MEAT & LIVESTOCK AUSTRALIA

Developing an Early Flowering ARGT Resistant Ryegrass Cultivar

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Locked Bag 991

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Developing an early flowering ARGT resistant ryegrass cultivar

Full Report

DAS.035
December 1997

Meat Research Corporation

A report of research conducted
July 1994-June 1997 by the

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

South Australian Research and Development Institute
Adelaide, SA

This research project was funded by the

Meat Research Corporation
PO Box A498
Sydney South, NSW 2000
Phone (02) 9380 0666
Fax (02) 9380 0699

Abstract

A new ARGT nematode resistant annual ryegrass cultivar has been developed for livestock producers in districts with short growing seasons. It was developed from crosses between Guard, the first ARGT nematode resistant cultivar, Progrow a high yielding Westerwold cultivar and an early flowering ecotype from WA. It is as resistant to the ARGT nematode as Guard, but runs to head about 4 weeks earlier and is potentially higher yielding. It is also resistant to cereal cyst nematode and is as resistant as standard annual ryegrass populations to the wheat and oat attacking strains of take-all. Valley Seeds were supplied with several grams in early 1997 and have multiplied this to 10 kg. A limited commercial release is expected in 2000. In field plots, a mixture of 3:1 (Guard to one local ryegrass), produced a ryegrass population that reduced nematode multiplication by 90% in each of the four years the trial was conducted.

Contents

Abbreviations

ARGT	annual ryegrass toxicity
CCN	cereal cyst nematode
Gga	Oat race of take-all, *Gaeumannomyces graminis* var *avenae*
Ggt	Wheat race of take-all, *G graminis* var *tritici*
MRC	Meat Research Corporation
SA	South Australia
SARDI	South Australian Research and Development Institute
WA	Western Australia

Executive summary

Purpose

To control annual ryegrass toxicity (ARGT), livestock producers have generally had to reduce the ryegrass content in their pastures to a low level. Guard, the first ARGT nematode resistant ryegrass, developed from Wimmera ryegrass, has given livestock producers in the medium to high rainfall cropping regions the option to maintain ryegrass in the pastures.

Most outbreaks of ARGT now occur in the low rainfall regions, where Guard is not adapted. An early flowering ARGT nematode resistant cultivar would provide stockowners in districts with short growing seasons, the option to retain ryegrass as a significant component in their pastures.

A high frequency of the ARGT nematode resistance genes in ryegrass pastures can provide effective biological control of the nematode *Anguina funesta*, thus preventing the toxin producing bacterium *Clavibacter toxicus* reaching hazardous levels in the pasture.

To improve the agronomic performance of the new cultivar, Guard, the first ARGT resistant cultivar released in 1994, was crossed with Progrow a Westerwold ryegrass. Selected plants from this cross were then crossed with an early flowering ecotype from Western Australia (WA) to shorten the time to maturity. Later flowering lines were kept as possible replacements for Guard.

To minimise adverse affects on cereals grown in rotation with the pasture, the new cultivar was screened to ensure it was resistant to cereal cyst nematode and take-all, and susceptible to grass selective herbicides.

Outcome

A new early flowering ARGT nematode resistant cultivar has been developed. Early observations indicate it has excellent seed yield, which reduces the cost of production per unit yield. It also appears to have vigorous, leafy growth, characteristics inherited from Progrow. Confirmation of its agronomic performance will have to wait till there is sufficient seed for comparative studies.

Three other lines are being evaluated, two may be combined as a potential replacement for Guard if they have better early vigour and / or higher dry matter yields, the other line may be useful in high rainfall pastoral areas.

All potential cultivars have been screened to confirm they are resistant to CCN and take-all and susceptible to grass selective herbicides.

Resistance to the nematode has potential to achieve long term control of ARGT. A field trial established at Turretfield SA, to study persistence of nematode resistant plants in different mixtures of Guard and the local ryegrass found the proportion remained unchanged for four years. A mixture of 3:1 (Guard to local ryegrass), produced a ryegrass population that reduced nematode multiplication by 90% relative to the local ecotype in each of the 4 years the trial was established.

