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**Herbicide strategies for controlling key
weeds of fresh and processing vegetables**

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Industries**



Know-how for Horticulture™

This report is published by the Horticultural Research and Development Corporation to pass on information concerning horticultural research and development undertaken for the vegetable industry.

The research contained in this report was funded by the Horticultural Research and Development Corporation with the financial support of the Queensland Fruit & Vegetable Growers Association.

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Cover Price \$20.00

HRDC ISBN 1 86423 445 8

Published and Distributed by:



Horticultural Research and Development Corporation
Level 6
7 Merriwa Street
Gordon NSW 2072

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Industry and technical summary.

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Between August 1989 and November 1993, we evaluated herbicides in 52 separate experiments in lettuce, broccoli, cabbage, cauliflower, green beans, beetroot, sweet corn and green peas. In transplanted lettuce, only STOMP (pendimethalin) and RAMROD (propachlor) gave acceptable results. Optimum STOMP rate was 3-3.5 L/ha, applied before transplanting to avoid lettuce damage. RAMROD had a greater risk of phytotoxicity; results suggested less damage if applied after transplanting, rather than before. Optimum application rates were 3-4.5 L/ha; no more than 3 L/ha if applied before transplanting. Mixtures of STOMP/RAMROD controlled a broad range of weeds, including sowthistle (*Sonchus oleraceus*) and potato weed (*Galinsoga parviflora*), poorly controlled by previously registered herbicides. STOMP has recently become registered for use in lettuce; registration of RAMROD is still being pursued.

We evaluated herbicides STOMP, RAMROD, DUAL (metolachlor) and GOAL (oxyfluorfen) for use in brassicas. STOMP and DUAL have highest risks of crop damage. STOMP must be applied before transplanting, at a maximum rate of 3 L/ha; no more than 2.5 L/ha if mixed with another herbicide (e.g. RAMROD). Mixtures gave more comprehensive weed control. We noted significant crop damage where >3.5 L/ha of DUAL was sprayed before transplanting; application after transplanting appeared safer. We rarely improved weed control using >7-8 L/ha of RAMROD, particularly if mixed with another herbicide. GOAL gave an excellent weed control spectrum, with few risks of crop damage, when sprayed at 1-1.5 L/ha before transplanting. Cabbage and cauliflower were slightly more sensitive to GOAL than was broccoli. Only GOAL is unregistered in brassicas; a submission is still being prepared.

Research in green beans focused on DUAL and STOMP for pre-emergence use. STOMP has recently become registered at 3-4 L/ha (Lockyer and Fassifern Valleys only). Although there was concern about STOMP causing lodging, we did not encounter this problem, even where 8 L/ha was used. Cool, wet conditions may increase the risk. DUAL was effective at 3-4 L/ha; registration is being pursued. BLAZER (acifluorfen), not registered for beans, may be a promising adjunct to BASAGRAN (bentazone).

Mixtures of metribuzin and BLADEX (cyanazine) gave good post-emergence weed control in peas, although metribuzin can cause crop damage. IGRAN (terbutryn), not registered in Queensland, may be a cheap post-emergence option. At 1 L/ha, it gave excellent control of blackberry nightshade (*Solanum nigrum*) and fat hen (*Chenopodium album*), with no deleterious effects on crop yields. Use of STOMP at 2-3 L/ha pre-emergence may prove beneficial in heavy weed burdens. All these herbicides are now registered, except for IGRAN (which is still being discussed).

In beetroot, there appears to be scope for better use of existing products such as RAMROD and BETANAL (phenmedipham). With sweet corn, both STOMP and BLADEX could be safely used pre-emergence, if registration could be obtained. These issues are subject to ongoing discussion.

Recommendations.

Extension/adoption by industry.

During this project, updated research summaries have been regularly sent to both the Queensland Fruit and Vegetable Growers (QFVG) and the Horticultural Research and Development Corporation (HRDC). These research summaries have been published in the HRDC Research Reports via the Good Fruit and Vegetables magazine. In addition, QFVG published a current research booklet in 1994, which included information on the conduct and results from this project. As a result of the publicity generated by publication of these research summaries, individual producers and producer groups have contacted me for more detailed information, which I have provided where possible. Respective chemical companies were furnished with research results to assist with registration of uses in vegetables. Companies which received reports included Incitec, Ciba, Monsanto, Rohm and Haas, Rhone-Poulenc, Bayer, Hoechst, Schering, Shell.

Our research, in combination with work by the responsible chemical companies, has led to registration of STOMP in lettuce, brassicas and green beans, as well as a range of other vegetables (such as carrots and onions). We also assisted in the registration of BLADDEX in peas. Our results are included in submissions for new registrations for DUAL in green beans, GOAL in brassicas, RAMROD in lettuce and possibly beetroot. We are still discussing registration options for IGRAN in peas and BLAZER in green beans, as well as post-emergence GOAL in brassicas.

As would be appreciated, it is often difficult to extend results from this project to producers, without being seen to advocate an illegal activity, i.e. the unregistered use of pesticides. Thus the emphasis is on developing data and facilitating registration as much as possible. Nevertheless, I have sought to promote our findings as much as possible within these legal and moral obligations.

Information and results from the project have been regularly included in general articles for newspapers and magazines such as Queensland Country Life, Country Living Magazine, Rural Times, Toowoomba Chronicle, Gatton Star, Fruit and Vegetable News.

To date I have written scientific papers on herbicides in lettuce and green beans, both published in the Australian Journal of Experimental Agriculture (see reference section for details). Articles on weed control in asparagus and green peas have been published in September 1990 and June 1992 issues of Fruit and Vegetable News respectively. I plan to submit articles on our findings to Good Fruit and Vegetable magazine in 1994 and 1995.

Information on weed control for specific vegetable crops is currently being included in extension packages being prepared by QDPI. To date, sections for lettuce and potatoes have been completed. Other crops will be included as extension information is reviewed by specialist teams, as part of an overall extension program.

I developed and conducted a display on weed management strategies at the Gatton College's EXPO 13 Horticultural Field Days. I have also run field days at Gatton Research Station and on producers' properties, showing our current thinking on weed

management in a range of crops. These have included days on pea and beetroot herbicides (Gatton Research Station - GRS, August 1991); general herbicide research (GRS, October '91); bean and sweet corn (GRS, December '91); brassica and lettuce (GRS, June '92); brassicas (Applethorpe, March '93); lettuce and brassicas (GRS, June '93); lettuce, brassicas, beans (GRS, September '93), beans (Gympie, October '93). I have given seminars on different aspects of herbicide research to scientists, public sector extension personnel, private consultants and producer groups in Queensland (and Tasmania), to international visitors and scientists, conference delegates, as well as to Gatton College students.

In response to the publications, field days and seminars, producers are continually requesting advice on weed control in specific crops and situations. I have assisted them as much as possible, with the legal restrictions previously mentioned. Many producers have readily adopted the results of our work with STOMP, and are eagerly awaiting a successful outcomes for registration of GOAL in brassicas (and onions), IGRAN in peas, DUAL in beans and RAMROD in lettuce. Effective herbicide options are rapidly adopted by producers; the most significant impediment in the adoption chain is registration or approval of a new use. This will be further discussed in a later section.

The QFVG has agreed to fund a new project on integrated weed management in vegetables, targeting an ecological approach to weed control. Although primarily focused on a few key weeds, the results should form the basis for systems in a broader range of crops and weeds. Given the community and grower desires for reduced pesticide uses, any successful findings should also be readily adopted by vegetable producers.

As part of my scientific responsibility, I will continue to write scientific and extension articles on various results from the project, mainly focussing on crop responses to various herbicide rates and timings, with consideration of how new herbicides would fit into current production systems.

Directions for future research.

The most significant impediment to adoption of research findings from this and other weed control projects is the increasing difficulty in obtaining legal approval for proposed uses. As the general community has become increasingly (and legitimately) concerned about the use of chemicals in agriculture, legal requirements for specific uses have become more stringent. Without going into a prolonged discussion, the horticultural producer is in a position where registrations of new uses are becoming less likely. With the advent of the new National Registration Authority, the costs for evaluating a submission have risen substantially. Charges vary from \$ 5000 for a simple label change, to more than \$ 50,000 for registration of a new product. These charges are on top of the costs incurred in conducting efficacy, phytotoxicity and residue experiments, as well as preparing submissions, changing labels and packaging.

Most vegetable crops are grown on relatively small areas, with relatively high value crops and land. All these factors mean profits from marketing to horticultural producers are generally low, while potential pay-outs for crop damages are high. Given substantial development costs, high regulatory costs and low profit margins, it is little wonder that few chemical companies are very interested in registering new products for use in vegetables.

The current system seems both economically unsustainable and slightly hypocritical. Overseas competitors have access to products not available in Australia. As an example, New Zealand growers can use GOLTIX herbicide, which is very cost-effective in beetroot. This herbicide would also be very useful in Australia; our research shows it safe to beetroot and giving excellent weed control. New Zealand authorities have accepted overseas data for registration purposes, (the product having been successfully used in Europe for many years). Given the small potential market in Australia, the responsible chemical company cannot justify registration costs in this country, and have declined to proceed with its importation and registration. Beetroot producers have indicated they may meet some of these costs, and would probably be willing to indemnify the company against damages claims. Note that even though GOLTIX is used on beetroot in New Zealand, there is still no impediment to the harvested beetroot being imported, sold and consumed in Australia. This certainly puts Australian producers at a disadvantage.

It would be a very useful activity for HRDC or an affiliated organisation to discuss with regulatory authorities the possibility of developing an alternative registration protocol for minor uses (under which many of proposed uses in vegetables would be categorised). Minor uses could include aspects such as:

- (a) acceptance of overseas data for setting of Maximum Residue Limits;
- (b) a minor use approval system that doesn't require label changes, but simply a central logging of approval;
- (c) an indemnifying registration that limits liability of the chemical company for damages and shifts the onus of responsibility to the user.

Without these changes, the practical justification of research into new herbicides in vegetables become more difficult.

Scientists and horticulturalists throughout the world are realising that simple 'quick-fix' solutions to pest control, whilst they may have worked to some degree in the past, may no longer be appropriate nor even acceptable to society. Weed control is no exception; the focus must be changed from the traditional single-solution in a monoculture situation, to a more integrated and 'holistic' approach. Because of shifting weed spectrums, concerns about pesticide use and the development of herbicide resistance, we must become more conscious of alternative weed management techniques.

Through its priorities, HRDC has emphasised the need for 'IPM' type solutions to pest problems. This emphasis should be continued, along with a recognition of the need for weed management practices to take into account the overall production system into which they are to be integrated. As with all other HRDC funded research, there should be considerable concentration on extension/adoption programs and outcomes in any new project proposals. HRDC also needs to accept that there will always be a need for regional and district level research and extension, because of the restricted natures of weed/crop/environment combinations.

There is certainly a need for regional evaluation and demonstration of technologies for particular district production systems. In this way, the new technologies can be better integrated into the overall farm operation, enhancing the likelihood of adoption. These demonstration type projects could be jointly operated by interested producer and community organisations, equipment suppliers, private consultants and general funding agencies. The emphasis should be on adapted regional solutions to regional problems.

Financial/commercial benefits.

This project has developed a number of new herbicide uses. Some of these have become registered; some should be registered within the next 12-18 months; some may become available in the medium to longer term. The financial benefits to producers will very much depend on the timing of these registrations.

In lettuce, the previously registered herbicides DACTHAL and KERB each cost around \$ 400-450/ha at registered rates. A STOMP/RAMROD mixture would reduce this cost to about \$ 85/ha, whilst giving superior weed control. The reduced costs would be worth \$ 300,000-500,000 per annum to lettuce producers in southern Queensland.

With brassicas, current weed control costs are around \$ 90-110/ha. This project has already assisted in expanding the range of herbicides available, reducing risks of resistant weed build-up. Registration of GOAL would enable improved weed control at a cost about 50% less than currently required. Post-emergence use of 0.3 L/ha of GOAL would reduce herbicide costs to less than \$15/ha, a huge saving.

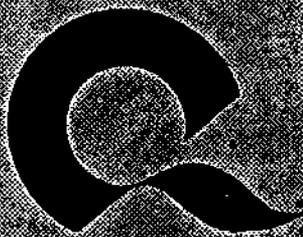
The opportunity for broad-spectrum weed control in green beans, using either STOMP or DUAL, without the need for expensive post-emergence sprays, has the potential to substantially reduce weed management costs by \$ 60/ha. Similarly, there is a possibility for reducing the substantial herbicide costs in beetroot (currently \$ 300-400/ha), by registering a higher rate of RAMROD and utilising lower rates of BETANAL/TRAMAT, applied when the weeds are very young. Post-emergence mixtures in green peas currently cost about \$ 45-60/ha; registration of IGRAN could reduce these costs by 80%, whilst giving equally effective weed control.

Apart from these obvious cost savings, this project has also identified application methods that will improve weed control and reduce the risks of crop damage. Examples are STOMP, RAMROD and DUAL applications with respect to lettuce and brassica transplants, where incorrect timing markedly increases the risks of crop damage. The importance of accurate application with respect to BASAGRAN, to minimise the risk of damage to green beans was also emphasised. In green peas, the critical levels of potentially phytotoxic herbicides such as SENCOR were determined, to reduce the chances of yield limiting injuries to the crop.

The nett result of this research, and future weed management studies, is provision of cost-effective herbicide strategies capable of sustainable use over extended periods. The long term productivity of soil and water resources should not be compromised by chemical residues, as has happened in other parts of the world. Off-site damage should also be restricted by use of herbicides and application strategies that minimise non-target effects. Current and new markets can be retained or captured by the vegetable industries demonstrating and marketing a commitment to reduced pesticide use in the context of IPM-type weed management strategies.

Technical Report

Herbicide strategies for controlling key weeds of fresh and processing vegetables



Queensland Fruit and
Vegetable Growers



Introduction.

During the past few decades, the use of herbicides for weed management has become an integral part of many vegetable production systems. This period coincided with an expansion of the range of chemicals available for weed control in crops. Unfortunately, economic considerations meant that only a limited number of these herbicides were specifically registered for use in vegetables.

In the late 1980's, community concerns with environmental and health risks associated with pesticides resulted in new legislation. This prohibited use of pesticides in vegetables, except where such uses were specifically included on registration labels, or approved by relevant State authorities. At the same time, several herbicides commonly used in vegetables, e.g. LASSO (alachlor) and DINOSEB (DNBP), were withdrawn from sale.

These influences coincided with a desire by both vegetable producers and the wider community for more efficient use of herbicides. For various reasons, both groups wanted lower application rates, less toxic products, reduced risks of off-site damage, less undesirable residual activity and more easily and safely handled formulations.

In response, both QDPI and producer organisations recognised the need to research, develop and assist in the registration of new herbicide options in vegetables. There was also a perceived need to improve the cost-effectiveness and efficiency of products already legally able to be used.

After consultation between QDPI, producer organisations and numerous individual growers, we noted the main vegetables in which there were significant herbicide deficiencies. These included lettuce, brassicas, green beans, beetroot, sweet corn, and green peas. Weeds compete with these crops for water, nutrients and light, particularly during the early establishment phases. Weeds can also harbour pests and diseases, e.g. sowthistle (*Sonchus oleraceus*) is a host for lettuce necrotic yellows virus (Lubach 1984; Persley *et al.* 1989). They can interfere with pesticide application and droplet deposition. Late growth of weeds such as potato weed (*Galinsoga parviflora*) can impede access to crops at maturity, increasing harvesting costs (Henderson and Webber 1993).

In lettuce, the registered pre-emergence herbicides (KERB, BALAN, DACTHAL) gave poor control of Asteraceae weeds, including important species such as sowthistle and potato weed (Swarbrick 1982; Beavis *et al.* 1991). These herbicides are relatively expensive, with both KERB and BALAN injurious to sensitive follow-up crops, for up to 10-12 months after spraying (Swarbrick 1982, WSSA 1989). Most lettuce growers need to include expensive hand-weeding into their weed management program, because of the problems with previously mentioned weed species.

The withdrawal of LASSO caused a significant gap in herbicide programs for a number of crops, with brassicas particularly affected. In many instances, DUAL (metolachlor) has been used as a replacement, but has a less useful weed spectrum, with some phytotoxicity in certain brassica cultivars and soil conditions. Having a range of herbicides available (hopefully with different modes of action) would reduce potential for build up of resistant and uncontrolled weed spectrums.

Similar to brassicas, withdrawal of LASSO also caused weed management problems in green beans. For broadleaf weed control, the options were EPTC, trifluralin, DACTHAL applied pre-emergence, and BASAGRAN (bentazone) post-emergence. EPTC and trifluralin both require mechanical incorporation immediately after application, which increases the erosion hazard. Both herbicides are ineffective against Asteraceae weeds (Swarbrick 1982; Beavis *et al.* 1991). The high cost of DACTHAL limits its use in green beans. Whilst BASAGRAN controls many weed species, it must be applied before weeds develop more than 4 true leaves. In some instances it can cause transient leaf scorch, and in high ambient temperatures reduce bean yields. BASAGRAN does not control some key weed species such as giant pigweed (*Trianthema portulacastrum*), wireweed (*Polygonum aviculare*), *Amaranthus spp.* or grasses. Bean growers need more cost-effective and a broader range of herbicide options to remain competitive.

Theoretically, herbicides registered in beetroot, i.e. PYRAMIN (chloridazon), BETANAL (phenmedipham) and TRAMAT (ethofumesate) should control most of the important weeds in the main growing areas. However, for undefined reasons some weeds, notably wireweed, sowthistle, potato weed and fat hen (*Chenopodium album*) appear to be surviving through the growing season to cause problems at harvest. The causes of these problems need to be resolved. Producers were also legitimately concerned about the quantities and costs of herbicides used, as well as residual activity in following crops.

Weed management in sweet corn was also hard hit by the withdrawal of LASSO, particularly in horticultural areas, where use of herbicides like atrazine and 2,4-D is necessarily restricted. Producers were looking for alternative products that could give cost-effective pre-emergence control of broadleaf weeds and grasses. There was also a perceived need for post-emergence options to control difficult species, such as bellvine (*Ipomoea plebia*), which has the potential to disrupt harvest operations.

In common with most processing crops, there is a requirement in green peas for no contamination with certain proscribed weed products, such as seeds of blackberry nightshade (*Solanum nigrum*) or spiny emex (*Emex australis*). Both seeds are difficult to remove from harvested peas, hence their detection can result in the rejection of whole loads. Herbicides registered at the time would not consistently control these weeds, particularly blackberry nightshade. The gross margins for peas are relatively low compared to other vegetable crops, hence the need for low cost weed management options is critical. There may also be a role for pre-emergence herbicides in peas, as these are frequently less expensive, with fewer risks of being unable to spray at the correct time due to weather conditions.

In 1988, a workshop was held in Adelaide to review weed control problems and potential herbicides in a range of vegetable crops (Rogers 1989). This review was used as the basis for selecting a number of the herbicides used in the initial herbicide screening experiments. I also reviewed lists of herbicides used overseas, including publications such as the Weed Science Society of America Handbook. I discussed likely herbicide options with several of the companies, including Incitec, Ciba, ICI, Rohm and Haas, Monsanto, Rhone-Poulenc, Schering, Hoechst and Bayer. Given the financial and labour inputs involved in registering new chemical uses, it was important to identify those

products with a reasonable likelihood of successful field application and support from the responsible company.

In response to the perceived needs of the vegetable industries, a project to develop herbicide options in the previously mentioned crops was submitted to and jointly funded by Queensland Fruit and Vegetable Growers (QFVG) and the Horticultural Research and Development Corporation (HRDC). The main objectives were to screen a range of herbicides with potential for overcoming weed control problems in the priority vegetable crops; to develop programs using these products and test them over a range of environmental conditions. It was also important to assist (as far as possible) registration of these herbicides for legal use. This report details research and results from that project.

Materials and methods.

Herbicides for weed management in vegetables were investigated over 4 years, in a total of 44 experiments and 8 on-farm demonstrations. (Note, some experiments were conducted on farms). Most of the intensive evaluations were conducted at Gatton Research Station, where we could take advantage of known paddock histories, suitable equipment, expert labour and less restrictive legal requirements. Other sites where project work was conducted included the Lockyer and Fassifern valleys, Toowoomba, Redland Bay, Gympie, and the Granite Belt. Initial experiments evaluated a broad range of prospective herbicides, whilst later experiments concentrated on those with obvious potential for further development and eventual registration.

Detailed methodologies for each experiment are not included in this report. A sample report for an individual experiment is included as Appendix 2. Within this report is an example of a detailed methodology.

During the project we experimented with herbicides in lettuce; brassicas; green beans; beetroot; sweet corn and green peas (Tables 1-6). Sites in the Fassifern and Lockyer valleys (including Gatton Research Station) were on black earth soils; those at Toowoomba and Redland Bay on krasnozems; in the Granite Belt on siliceous sands; and at Gympie on red-brown sandy loams.

Table 1. Experiments evaluating herbicides in lettuce.

Experiment code	Planting date	Harvest date	Cultivars	Herbicides	Location
S8901.05	10.01.90	28.02.90	Classic	Carbetamex, Ronstar, Dual, Ramrod, Stomp	Toowoomba
S8901.10	30.04.90	18.07.90	Yatesdale	Dual, Ramrod, Stomp	Gatton R.S.
S8901.14	04.09.90	30.10.90	Yatesdale	Ronstar, Dual, Ramrod, Stomp	Gatton R.S.
S8901.23	09.01.91	12.02.91	Classic	Ramrod, Stomp	Granite Belt
S8901.28	16.04.91	12.06.91	Yatesdale	Ramrod, Stomp	Gatton R.S.
S8901.31	16.06.91	09.09.91	Oxley	Ramrod, Stomp, Dacthal, Kerb	Gatton R.S.
S8901.37	10.04.92	09.06.92	Yatesdale, Oxley, Seagreen, Supergreen	Ramrod, Stomp	Gatton R.S.
P376.02	18.02.93	12.04.93	?	Ramrod, Stomp	Granite Belt
P376.03	09.02.93	30.03.93	?	Ramrod, Stomp, Kerb	Granite Belt
P376.08	28.04.93	28.06.93	Seagreen	Ramrod, Stomp, Dacthal	Gatton R.S.
P376.14	01.08.93	27.09.93	Yatesdale	Ramrod, Stomp, Dacthal	Gatton R.S.

Table 2. Experiments evaluating herbicides in brassicas.

