THE USE OF SEED HANDLING TECHNIQUES TO REDUCE THE IMPACT OF HERBICIDE RESISTANT *LOLIUM RIGIDUM* WITHIN CONTINUOUS CROPPING SYSTEMS

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Summary Results from a series of related projects conducted over the period 1992 to 1995 confirm that seed handling techniques can confer benefits in terms of reduced *Lolium rigidum* Gaud. (annual ryegrass) populations and improved grain yield and thus may be used to advantage within integrated weed management programmes. This will have particular significance for continuous cropping programmes facing the development of resistant populations of this species as such systems do not have the option available to mixed stock/crop programmes of using the pasture/stock phase to run down grass weed seed banks.

INTRODUCTION

Integrated weed management (IWM) programmes to control (resistant) *Lolium rigidum* frequently involve a pasture phase during which grazing stock can be used to advantage to reduce weed populations. Continuous cropping programmes have fewer options for non-herbicidal weed control and there has been renewed interest in the concept of seed capture techniques to assist in the reduction of weed seeds returning to the soil bank. Such techniques offer an option for use to control weeds which have erect weed structures holding viable seeds at the time of crop harvesting. In this respect *Lolium rigidum* can often be a suitable candidate.

Seed capture systems rely on header modifications which collect weed seeds harvested with the crop and transfer them to a trailed cart from which they can be dumped and handled in situ or removed from the paddock. Alternatively weed seeds together with the chaff component may be placed into a narrow trail behind the header with minimum modification to the machine and in this position can be subsequently destroyed by burning or by treatment with a non-selective herbicide in the following crop or a combination of both. This paper reports on studies conducted to examine the issues involved in seed collection and the effect on *Lolium rigidum* densities in the subsequent cropping years.

The topic of seed capture techniques has recently taken on an added dimension with the reporting of SU resistant *Raphanus raphanistrum* in Western Australia. Like *Lolium rigidum* this species has a significant percentage of its seed in an ideal position to be captured in the normal process of grain harvesting.

MATERIALS AND METHODS

A series of studies was conducted during the period 1992–95 to examine the use of seed handling techniques within IWM programmes.

ACR1F-01 Following an evaluation of several sites in 1992 a paddock was selected on a property at Wongan Hills (30° 50'S, 116° 42'E) which contained a *Lolium rigidum* population resistant to 'fop' herbicides and exhibiting cross resistance to the SU group. The population density was assessed prior to the commencement of the project and an estimate made of the potential seed production which would be available to contribute to the seed bank. The crop in 1992 was lupins.

The basal treatment of this examination which ran from 1992 to harvest 1995 was the use of a Redekop collector fitted to a John Deere harvester with a trailed cart manufactured to the farmers specifications. The collector transfers the chaff/seed material from the rear of the sieve to a cart which is trailed behind the header. Within the cart a stack is formed which is automatically tipped out when it reaches a pre-set size.

A number of options were imposed on this treatment within the regular wheat/lupin programme as part of an IWM package. These options were, burning to destroy viable weed seeds, tickling to stimulate germination, use of triasulfuron to suppress the *Lolium rigidum* population in the wheat phase and the inclusion of alternative herbicide options within the lupin phase. All operations in this project were conducted with standard farm equipment to allow a scale consistent with broadacre practice.

Surviving *Lolium rigidum* plants and seed heads produced were assessed each year by counting. Grain yield was determined by harvesting strips within the blocks using a Hege 125C small plot harvester. Results include data from the four option packages carried through for the duration of the examination. Additional data generated by the project has not been included.

Related studies In 1994/95 related studies were initiated on a property north east of Corrigin (32° 15'S, 118° 15'E) to examine an alternative system whereby the chaff/seed component of harvested material was directed into a narrow (30 cm) windrow. Two small plot trials were conducted.

ACR1F-02 A trial of three replications of complete randomized block design was initiated in early 1995 following a harvest operation in the 1994 wheat crop which placed the chaff/seed component in a narrow windrow. In 1995 five treatments were established:

1. stubble left entire,
2. stubble totally removed by burning,
3. windrow burnt,
4. windrow burnt and windrow area treated with glyphosate, and
5. windrow area treated with glyphosate.

Burning was conducted on 1 May and glyphosate was applied on 17 July at 450 g a.c. ha^{-1} when the crop was 4–6 true leaves. To provide fuel for windrow burning an area one metre either side was raked (by hand) on to the central windrow area. A Merrit lupin crop was grown. The *Lolium rigidum* population was assessed by counting (12 September) and seed heads were assessed by counting between windrow areas and within windrow areas (4 October). Crop yield was not determined as the crop was harvested by the farm Class header to re-create the narrow windrow pattern for further evaluation in 1996.