Commercialisation

Valley Seeds is our commercial partner for the ARGT nematode resistant ryegrass cultivars. By 2000, they should have sufficient seed for a limited commercial release of the new early flowering cultivar. Seed multiplication of possible later flowering cultivars is less advanced, so commercial release of these is not expected until at least 2001.

Potential Beneficiaries

Graziers in districts with short to medium growing seasons who want a productive grass in their pastures to increase stocking rates and minimise the risk of ARGT will benefit from the new early flowering cultivar. Graziers in the medium to high rainfall regions will have the option to use a later maturing ARGT nematode resistant cultivar.

Hay producers may benefit by using the cultivars to reduce reservoirs of the nematode and bacterium in non arable areas. Infection in these areas can spread to infest hay crops making it potentially unsaleable.

Use of these cultivars will potentially provide long term suppression of the nematode and bacteria associated with ARGT. Reducing reservoirs of infection will benefit all farmers operating in the district as this will reduce the rate of spread into uninfected paddocks.

Benefits

It is difficult to quantify the benefits of the new cultivar(s) until they have been evaluated in the field to determine dry matter yields in a range of regions.

Use of ARGT nematode resistant cultivars could provide long term, non chemical control of ARGT. This could be important with herbicide resistance becoming more common.

Unlike classic predator / prey biological control systems, the level of resistance in the ryegrass population is not dependent on maintaining a significant population of the target organism. The main factor determining the proportion of nematode resistant plants is the amount of background ryegrass present in the paddock when the new cultivar is sown. To be sure the resistance to the nematode persists the new cultivar will need to be managed to flower at the same time as the locally adapted ryegrass.

Research Report

Introduction

Guard, the first ARGT nematode resistant ryegrass, is suited to cropping districts with medium to long growing seasons, but it does not grow or persist well in low rainfall regions with short growing seasons.

Two crossing programs were used to produce the early flowering cultivar. In the first Guard was crossed with an early flowering ecotype from WA. The second approach aimed to improve agronomic performance of the new cultivar. To achieve this, Guard (developed from Wimmera ryegrass) was crossed with Progrow, a Westerwold ryegrass. The best progeny were then crossed with an early flowering WA ecotype.

Early flowering progeny (F1) from these crosses were crossed amongst themselves to produce an F2 generation. The genes for nematode resistance in this generation occur in all combinations, and in theory 1 in 16 should be homozygous for both nematode resistance genes. To identify these plants, each resistant plant was cloned and crossed to a homozygous susceptible plant. Homozygous resistant clones produce all resistant progeny even when crossed to a susceptible plant.

Selected nematode resistant clones and their progeny were then screened for resistance to CCN and take-all. When sufficient seed was available each potential cultivar was screened for susceptibility to grass selective herbicides.

Producing early flowering ARGT nematode resistant parents

The first crosses between Guard and Progrow were made in 1990. In 1993 selected vigorous plants from this cross and Guard were crossed with an early flowering ecotype from Wongan Hills, WA (WA 656). Two thousand plants were established from these crosses, and the 20 most vigorous plants, which had no nematode galls and reached head emergence 3 to 4 weeks before Guard, were selected. Eleven came from Guard X WA early flowering crosses, and nine from Guard X Progrow X WA early flowering.

The 20 plants selected in 1994 were crossed to produce seed which was used to establish 800 plants in January 1995; from these 349 early flowering plants were selected. The selected plants were cloned and crossed with ARGT susceptible early flowering ryegrass plants from WA, 280 produced sufficient seed for genetic studies to determine if they were homozygous for both ARGT nematode resistance genes. The 280 clones were also maintained in growth rooms for controlled crossing when the homozygous ARGT nematode resistant plants had been identified.