Experiment code	Planting date	Harvest date	Cultivars	Herbicides	Location
S8901.04	05.01.90	05.04.90	Cavalier (Cabb.)	Casuron, Gesagard, Goal, Dual, Ramrod, Stomp	Redland Bay
S8901.08	30.04.90	25.07.90	Pacific (Broc.)	Dual, Ramrod, Stomp, Goal	Gatton R.S.
S8901.09	04.09.90	21.08.90	Pacific (Broc.) Shogun (Broc.) Hurricane (Cabb.)	Goal, Gesagard, Stomp	Gatton R.S.
S8901.15	05.09.90	20.12.90	Venturer (Cabb.) Hurricane (Cabb.) Bountiful (Caul.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
S8901.24	24.01.91	26.04.91	Premium Crop (Broc.)	Ramrod, Stomp, Dual, Goal	Granite Belt
S8901.26	16.04.91	04.07.91	Pacific (Broc.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
S8901.27	16.04.91	30.07.91	Stariha (Cabb.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
S8901.29	18.06.91	10.09.91	Pacific (Broc.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
S8901.30	20.06.91	09.10.91	Stariha (Cabb.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
S8901.38	10.04.92	23.07.92	Stariha (Cabb.) Green Coronet (Cabb.) Neptune (Cabb.) Kameron (Cabb.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
S8901.39	02.06.92	28.08.92	Greenbelt (Broc.) Dominator (Broc.) Marathon (Broc.) Shogun (Broc.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
S8901.40	02.06.92	10.09.92	Plana (Caul.) Hunter (Caul.) Elby (Caul.) Lucy (Caul.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
P376.04	09.02.93	25.05.93	?	Ramrod, Stomp, Goal	Granite Belt
P376.05	22.02.93	08.06.93	?	Ramrod, Stomp, Goal	Granite Belt
P376.09	28.04.93	28.07.93	Pacific (Broc.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
P376.10	28.04.93	28.07.93	Green Coronet (Cabb.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
P376.11	28.04.93	02.08.93	Plana (Caul.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.
P376.14	01.08.93	27.09.93	Pacific (Broc.) Green Coronet (Cabb.)	Ramrod, Stomp, Dual, Goal	Gatton R.S.

Table 3. Experiments evaluating herbicides in green beans.

Experiment code	Planting date	Harvest date	Cultivars	Herbicides	Location
S8901.16	24.10.90	28.12.90	Labrador, Bronco, Superstar	Dual, Stomp	Gatton R.S.
S8901.17	13.03.91	24.05.91	Labrador	Dual, Stomp	Gympie
S8901.18	24.10.90	28.12.90	Labrador	Blazer, Brodal, Sencor, Gesagard, Tribunil, Goal, Bladex, Igran	Gatton R.S.
S8901.25	07.03.91	13.05.91	Labrador	Basagran, Blazer, Brodal	Gatton R.S.
S8901.34	10.10.91	10.12.91	Superstar	Stomp, Dual, Bladex, Blazer, Brodal, Basagran	Gatton R.S.
S8901.36	31.03.92	09.06.92	Bronco, Superstar, Labrador, Montano, Redlands Pioneer	Stomp, Dual, Basagran, Blazer, Brodal	Gatton R.S.
P376.01	08.10.92	10.12.92	Bronco, Labrador, Superstar	Stomp, Dual, Treflan, Basagran	Gatton R.S.
P376.02	09.09.93	10.11.93	Labrador	Stomp, Dual, Basagran, Blazer	Gympie
P376.07	08.03.93	17.05.93	Labrador	Stomp, Dual, Basagran, Blazer	Gatton R.S.

Table 4. Experiments evaluating herbicides in beetroot.

Experiment code	Planting date	Harvest date	Cultivars	Herbicides	Location
S8901.12	01.07.90	02.11.90	Detroit Short Top	Goltix	Lockyer Valley
S8901.21	11.09.90	14.12.90	Detroit Short Top	Goltix	Fassifern Valley
S8901.33	04.06.91	12.09.91	Detroit Short Top	Dual, Ramrod, Carbetamex, Goltix	Gatton R.S.
S8901.42	01.06.92	17.09.92	Detroit Short Top	Ramrod, Betanal, Pyramin	Gatton R.S.

Table 5. Experiments evaluating herbicides in sweet corn.

Experiment code	Planting date	Harvest date	Cultivars	Herbicides	Location
S8901.01	23.11.89	09.01.90	Kulara II	Dual, Stomp, Bladex, Basagran	Gatton R.S.
S8901.19	14.11.90	04.02.91	Kulara II	Stomp, Basagran	Gatton R.S.
S8901.20	14.11.90	04.02.91	Kulara II	Stomp, Dual, Atrazine	Gatton R.S.
S8901.35	28.10.91	15.01.91	Kulara II	Stomp, Dual, Bladex, Gardaprim, Afalon, Basagran	Gatton R.S.

Table 6. Experiments evaluating herbicides in green peas.

Experiment code	Planting date	Harvest date	Cultivars	Herbicides	Location
S8901.00	17.07.89	10.08.89	Bounty	Bladex, Sencor, Gesagard	Lockyer Valley
S8901.07	12.06.90	27.09.90	Bounty	Sencor, Gesagard, Basagran, Bladex, Tribunil	Gatton R.S.
S8901.13	16.07.90	12.10.90	Bounty	Sencor, Gesagard, Stomp, Bladex, Igran	Gatton R.S.
S8901.32	04.06.91	19.09.91	Bounty	Sencor, Stomp, Bladex, Igran, Brodal	Gatton R.S.
S8901.**	25.06.92	15.10.92	Bounty	Igran	Lockyer Valley
S8901.**	14.07.92	-	Bounty	Igran	Fassifern Valley

Experiments were generally designed as randomised complete blocks or split-plots, with 2-4 replications, depending on the number of treatment factors. Hand-weeded and unweeded control treatments were included in almost all experiments, frequently with more replications than other treatments.

Experiments were grown using agronomy appropriate for the particular vegetable, with all factors apart from weed control kept as non-limiting as possible. Rainfall, irrigation, fertiliser and pesticide applications were recorded.

In almost every instance, both pre- and post-emergence herbicides were applied with a specially constructed hand-held boom. The boom comprised six 110° flat-fan hydraulic nozzles, each 0.305 m apart. Operating pressures varied from 180-250 kPa, with liquid output of 200-300 L/ha. Pressure for boom operation was provided by a small, regulated, compressed air cylinder, connected to a reservoir capable of dispensing 2 L of

herbicide/water mixture. Herbicide treatments were usually applied between 5 am and 9:30 am in the morning, to take advantage of relatively still weather conditions that usually prevailed at that time of day. Temperature and relative humidity at the time of spray application were recorded, as were estimates of wind strength and direction. The developmental stages of both crops and weeds were recorded for post-emergence sprays.

Herbicide formulations used during this project are shown below in Table 7. Almost all were commercially available at the time, although many of the wettable powders are no longer in production.

Table 7. Active ingredients and formulations of herbicides used during the project.

Herbicide	Active constituent	Concentration	Formulation type
CARBETAMEX	carbetamide	700 g/kg	wettable powder
DUAL	metolachlor	720 g/L	emulsifiable concentrate
RAMROD	propachlor	480 g/L	suspension concentrate
STOMP	pendimethalin	330 g/L	emulsifiable concentrate
RONSTAR	oxadiazon	20 g/kg	dry granule
DACTHAL	chlorthal di-methyl	750 g/kg	wettable powder
KERB	propyzamide	500 g/kg	wettable powder
GOAL	oxyfluorfen	240 g/L	liquid concentrate
GESAGARD	prometryn	500 g/L	suspension concentrate
GESAGARD	prometryn	500 g/kg	wettable powder
CASURON	dichlobenil	67.5 g/kg	dry granule
BLADEX	cyanazine	500 g/L	suspension concentrate
SENCOR	metribuzin	700 g/kg	wettable powder
IGRAN	terbutryn	500 g/L	suspension concentrate
BASAGRAN	bentazone	480 g/L	liquid concentrate
TRIBUNIL	methabenzthiazuron	700 g/kg	wettable powder
BRODAL	diflufenican	500 g/kg	aqueous concentrate
BLAZER	acifluorfen	224 g/L	liquid concentrate
TREFLAN	trifluralin	400 g/L	emulsifiable concentrate
ATRAZINE	atrazine	500 g/L	suspension concentrate
GARDAPRIM	terbuthylazine	500 g/L	suspension concentrate
AFALON	linuron	500 g/kg	wettable powder
GOLTIX	metamitron	700 g/kg	wettable powder
BETANAL	phenmedipham	157 g/L	emulsifiable concentrate
PYRAMIN	chloridazon	650 g/kg	wettable powder

During the growing periods of the crops, counts of individual weed species were conducted at regular intervals. Depending on plot sizes, number of treatment replications, and relative abundance of weeds, the sample area for weed counts comprised either the whole plot (excluding buffer areas at either end and lateral edge), or randomly placed quadrats within each plot. Quadrat size was generally 0.2-0.5 m², with 2 placements per plot. Because of the clumped nature of their distributions, weed counts were generally log-transformed prior to analysis, to provide better estimates of treatment effects.

Weed competition and herbicide effects on crop performance were also assessed during the growing period. At regular intervals, heights and/or widths of 5-10 randomly selected, individual crop plants from each plot were recorded. Any symptoms of crop damage were also noted. In some experiments, crops were destructively sampled to determine biomass at key growth stages, e.g. flowering in green beans. Almost all experiments were carried through to final yield, with the bulk of plots (apart from buffer areas) being harvested. Numbers and weights of individual harvested pieces (e.g. broccoli or lettuce heads) were determined for each plot. Any effects of treatments on produce quality or maturity were also noted.

Data were usually analysed using analysis of variance procedures, to compare treatment differences. In experiments where more than 3 rates of a herbicide were investigated, regression analyses were also conducted, to estimate rate response curves of both weeds and crops to herbicide dosage. Mean rate response curves for several herbicides are shown in the Results section of this report.

Results and discussion.

Results and discussions are presented separately for each vegetable crop. Because some herbicides were common across several vegetables, there is some cross referencing (particularly with regards weed control spectrums) to avoid unnecessary duplication.

Lettuce.

During initial screening experiments, we investigated several herbicides in lettuce, including CARBETAMEX (carbetamide), RONSTAR (oxadiazon), DUAL (metolachlor), STOMP (pendimethalin) and RAMROD (propachlor).

Literature suggested CARBETAMEX may control weeds both pre and post-emergence in lettuce. In 3 experiments at Toowoomba, Gatton and Redlands, we found this herbicide gave no control of potato weed (*Galinsoga parviflora*), sowthistle (*Sonchus oleraceus*) nor bellvine (*Ipomoea plebia*). Because of its lack of weed efficacy, we did not continue research with CARBETAMEX in later experiments.

Similar to CARBETAMEX, RONSTAR achieved poor control of several weeds important in lettuce production. In one of 2 experiments in which RONSTAR was evaluated, there

was also significant phytotoxicity to the lettuce, reducing yield by 25% compared to the hand-weeded treatment. The formulation of RONSTAR used in Australia has a very low concentration of active ingredient (Table 7); completely unsuitable for field use. Registration of a new formulation for use in vegetable crops is very unlikely. All these factors combined to make this herbicide inappropriate for further evaluation for a vegetable weed management program.

The phytotoxicity of DUAL in lettuce was substantial in 2 of the 3 experiments in which it was evaluated. The general yield curve (Fig. 1) showed a mean reduction in lettuce yields of 20% where 4 L/ha of DUAL (a rate common across the 3 experiments) was applied prior to transplanting. Where lettuce producers had experimented with this herbicide in the past, they also expressed concern about levels of crop damage from rates of DUAL required for effective weed control (3-4 L/ha). Symptoms of lettuce damage from DUAL included slight chlorosis and substantial wrinkling of leaves in young plants; general stunting of plants; and slow formation of loose, ill-defined heads. Symptoms worsened as application rate increased above 2 L/ha. Following our observations of lettuce damage from DUAL in the 1991 experiments, we ceased evaluating this herbicide in lettuce.

The pre-emergence herbicide STOMP was used in 8 detailed experiments and several on-farm demonstrations in lettuce. Mean effects of STOMP on lettuce yields over the 8 experiments are shown in Fig. 1. Applied 1-7 days before transplanting lettuce, we found no adverse effects of up to 3 L/ha of STOMP on lettuce yields. In 1 experiment in 1991 at Gatton, there was a significant yield reduction (circa 25%) where 4 L/ha was used; in the other 7 experiments this rate proved safe. Lettuce on krasnozem soil appeared to tolerate a higher rate of STOMP than those grown on black earth or sandy soils.

Symptoms of STOMP damage to lettuce are most noticeable in the first few weeks after transplanting. Affected transplants suffer leaf chlorosis, and are generally slow growing and stunted. Lettuce suffering slight early damage can generally recover by harvest, with no significant adverse effects on head quality or overall yields.

In an experiment in the Granite Belt region of Queensland, STOMP herbicide was applied 1 day after transplanting. Even at 3 L/ha, there was substantial stunting and leaf chlorosis in the lettuce transplants. Although mainly taken up by root and germinating shoot tissues, there is also considerable foliar absorption of STOMP by young dicotyledonous plants (WSSA 1989). I hypothesise that the proportionally large quantity of STOMP absorbed directly into the leaf tissue is responsible for the damage to lettuce seedlings when STOMP is applied after transplanting. The level of damage we observed would preclude the use of STOMP after transplanting in lettuce.

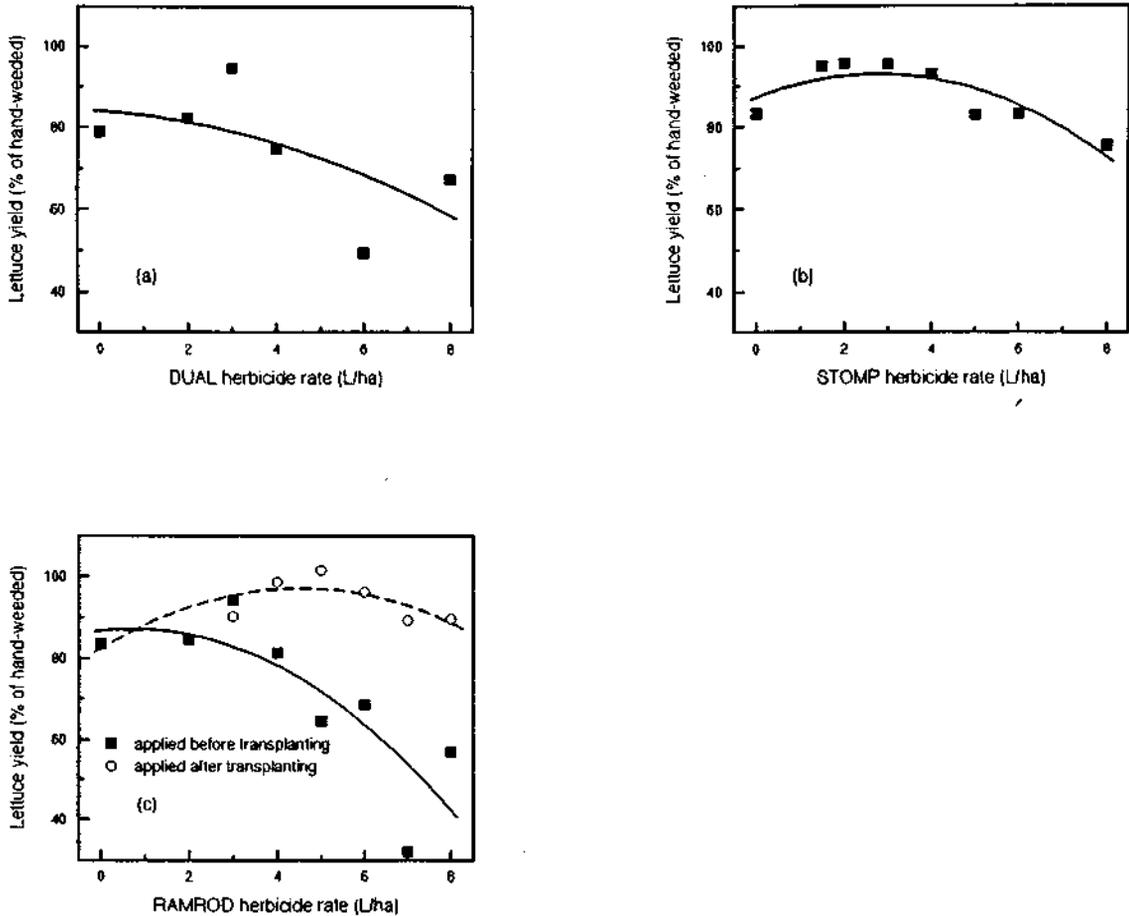


Figure 1. Mean effects of (a) DUAL, (b) STOMP and (c) RAMROD pre-emergence herbicides on lettuce yields, evaluated over 8 experiments.

The pre-emergence herbicide RAMROD was used in 8 experiments and several farm demonstrations during the period of this project. Average effects of RAMROD on lettuce yields are shown in Fig. 1. Lettuce were susceptible to damage from RAMROD at rates registered in other vegetables (7-12 L/ha). A key finding from our research was that the risk of RAMROD phytotoxicity to lettuce was much greater where the herbicide was applied prior to transplanting, compared to spraying after transplanting (Fig. 1). Our results suggest it was safe to spray up to 5 L/ha of RAMROD after transplanting lettuce. If applied before transplanting, the maximum safe rate was 2.5-3 L/ha. The sensitivity to higher rates of RAMROD was also much greater in the pre-transplant applications.

The active ingredient of RAMROD, propachlor, is mainly absorbed via germinating coleoptiles or roots, with little foliar absorption (WSSA 1989). Where propachlor was applied before transplanting, there would have been substantial contact between herbicide treated-soil and the lettuce root mass in the transplant cell. In contrast, where the propachlor was sprayed after transplanting, most of the herbicide would have been evenly

distributed in a layer above the main mass of lettuce seedling roots. This is probably the reason for the increased crop safety in the post-transplant RAMROD applications.

As with STOMP herbicide, the main symptoms of RAMROD phytotoxicity in lettuce are leaf chlorosis and plant stunting. Lettuce suffering from RAMROD damage are less likely to recover, and tend to remain small for the life of the plant. Lettuce grown on krasnozern soils appear to tolerate higher rates of RAMROD herbicide than those grown on black earth soils.

In several experiments, STOMP and RAMROD herbicides were evaluated as mixtures or sequential sprays, to examine possible synergistic effects between the 2 herbicides, in terms of both weed control and the potential for crop damage. Because of the improved crop safety where RAMROD was applied after transplanting, we concentrated our evaluations on herbicide sequences, with STOMP before and RAMROD after transplanting; in contrast to mixtures of STOMP and RAMROD, applied before transplanting. Where we did investigate pre-transplant mixtures, the lowest rates of 3 L/ha STOMP + 5 L/ha RAMROD reduced lettuce yields by more than 20%. Sequences of 3-4 L/ha of STOMP before transplanting, followed by 4-4.5 L/ha of RAMROD after transplanting, resulted in lettuce yields an average 97% of yields from hand-weeded areas. Thus there did not appear to be any additional phytotoxicity when sequences of STOMP and RAMROD were used at rates shown to be safe for the individual herbicides.

In an experiment where responses of lettuce cultivars *Yatesdale*, *Oxley*, *Seagreen* and *Supergreen* to STOMP and RAMROD were evaluated, there were no differences in tolerances to either herbicide. This suggests there is little genetic variation across cultivars in terms of overall response to these herbicides.

Based on experimental evidence, at the 3-4 L/ha rate registered in lettuce, STOMP alone would control pigweed (*Portulaca oleracea*), giant pigweed (*Trianthema portulacastrum*), deadnettle (*Lamium amplexicaule*), fat hen (*Chenopodium album*), chickweed (*Stellaria media*), bladder ketmia (*Hibiscus trionum*), dinebra (*Dinebra retroflexa*) and crowsfoot grass (*Eleusine indica*). It should also prevent emergence of 80-90% of sowthistle, shepherd's purse (*Capsella bursapastoris*) and blackberry nightshade (*Solanum nigrum*) seedlings. Suppression/control of several other weed species is also suggested on the registration label. Unfortunately, STOMP will not affect several key weeds of lettuce, including potato weed, amaranthus spp. and slender celery (*Apium leptophyllum*). Rate response curves for STOMP against several weed species are shown in Fig. 2.

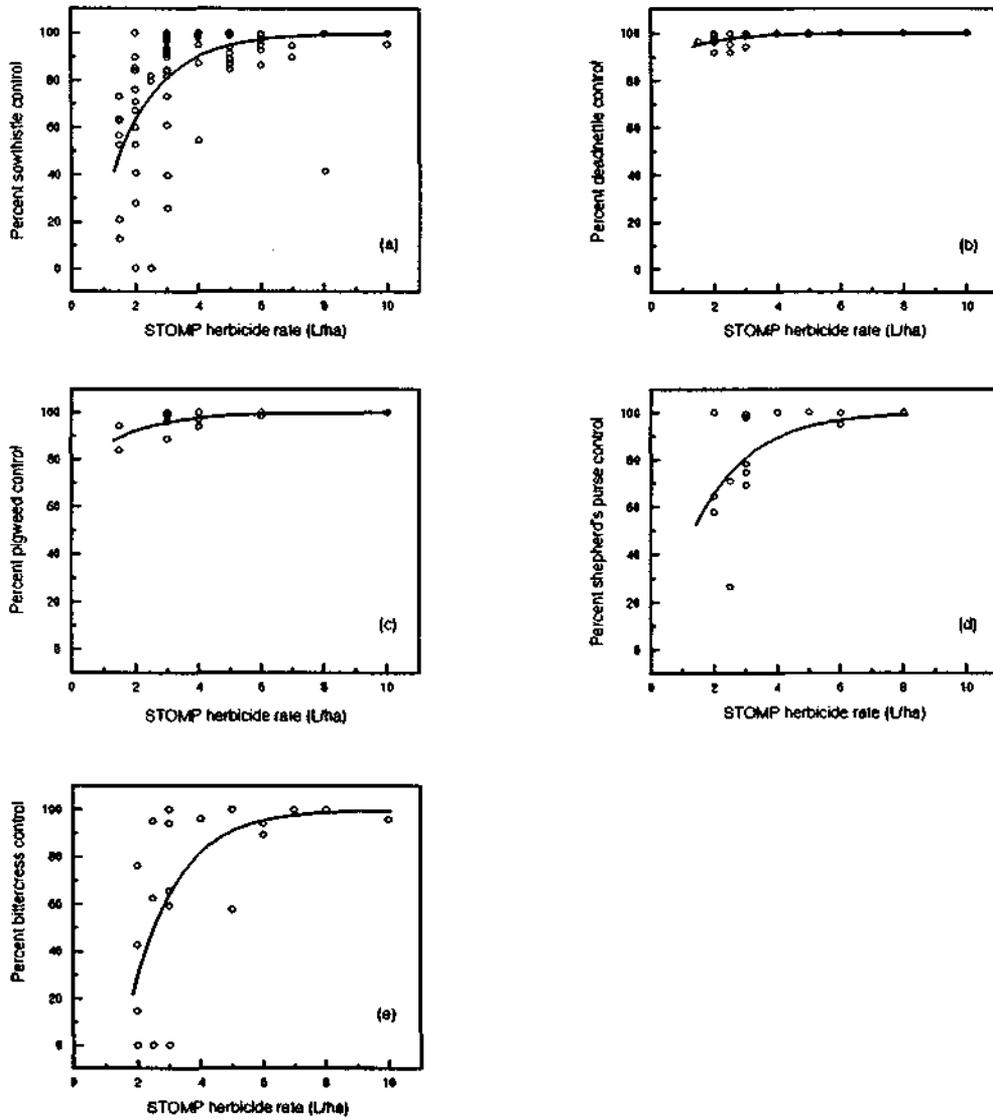


Figure 2. Control of (a) sowthistle, (b) deadnettle, (c) pigweed, (d) shepherd's purse, and (e) bittercress by STOMP pre-emergence herbicide, evaluated in a series of experiments in lettuce, brassicas, green beans, peas and sweet corn.

