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# THE ACTIVITY, PRE-EMERGENCE AND POST-EMERGENCE SELECTIVITY AND PERSISTENCE OF THE HERBICIDE SAN 582 H

SAN 582 is dimethenamid

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# THE ACTIVITY, PRE-EMERGENCE AND POST-EMERGENCE SELECTIVITY AND PERSISTENCE OF THE HERBICIDE SAN 582 H

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## 1. SUMMARY

In pot experiments the herbicide SAN 582 H, at 0.4, 1.2 and 3.6 kg a.i.ha$^{-1}$ was tested for pre-emergence and post-emergence activity and selectivity on up to 19 temperate crop and 28 temperate weed species. The selectivity experiments also included a second series of the cereal crops that were seed dressed with the safener 1,8-naphthalic anhydride (NA) to investigate possible protection from herbicide injury. In a separate experiment, SAN 582 H was applied using four different methods to determine the route of herbicide entry into the plants of six selected species. Soil persistence of SAN 582 H was assessed over a 52-week period.

SAN 582 H was active when applied pre-emergence and also showed post-emergence activity when the herbicide was allowed to act via the soil (as a soil drench treatment), but there was little or no activity when SAN 582 H was applied to plant foliage with the soil protected.

A wide range of important temperate grass and broad-leaved weed species were susceptible to SAN 582 H applied pre-emergence. Maize showed good tolerance at 1.2 kg a.i.ha$^{-1}$, while pea, dwarf bean, field bean, oilseed rape and sugar beet were unaffected by 0.4 kg a.i.ha$^{-1}$. The tolerance of maize and oat was increased by seed dressing with the NA safener.

SAN 582 H proved less active when applied post-emergence as an overall spray with the soil unprotected. Only a few weed species, which included Bromus sterilis, were susceptible. The leguminous crops and maize, sugar beet, oilseed rape, onion and oat showed appreciable tolerance.

Soil persistence, assessed using perennial ryegrass as a sensitive test species, was found to be short-to-moderate compared with cyanazine (short persistence) and simazine (long persistence).

## 2. INTRODUCTION

The pre- and post-emergence activity and selectivity of new herbicides are investigated by LARS Crop and Environmental Sciences Department on a range of temperate crop and weed species, grown in pots, to indicate possible uses and potential problems. Persistence in the soil is also assessed and provides data which, in conjunction with data on crop susceptibilities, are useful in considering subsequent cropping of treated land. Although in these investigations, only one crop variety or source of weed species is used, and in one soil type, at one depth of sowing, the results provide a guide for more detailed studies where warranted.

SAN 582 H is a new herbicide active ingredient discovered and being developed by Sandoz Agro Ltd. The original information from this company (in 1986) suggested that the herbicide had potential as a pre-emergence compound for use in maize, soyabean, cotton, peanut, potato and sunflower. Preliminary evaluation by the company showed activity against most annual grass weeds and some important broad-leaved weeds at 1-2 kg a.i.ha$^{-1}$. A recent report (Harr et al., 1991) showed that after extensive field testing, SAN 582 H offered a new alternative, alone or in herbicide mixtures, for pre-emergence weed control in maize and soyabean.

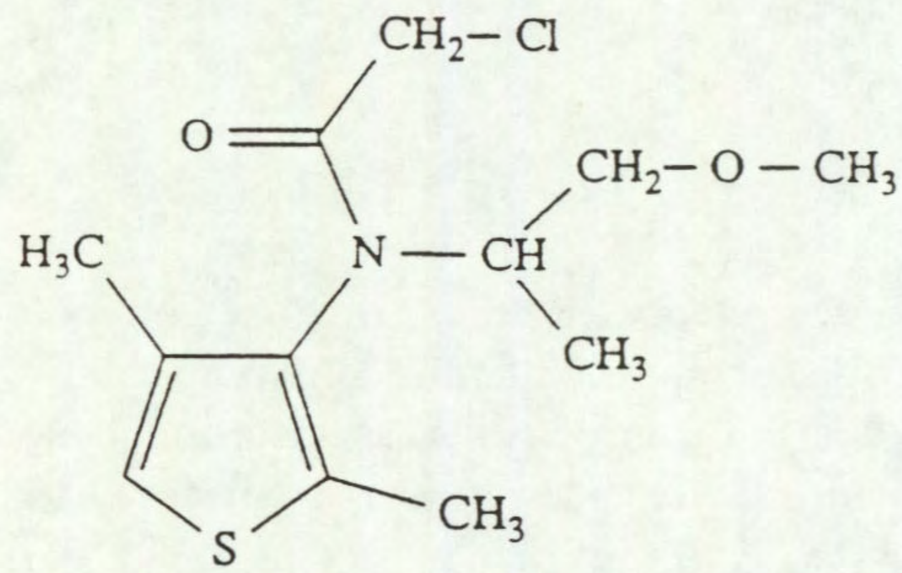
This report gives information on the pre- and post-emergence activity and selectivity of SAN 582 H on temperate species and on soil persistence. Results of an experiment to investigate the response of plants to SAN 582 H applied separately to the shoot, root or seed, are also included to provide information on route of herbicide entry into the plant, and the type and degree of phytotoxicity.