During the winter of 1995, 20 seedlings per cross were established from 226 clones, 15 from an additional 20 crosses and 10 from another 13 crosses. Seed from some crosses could not be germinated due to lack of time to break dormancy. Gall production on the progeny was assessed in spring and this enabled 15 homozygous clones to be identified. These were screened against CCN (20 cysts per 250g soil, as per pot experiment method page 10). Four susceptible plants 21, 120, 190 and 267 were identified and removed from the program (Table 1).

The clones were also screened against an isolate of take-all from Eyre Peninsula, but the infected rate was too low to eliminate any of the ryegrass plants.

Table 1. CCN hosting ability of selected 15 ARGT nematode resistant clones

Plant	Number of plants	Mean number of CCN cysts per plant
Egret wheat (CCN susceptible)	33	65
Guard	32	2
4	2	0
6	3	1
21	3	6
30	1	0
54	3	0
109	3	0
120	3	6
122	3	1
127	2	1
167	3	1
190	3	33
267	3	35
285	3	0
331	3	1
332	3	0

The remaining 11 plants were grouped for crossing by heading date and plant morphology to produce nine lines (Table 2.). Lines 3 was the best, Line 2 was the second choice, but was rejected in the final stages of the project due to resistance to the herbicide Hoegrass (Table 7.). Most of the nine lines, including Line 3 (Fig 1.), were derived from crosses involving Progrow.

Line 3 performed well in the growth room and in the field at Valley Seeds in 1997. The lack of genetic diversity may be a problem in some situations since Line 3 is based on only two parents. However, the two Line 3 parents will have greater genetic diversity than the three parents of Guard which were produced from inbred lines. Line 3 was derived from crosses between Guard, Progrow and an early flowering ryegrass population from WA.

Line 3 is as a resistant as Guard to the ARGT nematode, reached head emergence 27 days before Guard and despite flowering early when conditions for seed set were not ideal, had the highest seed yield per pot of the nine lines (Table 2.). Seed yield is important, as it affects the retail price of seed.

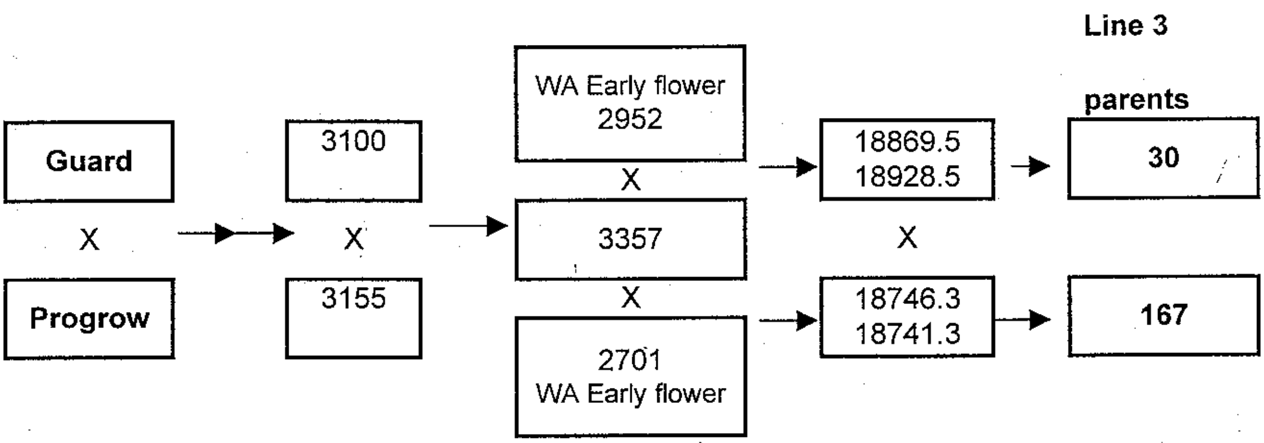
The other 7 lines were rejected because of:

- Doubts about the purity of nematode resistance; Lines 6, 7, 9 and 10.
- Delayed head emergence; Lines 4, 5, 6 and 7.
- Poor seed yield; Lines 4, 5 and 8.
- Poor vigour; Lines 4 and 7.