If a registration of up to 4.5 L/ha of RAMROD for use in transplanted lettuce could be obtained, application after transplanting (following STOMP before transplanting) would give 80-90% suppression of potato weed, as well as improving control of sowthistle, shepherd's purse, bittercress (*Coronopus didymus*) and some amaranthus spp (Fig. 3).

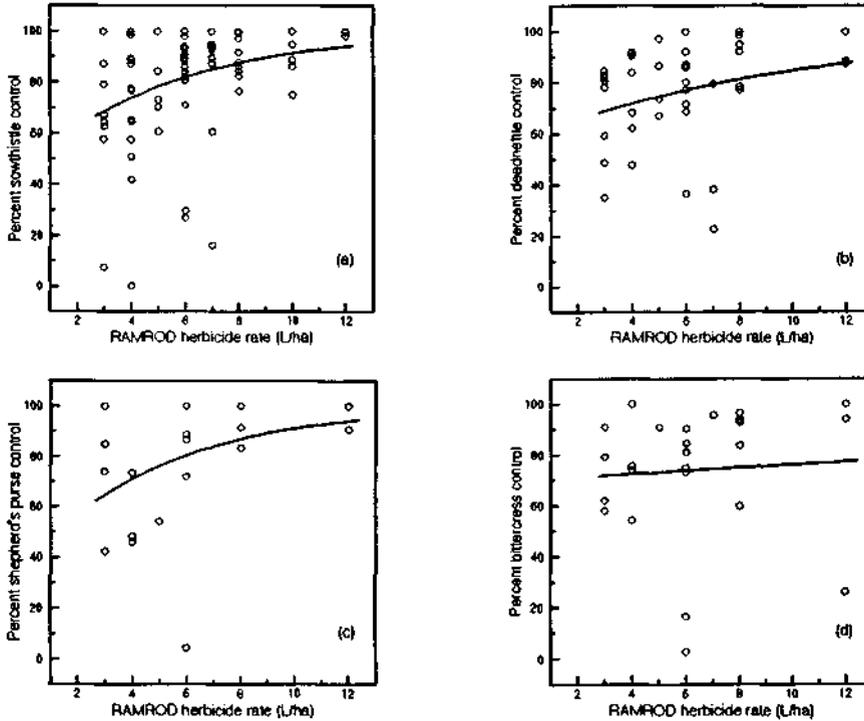


Figure 3. Control of (a) sowthistle, (b) deadnettle, (c) shepherd's purse, and (d) bittercress by RAMROD herbicide applied pre-emergence, evaluated in a series of experiments in lettuce, brassicas and beetroot.

Until recently, lettuce growers used either 12-15 kg/ha of DACTHAL, or 4.5 kg/ha of KERB as their pre-emergence herbicide treatments. These cost \$ 390-490 and \$ 410 respectively. Despite this expense, hand-weeding was still generally required. The recent registration of STOMP at up to 4 L/ha (\$ 48) has given an opportunity for lettuce growers to dramatically reduce their pre-emergence herbicide costs. Because of the smaller margin between the rates used for weed control and those that cause crop damage, STOMP may not be suitable for all producers. Most would need to fine-tune the application rate to suit their soil and weather conditions, as well as fit in with their other agronomic practices.

Because of the poor control of potato weed, hand weeding of lettuce where only STOMP herbicide was used would probably still be required. If registration for use of RAMROD in lettuce could be obtained, this may improve control of several weed species, including sowthistle and potato weed, to the extent that hand-weeding would be dramatically reduced, if not altogether eliminated. In my latest discussions with Monsanto Australia

P/L, they were expressing an intention to proceed with registration of RAMROD in lettuce.

Brassicas.

In early screening experiments, we evaluated the use of STOMP (pendimethalin), GOAL (oxyfluorfen), DUAL (metolachlor) and RAMROD (propachlor) herbicides applied before transplanting; CASURON (dichlobenil) and GESAGARD (prometryn) herbicides applied after transplanting. CASURON did not control any of the important weeds in brassica crops. At rates required for weed control (1-1.5 L/ha), GESAGARD was too phytotoxic to brassicas, reducing yields by up to 80%. Our research on these latter 2 herbicides in brassicas was discontinued in 1990.

Most of our investigations with GOAL involved spraying between 1 and 7 days before transplanting, at rates of 0.5-5 L/ha. With broccoli and cabbage, there appeared to be no crop damage from spraying up to 2 L/ha prior to transplanting, while cauliflower may have been marginally more sensitive to this herbicide (Figs. 4-6). Experiments evaluating effects of GOAL on different cultivars suggested no difference in the relatively high tolerance of broccoli cultivars *Greenbelt*, *Dominator*, *Marathon* and *Shogun*. With cabbage, there appeared to be some variation in cultivar tolerance. A rate of 2 L/ha of GOAL applied pre-emergence causing some damage to *Stariha* (yield 85% of hand-weeded) and *Green Coronet* (82% of hand-weeded) cultivars, compared to *Neptune* (116% of hand-weeded) and *Kameron* (87% of hand-weeded). At 1.5 L/ha, there were no adverse effects of GOAL on any of the cabbage cultivars evaluated. Experimental evidence did not indicate any differences in tolerances of the cauliflower cultivars *Plana*, *Hunter*, *Elby* and *Lucy* to pre-transplant applications of GOAL herbicide at up to 2 L/ha.

Optimum application rate of GOAL seemed to be 1-1.5 L/ha, sprayed 2-3 days before transplanting. At these rates, our experiments suggest control of more than 90% of sowthistle, deadnettle, potato weed, shepherd's purse, bittercress, fat hen, pigweed, burr medic (*Medicago polymorpha*) and blackberry nightshade (Fig. 7). Numerous other species, including many grasses, several *Amaranthus spp.*, thornapples (*Datura spp.*), wild radish (*Raphanus raphanistrum*) and wireweed (*Polygonum aviculare*) are also on the registration label where 3-4 L/ha are used in tree crops. I am not sure whether GOAL has activity against these weeds at the lower rates used in brassica crops.

Unfortunately, GOAL is not yet registered for use in brassicas; hence such application is illegal in Queensland. ROHM and HAAS are still intending to submit such a registration for use in brassicas to the National Registration Authority.

During this project, we did some preliminary evaluations of the use of GOAL as a post-transplanting, post-emergence herbicide in brassicas. Broccoli seemed to tolerate up to 0.5 L/ha of GOAL sprayed over the top at 2 weeks after transplanting. Although this caused substantial necrotic spotting and curling of the leaves, and some initial plant stunting, yield and head quality were not adversely affected. Cabbage seemed less tolerant of post-transplant spraying, with significant yield reductions where more than

0.3 L/ha was used. Initial experimentation suggests this post-transplant treatment could give good suppression/control of sowthistle, deadnettle, shepherd's purse, fat hen and potato weed. Because of the low rates of herbicide used in this strategy, it is an attractive option from the brassica producers point of view. Further evaluation of this method of application, with a view to generating data for registration, should be conducted; provided ROHM and HAAS would be willing to support such a registration.

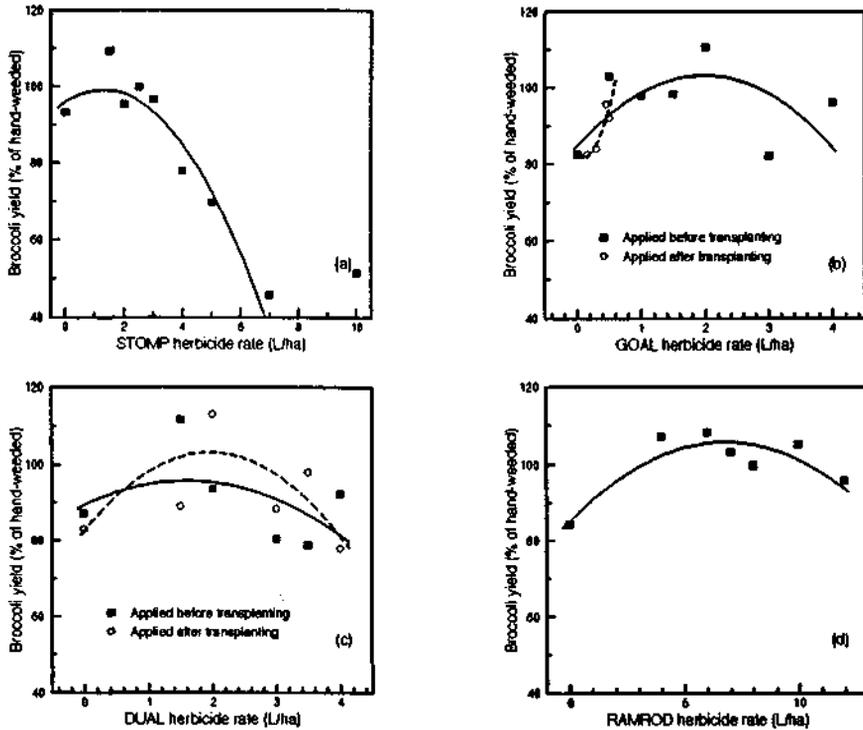


Figure 4. Mean effects of (a) STOMP, (b) GOAL, (c) DUAL, and (d) RAMROD pre-emergence herbicides on broccoli yields, evaluated over 7 experiments.

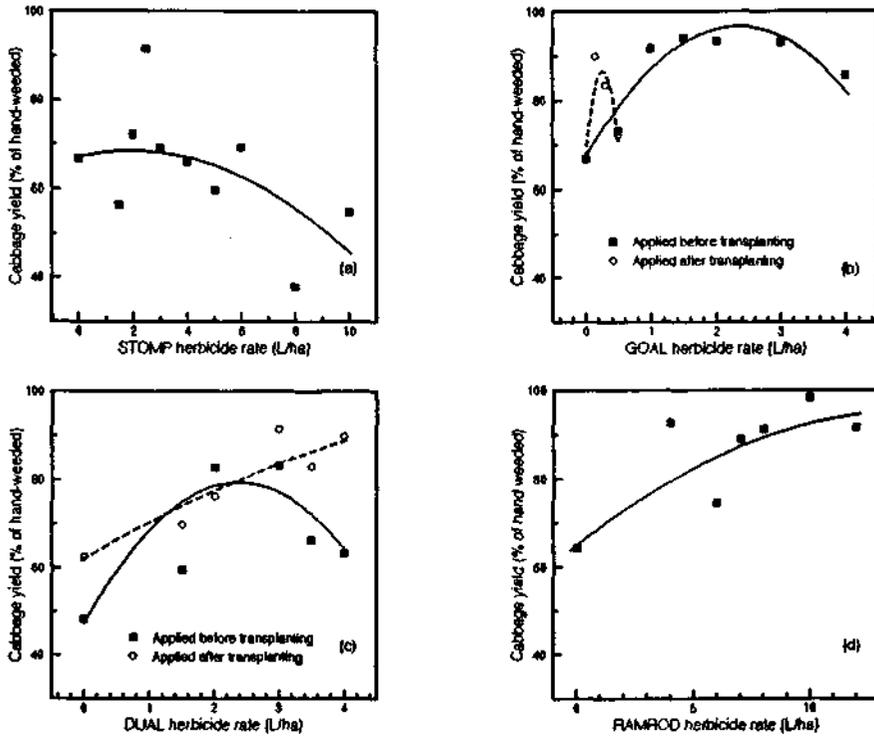


Figure 5. Mean effects of (a) STOMP, (b) GOAL, (c) DUAL, and (d) RAMROD pre-emergence herbicides on cabbage yields, evaluated over 7 experiments.

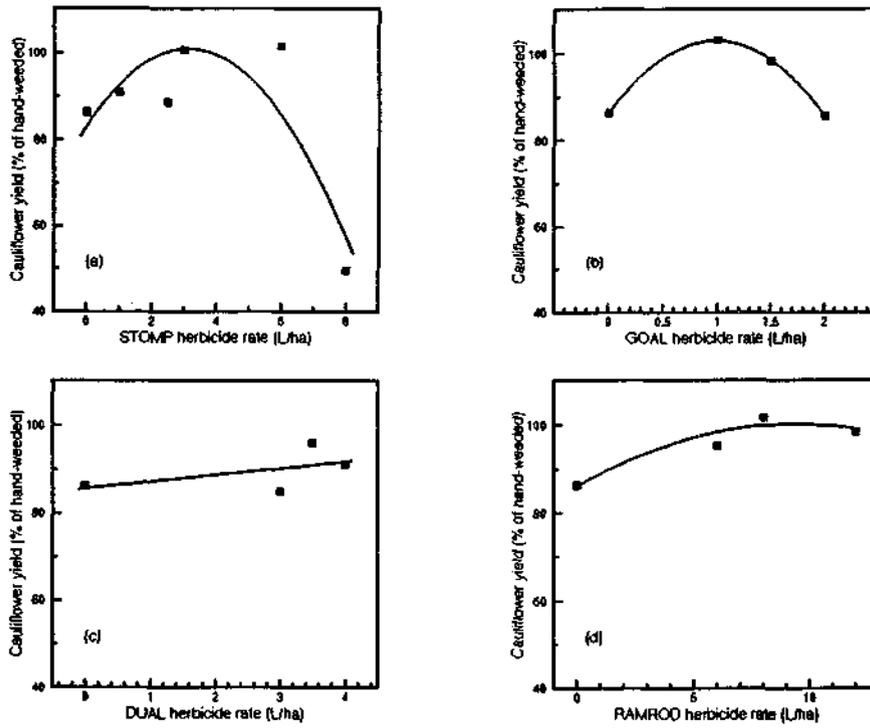


Figure 6. Mean effects of (a) STOMP, (b) GOAL, (c) DUAL, and (d) RAMROD pre-emergence herbicides on cauliflower yields, evaluated over 3 experiments.

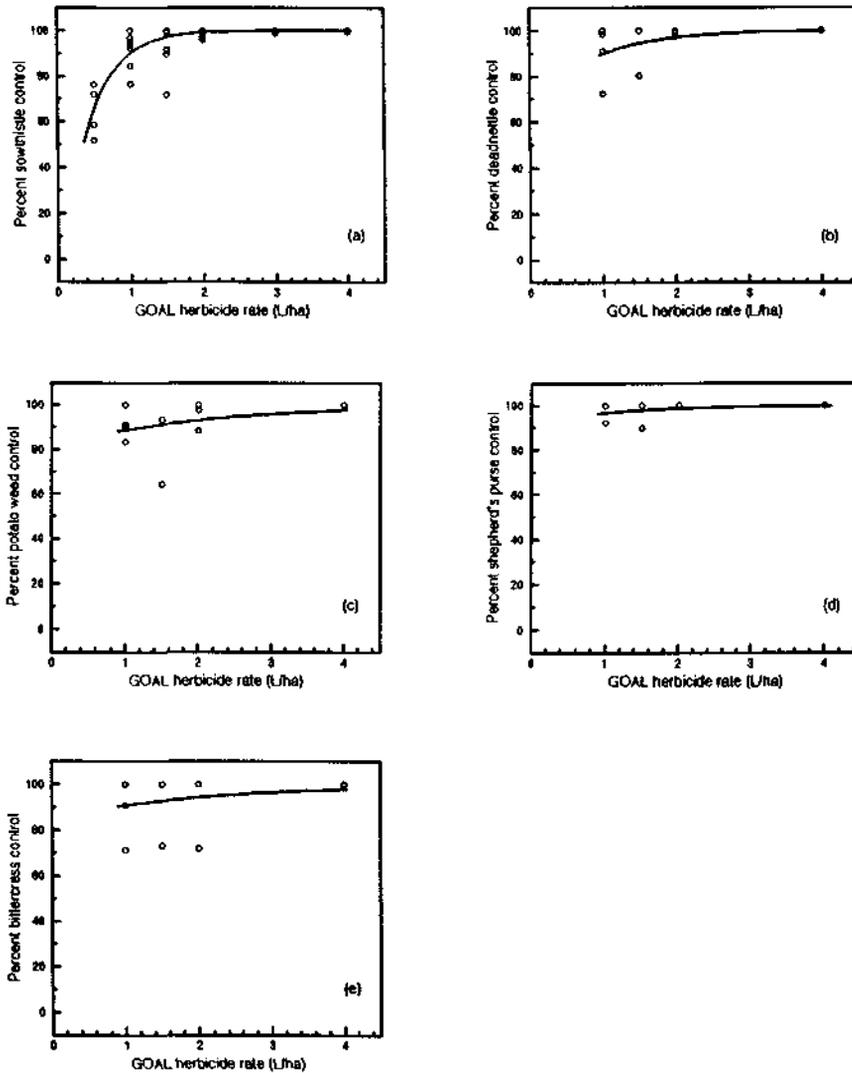


Figure 7. Control of (a) sowthistle, (b) deadnettle, (c) potato weed, (d) shepherd's purse, and (e) bittercress by GOAL herbicide applied pre-emergence, evaluated in a series of experiments in brassicas.

Brassica growth and yield were very sensitive to rates of STOMP above 3 L/ha, demonstrated by the yield response curves averaged across 15 separate experiments. Broccoli were more sensitive to STOMP than cabbage, which in turn were probably more sensitive than cauliflower (Figs 4-6). For the reasons previously discussed in the lettuce section, STOMP can only be applied before transplanting in brassicas.

Symptoms of STOMP damage to brassicas include leaf chlorosis and general stunting, with poor growth. Brassicas suffering slight early damage can generally recover by harvest, although this recovery is less pronounced than with lettuce. There appeared to be slight variation in the tolerance of broccoli cultivars to STOMP. At 2.5-3 L/ha, STOMP slightly delayed the maturity of cultivars *Dominator* and *Shogun*, whilst having

no effects on *Greenbelt* nor *Marathon*. Apart from these maturity delays, there were no other differential effects of STOMP on broccoli cultivar yields or quality.

There were significant differences in the tolerances of cabbage cultivars to STOMP rates of 2.5-3 L/ha. Of the cultivars evaluated, *Neptune* seemed most tolerant, with no adverse effects on growth and yield from STOMP at 3 L/ha. At the same herbicide rate, *Green Coronet* plants suffered slight diameter reductions (11%) at both 5 and 10 weeks after transplanting, however yields were not adversely affected. *Stariha* was more sensitive; where STOMP was applied at 3 L/ha, yield was 30% less than from hand-weeded plots. *Kameron* was the most sensitive cultivar tested, with a similar yield reduction when 2.5 L/ha of STOMP was sprayed prior to transplanting.

Experimental evidence did not indicate any differences in tolerances of cauliflower cultivars *Plana*, *Hunter*, *Elby* and *Lucy* to pre-transplant applications of STOMP herbicide at up to 2.5 L/ha.

Based on our experimental evidence, at the 2-3 L/ha rate registered in transplanted brassicas, STOMP applied by itself would control pigweed, giant pigweed, deadnettle, fat hen, chickweed, bladder ketmia, dinebra and crowsfoot grass. It should also prevent emergence of 60-80% of sowthistle and shepherd's purse seedlings. Suppression/control of several other weed species (such as many grasses, wireweed, wild radish) is also suggested on the registration label. Unfortunately, STOMP will not affect several important weeds of brassicas, including potato weed, several amaranthus spp. and slender celery.

Brassicas seem very tolerant of RAMROD herbicide at registered rates. In broccoli, cabbage and cauliflower experiments, there were no phytotoxic effects where RAMROD was applied at up to 12 L/ha (e.g. Figs 4-6). From a phytotoxic point of view, it does not matter whether RAMROD is applied before or after transplanting in brassicas. As would be expected, there were also no differences in RAMROD tolerance between cultivars of broccoli, cabbage and cauliflower that we evaluated.

At the registered rate of 12 L/ha, RAMROD is registered to control amaranths, sowthistle, deadnettle, potato weed, scrub nettle (*Urtica spp.*), shepherd's purse, and numerous grasses. In our experiments, we found 7-8 L/ha of RAMROD controlled potato weed, gave 80-90% control of sowthistle and shepherd's purse, with reasonable suppression of deadnettle, pigweed and fat hen. RAMROD was not consistently effective against bittercress, blackberry nightshade, bladder ketmia, slender celery or apple of Peru (*Nicandra physalodes*).

DUAL herbicide is registered for use on brassicas at 3-4 L/ha. Although the registration is for application after transplanting, producers occasionally apply this herbicide before transplanting. In our experimental work we have consistently noted increased crop damage to both broccoli and cabbage where DUAL is sprayed before, rather than after transplanting (Figs 4-6). The DUAL registration label notes some stunting and yield loss is possible in brassicas grown on lighter textured or alluvial soils. In our experience, we often noted slight crop damage and yield reductions (circa 10%) in brassicas where we

used more than 3.5 L/ha on even the black earth soils of the Lockyer Valley. On this basis, I would be reluctant to use more than 3.5 L/ha of DUAL herbicide on brassicas in Queensland. Our research did not show any differences in sensitivity to DUAL herbicide across 4 cultivars in separate experiments on broccoli, cabbage and cauliflower.

The Queensland registration for DUAL herbicide in transplanted brassicas suggests it will control deadnettle, fat hen, potato weed, shepherd's purse, stinging nettle (*Urtica urens*), and a range of grasses, whilst giving suppression against blackberry nightshade, chickweed, pigweed and wireweed. In our experiments, we found that 3.5 L/ha of DUAL controlled deadnettle, shepherd's purse, bittercress, blackberry nightshade, slender celery and some amaranthus spp (Figs 8-9). It also gave 80-90% suppression of sowthistle, potato weed, chickweed and giant pigweed. It was not effective against bladder ketmia or fat hen under Queensland conditions.