ACR1F-03 A trial of three replications of complete randomized block design was conducted in 1995 on a site which had been harvested according to a narrow windrow pattern by the farm Class header in the lupin phase of 1994. Seven treatments were examined:

1. triasulfuron 26.2 g a.c. ha^{-1} -IBS,
2. trifluralin 400 g a.c. ha^{-1} -IBS,
3. triasulfuron 26.2 g a.c. ha^{-1} -IBS followed by triasulfuron 7.5 g a.c. ha $^{-1}$ -EPE,
4. triasulfuron 26.2 g a.c. ha^{-1} -IBS followed by triasulfuron 7.5 g a.c. ha $^{-1}$ -EPE plus windrow area treated with glyphosate,
5. diclofop methyl 375 g a.c. ha^{-1} -EPE,
6. windrow area treated with glyphosate, and
7. untreated control.

The trial was sown to Eradu wheat on 18 May with the IBS treatments being applied the same day. EPE treatments were applied on 15 June when the wheat stage was Z12-13 and the *Lolium rigidum* ranged from 1 leaf to early tillering. The glyphosate treatment was applied to the windrow areas on 17 July at 450 g a.c. ha^{-1} when the crop was Z23. *Lolium rigidum* seed heads were assessed by counting between windrows and within windrows (4 October) and seeds per seed head were assessed within the windrow areas (24 October). Wheat yield was established by means of a Hege 125C plot harvester.

Table 1. Estimated initial population of *Lolium rigidum*, 1992.

Count	No. m^{-2}
Lolium rigidum seed heads	638
Lolium rigidum seeds	34 423

Table 2. Outline of operations conducted during three year trial period.

Programme	1992/93	1993/94	1994/95
1	C/Ht/S	C/B/Hs/S/Hc	C/B*/Ht/S
2	C/S	C/B/S	C/B*/S
3	C/T/S	C/S	C/B*/S
4	C/T/Ht/S	C/Hs/S/Hc	C/B*/Ht/S

Key to programme operations:

C – chaff/seed collected
B – wheat stubble burn
B* – poor lupin stubble burn
T – tickle (cultivation)
S – seeding
Ht – triasulfuron herbicide treatment 25 g a.c. ha^{-1}
Hs – simazine herbicide treatment 1000 g a.c. ha^{-1}
Hc – clethodim herbicide treatment 60 g a.c. ha^{-1}

Table 3. Density of *Lolium rigidum* plants m^{-2} assessed in crop.

Programme	1993	1994	1995
1	517	110	37
2	481	120	170
3	518	338	236
4	493	184	143
LSD (P=0.05)	ns	40	52

RESULTS

ACR1F-01 The initial population (Table 1) was typical of the location and indicated a considerable potential for enhancement of the seed bank if an intervention technique was not employed.

The series of programme options (Table 2) does not contain one without chaff/seed being collected due to the difficulty in modifying the header to remove the collector during the commercial harvest operation.

The data illustrates a trend downwards over time of the in crop *Lolium rigidum* population in all four systems using the seed catching method being examined. The added influence of other operations such as burning stubble and the suppression effect of triasulfuron is also evident. The herbicidal effect is further illustrated in seed head data where suppression effects have influenced the number produced relative to plant numbers (Table 4).

Grain yields reflected the level of competition provided by the *Lolium rigidum* under the four regimes (Table 5).

ACR1F-02

The data for the two treatments where the windrow was treated with glyphosate demonstrates that the additional benefit of the earlier burn over this treatment was insignificant (Table 6).

ACR1F-03

The seed number per seed head (C) data suggests a minor suppression effect in survivors where the windrow had been treated with glyphosate. This would be consistent with these plants being 'late germinators' or plants exhibiting 'enhanced tolerance' to glyphosate (Table 7).

Table 4. Density of *Lolium rigidum* seed heads m^{-2} assessed in crop.

Programme	1993	1994	1995
1	512	370	61
2	824	358	395
3	960	643	411
4	488	397	231
LSD (P=0.05)	84	57	50

Table 5. Crop grain yield t ha^{-1}.

Programme	1993 Wheat	1994 Lupins	1995 Wheat
1	1.12	1.15	1.48
2	0.32	1.07	0.35
3	0.47	0.56	0.51
4	1.38	0.80	1.19
LSD (P=0.05)	0.05	0.26	0.31

Table 6. *Lolium rigidum* seed head population m^{-2}.

Treatments	Between windrows	Within windrows
Stubble retained	247	625
Full stubble burn	153	458
Only windrows burnt	202	900[A]
Windrows burnt/sprayed in crop	248	75
Windrows sprayed in crop	232	67
LSD (P=0.05)	51	321

[A] This value was enhanced by counts in one of the blocks being high relative to the other two. It is suggested that as the heat of the fire is important in achieving a good kill of the seed, variations in this factor may have been a contributing cause. Supporting this suggestion is the lower number following the full stubble burn which generated a greater total heat intensity reflecting the greater fuel volume.

Grain yields reflect the success or otherwise of the various treatments in controlling the *Lolium rigidum* population and at the same time illustrates no significant penalty as a result of spraying out the windrow (Table 8).

