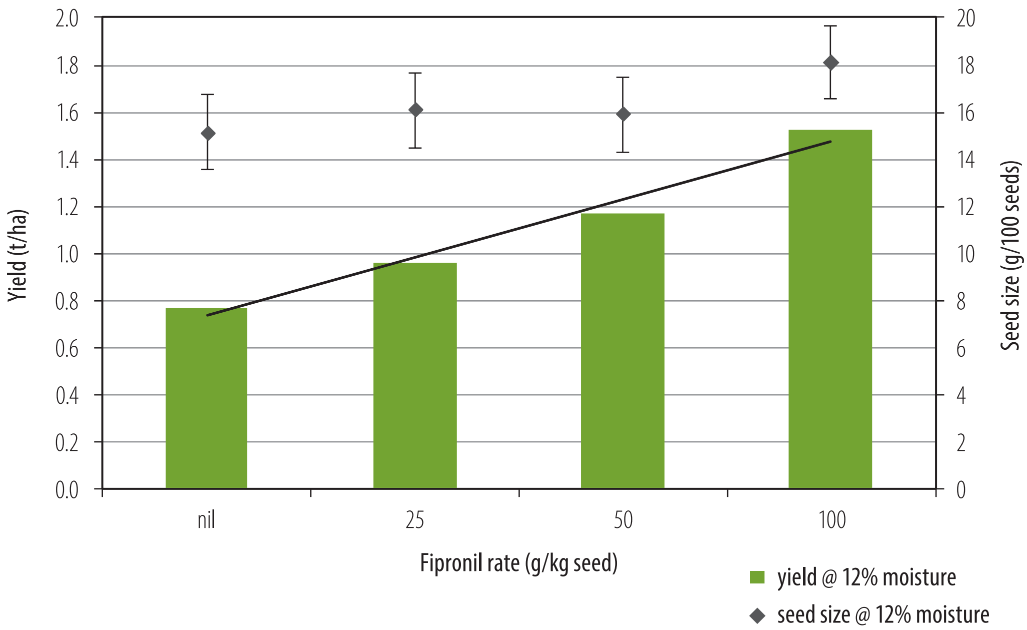

Figure 3. Effect from fipronil rate on yield and seed size at Breeza – 2015/16.
Error bars denote least significant difference (l.s.d.).
Yield l.s.d. (P<0.001) = 0.41 t/ha; seed size l.s.d. (P<0.001) = 1.58

Table 2. Sowing date effect on establishment, yield, seed size, root nodulation and time to maturity at Breeza – 2015/16.

Sowing date	Establishment (plants/m²)	Root nodulation score (/5)	Yield (t/ha)	Seed size (g/100 seeds)	Days to physiological maturity
SD1: 10 November	23 [a]	1.3 [a]	1.02 [a]	15.8 [a]	190 [a]
SD2: 14 December	21 [a]	0.2 [a]	1.18 [a]	16.8 [a]	155 [b]
Site mean	22	0.8	1.10	16.3	173
l.s.d.	ns*	ns*	ns*	ns*	10*

Values with the same letter are not significantly (ns) different at 95% – * (*P*<0.05) confidence levels

Table 3. Effects of fipronil rate on establishment, yield, seed size, root nodulation and time to maturity at Breeza – 2015/16.

Rate of fipronil (g/kg seed)	Establishment (plants/m²)	Root nodulation score (/5)	Yield (t/ha)	Seed size (g/100 seeds)	Days to physiological maturity
nil	23 [a]	0.6 [a]	0.76 [c]	15.1 [b]	176 [a]
25 g	22 [a]	0.7 [a]	0.96 [bc]	16.0 [b]	175 [ab]
50 g	21 [a]	0.9 [a]	1.16 [b]	15.9 [b]	171 [bc]
100 g	23 [a]	0.8 [a]	1.52 [a]	18.1 [a]	168 [c]
Site mean	22	0.8	1.10	16.3	173
l.s.d.	ns*	ns*	0.21**	1.6*	4*

Values with the same letter are not significantly different at 99.9% – ** (*P*<0.001) or 95% – * (*P*<0.05) confidence levels

Pest abundance and damage

Plant assessments during the experiment revealed a marked decrease in the number of live LCB larvae in stems in 50 g/kg and 100 g/kg fipronil-treated plants. There was a clear decrease in larval size, indicating delayed successful larvae establishment, and increased larval mortality (data not shown), with dead larvae being shrunken and black (Figure 4).