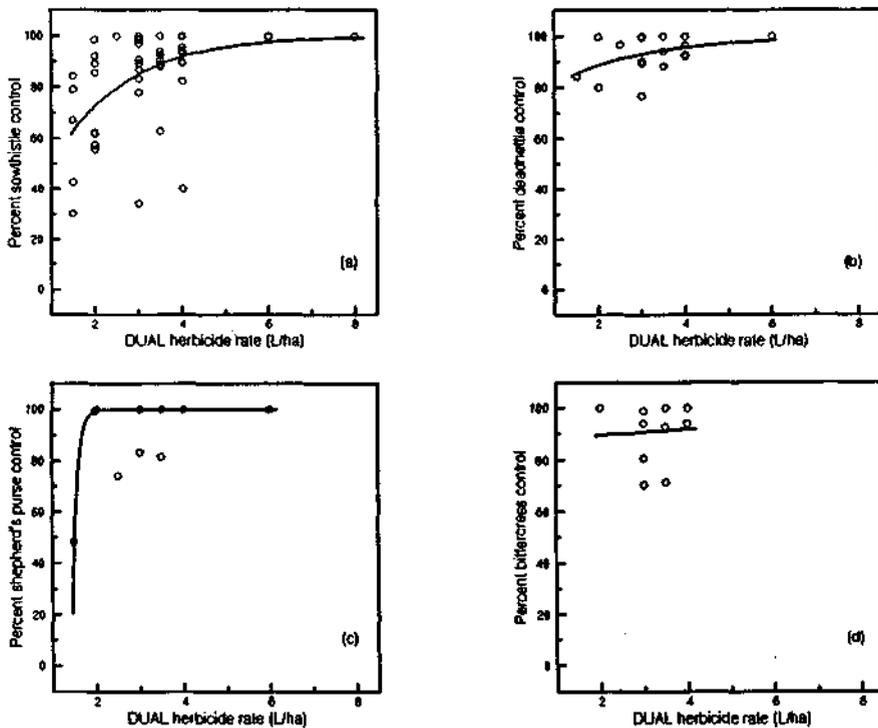


Figure 8. Control of (a) sowthistle, (b) deadnettle, (c) shepherd's purse, and (d) bittercress by DUAL herbicide applied pre-emergence, evaluated in a series of experiments in lettuce, brassicas, green beans, sweet corn and beetroot.

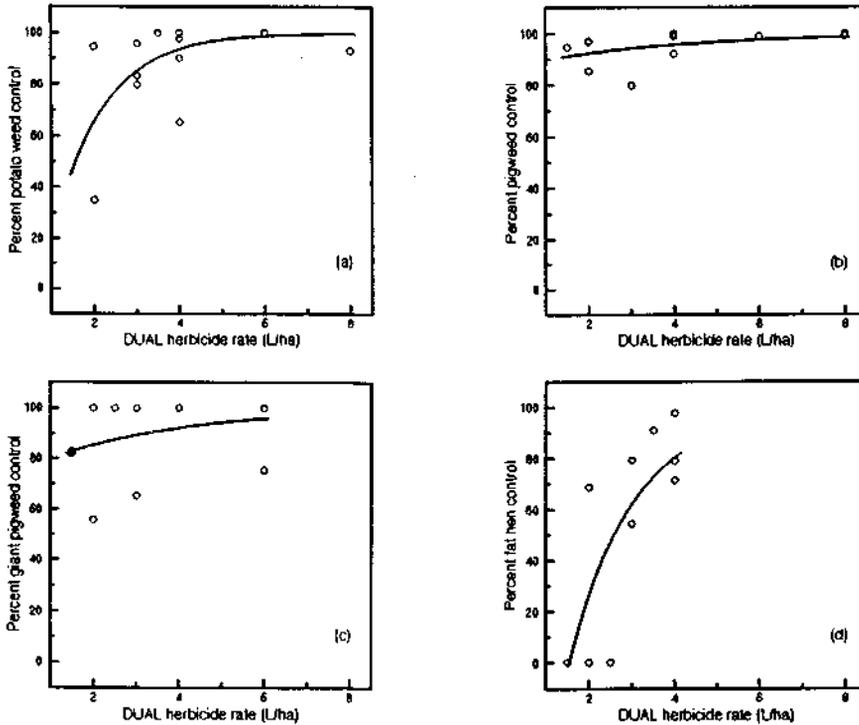


Figure 9. Control of (a) potato weed, (b) pigweed, (c) giant pigweed, and (d) fat hen by DUAL herbicide applied pre-emergence, evaluated in a series of experiments in lettuce, brassicas, green beans, sweet corn and beetroot.

Many brassica producers would currently be using DUAL for pre-emergence weed control. At 3.5 L/ha, this would cost around \$ 90. Apart from a slight risk of crop phytotoxicity, continuous use of this herbicide will also result in the build up of weeds not controlled by this herbicide, notably fat hen. I would recommend that brassica growers should consider using a STOMP/RAMROD combination every few years, to reduce this problem of weed build-up. A mixture of 2 L/ha of STOMP and 7-8 L/ha of RAMROD would cost around \$ 110; more expensive than DUAL alone but more effective against a different weed spectrum. Registration of GOAL herbicide in brassicas would be a substantial benefit to producers. At 1.5 L/ha, GOAL will control most of the important weeds in brassica crops, providing an excellent rotation herbicide to compliment the other pre-emergence products. The economics are also very encouraging, as GOAL currently sells for around \$ 35 per litre. Low rates used post-emergence in brassicas has tremendous possibilities for improving weed control in direct-sown crops, as well as substantially reducing the overall quantities and costs of herbicides used in brassica weed control programs. Registration of GOAL in brassicas should be a priority outcome from this research program.

Green beans.

Our research on herbicides for green beans evaluated both pre and post-emergence products. Pre-emergence herbicides included STOMP (pendimethalin), DUAL (metolachlor) and BLADEX (cyanazine). BLADEX was only evaluated in 1 experiment; even the lowest rate tested (1.5 L/ha) reduced yield by 40%.

Over 7 experiments in which we evaluated STOMP and DUAL, at sites in the Lockyer Valley and Gympie areas, we did not encounter a single instance of herbicide damage. As shown in Fig. 10, STOMP rates of up to 10 L/ha and DUAL rates of 8 L/ha resulted in green bean yields equivalent to, or higher than, those from hand-weeded plots. Previous research by QDPI in the Gympie area (unpublished) and some grower experience has suggested problems with crop lodging where 3-6 L/ha of STOMP has been used under cold growing conditions. Overseas research (Struckmeyer *et al.* 1976) has shown that STOMP can cause thinning of cell walls and callus formation in green bean stems, particularly at ground level. Conditions that reduce growth rates of bean plants, such as water or nutrient stress, waterlogging, and cool weather may increase the risk of weak stems and crop lodging. Even with this risk, I suggest that 4 L/ha of STOMP should be safe for post-sowing, pre-emergence use in green beans, where normal summer growing conditions apply. STOMP has recently become registered for use on green beans, however the registration is restricted to warm season crops in the Lockyer and Fassifern Valleys of South-east Queensland. Registration of DUAL for green beans is still awaiting preparation of a submission by Ciba Australia P/L, the responsible company.

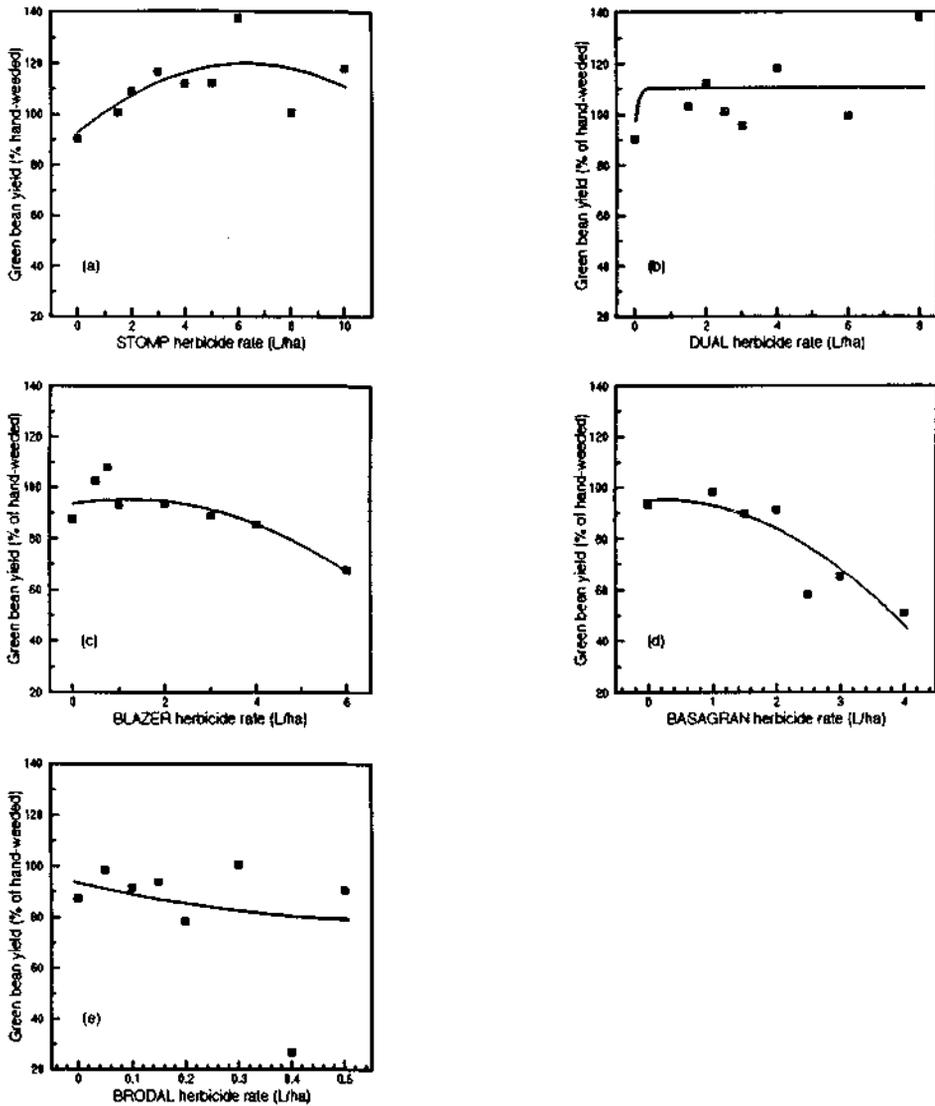


Figure 10. The mean effects of (a) STOMP, and (b) DUAL herbicides applied pre-emergence, and (c) BLAZER, (d) BASAGRAN, and (e) BRODAL herbicides applied post-emergence, on green bean yields, evaluated over 9 experiments.

At 3-4 L/ha for STOMP, and 3-4 L/ha for DUAL, the spectrum of weeds controlled are the same as indicated in the sections on lettuce and brassicas respectively. Because beans are predominantly grown in warmer seasons, the most important weeds are the range of common grasses, giant pigweed, common pigweed, various amaranthus species, fat hen, cobbler's pegs (*Bidens pilosa*) etc. Selection of the appropriate pre-emergence herbicide (if DUAL becomes registered) would very much depend on the spectrum of weeds present. For example, if fat hen or pigweed were the most significant weeds, then STOMP would be appropriate. If *Amaranthus* or potato weed were more important, then DUAL would be a better herbicide selection. ✕

We screened a large number of post-emergence herbicides for use in green beans, including BLADEX (cyanazine), BLAZER (acifluorfen), BRODAL (diflufenican), SENCOR (metribuzin), GESAGARD (prometryn), IGRAN (terbutryn), TRIBUNIL (methabenzthiazuron), GOAL (oxyfluorfen) and BASAGRAN (bentazone). BLADEX, SENCOR, GESAGARD, IGRAN, TRIBUNIL and GOAL all killed the bean plants; research on those herbicides in green beans was discontinued in 1990.

In 5 experiments on green beans, post-emergence spraying up to 2 L/ha of BLAZER did not cause any yield reduction. There was initial leaf necrosis and plant stunting immediately after spraying, however the plants recovered by flowering to set and fill the same number and size of pods as hand weeded plots. In a sixth experiment however, 0.5 L/ha of BLAZER was safe, whilst 1 L/ha reduced bean yields by 20%. The bean yield response to BLAZER averaged over 6 experiments is illustrated in Fig. 10. Reasons for differences in phytotoxicity are unclear. Weather conditions and age of bean plants at the time of spraying were similar for the bean crops sensitive to BLAZER, compared to those that were less affected. We initially thought that increased sensitivity of the cultivar used in the affected experiment (*Superstar*), compared to the cultivar *Labrador* used in the other experiments, may have caused the yield penalty. In an experiment where we specifically evaluated sensitivities of green bean cultivars to herbicides, we found no significant differences. There were non-significant trends for *Bronco* to be the most sensitive to BASAGRAN and BLAZER, with *Labrador* and *Montano* least affected. *Superstar* and *Redlands Pioneer* were intermediate.

BASAGRAN is the only post-emergence broadleaf herbicide registered for green beans. In one experiment, spraying at the maximum recommended rate of 2 L/ha had no phytotoxic effect on the beans, whilst in another it caused initial crop stunting and reduced yields by 15%. As can be seen in Fig. 10, applying more than the maximum registered rate can certainly result in substantial yield penalties.

At 1.5-2 L/ha, the registered post-emergence herbicide BASAGRAN controlled sowthistle, chickweed and shepherd's purse, whilst giving 80-90% suppression of deadnettle, amaranthus and fat hen. It does not control giant pigweed. At 0.75-1 L/ha, BLAZER controlled sowthistle, pigweed, deadnettle, fat hen, amaranthus spp., with some suppression of giant pigweed.

The effects of BRODAL on the growth and yields of green beans was inconsistent across the 3 experiments in which it was evaluated. In all instances it caused white flecking on leaves and stems, which developed into substantial necrotic areas on bean leaves at application rates > 0.2 L/ha. In 2 of the 3 experiments, there were no reductions in bean yields where 0.2-0.3 L/ha of BRODAL was applied, whereas in a third experiment yield declined by 60-70%. The bean yield response to BRODAL averaged over these 3 experiments is illustrated in Fig. 10. In our experimental work, 0.2-0.3 L/ha of BRODAL controlled blackberry nightshade and giant pigweed, and gave 85% suppression of deadnettle and amaranthus. Its registration in other crops is mainly for control of brassica weeds (generally not important in green bean production). Because of the substantial variation in phytotoxic effects on beans, and the restrictive weed spectrum, further research on BRODAL in green beans is probably not warranted at this point in time.

There were several key points to come out of our research into weed management in green beans. There is a need to pursue the registration of DUAL for pre-emergence use. At the time this report was written, Ciba Australia P/L are still unclear as to when a submission for a new DUAL registration will be made. I believe complete data sets for inclusion of new crops (e.g. green beans, sweet potato) on the label are held by Ciba for inclusion in any submission.

Depending on positive experiences in other districts, it may also be possible to convince CropCare to extend the registration for STOMP in green beans to areas outside the Lockyer and Fassifern Valleys. I believe it would be useful to precisely define weather and physiological variables affecting phytotoxicity of BASAGRAN to green beans, to allow more cost-effective use of this herbicide. Because of an expanded weed spectrum, it would also probably be useful to conduct similar work with BLAZER. The eventual aim would be registration of low-rate mixtures of BASAGRAN and BLAZER in green beans.

Beetroot.

In our early experimental work with beetroot herbicides, we concentrated on evaluating the performance of GOLTIX (metamitron). This herbicide is used extensively in Europe and New Zealand, but is not registered in Australia (or interestingly, in the United States). It has a particular role for spraying around the time of beetroot emergence, when other herbicides may cause too much damage to beetroot seedlings.

Over the 3 experiments in which GOLTIX was used, we sprayed up to 12 kg/ha with no adverse effects on beetroot growth or yield (Fig. 11). Our earliest spray applications were 21 days after sowing; in 2 experiments there were a second series of applications 3 weeks after the initial spray.

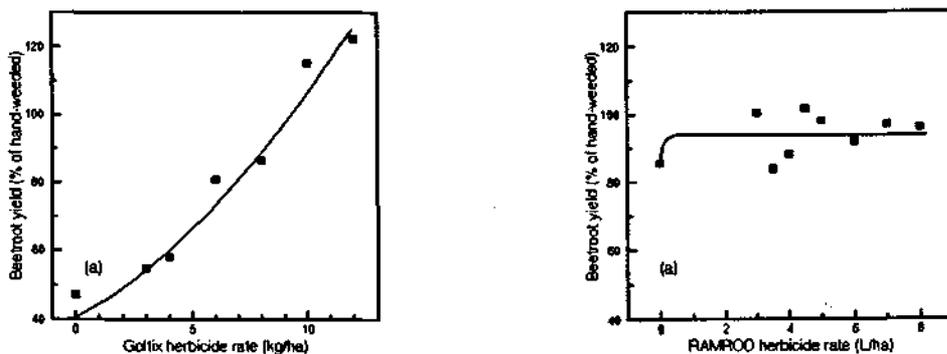


Figure 11. The mean effects of (a) GOLTIX herbicide, applied post-emergence, and (b) RAMROD pre-emergence herbicide, on beetroot yields, evaluated over 4 experiments.

When weeds were small (i.e. less than 3 true leaves), 4-5 kg/ha of GOLTIX controlled fat hen, shepherd's purse and sowthistle, also giving good suppression of wireweed. As weeds aged, higher rates of 8-10 kg/ha were required to give the same levels of control. At these higher rates, we found GOLTIX also controlled deadnettle, with reasonable pre-emergence residual activity against the weeds previously mentioned. The increasing effectiveness against weeds (in terms of numbers of weeds killed and duration of control) with higher rates of GOLTIX corresponds with the increasing beetroot yields is shown in Fig. 11.

Although the experimental work with GOLTIX was very encouraging, administrative and commercial considerations mean it is unlikely to become available in Australia. The responsible company, Bayer Australia P/L, cannot justify the costs associated with registering and marketing a completely new herbicide in this country, given the small size of the beetroot industry. When this became evident, we ceased experimental work on this herbicide (with some reluctance, given its potential usefulness in a beetroot weed management program).

As with other crops referred to previously in this report, although CARBETAMEX (carbetamide) at up to 5 kg/ha did not damage beetroot, it did not effectively control weeds. This poor efficacy meant that research into CARBETAMEX was discontinued in 1991.

In contrast, DUAL (metolachlor) gave reasonable weed suppression at 3 L/ha, with beetroot yields at 96% of hand-weeded areas. However, where DUAL was sprayed at 4 L/ha after sowing, yields declined to 70% of the hand-weeded plots. Yield penalties were mainly due to reductions in the numbers of beetroot plants established. DUAL is not particularly effective against several key weeds in beetroot, notably fat hen and wireweed. In conjunction with the significant risk of crop damage, I decided to downgrade the priority of registration of DUAL for use in beetroot, and determined rather to concentrate on optimising the use of currently registered products.

RAMROD (propachlor) is currently registered for post-sowing, pre-emergence use in beetroot, at a maximum rate of 3.8 L/ha. In 2 experiments, we tested higher rates of up to 8 L/ha, looking at achieving broader spectrums and longer periods of weed control. In both experiments, there was no evidence of beetroot phytotoxicity at the highest rates tested, as shown in Fig. 11. The current registration for RAMROD in beetroot is only to control potato weed. At our higher rates of 6-7 L/ha, this herbicide also gave 80-90% control of sowthistle and shepherd's purse, with reasonable suppression of deadnettle, pigweed and fat hen. RAMROD was not consistently effective against bittercress, blackberry nightshade, bladder ketmia, slender celery or apple of Peru.

In our final beetroot experiment in this project, we checked the responses of beetroot to high rates of herbicides already registered, i.e. PYRAMIN (chloridazon) and BETANAL (phenmedipham). Although some beetroot producers have experienced crop damage from both these herbicides, we found no phytotoxicity where BETANAL or PYRAMIN were sprayed at 10 L/ha or 10 kg/ha respectively. These rates are 25% above the maximum registered. Major weeds in this experiment were deadnettle, sowthistle and bittercress. PYRAMIN applied at 5-6 kg/ha pre-emergence gave sufficient weed control to enable

yields equivalent to hand-weeded areas. There were no advantages from post-emergence applications of PYRAMIN, in terms of improved weed control or higher beetroot yields. Unfortunately in this experiment, BETANAL was applied too late to achieve effective weed control (i.e. weeds had more than 6 true leaves).

Currently, a herbicide program involving minimum registered rates of PYRAMIN pre-emergence, and BETANAL/TRAMAT post-emergence, still costs \$880/ha. This is obviously prohibitive; costs can be reduced by band spraying only 1/3 of the area directly over each row, mechanically cultivating the inter-row. At \$300/ha, this is still very expensive weed management. A new research program is investigating very low rates of herbicides, with precision application over the row, to try and reduce costs further.

Sweet corn.

The main objective of the sweet corn herbicide work was to determine the most cost-effective program that did not involve the use of hormone-type herbicides (e.g. 2,4-D) or very persistent chemicals (e.g. sulfonyl ureas, atrazine). We investigated pre-emergence products such as STOMP (pendimethalin), DUAL (metolachlor), and BLADEX (cyanazine). Over the course of the 4 main experiments, we also used atrazine, linuron, terbutylazine.

We sprayed STOMP immediately after sowing at rates up to 8 L/ha over 4 experiments. In no instance did we observe any phytotoxicity to sweet corn from even the highest concentrations. Concern has been expressed by chemical and vegetable processing company representatives that STOMP has caused significant lodging in sweet corn in other districts. Our investigations were conducted during summer at Gatton Research Station; it is possible that the risk of lodging may be greater under cooler or wetter conditions. Similar to green beans, it has been suggested that the band of STOMP at the soil surface may both prevent the development of adventitious 'prop' roots in the sweet corn, and promote weakening of the main stem at ground level. We did not see this in any of our experiments.

As can be seen in Fig. 12, sweet corn yields (averaged over the 4 experiments) from areas treated with STOMP were always equivalent to those from hand weeded plots. As in other crops, the optimum rate for STOMP application was probably 3-4 L/ha. This would control numerous grass and broadleaf weed species, as indicated previously in the report.

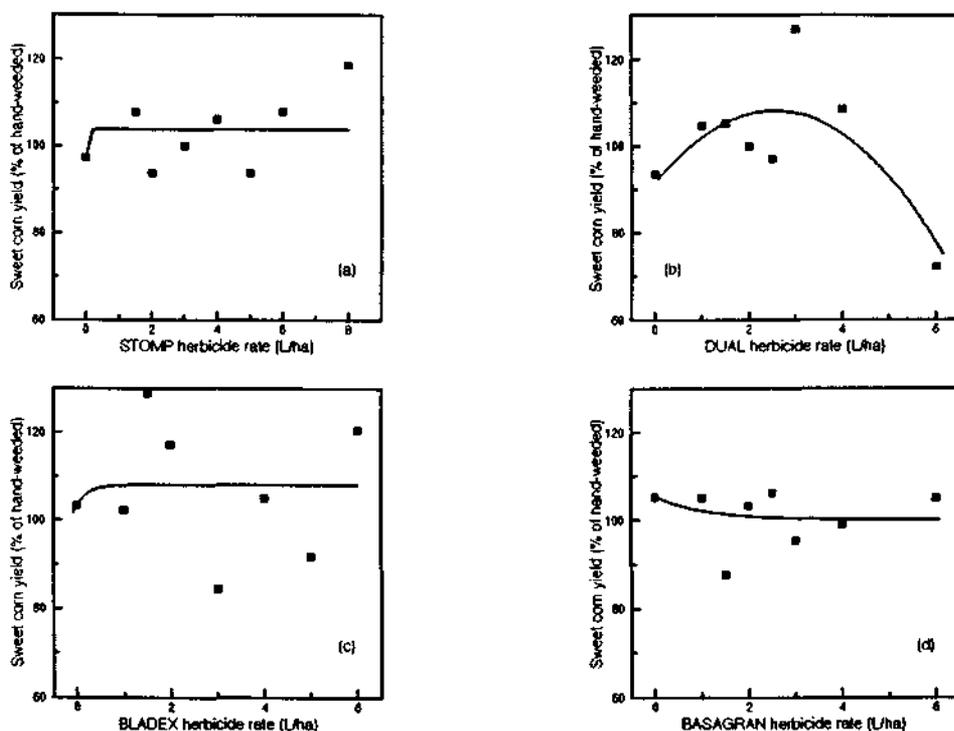


Figure 12. The mean effects of (a) STOMP, (b) DUAL, and (c) BLADEX pre-emergence herbicides, and (d) BASAGRAN post-emergence herbicide, on sweet corn yields, evaluated over 4 experiments.