## 3. MATERIALS AND METHODS

### 3.1 Herbicide details

| | |
|---|---|
| Source: | Sandoz Crop Protection Limited<br>Norwich Union House, 16/18 Princes Street,<br>Ipswich, Suffolk IP1 1QT |
| Code number: | SAN 582 H |
| Common name: | dimethenamid (proposed ISO) |
| Trade name: | FRONTIER |
| Chemical name: (IUPAC) | (1RS, aRS)-2-chloro-N-(2-4-dimethyl-3-thienyl)-N-(2-methoxy-1-methylethyl)acetamide |

Chemical structure:




| | |
|---|---|
| Formulation used: | 720 g a.i. litre$^{-1}$ emulsifiable concentrate |
| Doses applied: | Activity experiment:- 0.2, 0.8, and 3.2 kg a.i.ha$^{-1}$.<br>Selectivity and persistence experiment:- 0.4, 1.2 and 3.6 kg a.i.ha$^{-1}$ |

## 3.2 Activity experiment

This was carried out in a glasshouse on six species, using the techniques described by Richardson and Dean (1974). The four annual species were raised from seeds and the two perennials from rhizome fragments in 9 cm diameter pots containing a Mendip sandy clay loam (Table 1). Environmental conditions and dates of spraying and assessments are given in Table 2. Species information and the growth stages of plants at spraying and assessment are summarised in Appendix 1. Herbicides were applied by four different methods.

(i) A post-emergence spray to the foliage only, avoiding contact with the soil

(ii) A post-emergence soil drench, avoiding contact with the foliage

(iii) Pre-emergence to the soil surface

(iv) Pre-emergence with thorough incorporation to 5 cm depth before planting

## 3.3 Pre-emergence selectivity experiment

For each species, pre-counted seeds, rhizomes or roots were planted prior to spraying in 9 cm diameter plastic pots containing a Mendip sandy clay loam (Table 1) with Vitax Q4 fertilizer added at 3.3 g litre$^{-1}$. Plant species, numbers of seeds per pot, depths of sowing, seed sources and growth stages at assessment are described in Appendix 2.

To improve germination, Chenopodium album seeds were kept in 0.1M potassium nitrate solution for 48 h in the light before sowing, and Fallopia convolvulus seeds were stored at 4°C in moist sand for two weeks before sowing. Cirsium arvense root fragments were soaked in thiram (0.55 g litre$^{-1}$) for one hour to protect from soil-borne pathogens. The brassica crops and Veronica persica were given a soil drench with Cheshunt compound (ammonium carbamate + copper sulphate), at 3.05 g litre$^{-1}$. one week after spraying to prevent damping-off disease.

An additional series of wheat, barley, oat and maize were treated with the safener, 1,8-naphthalic anhydride (NA) formulated as a wettable powder, to investigate possible protection from herbicide injury. Seeds were dressed by shaking in a polyethylene bag with NA, at 0.5% of the seed weight.

The herbicide was applied as a pre-emergence surface spray using a laboratory track sprayer fitted with an 8002E Spraying Systems Tee Jet flat fan Evenspray nozzle delivering 405 litres ha$^{-1}$ at a pressure of 210 kPa (30 psi) and moving at 0.5 m sec$^{-1}$, 30 cm above the stationary pots. There were two replicates for each treatment. After spraying, pots were set out in two randomised blocks per species in a heated glasshouse (Table 2) where

normal daylight was supplemented by mercury vapour lamps to provide 14 h photoperiods. Irrigation was by overhead hand watering.