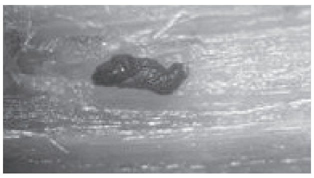

Figure 4. Dead lucerne crown borer (*Zygrita diva*) larva (5 mm).
Source: H. Brier, QDAF.

The percentage of LCB-infested plants averaged 62% across all plots in both experiments, with no significant difference between the two sowing dates (Table 4). However, a significantly higher percentage of plants were girdled (ringbarked) and lodged in SD2 compared with SD1 due to LCB infestation.

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Table 4. Effect from sowing date on percentage of infestation, girdled plants and crop lodging at Breeza – 2015/16.

Sowing date	Infested plants (%)	Girdled plants (%)	Lodging (%)
SD1: 10 November	59.3 a	31.1 b	6.5 b
SD2: 14 December	64.0 a	45.1 a	16.1 a
Site mean	61.7	38.1	11.3
l.s.d.	ns*	5.7**	3.6**

Values with the same letter are not significantly different (ns) at 99.9%; ** (P<0.001) or 95%; * (P<0.05) confidence levels

In both experiments, the effects from fipronil on the percentage of infested plants, girdled plants and crop lodging was rate dependant (Table 5 shows the averages for both experiments). The high concentration of fipronil delayed girdling with just 17.6% of plants affected compared with 57.3% in the untreated treatment. Comparing the same treatments, there was a six-fold difference in subsequent lodging.

Table 5. Impact of fipronil rate on percentage of infested and girdled plants and lodging at Breeza – 2015/16.

Rate of fipronil (g/kg seed)	Infested plants (%)	Girdled plants (%)	Lodging (%)
nil	82.1 a	57.3 a	20.9 a
25 g	75.4 a	47.4 b	13.2 b
50 g	53.8 b	30.0 c	7.4 c
100 g	35.4 c	17.6 d	3.6 d
Site mean	61.7	38.1	11.3
l.s.d.	9**	8.1**	5.1**

Values with the same letter are not significantly different at 99.9%; ** (P<0.001) confidence levels

These results for SD1 and SD2 clearly demonstrate the effectiveness of fipronil for protection against LCB incursions in soybeans with yield doubling at the highest rate versus the untreated control, and a commensurate reduction in LCB infestation and damage (Table 6).

Table 6. Interaction between sowing date (SD) and fipronil rate on infestation, girdled plants and crop lodging at Breeza – 2015/16.

Rate of fipronil (g/kg seed)	Infested plants (%)		Girdled plants (%)		Lodging (%)	
	SD1	SD2	SD1	SD2	SD1	SD2
nil	78.2 a	85.9 a	44.3 a	70.4 a	10.5 bc	31.2 a
25 g	71.1 a	79.6 a	41.3 a	53.6 a	9.0 c	17.5 b
50 g	54.8 a	52.8 a	24.1 a	35.9 a	4.3 c	10.6 bc
100 g	33.0 a	37.8 a	14.6 a	20.5 a	2.1 c	5.1 c
Site mean	59.3	64	31.1	45.1	6.5	16.1
l.s.d.	*ns	*ns	*7.24			

Values with the same letter are not significantly different (ns) at 95%; * (P<0.05) confidence levels

Results – Narrabri 2016/17

Crop establishment

The Narrabri site was sown on 24 November. Seed bed moisture was ideal after pre-watering on 17 November with a soil temperature of 24.1 °C at 9:00 am (AEST). Crop establishment was measured 18 days after sowing at the two trifoliate leaf stage (V2). All varieties exceeded the target population of 35 plants/m^2 (Table 7).