Table 2 Resistance to the ARGT and heading dates, 1996

Line	Parents	Galls per pot		Seed production g/pot	Head emergence	Growth
		Mean 25 pots	Range		Days from sowing	(1 –5) (low to high)
Guard		11	(0-47)	8.7	104	4 (8)
WA Early Flowering		353	(119 –1357)	9.1	77	
Turretfield		442	(108 – 2657)	10.5	84	
Line 2 gen 1	6, 127,167	8	(0 – 29)	5.9	77	5
Line 2 gen 2	6, 127, 167	10	(0 –52)	5.7	79	5
Line 3	30,167	9	(0 – 49)	9.9	77	5 (8.5)
Line 4	76,122	3	(0 –10)	5.3	90	2
Line 5	109, 127, 331	7	(0 –31)	4.1	86	-
Line 6	109, 323	12	(0 – 132)	6.6	90	5
Line 7	54, 323, 331	10	(0 –78)	6.3	86	3 (8.5)
Line 8	76, 109	4	(0 - 18)	3.9	82	4
Line 9	4, 54, 285	27	(0- 95)	5.3	79	4 (9)
Line 10	4, 127, 331	22	(0-74)	6.7	77	5
Line 17	23061.4, 23523.1	6	(0-18)	4.6	107	
Line 18	23062.4, 23522.5	4	(0-21)	8.2	110	
Line 19	23062.4, 23061.4	3	(0-14)	5.2	107	

Fig 1. Pedigree of the parents of the early flowering cultivar (Line 3)



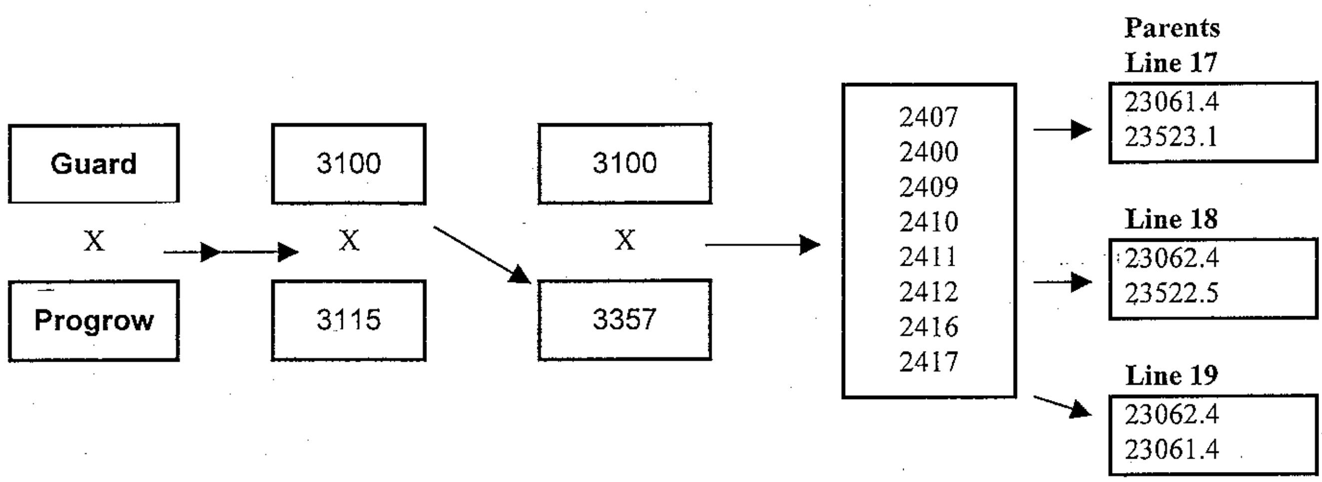
Late flowering Lines

Late flowering selections were also produced from 3100 X 3115 derived from the Guard X Progrow cross. Other crosses were made, but failed to produce useful lines. Plant 3357 was the best progeny from the 3100 X 3100 cross. It was crossed with a wide range of plants and backcrossed to 3100. The best late flowering plants were produced from the backcross.