### 3.4 Post-emergence selectivity experiment

Plants were grown outside in 9 cm plastic pots containing Mendip loam (Table 1) plus fertilizer ( as in 3.3). Sowing dates were staggered so that the majority of species would reach the 2 to 4 leaf growth stage by the time of spraying. Before spraying, plants of each species were thinned to the same number per pot. Dates of spraying and assessments, and information on outside air temperatures are given in Table 2. Plant species, sources, numbers and growth stages are described in Appendix 3.

Herbicide was applied using a laboratory track sprayer fitted with an 80015 Kemetal flat fan nozzle delivering 328 litres $ha^{-1}$ at a pressure of 210 kPa (30 psi) and moving at 0.5 m $sec^{-1}$, 45 cm above the target area of the plants. After spraying, plants were protected from rainfall for 24 h and put outside in two randomised blocks per species. Watering was by natural rainfall plus additional overhead hand watering as necessary.

### 3.5 Assessments

Assessments were made five to six weeks after spraying the pre-emergence treatments, and three to four weeks after spraying the post-emergence treatments. Survivors were counted and scored for vigour on a 0-7 scale as follows:

0 = completely dead
1 = moribund, but not all tissue dead
2 = alive, with some green tissue, but unlikely to make much further growth
3 = very stunted, but apparently still making some growth
4 = considerable inhibition of growth
5 = readily distinguishable inhibition of growth
6 = some detectable adverse effect as compared with untreated - colour differences, morphological abnormality, epinasty or slight reduction in growth
7 = indistinguishable from untreated control

Histograms of data are presented for each treatment on each species, showing both plant survival and plant vigour, calculated as percentages of untreated controls. Observed selectivities, determined using the criteria specified, are presented in Tables 3 and 4, along with comments highlighting important results.

### 3.6 Persistence in the soil

Residual phytotoxicity was assessed by bioassay on seven dates after spraying. SAN 582 H at 0.4, 1.2 and 3.6 kg a.i.$ha^{-1}$ was applied as a surface spray to pots (7.5 cm diameter) containing Mendip loam plus fertilizer (as in 3.3). "Standard" treatments of cyanazine (short persistence) at 1 kg a.i.$ha^{-1}$, and simazine (long persistence) at 1 kg a.i.$ha^{-1}$ were

included. Pots were kept in a temperate glasshouse where night-time temperatures were not allowed to fall below 10°C and ventilation occurred during daytime above 15°C. Pots were watered from overhead as required to keep the soil moist.

For each bioassay, three replicate pots for each treatment were sown with perennial ryegrass, 12 seeds $pot^{-1}$ and 0.5 cm deep. Plants were harvested at a pre-determined growth stage of the untreated controls, the number and fresh weight of shoots being recorded. Bioassays commenced within a day of spraying and were repeated at seven to eleven week intervals for one year. Residual phytotoxicity was considered to be negligible when plant numbers and shoot fresh weights exceeded 85% of the untreated control plants.

Results are presented graphically in Fig. 8 (shoot weights only) and comments are made in the text.

3.7 Table 1 Soil analysis

| Mendip sandy clay loam | | |
|---|---|---|
| Particle size analysis | | % |
| Coarse sand | (600 μm - 2 mm) | 2.1 |
| Medium sand | (212 μm - 600 μm) | 41.4 |
| Fine sand | ( 63 μm - 212 μm) | 13.8 |
| Silt | ( 2 μm - 63 μm) | 26.6 |
| Clay | ( <2 μm ) | 16.1 |
| Organic matter (%) | | 4.6 |
| pH (in water 1 : 2 soil : water ratio) | | 6.0 |

3.7 Table 2. Soil and environment conditions

| | Type of experiment | | |
|---|---|---|---|
| | Activity | Pre-emergence selectivity | Post-emergence selectivity |
| Dates of spraying | 14 Nov 1986 | 29 Jan 1987 | 28 Jul 1987 & 7 Aug 1987 |
| Main assessment completed | 5 Jan 1987 | 23 Mar 1987 | 1 Sep 1987 |
| | Temperature (°C) | | |
| | Glasshouse | Glasshouse | Outside |
| Mean | 15 | 16 | 16 |
| Maximum | 20 | 25 | 26 |
| Minimum | 10 | 10 | 5 |
| | Relative humidity (%) | | |
| Mean | 60 | 62 | - |
| Maximum | 85 | 86 | - |
| Minimum | 35 | 25 | - |