Similar to STOMP, we did not find any phytotoxicity to sweet corn from BLADEX herbicide applied at 6 L/ha (Fig. 12). The optimum rates for pre-emergence application appeared to be about 3 L/ha, which controlled sowthistle, pigweed, giant pigweed, deadnettle and dinebra grass.

DUAL (metolachlor) is registered for weed management in sweet corn, at up to 4 L/ha. In our experience, DUAL was did not damage sweet corn when used at the maximum registered rate (4 L/ha), however at 6 L/ha there were occasionally significant yield reductions (Fig. 12). The DUAL registration label indicates control of mainly grass species. In sweet corn experiments we found it effective against dinebra grass and pigweed, with reasonable suppression of giant pigweed. In other crops, it also controlled deadnettle, shepherd's purse, bittercress, blackberry nightshade, slender celery and some amaranthus spp., with 80-90% suppression of sowthistle, potato weed and chickweed (Figs. 8-9).

Addition of 2 L/ha of ATRAZINE (500 g/L atrazine) to any of the above herbicides did not improve weed control. It appears that the only way to effectively use low rates of atrazine would be to band spray higher concentrations, cross cultivating after harvest to dilute atrazine residues for following crops. There were no weed management advantages of either linuron or terbutylazine over the previously mentioned herbicides, in terms of weeds controlled, residual activity or cost-effectiveness. We did not pursue research with these products.

Given that neither STOMP, DUAL nor BLADEX control bellvine, we needed to develop a method of controlling this important weed in sweet corn, without the option of hormone-type herbicides. We evaluated BASAGRAN (bentazone) in 3 experiments, with no evidence of any phytotoxicity to sweet corn (Fig. 12). Whilst BASAGRAN will effectively control bellvine, its high cost would limit its use to emergency/salvage operations.

Producers are currently less concerned with weed management in sweet corn than they were at the commencement of the project. Growers in the Lockyer Valley are achieving reasonable weed control with combinations of DUAL and mechanical cultivation. As most sweet corn in Queensland is grown during early summer, when grass weeds predominate, this is probably sufficient. However, with the development of new sweet corn cultivars that can markedly extend the growing season into late autumn, broadleaf weeds may become more important. There is also the problem of weed species not controlled by DUAL becoming more frequent with repeated use of the same herbicide. For these reasons it would be desirable for STOMP and/or BLADEX to also be available for sweet corn producers. At this time, registration for either herbicide in sweet corn is not likely in the near future, due to commercial considerations.

Green peas.

During the course of this project, we investigated herbicides for post-sowing, pre-emergence application, including STOMP (pendimethalin), SENCOR (metribuzin), GESAGARD (prometryn), BLADEX (cyanazine) and IGRAN (terbutryn). We also tested post-emergence applications of BLADEX, GESAGARD, SENCOR, IGRAN, BASAGRAN (bentazone), TRIBUNIL (methabenzthiazuron) and BRODAL (diflufenican).

Where we used STOMP post-sowing, pre-emergence in green peas, we occasionally got symptoms of crop phytotoxicity at rates of 4-5 L/ha. Damage included leaf chlorosis and crop stunting. However, these symptoms disappeared as the crop progressed, with no deleterious effects on pea yields, as shown in Fig. 13. From our experimental work, the optimum rate for STOMP application in peas is probably around 3 L/ha. In our experiments, this generally provided sufficient weed control to maximise pea yields, minimising populations of weeds such as sowthistle, deadnettle, fat hen. Other weeds controlled at this rate are mentioned in the section on brassicas. Unfortunately, STOMP will not control species such as blackberry nightshade, burr medic or spiny emex, which can be key weeds in processing peas. In such situations, a post-emergence herbicide would also be required.

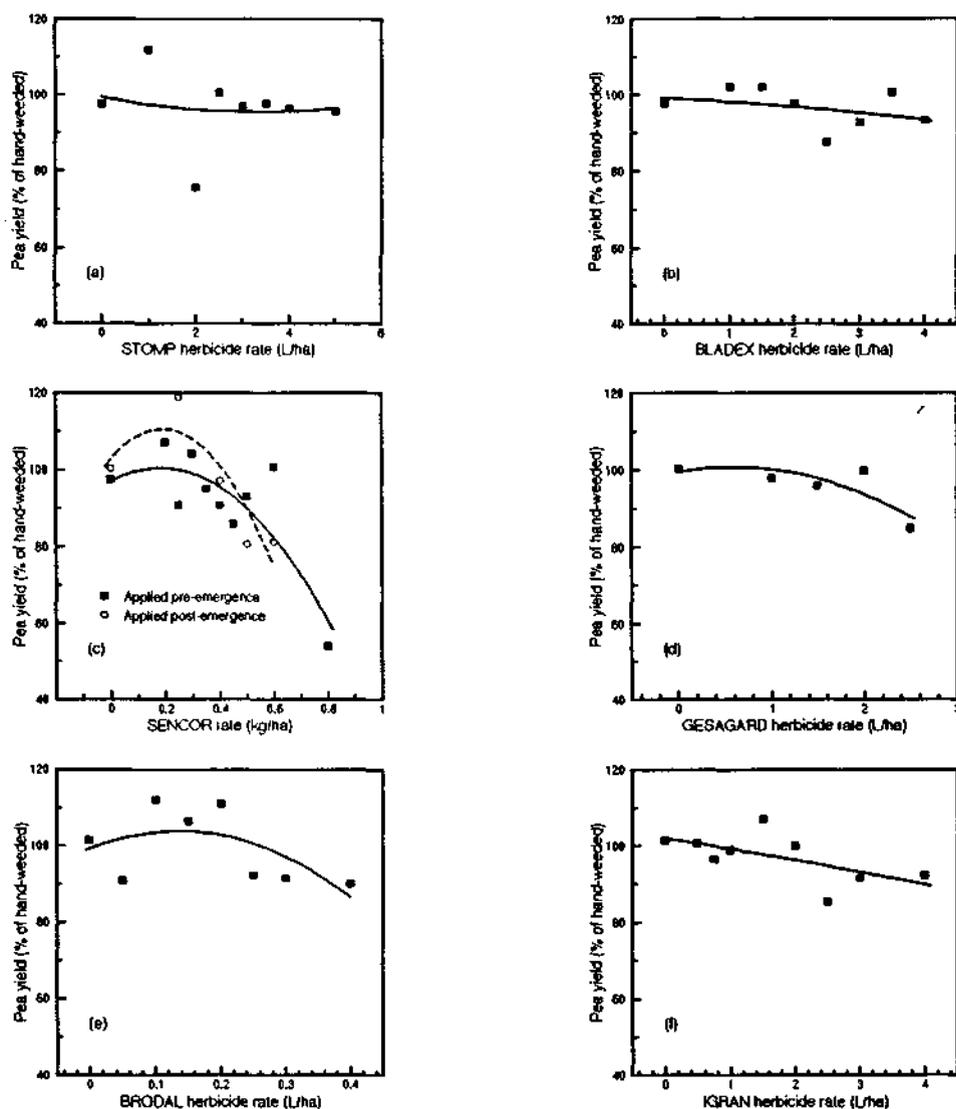


Figure 13. The mean effects of (a) STOMP, (b) SENCOR (applied pre and post-emergence), (c) BLADEX, herbicides applied pre-emergence; and (d) GESAGARD, (e) BRODAL and (f) IGRAN herbicides applied post-emergence, on pea yields, evaluated over 6 experiments.

Where SENCOR was used pre-emergence, there were consistent instances of crop damage where 0.4 kg/ha was used. Symptoms included reduced plant populations, chlorosis and stunting. Where more than 0.6 kg/ha was applied, early crop phytotoxicity was carried through to reductions in pea yields (Fig. 13). At 0.3-0.4 kg/ha, SENCOR gave 95% control of sowthistle and deadnettle in our experiments. The registration label also suggests control of weed species such as shepherd's purse, fat hen, spiny emex, wireweed, chickweed, nettles and wild radish. Generally, SENCOR will not control blackberry nightshade. Producers should not rely on a pre-emergence application of SENCOR for weed management; a follow up post-emergence spray may also be required.

Weed control may be reduced in dry conditions, due to poor herbicide uptake by the target species. Even at 0.3-0.4 kg/ha, there may be a risk of crop phytotoxicity where conditions for pea growth are sub-optimal, e.g. cold or waterlogged.

BLADEX can be applied to peas post-sowing, pre-emergence. At rates up to 4 L/ha, there were no significant symptoms of crop damage or yield reductions in our research (Fig. 13). Spraying 3-4 L/ha prevented sowthistle emergence, and gave around 80% suppression of deadnettle and blackberry nightshade. It was not particularly effective against fat hen. Using this herbicide pre-emergence is probably less effective than a post-emergence application (discussed later).

Although post-sowing, pre-emergence spraying of 2 L/ha of GESAGARD or 1.5 L/ha of IGRAN did not cause any damage to the emerging pea plants, these rates were also ineffective against sowthistle and deadnettle. Given the superior weed efficacy of other pre-emergence products in green peas, we did not continue pre-emergence research with these herbicides after 1990.

SENCOR is a very useful post-emergence herbicide in green peas, and is commonly used in southern Queensland. Although SENCOR was registered at rates of up to 0.75 kg/ha (525 g/ha active metribuzin), we generally found unacceptable damage to peas when more than 0.4 kg/ha (280 g/ha active metribuzin) was applied. The average pea yield responses to post-emergence spraying of SENCOR during our research is shown in Fig. 13. Even 0.4 kg/ha of SENCOR caused initial stunting of the pea plants, however they had recovered by flowering. At 0.25-0.3 kg/ha, we found SENCOR killed 90-100% of sowthistle, deadnettle, fat hen, shepherd's purse, chickweed and pigweed. It also occasionally killed blackberry nightshade, however this control was inconsistent.

In our experiments BLADEX applied post-emergence did not cause any damage to peas at rates up to 5.5 L/ha. At 2-2.5 L/ha, we found BLADEX killed chickweed, deadnettle and shepherd's purse. Contrary to the registration label, we noted poor control of sowthistle, even at 4 L/ha. In southern Queensland, BLADEX is commonly used in combination with SENCOR in a post-emergence mixture, giving a broad spectrum of weed control. Although below label rates, producer experience is that 1.5-2 L/ha of BLADEX with 0.2-0.3 kg/ha of SENCOR gives effective control of most weeds important in green peas.

Where we used IGRAN as a post-emergence herbicide in green peas, we noted no crop damage at rates up to 2 L/ha, with some minor yields reductions at 2.5-4 L/ha (Fig. 13). IGRAN is not registered for any crop in Queensland, however it is used extensively in green peas overseas, and is registered for use in Tasmania. It is registered for use in cereal crops in the southern states of Australia. Ciba Australia P/L suggested it caused too much damage to cereal crops for registration in Queensland. In our experimental work, 1 L/ha of IGRAN gave complete control of blackberry nightshade, deadnettle, sowthistle, fat hen, bittercress and pigweed. This herbicide treatment killed relatively old weeds, e.g. blackberry nightshade with 4-6 true leaves.

GESAGARD has an approval in Queensland for post-emergence use at 1 L/ha in peas. We found significant crop stunting at 1.5 L/ha, although yield reductions were up to

2 L/ha were sprayed were only minor, as shown in Fig. 13 (note that maturity was delayed by several days). Pea growers have experienced more severe damage on lighter textured soils. Producers using this product in peas would need to be relatively precise with their application rates, ensuring the approved 1 L/ha rate was not exceeded. At this rate, we found GESAGARD gave 80-90% control of chickweed, fat hen, blackberry nightshade, with slightly poorer suppression of shepherd's purse, deadnettle and sowthistle. GESAGARD would rarely be included in a post-emergence mixture because of the increased risk of crop damage.

In our experiments in peas, BASAGRAN did not cause any crop damage at rates up to 3.5 L/ha; peas appear very tolerant of this herbicide. At 1.5-2 L/ha, BASAGRAN controlled sowthistle, chickweed and shepherd's purse, whilst giving 80-90% suppression of deadnettle, amaranthus and fat hen. Although used overseas, BASAGRAN is not registered for peas in Australia; given the number of post-emergence products already available, commercial considerations mean that such a registration is unlikely in the foreseeable future.

There was some suggestion of BRODAL phytotoxicity (albeit relatively minor) in green peas when sprayed at more than 0.2 L/ha (Fig. 13). Symptoms of BRODAL damage were bleaching of leaves, accompanied by overall plant stunting. At 0.15-2 L/ha, BRODAL gave 80-85% suppression of deadnettle and fat hen, with some effects on sowthistle and amaranthus spp. Given its restricted weed spectrum compared to other post-emergence products in green peas, registration of BRODAL in this crop would not be a priority of either the responsible chemical company or pea producers at this time.

We only evaluated TRIBUNIL in green peas in 1 experiment. We found no significant crop damage at rates of 2 kg/ha; 2.5 times the maximum registered rate. Where 0.8 kg/ha was sprayed, we noted control of chickweed, shepherd's purse and deadnettle, with no effect on sowthistle. TRIBUNIL is also registered to control other weeds. In the course of this project, TRIBUNIL became re-registered for use in green peas. Because of its cost relative to other products, and its need to be sprayed when weeds are very young, it is unlikely to often be used in green peas.

Green peas are grown for both processing and fresh market, with relatively low gross margins compared with other vegetable crops. With the registration of BLADEX for green peas (partially as a result of the work from this project), weed management currently consists of a post-emergence spray when the peas have 3-7 nodes. The post-emergence spray generally comprises 1.5-2 L/ha of BLADEX with either 0.3-0.45 L/ha SENCOR or 2.5-3 L/ha TROPOTOX (MCPB). The herbicide costs of such applications are around \$42-60 for either mixture. Generally, BLADEX/SENCOR mixtures are preferred where blackberry nightshade, burr medic or spiny emex are a problem, using the higher rates where large numbers or older weeds are present. The BLADEX/MCPB mixtures are more effective on thistle type weeds.

If a registration or approval for the use of IGRAN in peas in Queensland could be obtained, this has the potential to dramatically reduce weed control costs. At \$ 12 per L, a post-emergence spray would cost \$ 8-12/ha at the recommended rate. This may give sufficient weed control in many situations; a 70-80% cost saving. In situations where

grasses a problem, a pre-emergence application of 2-3 L/ha of STOMP, or a post-emergence application of a grass herbicide would still mean lower costs than the current post-emergence treatments. In some situations, the pre-emergence STOMP treatment, at \$ 22-33/ha may also be sufficient. We are still discussing the options for obtaining approval to use IGRAN in Queensland with the relevant chemical companies and registration authorities.

Acknowledgments.

I wish to gratefully acknowledge the generous financial support from the Vegetable and Heavy Vegetable Sectional Groups of the Queensland Fruit and Vegetable Growers, and the Horticultural Research and Development Corporation. The Queensland Department of Primary Industries provided my salary and 50% of my experimentalist's salary for the duration of the project. Special thanks to those producers who participated in various parts of the project; Barry Peach, Geoff Storey, Craig Wilson, Ray Hawley, John Brent, Howard Poole, Chris Sweet, John Baronio, Percy Bichel, Peter Buchanan. I would also be remiss not to thank representatives from the various chemical companies who assisted the project by supplying products and technical information. Special mention is due to Glen Tucker (Incitec) and Kevin Bodnaruk (Ciba Australia). I would particularly like to express my appreciation to my co-worker Mick Webber, for his valuable contributions in the field, with spray equipment and on the computer, in often arduous and uncomfortable conditions.

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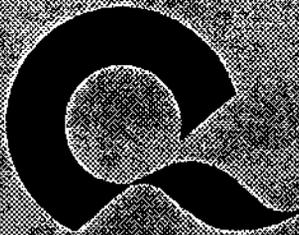
INDIVIDUAL EXPERIMENT SUMMARIES

LETTUCE	Toowoomba	\$8901.05
.	Gatton R.S.	\$8901.10
.	Gatton R.S.	\$8901.14
.	Stanthorpe	\$8901.23
.	Gatton R.S.	\$8901.28
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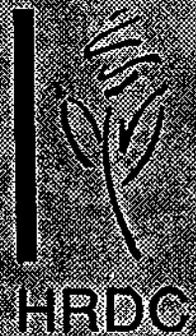
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CABBAGE	Redlands	\$8901.04
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CAULIFLOWER	Gatton R.S.	\$8901.40
.	Gatton R.S.	P376.11



Queensland Fruit and
Vegetable Growers



EXPERIMENT REPORT

1. Report Final Date of Report: 1-1-91
Initiation Date: 14-8-90 Completion Date: 30-10-90

Project Number: S8901

Project Title: Weed control in vegetables.

Experiment Number: S8901.14

Officers Responsible: Craig Henderson/Mick Webber

Experiment Title: Pre-emergence herbicides in lettuce.

2. Experiment Objectives

To investigate the efficacy and phytotoxicity of mixtures of 4 pre-emergence herbicides for broadleaf weed control in lettuce.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from September-October 1990. The lettuce (cv. *Yatesdale*) were grown using standard agronomy, with 15 treatments replicated 4 times in blocks. Plots were 1 bed (1.4 m) wide and 5 m long, with 2 rows of lettuce per bed. The herbicides tested included pendimethalin (STOMP), metolachlor (DUAL), propachlor (RAMROD), and oxadiazon (RONSTAR), at a range of application rates. All the herbicides were applied before transplanting. Weed counts and crop ratings were conducted during the growing season; yields were also measured. RONSTAR gave poor weed control, which may have been due to application technique, however it is not intended to continue research with this herbicide. As in other experiments, the optimum rate for STOMP application appeared to be 4-4.5 L/ha. This rate gave effective control of *Stellaria media*, *Lamium amplexicaule* and *Capsella bursapastoris*, whilst giving useful suppression of *Sonchus oleraceus* and *Solanum nigrum*. STOMP at 5 L/ha caused minor initial lettuce phytotoxicity, however final yield was not affected. In contrast with previous experiments, RAMROD at 6 L/ha caused significant crop damage, which was greater at higher rates of application. The advantage of this herbicide was its control of *Galinsoga parviflora* in addition to suppression of *S. oleraceus* and to a lesser extent *S. media*. RAMROD would be used as part of a mixture, rather than as the sole pre-emergence herbicide. DUAL at 2 L/ha also only gave partial suppression of the weeds present. At 4 L/ha the control was improved, however there was also noticeable crop phytotoxicity. At this stage it is felt that the margins between weed control and crop safety may be too close to enable the use of DUAL on lettuce in Queensland. It is intended to continue generating data to investigate the potential for registration of STOMP and RAMROD for use in lettuce. Probable pre-emergence mixtures in black earth soils would be 4.5 L/ha of STOMP with about 4.5 L/ha of RAMROD.

EXPERIMENT REPORT

1. Report Final Date of Report: 26-3-91
Initiation Date: 4-1-91 Completion Date: 12-2-910

Project Number: S8901

Project Title: Weed control in vegetables.

Experiment Number: S8901.23

Officers Responsible: Craig Henderson/Mick Webber

Experiment Title: Pre-emergence herbicides for lettuce on sandy soils.

2. Experiment Objectives

To investigate the efficacy and phytotoxicity of pendimethalin (STOMP) and propachlor (RAMROD) used pre-emergence in transplanted lettuce, with particular note of the responses on sandy soils.

3. Summary of Results

The experiment was conducted on the property of Mr H. Poole at Bapaume near Stanthorpe, from January to February 1991. Lettuce was grown using standard agronomy, with 12 treatments replicated 3 times in a RCB design. Plots were 5 rows (1.75 m) wide and 5 m long, with a total experimental area of 0.035 ha. The herbicides were applied 1 day after transplanting, with 2 assessments of weed densities and crop damage during the growing season. Due to adverse weed conditions in some plots, the grower ploughed in the lettuce prior to harvesting. Application of STOMP after transplanting caused damage to the lettuce, although the plants sprayed with less than 4 L/ha had recovered by 33 days after spraying. STOMP at 3 L/ha controlled *Eleusine indica*, *Chenopodium album* and *Stellaria media*. Application of RAMROD at 8 L/ha did not affect the lettuce, but gave only minor suppression of the weeds. A similar experiment will be repeated at this site in Spring 1991.

EXPERIMENT REPORT

1. Report Final Date of Report: 1-1-91
Initiation Date: 20-2-90 Completion Date: 21-8-90

Project Number: S8901

Project Title: Weed control in vegetables.

Experiment Number: S8901.26 Officers Responsible: Craig Henderson

Experiment Title: Herbicide phytotoxicity in brassicas.

2. Experiment Objectives

To investigate the efficacy and phytotoxicity of pre-emergence herbicides for broadleaf weed control in broccoli and cabbage.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from May-August 1990. Broccoli (cv. *Pacific* and *Shogun*) and cabbage (cv. *Hurricane*) were grown using standard agronomy, with 10 herbicide treatments replicated twice. Plots were one bed wide (1.4 m) and 5 m long, with two rows per bed. The herbicides used included pendimethalin (STOMP), oxyfluorfen (GOAL) and prometryn (GESAGARD), at a range of application rates. All the herbicides were applied prior to transplanting. Weed counts and crop ratings were conducted during the growing season, and yields were also measured. GOAL effectively controlled *Sonchus oleraceus*, *Apium leptophyllum*, *Coronopus didymus* and *Lamium amplexicaule*, at an application rate of 2 L/ha. There was no phytotoxicity with either the broccoli or cabbage at that rate of application. At 4 L/ha, there was significant yield reduction in the cabbage, with slight early growth reductions in the broccoli (not reflected in final yields). A low volatile formulation of oxyfluorfen performed similarly to the standard formulation. It is probable that 1-1.5 L/ha of GOAL would form the base of a pre-emergence herbicide mixture for use in brassicas. At 1.5 L/ha, GESAGARD effectively controlled *C. didymus* and *L. amplexicaule*, with some suppression of *S. oleraceus*. However, it had little effect on *A. leptophyllum*. At this rate of application, GESAGARD caused severe damage to both broccoli and cabbage. This product should not be used pre-transplanting in either crop. STOMP applied at 5 L/ha effectively controlled *C. didymus* and *L. amplexicaule*, while giving some suppression of *S. oleraceus* and *A. leptophyllum*. This application rate caused significant early damage to the broccoli, although the yields were not significantly lower than from the hand weeded areas. The cv. *Shogun* appeared more tolerant than did *Pacific*. The cabbage was more sensitive to this herbicide, with substantial reductions in yield at 5 L/ha. It is intended to assist in generating data to enable the registration of both GOAL and STOMP for use in brassicas. These experimental results should form the basis of both scientific journal and extension articles in the future.