Lines 18 and 19 (Fig. 2) flowered within a week of Guard (Table 2.). These may be bulked and used as a potential replacement for Guard if they produce better early growth and or total dry matter production. Line 17 flowers about two weeks after Guard and maybe useful in the high rainfall pastoral regions. During 1997, Valley Seeds produced 1 kg of seed lines 17, 18 & 19.

No rust was observed on any of the lines for which seed was multiplied, though it was not a bad season for rust. Resistance to rust is important, *Puccinia coronata* (crown rust) is a serious problem in later districts, particularly where tropical storms come in late spring. *P. graminis* (stem rust) can be an important constraint in seed crops. If spraying is required, seed production costs are significantly higher.

Fig. 2 Pedigree of parents of late flowering lines



Screening selected early and late flowering Lines for resistance to CCN

Pot experiments

Fifty plants from each line were grown in individual tubes (5 X 10 cm). The soil used was a Tailem Bend sandy loam, supplemented with slow release fertiliser (6 month osmocote) and inoculated with CCN cysts at the rate of 20 cysts per tube.

The plants were grown outside through the winter months and were assessed 15 weeks after seeding. Plants were assessed by removing the tube and counting the number of female CCN developing in the roots on the outside of the root ball (Table 3.).

Growth room experiment

Geminated seeds were sown in individual tubes filled with sterilised Palmer sandy loam. The tubes were inoculated with 100 CCN juveniles five times at three day intervals, commencing the day after seeding. Potassium nitrate (15.4 g /l water) was applied to the tubes as required to maintain good plant growth.

Plants were assessed 15 weeks after seeding. The soil was washed from the roots over a fine sieve. The roots and sieve contents were carefully examined to determine total cyst production per plant (Table 3.).

Table 3. Resistance to cereal cyst nematode, 1997

Line	CCN females per plant	
	Pot experiment	Growth room
Guard	0.1	-
Line 2 gen 1	0.1	0.2
Line 2 gen 2	0.1	0.4
Line 3	0.1	0.3
Line 4	1.0	-
Line 5	-	-
Line 6	0	-
Line 7	0	-
Line 8	0.3	-
Line 9	0.1	-
Line 10	0	
WA Early Flowering	-	-
Turretfield	0.3	-
Egret (CCN susceptible)	22.5	47
Galleon (CCN resistant)	0.4	11
Line 17	-	0.5
Line 18	-	1.0
Line 19	-	0.6

Resistance to take-all

Methods

Tests plants were grown in small pots (350 g soil) using either naturally infected soil or Tailem Bend Sandy Loam inoculated with take-all inoculum. The plants were grown for six to eight weeks with moisture level maintained at around 15% and glasshouse temperature set for 19°C. The experiment using SA inoculum (Table 4.) was then assessed by washing and scoring the ryegrass root systems.

In the experiments using the WA isolates, the pots were dried for four to five weeks and the tops of the plants removed. Each pot was then watered and sown with five germinated wheat seedlings and grown for four weeks, then the roots were washed. The number of infected roots and total lesion length was recorded. Root length, root dry weight and top dry weights were also recorded (Tables 5 and 6).

Table 4. Resistance to SA Eyre Peninsula isolate of take-all , 1996

Test plants	Parents	Mean No. of roots with infection	T Grouping*	Percentage infected roots	T Grouping*
Egret Wheat		3.00	A	63.9	A
Take-all susceptible ryegrass		1.25	B	23.5	B
Guard		0.57	C D	10.7	C D
Line 2 Gen 1	6, 127,167	0.38	C D E	6.2	C D E
Line 2 Gen 2	6, 127, 167	0.38	C D E	6.2	C D E
Line 3	30,167	0.36	C D E	7.1	C D E
Line 4	76,122	0.00	E	0.0	E
Line 5	109, 127, 331	0.27	C D E	5.2	D E
Line 6	109, 323	0.31	C D E	4.8	D E
Line 7	54, 323, 331	0.29	C D E	4.8	D E
Line 8	76, 109	0.00	E	0.0	E
Line 9	4, 54, 285	0.43	C D E	7.9	C D E
Line 10	4, 127, 331	0.21	C D E	4.4	D E

* Values followed by the same letter are not significantly different at P=0.05.