DISCUSSION

The results generated by these studies confirm that a positive benefit can be derived from the use of seed handling techniques within IWM programmes in continuous crop situations both in terms of reduction in *Lolium rigidum* numbers and crop grain yield.

While not confirmed through replication the trends within ACR1F-01 indicate that a significant impact can be made in a *Lolium rigidum* population over a three year period by the appropriate choice of options included in the IWM package. Conversely the data also illustrates that unless the correct choices are made the outcome of continuing with a cropping programme after the development of a resistant population will be catastrophic.

There is evidence in the data from ACR1F-01 that the end result of option 1 resulted from a combination of the positive impact of judicious burning, tickling, the suppression effects of triasulfuron in the wheat phase, and the use of alternative herbicide options in the lupin phase in addition to the seed capture system. While a

Table 7. *Lolium rigidum* seed head population m^{-2} between windrows (A), within windrows (B) and seed number per seed head within windrows (C).

Treatment	A	B	C
triasulfuron	157	1300	66
trifluralin	363	2033	71
triasulfuron fb triasulfuron	197	1300	69
triasulfuron fb triasulfuron + wso	167	100	52
diclofop methyl	880	2758	71
windrow sprayed out (wso)	783	75	51
control	620	2208	71
LSD (P=0.05)	294	797	10

Table 8. Wheat grain yield t ha^{-1} (D).

Treatment	D
triasulfuron	1.70 a
trifluralin	1.09 b
triasulfuron fb triasulfuron	1.78 a
triasulfuron fb triasulfuron + wso	1.66 a
diclofop methyl	0.60 b
windrow sprayed out (wso)	0.56 b
control	0.91 b
LSD (P=0.05)	0.49

'normal' harvest control treatment was not included the data does suggest that the collection technique itself made an impact on population numbers as testified by the *Lolium rigidum* seed head numbers in 1995 which were lower than the initial numbers in 1992. The numbers rather than building up in the absence of any other positive control influences trend downwards. The difference in wheat yield between treatment 1 and that of treatments 2 and 3 is supported by the broadacre experience on the same property where paddocks which prior to the employment of the catcher/cart system were at the point of being pulled out of cropping are still being cropped profitably.

A linked study highlighted one of the real practical problems imposed by 'complete' collection systems and at the same time indicated the opportunity for further exploitation.

The chaff/seed component was considerable both in terms of volume and weight. Both are directly related to the grain yield and vary according to crop type. The study (using a Redekop collector) indicated that for every tonne of grain harvested there will be approximately 4 m^3 chaff/seed weighing 0.2 tonne in the case of wheat and 7.5 m^3 chaff/seed weighing 0.75 tonne for lupins. If the stacks are simply burnt in situ the following autumn considerable manpower is required. This may provide a management challenge in terms of stack burning. If the material is seen as a source of energy/protein, then it may be possible to utilize it in a value added enterprise. By-products from legume crops could be highly valued in this direction and the data indicates that considerable quantities of material would be available depending on the level of the crop yield.

Such operations will not be without their own challenges. The handling of the volume/weight would impose limitations on the average farm and care would be required where ryegrass toxicity problems existed.

Detailed cost/benefit studies of the potential of value added operations require to be conducted. A break even operation would be attractive.

The alternative technique examined in studies ACR1F-02 and ACR1F-03 may offer the same end result with less investment and at least equivalent benefits in terms of reduced weed seed banks and enhanced grain yields. As with the catcher/cart technique the success will depend initially on the volume of ryegrass seed still in the head at harvest time and which is picked up by the harvester cutting low. This in itself imposes a cost, common to all seed capture by harvesting techniques, in that the speed of the harvest operation has to be reduced as a result of the increased volume of material which requires to be handled by the machine. The subsequent operations with a modified windrow system may involve the need to equip with a two way rake to gather in fuel from the immediate area on either side of the windrow and/or to have a hooded spray unit to apply the non-selective herbicide to the windrow line within the following crop. The spray unit should be suitable for mounting on either four wheel drive motor bikes or farm utes/tractors. Work is continuing with the development of prototypes for both a suitable rake and spray unit.

Results from the two trials indicate the potential to make a substantial impact in reducing the return to the seed bank by a) concentrating seed into a narrow area and b) subsequently destroying the seed in this area by either burning (the windrow area only), spraying out in crop or a combination of both. The yield results derived in ACR1F-03 suggest no yield penalty following the spraying out of the windrow area which in this case covered three to four rows in every thirty and it is postulated that compensatory growth in the adjacent rows made up for the loss.

A development rake has been tested at site ACR1F-02 following the 1995 harvest and a wheat crop will be grown in 1996 to further evaluate the options examined in this project.

There will be a need to employ seed handling techniques only within well managed integrated weed management programmes as the techniques will themselves apply their own selection pressure on *Lolium rigidum* populations favouring early shattering and/or prostrate growth habit types. The use of non-selective herbicides to control the species in windrow areas with concentrated densities will impose another rigorous selection pressure.

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