EXPERIMENT REPORT

1. **Report** Final **Date of Report:** 14/5/91
Initiation Date: 4/1/91 **Completion Date:** 26/4/91
Project Number: S8901
Project Title: Weed control in vegetables
Experiment Number: S8901.24 **Officer Responsible:** Craig Henderson
Experiment Title: Pre-emergence herbicides for broccoli on sandy soils.

2. Experiment Objectives

To investigate the efficacy and phytotoxicity of oxyfluorfen (GOAL), pendimethalin (STOMP), metolachlor (DUAL) and propachlor (RAMROD) used pre-emergence in transplanted broccoli, with particular note of the responses on sandy soils.

3. Summary of Results

The experiment was conducted on the property of Mr G. Widderick at Cottonvale near Stanthorpe, from January to April 1991. Broccoli was grown using standard agronomy, with 13 treatments replicated 3 times in a RCB design. Plots were 2 rows (1.5 m) wide and 5 m long, with a total experimental area of 0.035 ha. The herbicides were applied 1 day after transplanting, with 3 assessments of weed densities and crop damage during the growing season. Application of STOMP caused initial damage to the broccoli, however the plants appeared to recover. Neither DUAL nor RAMROD caused significant crop damage. Plots treated with STOMP alone were overrun by *Galinsoga parviflora* (yellow weed), although there was an initial indication that 4 L/ha controlled *Portulaca oleracea* (pigweed). RAMROD gave moderate suppression of *G. parviflora*, however the plots were overrun by *P. oleracea*. Application of DUAL at 4 L/ha gave reasonable early weed control, however late germinations of both weed species mentioned previously were substantial. GOAL was the most effective herbicide, although there were still sufficient weeds to cause harvesting problems, particularly *G. parviflora* and *Capsella bursa-pastoris* (shepherd's purse). Increasing the rate of GOAL application above 1 L/ha did not improve weed kill, but appeared to reduce weed competitiveness in this experiment. Plots treated with GOAL or RAMROD yielded equivalent or better than the hand weeded areas, indicating few problems with crop phytotoxicity. Yields where DUAL was applied were slightly lower, suggesting a possible phytotoxic effect, with poor weed control at the lower application rate. Broccoli production from the STOMP treated plots was the lowest in the experiment, due to poor weed control as well as crop damage. It is apparent that STOMP can only be applied prior to transplanting. It is hoped to conduct a similar experiment in the Granite Belt area in Spring of 1991.

EXPERIMENT REPORT

1. Report Final Date of Report: 24-1-94
Initiation Date: 2-6-92 Completion Date: 28-8-92

Project Number: S8901

Project Title: Weed control in vegetables.

Experiment Number: S8901.39

Officers Responsible: Craig Henderson/Mick Webber

Experiment Title: Efficacy and phytotoxicity of herbicides across 4 broccoli cultivars.

2. Experiment Objectives

To determine the efficacy and phytotoxicity of herbicides with potential for use in broccoli, across a range of cultivars.

3. Summary of Results

The experiment was conducted at GRS, June-August 1992. STOMP, RAMROD, DUAL and GOAL herbicides were sprayed over a broccoli crop consisting of the cultivars *Greenbelt*, *Dominator*, *Marathon* and *Shogun*. The experiment design was a split-plot with the 4 cultivars as main plots and 15 herbicide treatments as sub-plots, replicated in 2 blocks. Each plot was one bed wide (1.5 m) wide x 5 m long with 2 rows of broccoli per bed, giving a total population of around 40 000 broccoli/ha. Herbicides were applied pre-transplant, post-transplant and 1 treatment as a post-emergence mixture. Weed counts were carried out during the growing period. The broccoli were hand harvested and determination of number of broccoli per hectare, diameter, diameter variability, yield and mean head weight was carried out. STOMP at 2 L/ha controlled deadnettle, bittercress and fathen. STOMP applied at 2.5-3 L/ha reduced overall broccoli growth. These rates of STOMP also set back maturity in the cultivars *Dominator* and *Shogun*. All application rates of RAMROD (6-12 L/ha) controlled the weeds present. RAMROD did not affect broccoli plant height, head yield nor quality. DUAL at all application rates (3-4 L/ha) controlled sowthistle, deadnettle, bittercress and shepherds purse. It did not reduce broccoli plant height. Maturity was unaffected across the range of cultivars. GOAL controlled all weed species present and overall broccoli plant height was unaffected across all herbicide rates (1-2 L/ha). Broccoli maturity was also unaffected across cultivars. The GOAL (0.3 L/ha)/DUAL (3 L/ha) mixture controlled sowthistle, shepherds purse, and fathen. *Dominator* and *Shogun* broccoli cultivars exhibited a minor trend of height reduction for this post-transplant mixture, however maturity across cultivars was unaffected. The range of herbicides used in this experiment had no effect on the total number of marketable broccoli heads. *Greenbelt* produced the most marketable heads and the largest mean diameter, albeit with the highest diameter variability. The highest yielding cultivar was *Marathon*, which also produced the highest mean head weight.

EXPERIMENT REPORT

1. Report Final Date of Report: 1-1-91
Initiation Date: 6-11-89 Completion Date: 5-4-90
Project Number: S8901
Project Title: Weed control in vegetables
Experiment Number: S8901.04 Officer Responsible: Craig Henderson
Experiment Title: Broadleaf weed control in cabbage.

2. Experiment Objectives

To investigate the efficacy and phytotoxicity of 6 herbicides with potential for broadleaf weed control in cabbage.

3. Summary of Results

The experiment was conducted on the property of Mr Craig Wilson at Redland Bay, from the 5/1/90 to 5/4/90. The cabbage were grown using standard agronomy, with the pre-emergence herbicides DUAL (metolachlor), RAMROD (propachlor), STOMP (pendimethalin) or GOAL (oxyfluorfen) applied before transplanting, while GESAGARD (prometryn) or CASURON (dichlobenil) were applied about 2 weeks after transplanting). Weed counts and crop ratings were conducted during the growing season; yields were also measured.

The GOAL treatments were most successful, with excellent weed control and no significant crop phytotoxicity, resulting in high yields. DUAL controlled most weed species except *Chenopodium murale*, but caused significant damage to the cabbage at rates greater than 2 L/ha. RAMROD gave good weed control, however numbers of *C. murale* and *Nicandra physalodes* were still present. Likewise STOMP did not affect *Galinsoga parviflora*. GESAGARD resulted in excellent weed control, however crop damage was also severe, even though there was substantial recovery by the time of harvest. CASURON was ineffective against most weeds. Mixtures of GOAL, RAMROD, STOMP and DUAL will be further investigated at GRS during the winter. The results should lead to registration of at least some herbicides for use in cabbage. The research will be submitted for publication in a scientific journal.

EXPERIMENT REPORT

1. Report Final Date of Report: 30-1-91
Initiation Date: 14-8-90 Completion Date: 20-12-90
Project Number: S8901
Project Title: Weed control in vegetables
Experiment Number: S8901.15 Officer Responsible: Craig Henderson
Experiment Title: Phytotoxicity of pre-emergence herbicides on
cabbage and cauliflower

2. Experiment Objectives

To investigate the efficacy and phytotoxicity of pre-emergence herbicides with potential for controlling broadleaf weeds in brassicas.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from September-December 1990. The design was a split-plot, with brassica cultivar main plots and weed control treatment subplots. The brassica cultivars were cabbage (cv. *Venturer* and *Hurricane*) and cauliflower (cv. *Bountiful*), grown using standard agronomy. Plots were 1 bed wide (1.4 m) and 5 m long, with 2 rows per bed. The herbicides tested included pendimethalin (STOMP), propachlor (RAMROD), metolachlor (DUAL) and oxyfluorfen (GOAL), at a range of application rates. All the herbicides were applied prior to transplanting. Weed counts and crop ratings were conducted during the growing season; yields were also measured.

GOAL gave good control of *Galinsoga parviflora*, *Lamium amplexicaule*, *Capsella bursa-pastoris*, *Sonchus oleraceus*, *Solanum nigrum* and *Coronopus didymus* at application rates of 1-2 L/ha. There was no crop damage from this herbicide.

STOMP applied at 3 L/ha gave effective control of *C. didymus*, *L. amplexicaule* and *Capsella bursa-pastoris*, with useful suppression of *Sonchus oleraceus*. Even at this low rate of application there were minor growth and yield reductions in the cabbage, although the cauliflower appeared more tolerant. At application rates of 6 L/ha or above, there was substantial phytotoxicity in the cabbage, and some damage to the cauliflower.

Application of DUAL and RAMROD at rates of 3 or 8 L/ha respectively controlled *G. parviflora*, *L. amplexicaule*, *C. bursa-pastoris* and *C. didymus*. There were no effects of RAMROD on the growth or yield of the brassicas, however there were some minor effects from DUAL application.

EXPERIMENT REPORT

1. Report Final Date of Report: 25-2-94
Initiation Date: 16-4-91 Completion Date: 30-7-91

Project Number: S8901

Project Title: Weed control in vegetables.

Experiment Number: S8901.27

Officers Responsible: Craig Henderson/Mick Webber

Experiment Title: Efficacy and phytotoxicity of pre-emergence herbicides in autumn cabbage.

2. Experiment Objectives

To determine the effects of rates and application times on the efficacy and phytotoxicity of pre-emergence herbicides in autumn-grown cabbage.

3. Summary of Results

The experiment was conducted at GRS, April-July 1991. STOMP, RAMROD, GOAL and DUAL herbicides were sprayed before or after transplanting a cabbage crop. The experiment design was a randomised complete block of 60 plots, consisting of 30 treatments replicated twice in blocks. Each plot was one bed wide (1.5 m) wide x 5 m long, with 2 rows of cabbage per bed, giving a total population of around 20 000 cabbage/ha. During the growing period, weed counts were carried out and cabbage plant heights and diameters measured. Cabbage were hand harvested to determine yields. STOMP at 4-5 L/ha suppressed sowthistle. Sowthistle was controlled by 3 L/ha applied post-transplant. Pre-transplant STOMP reduced cabbage plant heights and diameters at 3-5 L/ha, while post-transplant, 3 L/ha of STOMP was sufficient to reduce growth. Pre-transplant GOAL rates of 1.5-3 L/ha and post-transplant GOAL at 0.5 L/ha controlled sowthistle. The GOAL treatments did not affect cabbage yields. DUAL applied 3.5 L/ha pre-transplant gave some suppression of sowthistle. The same rate post-transplant was not effective against sowthistle. Pre-transplant DUAL reduced cabbage heights and diameters at 3.5-4 L/ha. The post-transplant, 3.5 L/ha DUAL treatment did not affect cabbage production. Pre-transplant RAMROD rates of 6-10 L/ha gave some suppression of sowthistle. Suppression of sowthistle was achieved with 7 L/ha RAMROD post-transplant. No RAMROD treatment adversely affected cabbage production. High weed numbers complicated the investigation of herbicide phytotoxicity to cabbage.

EXPERIMENT REPORT

1. Report Final Date of Report: 8-3-94
Initiation Date: 20-6-91 Completion Date: 9-10-91

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.30

Officer Responsible: Craig Henderson/Mick Webber

Experiment Title: Efficacy and phytotoxicity of pre-emergence herbicides in autumn cabbage.

2. Experiment Objectives

To investigate the effects of rate and application timing on the efficacy and phytotoxicity of pre-emergence herbicides in winter-sown cabbage.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from April 1991 to July 1991. Cabbage (cv. *Stariha*,) were grown using standard agronomy, with 26 weed control treatments replicated twice in a RCB design. Plots were 1 bed (1.5 m) wide and 5 m long, with a total experimental area, including buffer zones, of 0.045 ha. The herbicides were applied immediately before and after transplanting, with weed counts and crop growth assessments during the growing period. The cabbage were harvested early in October.

Pre-transplant STOMP at 4-5 L/ha controlled sowthistle and bittercress. This herbicide significantly reduced cabbage growth at 3 L/ha, with yield reductions (mainly due to smaller heads) at 4 L/ha. GOAL applied pre-transplant controlled sowthistle at 1 L/ha and bittercress at 0.5 L/ha. GOAL sprayed after transplanting controlled sowthistle and bittercress at 0.15-0.3 L/ha. DUAL applied post-transplant controlled sowthistle at 3-4 L/ha and bittercress at 1.5-2 L/ha. Post-transplant RAMROD controlled sowthistle and bittercress at rates of 7-10 L/ha. DACTHAL at 15 kg/ha after transplanting controlled both sowthistle and bittercress. Neither GOAL (3 L/ha), DUAL (4 L/ha), RAMROD (10 L/ha) nor DACTHAL (15 kg/ha) adversely affected cabbage yields at the highest rates tested.

EXPERIMENT REPORT

1. Report Final Date of Report: 7-1-94
Initiation Date: 10-4-92 Completion Date: 23-7-92

Project Number: S8901

Project Title: Weed control in vegetables.

Experiment Number: S8901.38 Officer Responsible: Craig Henderson

Experiment Title: Efficacy and phytotoxicity of herbicides across 4 cabbage cultivars.

2. Experiment Objectives

To determine the efficacy and phytotoxicity of herbicides with potential for use in cabbage, across a range of cultivars.

3. Summary of Results

The experiment was conducted at GRS, April-July 1992. STOMP, RAMROD, DUAL and GOAL herbicides were sprayed over a cabbage crop consisting of the varieties *Stariha*, *Green Coronet*, *Neptune* and *Kameron*. The experiment design was a split-plot with the 4 cultivars as main plots and 15 herbicide treatments as sub-plots, replicated in 2 blocks. Each plot was one bed wide (1.5 m) wide x 5 m long with 2 rows of cabbage per bed, giving a total population of around 20 000 cabbage/ha. Herbicides were applied pre-transplant, post-transplant and 1 treatment as a post-emergence mixture. Weed counts were carried out during the growing period. The cabbage were hand harvested and determination of growth rate, marketable cabbage, head weight and yield was carried out. STOMP at all application rates controlled deadnettle. STOMP applied at 2.5 L/ha significantly reduced the growth of *Kameron* while at 3 L/ha growth of both *Green Coronet* and *Kameron* was affected. STOMP at 3 L/ha caused an overall reduction in yield. RAMROD at all rates controlled potato weed and shepherds purse. RAMROD at up to 12 L/ha did not affect diameter nor yield of any of the cultivars. DUAL applied at all rates controlled bittercress, deadnettle, potato weed and shepherds purse. DUAL at 4 L/ha reduced initial growth of *Kameron* but did not reduce yields. GOAL at all rates controlled potato weed, shepherds purse and sowthistle. At 1.5 and 2 L/ha this herbicide reduced the diameters of *Kameron* but yield was unaffected. The mixture of GOAL and DUAL controlled potato weed and shepherds purse; it also reduced the diameters of *Green Coronet* and *Kameron* and significantly reduced yields in *Stariha* and *Green Coronet*. Overall, *Kameron* was initially the most affected over the range of herbicides as regards to plant diameter; *Stariha* had the most overall yield reductions over the range of herbicides tested. The post-transplant GOAL treatment (and possibly 3 L/ha of STOMP pre-transplant), despite having a favourable weed spectrum, exhibited minor detrimental effects to the cabbage cultivars used in this experiment.

EXPERIMENT REPORT

1. Report Final Date of Report: 18-3-94
Initiation Date: 28-4-93 Completion Date: 28-7-93

Project Number: P376

Project Title: Weed control in vegetables.

Experiment Number: P376.10

Officer Responsible: Craig Henderson/Mick Webber

Experiment Title: Efficacy and phytotoxicity of pre-emergence herbicides in autumn cabbage.

2. Experiment Objectives

To demonstrate the efficacy and phytotoxicity of herbicides with potential for use in cabbage.

3. Summary of Results

The experiment was conducted at GRS, April-July 1993. STOMP, RAMROD, GOAL and DUAL herbicides were sprayed before or after transplanting a cabbage crop. The experiment contained 10 plots, with 5 treatments replicated twice in blocks. Each block was 3 beds wide (4.5 m) X 5 m long, with 2 rows of cabbage per bed, giving a total population of around 20,000 cabbage/ha. Cabbage were hand harvested to determine yields. Pre-emergence / post-transplant application of DUAL at 3.5 L/ha significantly affected cabbage yield, reducing individual head weights. Pre-transplant STOMP at 3 L/ha was more severe on cabbage yield, significantly reducing the number and size of cabbage heads harvested.

EXPERIMENT REPORT

1. Report Final Date of Report: 18-3-94

Initiation Date: 28-4-93 Completion Date: 2-8-93

Project Number: P376

Project Title: Weed control in vegetables.

Experiment Number: P376.11

Officer Responsible: Craig Henderson/Mick Webber

Experiment Title: Efficacy and phytotoxicity of pre-emergence herbicides in autumn cauliflower.

2. Experiment Objectives

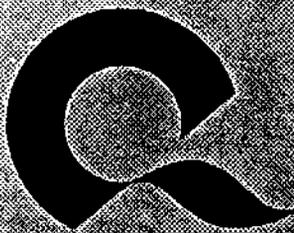
To demonstrate the efficacy and phytotoxicity of herbicides with potential for use in cauliflower.

3. Summary of Results

The experiment was conducted at GRS, April-August 1993. STOMP, RAMROD, GOAL and DUAL herbicides were sprayed before or after transplanting a cauliflower crop. The experiment contained 10 plots, with 5 treatments replicated twice in blocks. Each block was 3 beds wide (4.5 m) X 5 m long, with 2 rows of cauliflower per bed, giving a total population of around 20,000 broccoli/ha. Cauliflower were hand harvested to determine yields. Pre-transplant herbicide treatments of GOAL at 1.5 L/ha, STOMP at 2 or 3 L/ha, and the post-transplant application of DUAL at 3.5 L/ha or RAMROD at 8 L/ha did not adversely affect cauliflower growth nor yields.

INDIVIDUAL EXPERIMENT SUMMARIES

GREEN BEANS	Gatton R.S.	S8901.16
*	Gympie	S8901.17
*	Gatton R.S.	S8901.18
*	Gatton R.S.	S8901.25
*	Gatton R.S.	S8901.34
*	Gatton R.S.	S8901.36
*	Gatton R.S.	P376.01
*	Gatton R.S.	P376.07
BEETROOT	Forest Hill	S8901.12
*	Fassifern	S8901.21
*	Gatton R.S.	S8901.33
*	Gatton R.S.	S8901.42
GREEN PEAS	Glencire Groves	S8901.00
*	Gatton R.S.	S8901.07
*	Gatton R.S.	S8901.13
*	Gatton R.S.	S8901.32
*	Coominya	IGRAN
*	Fassifern	IGRAN
SWEET CORN	Gatton R.S.	S8901.01
*	Gatton R.S.	S8901.19
*	Gatton R.S.	S8901.20
*	Gatton R.S.	S8901.35



Queensland Fruit and
Vegetable Growers



EXPERIMENT REPORT

1. Report Final Date of Report: 22-2-91
Initiation Date: 14-8-90 Completion Date: 28-12-90

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.16 Officer Responsible: Craig Henderson

Experiment Title: Phytotoxicity of pre-emergence herbicides on bean cultivars

2. Experiment Objectives

To investigate the phytotoxicity and efficacy of STOMP and DUAL herbicides for use in green beans, both fresh and processing.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from October 1990 to December 1990. Green beans (cv. *Labrador*, *Superstar* and *Bronco*) were grown using standard agronomy, with 9 weed control treatments replicated twice in a split plot design. Plots were 1 bed (1.7 m) wide and 10 m long, with a total experimental area, including buffer zones, of 0.09 ha. The herbicides were applied 2 days after planting, with weed counts and crop growth assessments about 3 weeks later. The beans were machine harvested 9 weeks after sowing. There were no significant treatment effects on bean establishment. Application of STOMP at 10 L/ha reduced bean growth and yield, however rates of 6 L/ha or less had no adverse effects. Effective control of *Sonchus oleraceus*, *Solanum nigrum* and *Portulaca oleracea* was achieved with 3 - 4 L/ha of this herbicide. Application of DUAL at 3 - 4 L/ha gave good control of the previously mentioned weed species. There were no consistent phytotoxic effects on the growth or yield of beans where up to 8 L/ha of Dual was applied.

EXPERIMENT REPORT

1. **Report** **Final**

Date of Report: 25-7-91

Initiation Date: 14-8-90

Completion Date: 24-5-91

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.17

Officer Responsible: Craig Henderson

Experiment Title: Pre-emergence herbicides for green beans in the Gympie area

2. **Experiment Objectives**

To investigate the efficacy and phytotoxicity of pre-emergence herbicides STOMP (pendimethalin) and DUAL (metolachlor) in an autumn bean crop in the Gympie area.

3. **Summary of Results**

The experiment was conducted on an alluvial sandy loam on the property of Mr Peter Buchanan at Goomborian, 25 km north-east of Gympie. The experimental design was a randomised complete block, with 7 weed control treatments replicated 4 times. Each plot was 1.7 m wide and 5 m long, with a total experimental area of about 0.03 ha. The bean crop was grown as per standard practice for the Gympie area, with appropriate fertiliser, irrigation and pest control technology. The herbicides were applied 1 day after sowing, with weed counts and crop growth assessments 15, 42 and 62 days after spraying. The yields of the beans were not determined, as pickers inadvertently harvested some beans from the experimental area.

Both STOMP and DUAL provided weed control when applied pre-emergence to green beans. STOMP at 4 L/ha gave effective, long term control, with only slight improvements at 8 L/ha. While 3 L/ha of DUAL gave good initial weed control, it appeared that after 7 weeks, insufficient herbicide remained in the soil to prevent late weed germinations. These late weeds may cause harvesting problems. The optimum DUAL application rate in this situation was probably 4 L/ha. Neither herbicide caused any phytotoxicity problems, even using 8 or 6 L/ha of STOMP or DUAL respectively. This observation only refers to bean plant growth; yield data would be required to confirm this judgement. It is essential that a similar experiment be repeated in this environment, in particular to determine the safety of STOMP under colder and/or wetter conditions.