WA take-all isolates

Line 3, 2, 17, 18 and 19 were tested against a mixture of 6 WA take-all isolates DN 24, BB 26, WN 10, JM 21, NN 7 and WN 21 supplied by Richard Inwood CSIRO and included isolates of *Gaeumannomyces graminis* var *tritici* (Ggt) and *G. graminis* var *avenae* (Gga). The ryegrass lines were also tested against a single WA Ggt isolate PLA-28.

In both experiments, two levels of inoculum were used, 0.02% and 0.05% by weight. The test plants were grown for 7 weeks in the infected soil. Watering was then stopped for 5 weeks during which time the pots dried out and the tops of test plants removed. The pots were then watered and each sown with 4 germinated seeds of Egret wheat. The wheat seedlings were grown for one month then the soil was washed away and seedlings roots were scored for symptoms of take-all, measured and dried and weighed.

Resistance to a mixture of 6 WA take-all isolates

The test Egret seedlings grown in the Line 3 pots had more roots than those grown in the equivalent Barley grass, Egret, Dalyup oats, Guard and Line 2 pots (Table 3). Similar results were obtained for top dry weight and root length. Lesion length on the Egret seedlings grown in the Line 2 and 3 pots were similar, and much less than on those grown in the barley grass and Egret pots and slightly less on seedlings grown in the Dalyup oat and Guard pots.

Table 5. Bioassay of ryegrass lines screened against a mixture of 6 WA take-all isolates 1997.

Line	Root Dry Weight / Egret plant (g)		Top Dry Weight Egret (g)		Root length / Egret plant (cm)		Lesion length / Egret plant (cm)	
	Inoculum level by % weight							
	0.02%	0.05%	0.02%	0.05%	0.02%	0.05%	0.02%	0.05%
Barley grass	0.033	0.026	0.15	0.14	17.9	17.4	9.4	9.6
Egret wheat	0.035	0.039	0.18	0.2	22.8	21.3	9.1	9.6
Dalyup oats	0.051	0.044	0.29	0.3	26.4	26.2	5.0	6.5
Guard	0.058	0.050	0.3	0.27	28.0	24.0	5.7	6.6
Line 2	0.046	0.051	0.3	0.28	23.1	22.8	4.0	5.5
Line 3	0.058	0.061	0.35	0.29	27.7	27.5	4.7	5.3
Line 17	0.058	0.064	0.29	0.32	29.0	27.1	5.6	6.2
Line 18	0.071	0.053	0.31	0.28	33.3	27.4	6.4	6.5
Line 19	0.073	0.045	0.35	0.27	34.2	26.9	5.6	6.5

Resistance to a single Ggt WA take-all isolate

The performance Line 3 relative to the other Lines and cultivars against the single Ggt isolate was similar to the results obtained against the mixture of 6 isolates. The results for root and top dry weights and root length of Egret seedlings grown in Line 3 pots were as good or slightly better than for Dalyup oats, Line 2 and Guard, and were clearly better than wheat seedlings grown after barley grass and Egret wheat.

Thus Line 3 has good resistance to WA isolates of take-all, and is probably typical or slightly more resistant than average ryegrass populations

Table 6. Bioassay of ryegrass lines screened against a single WA take-all isolate, 1997.