# 4. RESULTS

## 4.1 Symptoms of SAN 582 H damage to plants

The most obvious symptoms from post-emergence treatments on sensitive grasses were stunting of new growth, small dark-green leaves being produced after spraying; growth inhibition was then followed by leaf necrosis and death of the plants. On the less susceptible, mainly broad-leaved, species symptoms showed as patchy necrosis, crinkling and pitting of sprayed leaves while new leaves were often small and dark-green with reduced internode extension.

Pre-emergence treatments had no effect on germination but shoot and root growth of sensitive grass and broad-leaved species was rapidly inhibited and plants died soon after emergence. In the more tolerant grasses leaf trapping was often apparent. Many broad-leaved species, particularly Cruciferae, showed twisting, crinkling and pitting of leaf laminae and swollen, brittle mid-ribs. The leaf laminae were often poorly developed, being restricted to a narrow band each side of the mid-ribs. Fusion of leaf pairs was observed in some of the more tolerant broad-leaved species, e.g. sunflower and sugar beet.

Generally, symptoms are similar to those produced by chloracetanilide herbicides, e.g. alachlor.

4.2 Activity experiment (Figure 1)

Post-emergence sprays, applied only to the foliage, were virtually inactive but post-emergence soil drench treatments at 0.8 or 3.2 kg a.i.ha$^{-1}$ caused severe damage to grass species. In comparison, there was more activity from pre-emergence treatments, which had moderate effects on broad-leaved species and severe effects on grass species. There were no distinct differences in activity between pre-emergence surface spray applications and soil incorporated treatments.

4.3 Pre-emergence selectivity (Table 3 and Figures 2,3 and 4)

A wide range of weed species was susceptible to SAN 582 H. At the lowest dose, 0.4 kg a.i.ha$^{-1}$, five grasses and seven broad-leaved species were sensitive including: Alopecurus myosuroides, Poa annua, Bromus sterilis, Galium aparine, Veronica persica and Solanum nigrum. Five more species were sensitive at 1.2 kg a.i.ha$^{-1}$, including: Avena fatua, Elymus repens and Stellaria media. The highest dose, 3.6 kg a.i.ha$^{-1}$, controlled some polygonaceous spp., Cirsium arvense and Viola arvensis. Weeds least affected by SAN 582 H were Convolvulus arvensis and cruciferous spp.