Yield and seed quality

The Narrabri site was harvested on 2 May 2017 (158DAS); the average yield was 2.86 t/ha. There was no significant difference in yield between Richmond$^{\Phi}$ and Soya 791, but both were significantly greater than Moonbi$^{\Phi}$ (Table 7). The fipronil rate did not significantly affect yield (Table 7).

There was no significant difference in seed size between Richmond$^{\Phi}$ and Moonbi$^{\Phi}$; Soya 791 was significantly smaller (Table 7). The fipronil rates had no significant effect on seed size (Table 8).

Pest abundance and damage

Pest damage was measured on 6 February 2017 (73DAS). At this time, the differences in maturity between the varieties were evident. Moonbi$^{\Phi}$ was at growth stage (GS) R4.3 (full pod development, just before visible seed development), Richmond$^{\Phi}$ – GS R2.5 (flowering, just before pod development) and Soya 791 GS – R2.4 (flowering).

Overall, there were low levels of LCB in the experiment, averaging 1.3%. Soya 791 had the highest number of insects (3.9% of plants affected), which was significantly higher than Moonbi$^{\Phi}$ (no plants affected) and Richmond$^{\Phi}$ (0.1% of plants affected) (l.s.d. = 1.3%; P<0.001) (Table 7).

In a separate experiment in 2014/15, levels of infested plants showed distinct differences between varieties. Infestation levels appeared to relate to the stage of plant growth at the time of egg laying.

Similarly, in this experiment there were significant differences between infestation levels of the varieties tested; Moonbi$^{\Phi}$ and Richmond$^{\Phi}$ have similar maturity, much quicker than Soya 791. These differences might influence how attractive the plants are to adult LCB at egg laying early in the season, and explain the apparent preference and subsequent infestation in Soya 791.

The rate of fipronil had no significant effect on the level of infestation (Table 8).

Table 7. Effect of variety on establishment, yield, seed size and level of LCB infestation at Narrabri – 2016/17

Variety	Establishment (plants/m^2)	Yield (t/ha)	Seed size (g/100 seeds)	No. infested plants (%)
Moonbi$^{\Phi}$	54 ^{a}	2.45 ^{b}	21.5 ^{a}	0.0 ^{b}
Richmond$^{\Phi}$	50 ^{a}	3.24 ^{a}	22.2 ^{a}	0.1 ^{b}
Soya 791	35 ^{b}	2.89 ^{a}	18.0 ^{b}	3.9 ^{a}
Site mean	47	2.86	20.6	1.3
l.s.d.	9*	0.4*	0.9**	1.1**

Values with the same letter are not significantly different at 99.9% – ** (P<0.001) or 95% – * (P<0.05) confidence levels

Table 8. Impact of fipronil rate on establishment, yield, seed size and level of LCB infestation at Narrabri – 2016/17.

Rate of fipronil (g/kg seed)	Establishment (plants/m²)	Yield (t/ha)	Seed size (g/100 seeds)	No. infested plants (%)
nil	47 [a]	2.89 [a]	20.5 [a]	1.3 [a]
100 g	46 [a]	2.83 [a]	20.6 [a]	1.4 [a]
Site mean	47	2.86	20.6	1.3
l.s.d.	ns*	ns*	ns*	ns*

Values with the same letter are not significantly (ns) different at 95% – * (P<0.05) confidence levels

Conclusions

Fipronil seed dressing has the potential to reduce LCB levels and the consequent severity of damage, including stem girdling and crop lodging.

It was most effective at the highest rate – 100 g/kg seed. The marked rate response in these experiments show that rates lower than 100 g/kg seed would give inferior performance, particularly at the 50 g/kg seed rate.

The information contained in this report and from experiments conducted at Grafton (NSW) and Kingaroy (Queensland) was subject to a Minor Use Permit from the Australian Pesticide and Veterinary Medicines Authority (PER83319 expiry 31 January 2018).

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