Line	Root Dry Weight / Egret plant (g)		Top Dry Weight Egret (g)		Root length / plant (cm)		Lesion length / plant (cm)	
	Inoculum level							
	0.02%	0.05%	0.02%	0.05%	0.02%	0.05%	0.02%	0.05%
Barley grass	0.033	0.036	0.2	0.17	17.3	18.1	6.5	7.5
Egret wheat	0.029	0.028	0.18	0.16	19.3	18.8	6.4	7.1
Dalyup oats	0.039	0.041	0.21	0.21	22.6	22.2	4.0	4.2
Guard	0.054	0.040	0.29	0.24	27.7	23.2	3.5	4.2
Line 2	0.043	0.043	0.26	0.27	20.7	23.7	3.25	3.4
Line 3	0.047	0.047	0.29	0.26	28.7	25.0	3.4	3.7
Line 17	0.047	0.044	0.29	0.26	27.3	28.2	3.3	3.6
Line 18	0.041	0.040	0.26	0.24	22.1	24.7	3.9	4.8
Line 19	0.036	0.036	0.25	0.21	21.7	21.6	3.4	4.3

Susceptibility to grass selective herbicides.

Screening of Lines 2, 3, 17, 18, and 19 for herbicide resistance was performed by Resistech, a private company offering herbicide resistance testing and advisory service operated by Dr John Matthews. Each line was screened against herbicides representing the four main groups of selective herbicides; Logran® (sulfonylureas), Hoegrass® (Aryloxyphenoxypropionates), Sertin® (Cyclohexanediones) and Treflan® (Dinitroanilines).

The herbicides were applied as per label recommendations. Four replicates of 25 plants were tested per herbicide for each line. The percentage of plants surviving each treatment was recorded at 6 weeks (Table 7). All Lines were susceptible to each herbicide, except Line 2, which had 38% of plants survive the Hoegrass® treatment. A plot of Line 2 which had been established to multiply seed, was consequently sprayed out with Roundup®.

Table 7. Percentage survival of ryegrass lines exposed to grass selective herbicides, 1997

Line	2	3	17	18	19
Logran®	0%	0%	0%	0%	0%
Hoegrass®	38%	0%	0%	0%	0%
Sertin®	0%	0%	0%	0%	0%
Trifluralin®	0%	0%	0%	0%	0%

Establishing ARGT nematode resistant ryegrass pasture

Method

A field trial with different mixtures of Guard and the local ryegrass was established at Turretfield in 1992. The following treatments 100%, 75% 50% 25% & 0% Guard were replicated three times. The plots were 6 X 6 metres with 8 metre buffers which were kept free of ryegrass. To encourage uniform flowering time, the plots were grazed to the ground in early spring then the stock were removed.

The outer two metres of each plot was treated as a pollen buffer. When flowering had finished this area was sprayed with paraquat to prevent seed set. The remaining inside 2 m² was harvested at the end of the season. In the following season the plot was resown in an adjoining buffer. This process was repeated for four seasons.

In 1996, seed harvested at the end of each of the four seasons from each plot was sown into three 28cm diameter pots inoculated with nematode galls. The ryegrass was harvested at the end of the season and gall production assessed.

Results

Persistence of ARGT nematode resistant plants in mixed ryegrass populations

The results show that the combined effect of resistant ryegrass treatments on gall production did not change significantly over the four years of the field trial (Table 8). Although not significant, there appears to be a slight increase in average gall production from 1992 to 1995. This could be due to the genes for resistance to the ARGT nematode segregating after Guard had crossed with susceptible plants, or from susceptible pollen drifting into the site from neighbouring paddocks.

Table 8. Average gall production on ryegrass plants established from seed harvested at the end of each of the four years the trial was maintained.

Year	Mean gall production	T grouping*
1992	25.2	A
1993	27.4	A
1994	30.8	A
1995	32.0	A

LSD = 10.5, * Years with the same T grouping character are not significantly different (P=0.05).

Effect of ARGT nematode resistant plants on gall production.

The proportion of ARGT nematode resistant ryegrass plants in the population had a highly significant (P=0.0001) effect on gall production (Table 9.). In the 100% Guard plots gall production increased 2.6 times for each increase for each additional gall used to inoculate the pot, compared to 80 times in the 100% of local Turretfield ryegrass pots (Table 9.).

Table 9. Effect of adding ARGT nematode resistant ryegrass to local ryegrass populations on multiplication rates of the nematode.