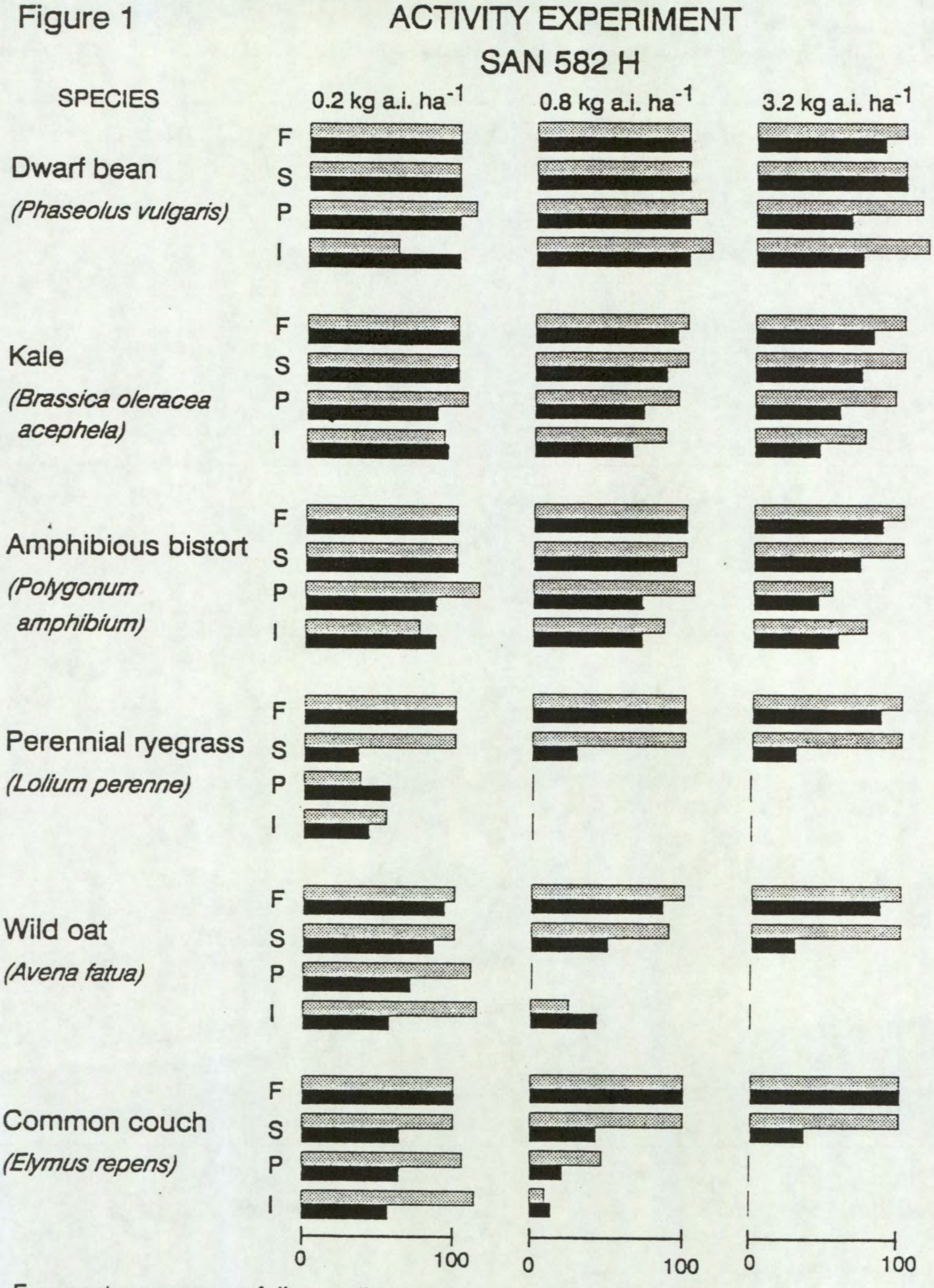
Maize treated with the NA safener was unaffected by 3.6 kg a.i.ha$^{-1}$,while maize without safener tolerated 1.2 kg a.i.ha$^{-1}$. Large seeded legumes, oilseed rape and sugar beet were unaffected by 0.4 kg a.i.ha$^{-1}$. Oat, when seed dressed with NA, also tolerated 0.4 kg a.i.ha$^{-1}$ but without the safener was damaged. Crops showing particular sensitivity to SAN 582 H were perennial ryegrass and white clover.

Table 3 Crop tolerance and weed sensitivity to pre-emergence treatments of SAN 582 H

| Dose (kg a.i.ha$^{-1}$) | Tolerant crops (plant number or vigour reduced by less than 15%) | Sensitive weeds (plant number or vigour reduced by 70% or more) |
|---|---|---|
| 3.6 | Maize + safener | Polygonum lapathifolium<br>Fallopia convolvulus<br>Viola arvensis<br>Rumex obtusifolius<br>Cirsium arvense<br>(plus species listed below) |
| 1.2 | (species listed above plus)<br><br>Maize | Avena fatua<br>Elymus repens<br>Chrysanthemum segetum<br>Stellaria media<br>Geranium dissectum<br>(plus species listed below) |
| 0.4 | (species listed above plus)<br><br>Oat + safener<br>Dwarf bean<br>Field bean<br>Pea<br>Sugar beet<br>Oilseed rape | Alopecurus myosuroides<br>Bromus sterilis<br>Festuca rubra<br>Poa annua<br>Poa trivialis<br>Matricaria perforata<br>Senecio vulgaris<br>Lamium purpureum<br>Galium aparine<br>Chenopodium album<br>Veronica persica<br>Solanum nigrum |

| Sensitive crops (severe damage or kill at 0.4 kg a.i.ha$^{-1}$) | Tolerant weeds (no or only slight to moderate effects at 3.6 kg a.i.ha$^{-1}$) |
|---|---|
| Perennial ryegrass<br>White clover | Raphanus raphanistrum<br>Sinapis arvensis<br>Convolvulus arvensis |