EXPERIMENT REPORT

1. Report Final Date of Report: 27-2-91
Initiation Date: 14-8-90 Completion Date: 28-12-90

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.18 Officer Responsible: Craig Henderson

Experiment Title: Phytotoxicity and efficacy of herbicides with potential for use in green beans

2. Experiment Objectives

To investigate the phytotoxicity and efficacy of a range of herbicides with potential for use in green beans, both fresh and processing.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from October 1990 to December 1990. Green beans (*cv. Labrador*,) were grown using standard agronomy, with 18 weed control treatments replicated 3 times in an RCB design. Plots were 1 bed (1.7 m) wide and 10 m long, with a total experimental area, including buffer zones, of 0.09 ha. The herbicides were applied 21 days after planting, with weed counts and crop growth assessments about 5 days later. The beans were machine harvested 9 weeks after sowing. The herbicides SENCOR, GESAGARD, TRIBUNIL, GOAL, BLADEX and IGRAN killed the bean plants. BRODAL was partially selective, however it did cause some crop damage at the rates tested (0.2 - 0.4 L/ha), and did not control *Sonchus oleraceus* nor *Portulaca oleracea*. BLAZER did not have any phytotoxic effects when sprayed at 4 L/ha, and killed *S. oleraceus*, *P. oleracea* and *Solanum nigrum* at 2 L/ha. This herbicide could have potential for use in green beans, however at 2 L/ha its cost would be prohibitive. Both BLAZER and BRODAL will be investigated in future experiments.

EXPERIMENT REPORT

1. Report Final Date of Report: 13.9.91
Initiation Date: 25.1.91 Completion Date: 13.5.91

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.25 Officer Responsible: Craig Henderson

Experiment Title: The potential of the herbicides acifluorfen and diflufenican for post-emergence weed control in green beans

2. Experiment Objectives

To investigate the phytotoxicity and efficacy of the herbicides bentazone (BASAGRAN), acifluorfen (BLAZER) and diflufenican (BRODAL) in green beans.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from March 1991 to May 1991. Green beans (*cv. Labrador*,) were grown using standard agronomy, with 16 weed control treatments replicated 3 times in an RCB design. Plots were 1 bed (1.7 m) wide and 10 m long, with a total experimental area, including buffer zones, of 0.09 ha. The herbicides were applied 19 days after planting, with weed counts and crop growth assessments 15 days later. The beans were machine harvested 67 days after sowing. BASAGRAN at 1.5 L/ha completely controlled sowthistle, bittercress and an *amaranthus* sp., while suppressing deadnettle. Up to 2 L/ha was needed to effectively suppress the fat hen population. Application of 2 L/ha of BASAGRAN caused slight stunting of the bean plants 2 weeks after spraying, however there was no effect on the bean yields. Only 0.5 L/ha of BLAZER was needed to give maximum control of fat hen, bittercress and *amaranthus*, while giving good suppression of sowthistle. Increasing the rate to 1 L/ha eliminated the latter species, as well as effectively controlling the deadnettle population. There was a significant trend for crop damage where more than 2 L/ha was used, although bean yields were only significantly less on the areas sprayed with 6 L/ha of BLAZER. Application of 0.15 L/ha of BRODAL controlled deadnettle and possibly bittercress, however it only provided partial suppression of the other weed species present. There was little weed control advantage from increasing the application rate above this concentration. At 0.15 L/ha there were significant symptoms of leaf damage and stunting of the bean plants, however yields on the areas sprayed with 0.15-0.2 L/ha were equivalent to the highest yields in the experiment. Both BLAZER and BRODAL will be investigated in future experiments.

EXPERIMENT REPORT

1. Report Final Date of Report: 10-12-92
Initiation Date: 25-1-91 Completion Date: 10-12-91

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.34 Officer Responsible: Craig Henderson

Experiment Title: Herbicides for spring-grown green beans.

2. Experiment Objectives

To investigate the efficacy and phytotoxicity of several herbicides with potential for use in green beans.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from October to December 1991. Green beans (cv. *Superstar*) were grown using standard agronomy, with 38 weed control treatments replicated twice in a RCB design. Plots were 1.75 m wide and 10 m long, with a total experimental area of 0.15 ha. The pre and post-emergence herbicides were applied 1 and 22 days after planting respectively, with weed counts and crop growth assessments during the growing period. The beans were machine harvested in mid-December. *Trianthema portulacastrum* (Giant Pigweed) was controlled by 2 L/ha of STOMP (pendimethalin), 2.5 L/ha of DUAL (metolachlor) or 1.5 L/ha of BLADEX (cyanazine) applied immediately after sowing and incorporated with irrigation. The post-emergence treatments were sprayed when the weeds had 4-6 true leaves. BLAZER (acifluorfen) at 2 L/ha killed *T. portulacastrum*, however neither 0.3 L/ha of BRODAL (diflufenican) nor 4 L/ha of BASAGRAN affected the abundance of this species.

STOMP herbicide appeared to be safe up to 8 L/ha, while DUAL did not affect bean growth at 4 L/ha, although there was a suggestion of crop damage at 6 L/ha. BLADEX applied immediately after sowing caused significant yield reductions at 1.5 L/ha, with higher rates causing plant death. In contrast to previous experiments, spraying with more than 0.5 L/ha of BLAZER post-emergence caused some reductions in crop yields. BASAGRAN also reduced bean yields when used at 2-2.5 L/ha. Although BRODAL caused leaf damage and some stunting at high rates, its effects on pod yields were inconsistent, with no significant reductions.

EXPERIMENT REPORT

1. Report Final Date of Report: 31-1-94
Initiation Date: 31-3-92 Completion Date: 9-6-92

Project Number: S8901

Project Title: Weed control in vegetables.

Experiment Number: S8901.36

Officers Responsible: Craig Henderson/Mick Webber

Experiment Title: Efficacy and phytotoxicity of herbicides across 5 bean cultivars.

2. Experiment Objectives

To determine the efficacy and phytotoxicity of herbicides with potential for use in beans, across a range of cultivars.

3. Summary of Results

The experiment was conducted at GRS, March-June 1992. STOMP, DUAL BASAGRAN, BLAZER and BRODAL herbicides were sprayed over a bean crop consisting of the cultivars *Bronco*, *Superstar*, *Labrador*, *Montana* and *Redlands Pioneer*. The experiment design was a split-plot with the 5 cultivars as main plots and 10 herbicide treatments as sub-plots, replicated in 2 blocks. Each plot was one bed wide (1.68 m) wide x 10 m long with 2 rows of beans per bed, giving a total population of around 235 000 beans/ha. Herbicides were applied as pre and post-emergence treatments. Weed counts were carried out during the growing period. Bean plant heights were measured during the growing period; beans were machine harvested to determine yields. STOMP applied at both treatment rates controlled common pigweed, giant pigweed, deadnettle and suppressed sowthistle. This herbicide did not affect bean plant height nor yield. DUAL herbicide at both rates tested exhibited identical results to those for the STOMP treatments. At 6 L/ha, this herbicide appeared to reduce the heights of bean plants but did not decrease yields. BASAGRAN controlled common pigweed, it did not reduce bean plant heights nor yield. BLAZER at both application rates controlled common pigweed. At 1 L/ha, this herbicide checked the growth of bean plants, yield was not affected. BRODAL was overall ineffective as regards to weed control, with only suppressive effects on common pigweed. BRODAL did not affect the heights of bean plants, however yields were reduced. *Redlands Pioneer* was the tallest growing bean cultivar and also the highest yielding. There was a non-significant trend for *Bronco* to be most affected by herbicide damage. This experiment was set back because of poor seedling emergence due to water quality and disease problems, therefore the results of this experiment should be used as a guide only.

EXPERIMENT REPORT

1. Report Final Date of Report: 4-3-91
Initiation Date: 16-7-90 Completion Date: 2-11-90

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.12 Officer Responsible: Craig Henderson

Experiment Title: Efficacy of GOLTIX herbicide for weed control in beetroot.

2. Experiment Objectives

To investigate the efficacy and phytotoxicity of metamitron (GOLTIX) herbicide for use in beetroot.

3. Summary of Results

The experiment was conducted on the property of Mr R. Hawley at Forest Hill, from August 1990 to November 1990. Beetroot (cv. *Detroit Short Top*) were grown using standard agronomy, with 8 weed control treatments replicated 4 times in an RCB design. Plots were 3 rows (1.5 m) wide and 5 m long, with a total experimental area of 0.024 ha. GOLTIX was applied 32 days after planting, with weed counts and crop growth assessments 7, 21 and 35 days later. The beetroot were hand harvested 18 weeks after sowing. GOLTIX suppressed *Chenopodium album*, without achieving complete control. It did not control the grasses that were present. There were no phytotoxic effects from the GOLTIX on the beetroot, even when it was applied at 12 kg/ha, twice the rate recommended in Europe. The beetroot yields improved as the application of GOLTIX was increased, from 10 t/ha where 3 L/ha of herbicide was applied, to 32 t/ha where 12 kg/ha was used. Further investigations of this product will be conducted in the next 12 months.

EXPERIMENT REPORT

1. **Report** **Final** **Date of Report: 7-3-91**
 Initiation Date: 14-8-90 **Completion Date: 14-12-90**

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.21 Officer Responsible: Craig Henderson

Experiment Title: Efficacy of GOLTIX herbicide for weed control in beetroot.

2. **Experiment Objectives**

To investigate the efficacy and phytotoxicity of metamitron (GOLTIX) herbicide for use in beetroot.

3. **Summary of Results**

The experiment was conducted on the property of Mr J. Brent at Boonah, from September 1990 to December 1990. Beetroot were grown using standard agronomy, with 8 weed control treatments replicated 4 times in an RCB design. Plots were 3 rows (2.4 m) wide and 5 m long, with a total experimental area of 0.038 ha. GOLTIX was applied approximately 21 days after planting, with one treatment receiving a further spray application 22 days after the first spraying. Weed counts and crop growth assessments were conducted 22, 45 and 86 days after the initial GOLTIX application. The beetroot were hand harvested on 14.12.90. The GOLTIX suppressed *Chenopodium album* and *Polygonum aviculare*, without achieving complete control. It had little or no effect on *Apium leptophyllum* nor *Raphanus raphanistrum*. There were no phytotoxic effects from the GOLTIX on the beetroot, even when it was applied at 12 kg/ha, twice the rate recommended in Europe. The beetroot yields improved as the application of GOLTIX was increased, from 22 t/ha where 3 kg/ha was used, up to 30 t/ha where 12 kg/ha of GOLTIX was sprayed. Even where 12 kg/ha was applied, weed competition still reduced beetroot yields compared to the hand weeded areas (38 t/ha). The number of *P. aviculare* remaining in the GOLTIX treated plots were sufficient to seriously affect machine harvestability. Further investigations of this product will be conducted in the next 12 months.

EXPERIMENT REPORT

1. Report Final Date of Report: 1-1-91
Initiation Date: 17-7-89 Completion Date: 10-08-89

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.00 Officer Responsible: Craig Henderson

Experiment Title: Weed control in processing peas with post-emergence herbicides.

2. Experiment Objectives

This was a cooperative project with the processing companies and Shell Chemicals Aust. P/L, to compare herbicides for post-emergence weed control in processing peas.

3. Summary of Results

The experiment was conducted on the property of Mr B. Peach at Glenore Grove, from 17/7/89 to 10/8/89. The peas were grown using standard agronomic practices. The experiment design included 12 treatments replicated 4 times in blocks, with each plot 2 m wide and 10 m long. The herbicides tested were BLADEX (cyanazine), GESAGARD (prometryn) and SENCOR (metribuzin), all applied when the peas had 5 nodes and many of the weeds had 3-4 true leaves. Weed counts were conducted 24 days after spraying.

BLADEX gave poor control of *Chenopodium album*, *Capsella bursapastoris*, *Lamium amplexicaule* and *Sonchus oleraceus*, with only fair suppression of *Solanum nigrum*. In contrast, GESAGARD killed most of the above species, although some *L. amplexicaule* survived. SENCOR gave effective control of all weeds. The results from this experiment conflict with grower experience and herbicide registration data; further work is required to determine the best herbicide strategies. These investigations will be pursued at Gatton Research Station and on grower properties in winter 1990.

EXPERIMENT REPORT

1. Report Final Date of Report: 1-1-91
Initiation Date: 20-2-90 Completion Date: 27-9-90

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.07 Officer Responsible: Craig Henderson

Experiment Title: Post-emergence herbicides in peas.

2. Experiment Objectives

To investigate the efficacy and phytotoxicity of five post-emergence herbicides for broadleaf weed control in processing peas.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from June-September 1990. Peas (cv. *Bounty*) were grown using standard agronomy, with 20 treatments replicated 3 times. Plots were 8 rows wide (1.6 m) and 8 m long. The herbicides tested included metribuzin (SENCOR), prometryn (GESAGARD), bentazone (BASAGRAN), cyanazine (BLADEX) and methabenzthiazuron (TRIBUNIL). The herbicides were applied 30 days after sowing, when the peas had 5 nodes and the weeds 2-4 true leaves. Weed counts and crop ratings were conducted during the growing season, and yields were also measured. SENCOR at 0.25 kg/ha controlled *Stellaria media*, *Lamium amplexicaule* and *Capsella bursa-pastoris*, however 0.4 kg/ha was required to kill *Sonchus oleraceus*. This higher rate initially stunt the peas, however this is unlikely to affect yields. GESAGARD gave adequate weed control at 1 L/ha, however substantial crop damage occurred at higher rates, so application must be precise. This product may delay pea maturation by 1-2 days. It should only be considered for use where *Solanum nigrum* is a problem. BASAGRAN at 1.5 L/ha effectively controlled the first 3 weed species mentioned, however a higher rate would be required if *S. oleraceus* was a problem. There was no significant crop phytotoxicity, however weeds must be sprayed whilst young for effective control. BLADEX did not damage the peas at any rate of application, however it also did not affect *S. oleraceus*. A rate of 2 L/ha would control many weed species. This product would probably be used as part of a mixture, rather than as a single herbicide application. TRIBUNIL at 0.8 kg/ha killed small seedlings of the first 3 weed species mentioned, however it did not control *S. oleraceus* at any of the rates tested. This product would be most useful where weeds had germinated with the peas, and early control was considered necessary. At this stage it is not intended to continue work on post-emergence herbicides in peas, as it is felt that there are sufficient products registered to manage most situations.

EXPERIMENT REPORT

1. Report Final Date of Report: 20-10-92
 Initiation Date: 25-6-92 Completion Date: 1-10-92

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901. Officer Responsible: Craig Henderson

Experiment Title: On-farm testing of IGRAN herbicide on processing peas.

2. Experiment Objectives

This experiment tested the efficacy and phytotoxicity of IGRAN herbicide in processing peas in an on-farm situation.

3. Summary of Results

The experiment was conducted on the property of Greg and Robyn Banff at Coominya. The soil at the experimental site had a red loamy sand - sandy loam texture, grading into a finer textured subsoil. The grower planted peas (cv. *Bounry*) on 25 June 1992, and sprayed them with 0.18 kg/ha of LEXONE and 0.7 L/ha of BLADEX on 24 July 1992, when the peas had 3.5-4 nodes. We sprayed our treatment area (12 m * 6 m) with 1 L/ha of IGRAN at 3 pm on 31 July 1992 (temperature 27°C, relative humidity 65%). At this time the peas were 12-15 cm high, with 5-6 nodes. Weeds present in the experimental area included *S. nigrum*, *Chenopodium album* (Fat Hen) and *Coronopus didymus* (Bittercress), all of which had 3-6 true leaves. At 5 days after spraying with IGRAN, the *S. nigrum* seedlings were not showing any visible symptoms of herbicide damage, even the smallest plants with only 2 true leaves. Small *C. didymus* seedlings were very chlorotic, however weeds more than 3 cm in diameter appeared less affected. By 27 days after spraying, the peas had just commenced flowering. At this time there were no weeds present in the area sprayed with IGRAN herbicide; even the relatively large *S. nigrum* plants that had seemed unaffected at the first assessment were successfully controlled. Either the herbicide had required irrigation/rainfall to be fully activated (this took place 1 day after the initial assessment), or it was slower acting than we expected. By 5 days after treating with IGRAN, the peas exhibited very slight chlorosis of the older leaves, but otherwise appeared little different from the crop sprayed by the grower. At flowering there were no discernible differences between the 2 areas. The crop heights in the IGRAN and BLADEX/LEXONE treated areas (determined from the mean heights of 10 pea plants per area) were 21.4 and 22.6 cm at 5 days after spraying, and 49.0 and 45.9 cm at flowering respectively, with a CV of 11%. Yield of the crop sprayed with IGRAN was 8.66 t/ha, with 25% medium / 75% large peas, and a maturity index of 320. Yield of the farmer sprayed area was 8.32 t/ha, with 20% medium / 80% large peas, at a M.I. of 360. The yield differences were not significant (overall CV was 18%), however it is possible that the IGRAN treated peas were marginally less mature than the other peas. Both crops were well beyond the optimum M.I. of 240. As in previous experimental work at Gatton Research Station, post-emergence application of 1 L/ha of IGRAN provided complete control of weeds present in the treated area, including the important *S. nigrum*. Environmental conditions at the Coominya site (high temperatures, low clay content soils) were conducive to maximum expression of any potential phytotoxicity from this herbicide treatment. Although there appeared to be very slight yellowing of the peas in the first week after treatment, there were no significant effects on pea growth or yield. A herbicide cost of \$12/ha, combined with the apparent effectiveness of the treatment, suggests that some form of registration for the use of IGRAN in green peas is very desirable.

EXPERIMENT REPORT

1. Report Final Date of Report: 1-8-91
Initiation Date: 14-8-90 Completion Date: 4-2-91

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.19 Officer Responsible: Craig Henderson

Experiment Title: Pre and post-emergence herbicides for sweet corn

2. Experiment Objectives

This experiment investigated the efficacy and phytotoxicity of STOMP (pendimethalin) and BASAGRAN (bentazone) in a summer sweet corn crop at Gatton Research Station.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from November 1990 to February 1991. Sweet corn (cv. *Kulara II*) were grown using standard agronomy, with 10 weed control treatments replicated 4 times in blocks. Plots were 2 rows (2 m) wide and 10 m long, with a total experimental area, including buffer zones, of 0.08 ha. The herbicides were applied 2 days after planting, with weed counts 48 and 62 days later. Crop growth assessments were carried out about 3 weeks after sowing, while the sweet corn were hand picked 9 weeks later.

Due to the lack of weeds in the experimental area, conclusions about weed control by the 2 herbicides can only be tentative. STOMP appeared to kill *P. oleracea* and *H. trionum* at the lowest application rate of 1.5 L/ha, whilst having no apparent effect on *T. portulacastrum*, even when sprayed at higher rates. No conclusions can be determined about control of *S. oleraceus* or *I. plebia* by this herbicide from the results of this experiment. BASAGRAN at 1-2 L/ha seemed to control *S. oleraceus*, *I. plebia* and *T. portulacastrum* in this experiment, whilst no conclusions can be made about its effects on either *P. oleracea* or *H. trionum*.

As in a previous experiment, there was no significant phytotoxicity from either STOMP or BASAGRAN on the sweet corn, even when applied at 3 times the standard rates. Given the relative costs of STOMP and BASAGRAN, a pre-emergence herbicide would probably be used as the standard treatment, with a post-emergence application only where there was a substantial threat from weeds such as *I. plebia*. The usual application rates would be; STOMP - 3 L/ha (\$33); BASAGRAN - 1.5-2 L/ha (\$36-48).

An experiment with sweet corn, including these herbicides, will be conducted in the summer of 1991/92 at Gatton Research Station.

EXPERIMENT REPORT

1. Report Final Date of Report: 2-8-91
Initiation Date: 14-8-90 Completion Date: 4-2-91

Project Number: S8901

Project Title: Weed control in vegetables

Experiment Number: S8901.20 Officer Responsible: Craig Henderson

Experiment Title: Pre-emergence herbicide mixtures for sweet corn

2. Experiment Objectives

This experiment investigated the increase in weed spectrum efficacy obtained when low rates of atrazine were combined with either STOMP (pendimethalin) or DUAL (metolachlor) in a summer sweet corn crop at Gatton Research Station.

3. Summary of Results

The experiment was conducted at Gatton Research Station, from November 1990 to February 1991. Sweet corn (cv. *Kulara II*) were grown using standard agronomy, with 10 weed control treatments replicated 4 times in blocks. Plots were 2 rows (2 m) wide and 10 m long, with a total experimental area, including buffer zones, of 0.08 ha. The herbicides were applied 2 days after planting, with weed counts 48 and 62 days later. Crop growth assessments were carried out about 3 weeks after sowing, while the sweet corn were hand picked 9 weeks later.

Due to the initial lack of weeds in the experimental area, conclusions about weed control by the 3 herbicides can only be tentative. STOMP applied at 3 L/ha appeared to kill *T. portulacastrum*, *P. oleracea* and *S. oleraceus*, while 2 L/ha of DUAL was probably less effective against all 3 species. Spraying ATRAZINE at 1.5 L/ha was also probably insufficient to improve weed control, either on its own or in combination with the other products. Increasing the rate to 2 L/ha may have marginally increased the control of *T. portulacastrum* and effectively killed *P. oleracea*, however it probably had little effect on *S. oleraceus*. There was no significant phytotoxicity from any of the herbicides used in the experiment, as would be expected from the low application rates. The yields from the different treatments suggest that there was substantially more weed competition than implied by the weed counts. The results indicate that only where 3 L/ha of STOMP was applied were cob numbers, and hence total production, equivalent to the hand weeded areas. The rates of DUAL and ATRAZINE applied appeared to be insufficient to maximise production.

An experiment with sweet corn, including these herbicides, will be conducted in the summer of 1991/92 at Gatton Research Station.

EXPERIMENT REPORT

1. Report Final Date of Report: 6-3-92
Initiation Date: 10-7-91 Completion Date: 15-1-92
Project Number: S8901
Project Title: Weed control in vegetables
Experiment Number: S8901.35 Officer Responsible: Craig Henderson
Experiment Title: Herbicides for sweet corn

2. Experiment Objectives

This experiment investigated the phytotoxicity and efficacy of a range of herbicides with potential for use in sweet corn, including STOMP (pendimethalin), DUAL (metolachlor), BLADEX (cyanazine), GARDOPRIM (metolachlor + terbuthylazine), AFALON (linuron) and BASAGRAN (bentazone).

3. Summary of Results

The experiment was conducted at Gatton Research Station, from October 1991 to January 1992. Sweet corn (*cv. Kulara II*) were grown using standard agronomy, with 44 weed control treatments replicated twice in blocks. Plots were 2 rows (2 m) wide and 10 m long, with a total experimental area, including buffer zones, of 0.176 ha. The herbicides were applied 2 days after planting, with weed counts 35 and 67 days after sowing (DAS). Crop heights were measured 25 and 51 DAS. The sweet corn were hand picked 78 DAS.

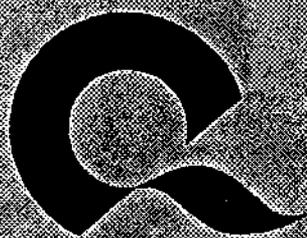
Due to the initial lack of weeds in the experimental area, conclusions about weed control by the herbicides can only be tentative. STOMP, DUAL or BLADEX applied at 3 L/ha, or AFALON at 3 kg/ha, appeared to kill *Trianthema portulacastrum*, *Portulaca oleracea* and suppress *Solanum nigrum*, with no significant effects on *Ipomoea plebia* nor *Macropitilium atropurpureum*. Application of BASAGRAN at 2 L/ha probably controlled *P. oleracea* and *S. nigrum*, while slightly suppressing *M. atropurpureum*. GARDOPRIM at 5 L/ha appeared to control all the weed species previously mentioned except *I. plebia*.