Percent Guard in mixture	Mean increase in gall production per gall of inoculum	T grouping*
0	80.0	A
25	34.5	B
50	17.0	C
75	9.9	C D
100	2.6	D

LSD = 11.8, * Treatments with different T grouping characters are significantly different (P=0.05).

Conclusion

Resistance to the ARGT nematode persists for a long time in pasture. In this experiment the ARGT nematode resistant ryegrass plants flowered at the same time as the local ryegrass population to facilitate crossing between both populations.

Establishing a pasture with at least 75% resistant plants should reduce nematode multiplication rates by around 90% (88% in the Turretfield trial) annually. This will have a dramatic effect on the nematode population and levels of the toxin producing bacterium *Clavibacter toxicus* carried by it into ryegrass.

Commercial Partner

The licensing agreement for Guard with Valley Seeds was extended in November 1993 to included the new cultivars developed by this project. Valley Seeds is responsible for maintaining and marketing the new ARGT nematode resistant cultivars and for obtaining the morphological data required to obtain PBR (Plant Breeders Rights). PBR will be obtained in 1999 prior to commercial release in 2000.

Valley Seeds contacted the PBR office to check the minimum requirements to obtain PBR on a new ryegrass cultivar. Distinguishing traits must be stable over two generations. While resistance to the ARGT nematode must be stable because the parents were selected by progeny testing, we only haveinformation for one generation for Line 3. The PBR can be obtained by comparing the heading dates of two generations of the new early flowering cultivar to Guard, along with morphological data on length and width of the flag leaf and height of seed head. Valley Seeds will obtain these data next growing season. Data obtained by SARDI on disease and herbicide resistance will be submitted as supporting data.

As seed production increases we will test at least one more generation of Line 3 to check it has not become contaminated. These data could be used to show resistance to the ARGT nematode is stable across two generations. This could be used to support the PBR application.

Recommendations

Adoption of the new cultivars will be enhanced if stockowners can monitor the amount of ARGT nematode resistance in ryegrass pastures. A service to assess the proportion of resistant plants would thus be important. Research to assist development of such a service is being conducted by Aaron Mitchell, a PhD student at the Waite Institute. This work should continue to be supported.

Further breeding of ARGT nematode resistant cultivars is not considered necessary at this time. When the ARGT nematode resistant cultivars developed by DAS 35 have been released there should be enough for most livestock producers to find one suited to their environment. If demand grows substantially, further breeding maybe justified to develop higher yielding, better adapted cultivars.

Acknowledgments

The following people played a vital role to achieve the outcomes of the project. Their dedicated involvement is gratefully acknowledged.

Tony Debicki, (Technical Officer) for conducting and maintaining all of the experiments.
Richard Inwood (CSIRO Division Soil and Land Management) for supervising the take-all experiments.

Administrative Details

Project Details

Project title:	Developing an early flowering ARGT resistant ryegrass cultivar.
Project number:	DAS.035
Research organisation:	South Australian Research and Development Institute
Principal investigator:	Dr Alan McKay, B.Ag.Sci., PhD Leader, Nematology Group
Contact details:	Plant Research Centre GPO Box 397 ADELAIDE SA 5001 Ph (08) 8303 9375 Fax (08) 8303 9393

Budget summary (MRC support)

	1994/95	1995/96	1996/97
Operating	55,106	54,576	48,749
Overheads	7,743	7,649	6,803
Travel	1,364	1,364	1,364
Capital	0	0	0
Total	**64,234**	**63,610**	**56,937**

Recommendations

Most work on managing ARGT to date has focused on minimising stock losses. If corynetoxin residues in grain and / or animal products become an issue, Australia's rural commodities could be vulnerable. More effective 'on farm' management strategies will be required to ensure safe levels are not exceeded.

Eradicating ryegrass using herbicides is not feasible due to development of herbicide resistant populations. ARGT nematode resistant ryegrass is one of the few control strategies that will provide long term suppression of nematode and associated bacterial populations. Used in combination with other treatments, these cultivars could provide a clean green solution to a potentially difficult problem.