The only apparent phytotoxicity from any of the treatments was a slight yield depression where 6 L/ha of DUAL was used; well above the maximum registered application rate of 4 L/ha. At this stage, we are not intending to conduct any further herbicide work in sweet corn, unless one of the chemical companies considers it necessary to obtain data for registration purposes.

SAMPLE EXPERIMENT REPORT

Pre and post-emergence herbicides

for weed control in green beans.



Queensland Fruit and
Vegetable Growers

DPI

QUEENSLAND
DEPARTMENT OF
PRIMARY INDUSTRIES

SOUTH EAST
REGION



HRDC

EXPERIMENT REPORT

Pre- and post-emergence herbicides for weed control in green beans.

by C. Henderson and M. Webber
Department of Primary Industries
Gatton Research Station

Experiment No. S8901.34 10.10.91-10.12.91

1. Relevance to Industry

The bean industry, both fresh and processing, was substantially affected when alachlor (LASSO) was withdrawn from use, as it was a major component of weed control strategies. Currently, chlorthal di-methyl (DACTHAL), EPTC (EPTAM) and trifluralin (various) are registered as pre-emergence herbicides in green beans, however each product has difficulties associated with its use. Chlorthal is expensive and does not control many of the important weed species present in bean growing areas. Both EPTC and trifluralin have to be mechanically incorporated immediately after spraying, which can create other agronomic problems. The herbicides pendimethalin (STOMP) and metolachlor (DUAL) have both been investigated for pre-emergence use in green beans and appear to be suitable for a range of environmental conditions.

In Queensland, the only post-emergence herbicide registered for use on broadleaf weeds is bentazone (BASAGRAN). This product has a wide weed spectrum, however its efficacy is dependent on spraying the weeds when they are small, frequently less than 2 true leaves. This can make weed control difficult in situations where weather factors prevent spraying for a few days. In addition, this herbicide is relatively expensive compared to other post-emergence products, which can affect the profitability of growing green beans, particularly for processing. In a previous experiment both acifluorfen (BLAZER) and diflufenican (BRODAL) showed some potential for post-emergence use in green beans.

The bean industry requires a weed control system that provides a similar level of weed control to that obtained using alachlor (at a similar cost), if it is to remain viable in the short-medium term.

2. Objectives

This experiment investigated the phytotoxicity of pre- and post-emergence herbicides with potential for controlling weeds in green beans. The herbicides tested were:-

- a. **STOMP** (pendimethalin 330 g/L EC) - registered for pre-emergence control of grasses and selected broadleaves in other legume, grain and oilseed crops. Pendimethalin is a DNA herbicide similar to trifluralin, which is registered for use in beans. The advantage of pendimethalin is that it can be readily incorporated by irrigation, rather than mechanically.
- b. **DUAL** (metolachlor 720 g/L EC) - registered for pre-emergence control of grasses and selected broadleaves in sorghum, corn and cotton, as well as other horticultural crops. Metolachlor can also be incorporated using irrigation. Previous research showed that metolachlor could be successfully used in green beans in the Gympie area.
- c. **BLADEX** (cyanazine 500 g/L SC) - recently registered for both pre and post-emergence use on processing peas in Queensland, this product is commonly added to herbicide mixtures specifically to control *S. nigrum*.
- d. **BLAZER** (acifluorfen 224 g/L LC) - registered for pre and post-emergence control of grasses and selected broadleaves in soybeans and peanuts, acifluorfen controls a range of weed species complementary to bentazone. These two herbicides are compatible and could prove a useful mixture for post-emergence weed control in green beans.
- e. **BRODAL** (diflufenican 500 g/L) - not yet registered in Queensland, this herbicide is particularly effective against cruciferous weeds, both pre and post-emergence. It would only be used in situations where that family of weeds were predominant, and unlikely to be controlled with other herbicides. The current registration submission is only for uses in lupins, peas and pastures at this stage.
- f. **BASAGRAN** (bentazone 480 g/L LC) - registered for use in green beans, soybeans and peanuts in Queensland. It controls a range of broadleaf weeds, however it must be applied when the weeds have fewer than 3-4 true leaves.

3. Materials and methods

The experiment was conducted on a black earth soil (*Ug5.15*) at Gatton Research Station (lat 27°33'S, long 152°20'E). The experimental design was a randomised complete block, with 2 blocks each comprising; 36 herbicide treatments, 4 hand-weeded plots and 4 unweeded plots. The herbicide treatments were:

- 1-6. STOMP at 1.5, 2, 3, 4, 5 and 8 L/ha.
- 7-12. DUAL at 1.5, 2, 2.5, 3, 4 and 6 L/ha.
- 13-18. BLADEX at 1.5, 2, 3, 4, 5 and 6 L/ha.
- 19-24. BLAZER at 0.5, 1, 2, 3, 4 and 6 L/ha.
- 25-30. BRODAL at 0.05, 0.1, 0.15, 0.2, 0.3, and 0.5 L/ha.
- 30-36. BASAGRAN at 1, 1.5, 2, 2.5, 3 and 4 L/ha.

Each plot was one bed (1.75 m) wide x 10 m long, with two rows of beans per bed. The soil was prepared as per standard practice for a bean crop. A basal application of 60 kg/ha of nitrogen as urea was applied prior at planting, with another 60 kg N/ha 4 weeks later. At the second urea application, 1 kg/ha of zinc sulphate was sprayed over the beans.

The beans (cv. Superstar) were sown into the prepared beds on the 10 October 1991. Inter and intra-row spacings within the beds were 0.80 m and 0.04 m respectively, giving a total population of around 295 000 bean plants/ha. The crops were sprayed with dimethoate, methomyl, and endosulfan for insect control during the growing season. There were few problems with disease in this experiment.

Rainfall and irrigation during the growing period are shown in Table 1. Maximum temperatures during November and December were hotter than average, with several days in November above 35°C.

Table 1. Rainfall and irrigation received from sowing to harvesting.

Week	Rainfall (mm)	Irrigation (mm)
1	8.0	59.0
2	39.0	0.0
3	6.0	0.0
4	0.0	58.0
5	0.0	31.0
6	6.0	32.0
7	23.0	86.0
8	62.0	0.0
9	26.0	0.0
TOTAL	170.00	266.00

All herbicides were applied with 250 L/ha of water (with surfactant if appropriate), using a 1.52 m wide hand held boom centred over the treated bed. The boom had 110° flat fan nozzles 0.305 m apart, operating at 220 kPa. The STOMP, DUAL and BLADEX treatments were sprayed 1 day after sowing (25°C, RH 80%) and incorporated with 29 mm of irrigation. Post-emergence treatments (BLAZER, BRODAL and BASAGRAN) were applied 27 days after sowing (21°C, RH 70%), when the beans were about 15 cm high. The weeds present at this stage had 4-6 true leaves. Hand-weeded treatments were hoed 4 and 6 weeks after sowing.

Measurements

The abundance of several weed species were recorded 25 and 54 days after sowing (DAS). Weeds within a single 0.2 m² quadrat randomly placed in the central area of each plot were counted.

The health of bean plants was assessed by randomly selecting 5 bean plants within each plot, noting any visual symptoms of herbicide damage and recording plant heights. These phytotoxicity assessments were conducted 34 and 56 DAS. Green pod yields were determined by mechanically harvesting a single 10 m row of beans from each plot and recording the fresh weight of the harvested sample (after removing any non-pod material). This harvest was conducted on 10 December 1991, 61 DAS.

Data analysis

Analysis of variance was conducted on weed counts, growth and yield variables, providing means for each of the herbicide and unsprayed control treatments, as well as estimates of error variance. Owing to the nature of their distributions, the weed data were log-transformed prior to analyses. Weed counts and bean growth parameters were plotted against herbicide rates and fitted to linear or quadratic functions using multiple regression techniques. Coefficients were included only if the associated *t* values were significant ($P < 0.1$).

4. Results and discussion

Weed control

Only *Trianthema portulacastrum* (Giant Pigweed) were sufficiently abundant to enable statistical analysis. Weed counts for the later time of assessment are presented, indicating the overall activity of the products under investigation.

STOMP at 1.5-2 L/ha gave good control of *T. portulacastrum* (Fig. 1). There were no *Portulaca oleracea* (Common Pigweed) in areas sprayed with more than 2 L/ha of STOMP, however this herbicide did not appear to affect the abundance of *Ipomoea plebia* (Bellvine).

In this experiment, spraying 2-2.5 L/ha of DUAL prevented establishment of *T. portulacastrum* (Fig. 1). There were also no *P. oleracea* present in areas treated with this rate of herbicide. DUAL had no effect on the distribution of *I. plebia*.

There were no significant numbers of *T. portulacastrum* in areas treated with at least 1.5 L/ha of BLADDEX pre-emergence (Fig. 1). *P. oleracea* was also absent from plots sprayed with more than 1.5 L/ha, however the impact of this herbicide on *I. plebia* was unclear.

It appeared that at least 2 L/ha of BLAZER was required to give suppression of *T. portulacastrum* in this experiment (Fig. 1). This was probably due to the age of the weeds when the herbicide was applied. Higher rates gave control of this weed species. There were no *P. oleracea* or *I. plebia* present in areas treated with at least 0.5 L/ha.

It is possible that 0.15 L/ha of BRODAL controlled *T. portulacastrum*, however the presence of some weeds in plots sprayed with 0.3 L/ha cast some doubts on this conclusion (Fig. 1). *P. oleracea* were not found in areas treated with at least 0.3 L/ha, while effects on *I. plebia* were inconclusive.

BASAGRAN was ineffective against *T. portulacastrum* (Fig. 1), however spraying with more than 1 L/ha killed all *P. oleracea* present. There were no *I. plebia* in areas sprayed with at least 1 L/ha.

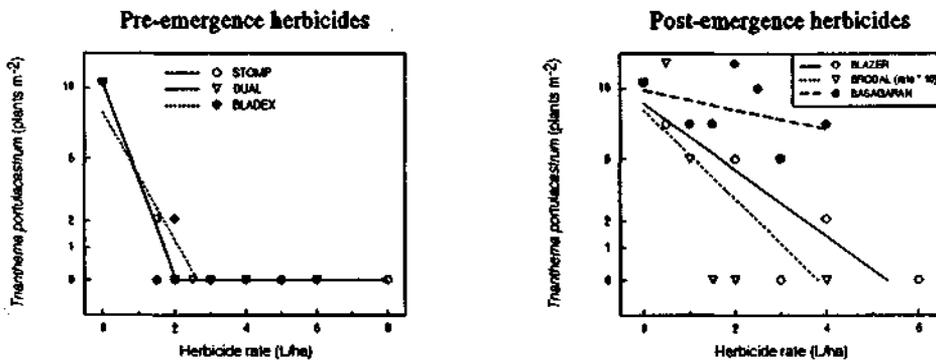


Fig. 1. The effects of pre- and post-emergence herbicides on the abundance of *T. portulacastrum* in green beans 54 days after sowing.

Phytotoxicity and yield

Spraying up to 8 L/ha of STOMP did not adversely affect heights of bean plants at either time of assessment, nor was there any significant relationship between bean yields with increasing herbicide application rate (Table 2).

Table 2. The effects of STOMP pre-emergence herbicide on bean plant height and pod yields.

Rate (L/ha)	Bean plant height (cm)		Bean yield (t/ha)
	34 DAS	56 DAS	
0.0	34.8*	60.6	10.05
1.5	33.5	60.2	11.22
2.0	32.9	65.0	12.12
3.0	35.1	65.2	13.04
4.0	34.7	62.7	10.94
5.0	34.5	60.9	12.49
8.0	32.0	60.8	11.19
Hand	33.0	62.1	11.13
l.s.d._{0.05}	4.7	5.0	3.52

* bold values are significantly worse than the hand weeded controls.

Application of DUAL at up to 6 L/ha had no significant effects on bean plant height during the growing period. Yields of beans treated with up to 4 L/ha were equivalent to the hand-weeded areas, although at 6 L/ha there may have been a slight yield depression (Table 3).

Table 3. The effects of DUAL pre-emergence herbicide on bean plant height and pod yields.

Rate (L/ha)	Bean plant height (cm)		Bean yield (t/ha)
	34 DAS	56 DAS	
0.0	34.8*	60.6	10.05
1.5	36.2	61.3	11.45
2.0	33.1	59.5	12.02
2.5	34.1	60.4	11.26
3.0	33.9	63.2	10.63
4.0	33.1	60.3	12.09
6.0	33.5	59.3	9.24
Hand	33.0	62.1	11.13
<i>l.s.d.</i> _{0.05}	4.7	5.0	3.52

* bold values are significantly worse than the hand weeded controls.

Use of BLADEX immediately after sowing was severely phytotoxic to green beans. Spraying more than 4 L/ha killed all the bean plants. There were significant linear reductions ($P < 0.05$) in both plant height and bean yields with increasing application rates (Table 4, Fig. 2). Even the lowest rates of 1.5-2 L/ha yielded only 65% of the hand weeded areas.

Table 4. The effects of BLADEX pre-emergence herbicide on bean plant height and pod yields.

Rate (L/ha)	Bean plant height (cm)		Bean yield (t/ha)
	34 DAS	56 DAS	
0.0	34.8*	60.6	10.05
1.5	28.6	57.5	6.96
2.0	31.1	56.6	7.60
3.0	25.1	50.6	4.44
4.0	26.5	51.6	4.38
5.0	-	-	-
6.0	-	-	-
Hand	33.0	62.1	11.13
<i>l.s.d.</i> _{0.05}	4.7	5.0	3.52

* bold values are significantly worse than the hand weeded controls.

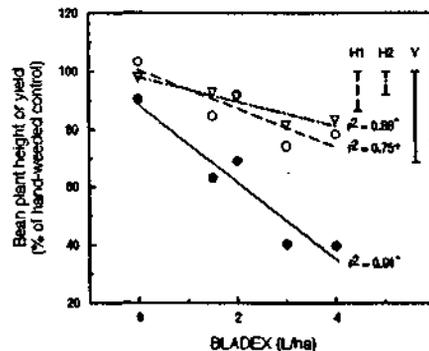


Fig. 2. The effects of BLADEX herbicide applied pre-emergence on bean plant height 34 DAS (H1) and 57 DAS (H2) and bean yield (Y). Vertical bars represent *l.s.d.*_{0.05} values for the respective treatment means.

Application of 3 or more L/ha of BLAZER reduced bean plant heights after spraying by more than 10%. The severity of stunting increased with herbicide application rate, although there was some recovery later in the growing period (Table 5, Fig. 3). In contrast to previous experiments, spraying more than 0.5 L/ha of BLAZER in this investigation reduced yields by around 20%, with a 50% decrease in yield at the maximum application rate of 6 L/ha.

Table 5. The effects of BLAZER post-emergence herbicide on bean plant height and pod yields.

Rate (L/ha)	Bean plant height (cm)		Bean yield (t/ha)
	34 DAS	56 DAS	
0.0	34.8*	60.6	10.05
0.5	34.5	61.9	10.86
1.0	33.6	61.5	9.03
2.0	31.7	57.1	8.75
3.0	28.9	59.1	8.57
4.0	30.6	59.5	9.18
6.0	24.1	54.1	5.91
Hand	33.0	62.1	11.13
<i>l.s.d.</i> _{0.05}	4.7	5.0	3.52

* bold values are significantly worse than the hand weeded controls.

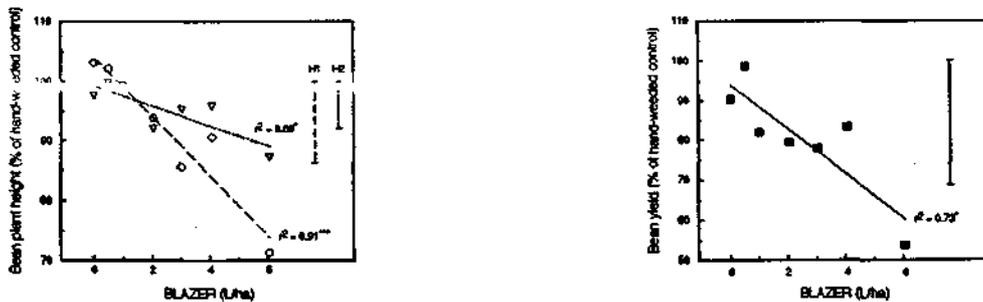


Fig. 3. The effects of BLAZER herbicide applied post-emergence on bean plant height 34 DAS (H1) and 57 DAS (H2) and bean yield (Y). Vertical bars represent *l.s.d.*_{0.05} values for the respective treatment means.

Spraying BRODAL caused white flecking of bean leaf and stem tissue, developing into necrosis of substantial areas of leaf at application rates > 0.2 L/ha. Heights of bean plants were reduced by more than 10% where around 0.3 L/ha was used. Yields were relatively variable, with no consistent relationship between herbicide rate and pod production (Table 6).

Table 6. The effects of BRODAL post-emergence herbicide on bean plant height and pod yields.

Rate (L/ha)	Bean plant height (cm)		Bean yield (t/ha)
	34 DAS	56 DAS	
0.0	34.8*	60.6	10.05
0.05	34.3	62.3	10.01
0.10	32.5	59.2	10.30
0.15	32.7	61.4	9.80
0.20	31.1	59.8	10.03
0.30	34.7	55.0	11.05
0.40	30.5	55.0	9.38
Hand	33.0	62.1	11.13
<i>l.s.d.</i> _{0.05}	4.7	5.0	3.52

* bold values are significantly worse than the hand weeded controls.

Application of BASAGRAN at more than 2 L/ha reduced bean plant height 7 days after spraying by at least 10% (Table 7). Yields from the areas treated with BASAGRAN were relatively variable, however there was a significant trend ($P < 0.05$) for substantial yield reductions where more than 1.5 L/ha was used (Fig. 4).

Table 7. The effects of BASAGRAN post-emergence herbicide on bean plant height and pod yields.

Rate (L/ha)	Bean plant height (cm)		Bean yield (t/ha)
	34 DAS	56 DAS	
0.0	34.8*	60.6	10.05
1.0	32.2	60.7	10.92
1.5	30.7	58.5	8.15
2.0	32.5	60.8	9.56
2.5	28.5	56.3	6.47
3.0	29.8	56.9	7.25
4.0	28.8	59.3	5.66
Hand	33.0	62.1	11.13
<i>l.s.d.</i> _{0.05}	4.7	5.0	3.52

bold values are significantly worse than the hand weeded controls.

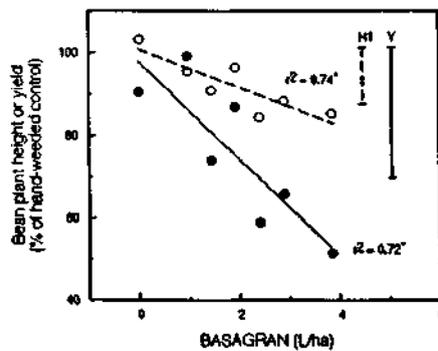


Fig. 4. The effects of BASAGRAN herbicide applied post-emergence on bean plant height 34 DAS (H1) and bean yield (Y). Vertical bars represent *l.s.d.*_{0.05} values for the respective treatment means.

5. Conclusions

Spraying 2-3 L/ha of STOMP controlled *T. portulacastrum* and *P. oleracea*, but had little impact on *I. plebia*. There was no crop phytotoxicity from using STOMP at up to 8 L/ha. Other investigations have occasionally found substantial lodging where 4 L/ha of STOMP was applied during cool growing conditions. Where bean growth rates are reduced by water or nutrient stress, waterlogging or cold weather, there may be an increased propensity for development of weak stems and thus the risks of crop lodging. We suggest that 2-4.5 L/ha of STOMP should be safe for post-sowing, pre-emergence use in green beans, where normal summer growing conditions apply.

Although 2-2.5 L/ha of DUAL gave satisfactory control of *T. portulacastrum* and *P. oleracea* in this experiment, previous investigations suggest that 3-4 L/ha is probably required for reliable results. Bean plants appeared to tolerate more than 4 L/ha before any possible phytotoxic effects.

Although 1.5-2 l/ha of BLADEX controlled *T. portulacastrum* and *P. oleracea* in this experiment, the severe bean yield reduction caused by pre-emergence application of this herbicide (circa 35%) would preclude its use in green beans.

Spraying at least 2 L/ha of BLADEX was needed for control of *T. portulacastrum*, although only 0.5 L/ha appeared necessary to kill *P. oleracea* (and possibly *I. plebia*). The high rate required for *T. portulacastrum* was almost certainly because the weeds had 4-6 true leaves. Blazer is more effective against younger weeds (2-4 true leaves). The significant bean yield reductions associated with 1-1.5 L/ha of BLAZER contrast with earlier experiments, where no adverse effects were obtained at similar application rates. Although factors such as plant age and weather conditions affect the phytotoxicity of BLAZER to green beans, differences in cultivar tolerance are also important. It is possible that Superstar is more susceptible to damage from BLAZER than Labrador, the cultivar used in previous experiments. Differences in cultivar tolerances to several bean herbicides, including BLAZER, will be investigated in future research. Because BLAZER controls some weed species (e.g. *T. portulacastrum*, *Amaranthus spp.*) that are not affected by BASAGRAN, investigations into this herbicide will continue.

In this experiment, the control of weeds by BRODAL was inconclusive. This herbicide is mainly active against members of the Brassicacea family (generally less important in green bean production). BRODAL certainly produces visible symptoms of damage in green beans, with 0.3 L/ha significantly reducing plant height in this experiment. Bean yields from plots sprayed with BRODAL varied substantially, however there were no significant trends nor differences from hand-weeded treatments. In previous experiments 0.2 L/ha of BRODAL has caused significant yield reductions in green beans. Without further studies into the factors affecting green bean tolerance of BRODAL, the risks of crop phytotoxicity would appear to outweigh benefits from this herbicides relatively narrow weed spectrum.

Although 1-1.5 L/ha of BASAGRAN appeared to control both *P. oleracea* and *I. plebia*, this herbicide was ineffective against the principal weed species *T. portulacastrum*, even

when sprayed at 4 L/ha. The phytotoxicity and reduced yields observed when more than 2 L/ha were used was unusual, given relatively mild weather conditions at spraying. Whether the adverse effects were due to phenological stage of the beans, or whether Superstar is more susceptible to BASAGRAN than other cultivars is unclear. The large quantities of *T. portulacastrum* still present in areas treated with BASAGRAN confirms the need for alternative herbicide strategies to control this, and other problem weed species.

In future experiments we intend to investigate the tolerance of several commonly grown bean cultivars to those herbicides considered to have potential for use in green beans.