Figure 1




F = post-emergence, foliar application
S = post-emergence, soil drench
P = pre-emergence, surface spray
I = pre-planting, soil incorporated

Figure 2 PRE-EMERGENCE SELECTIVITY EXPERIMENT

SAN 582 H

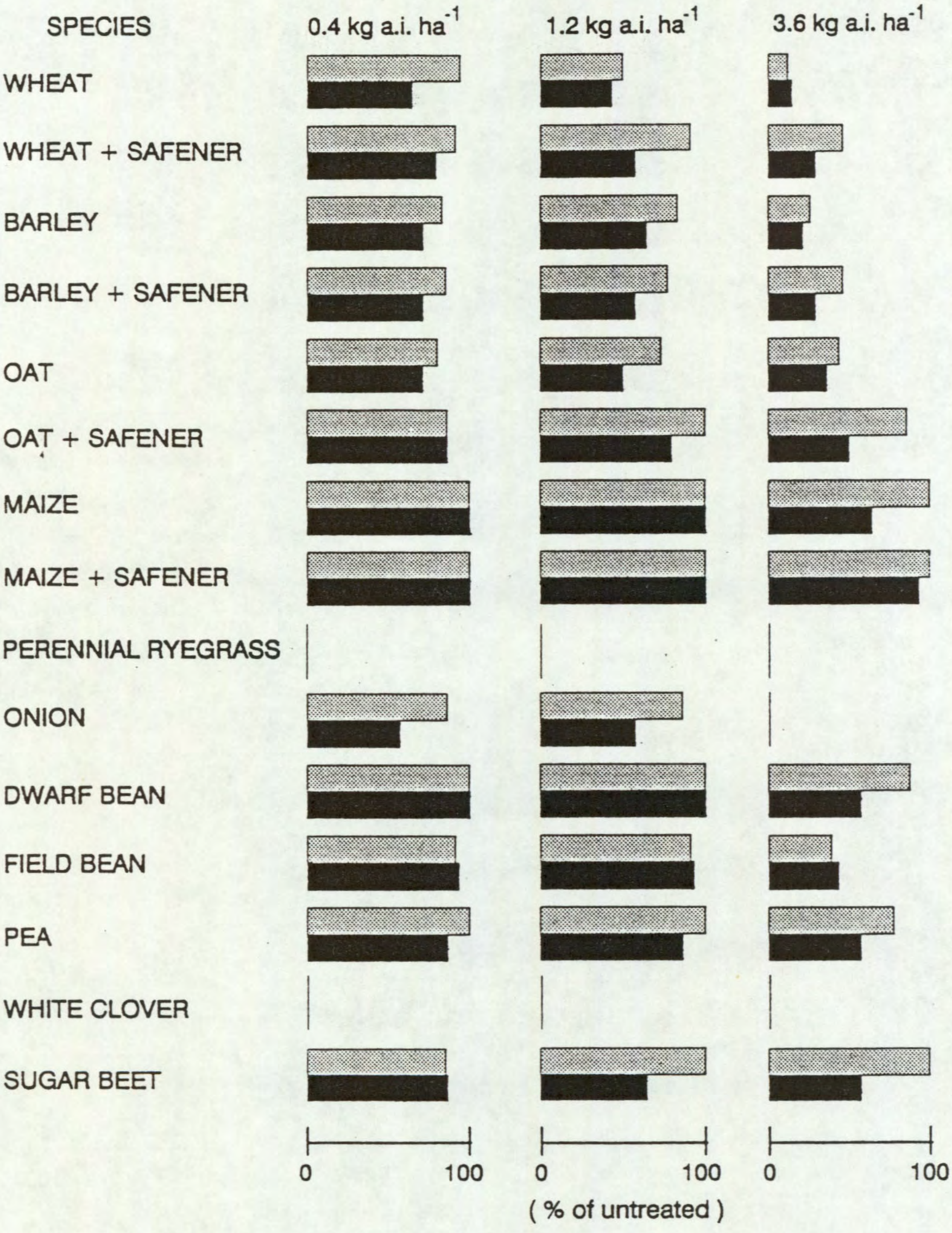


Figure 3 PRE-EMERGENCE SELECTIVITY EXPERIMENT

SAN 582 H

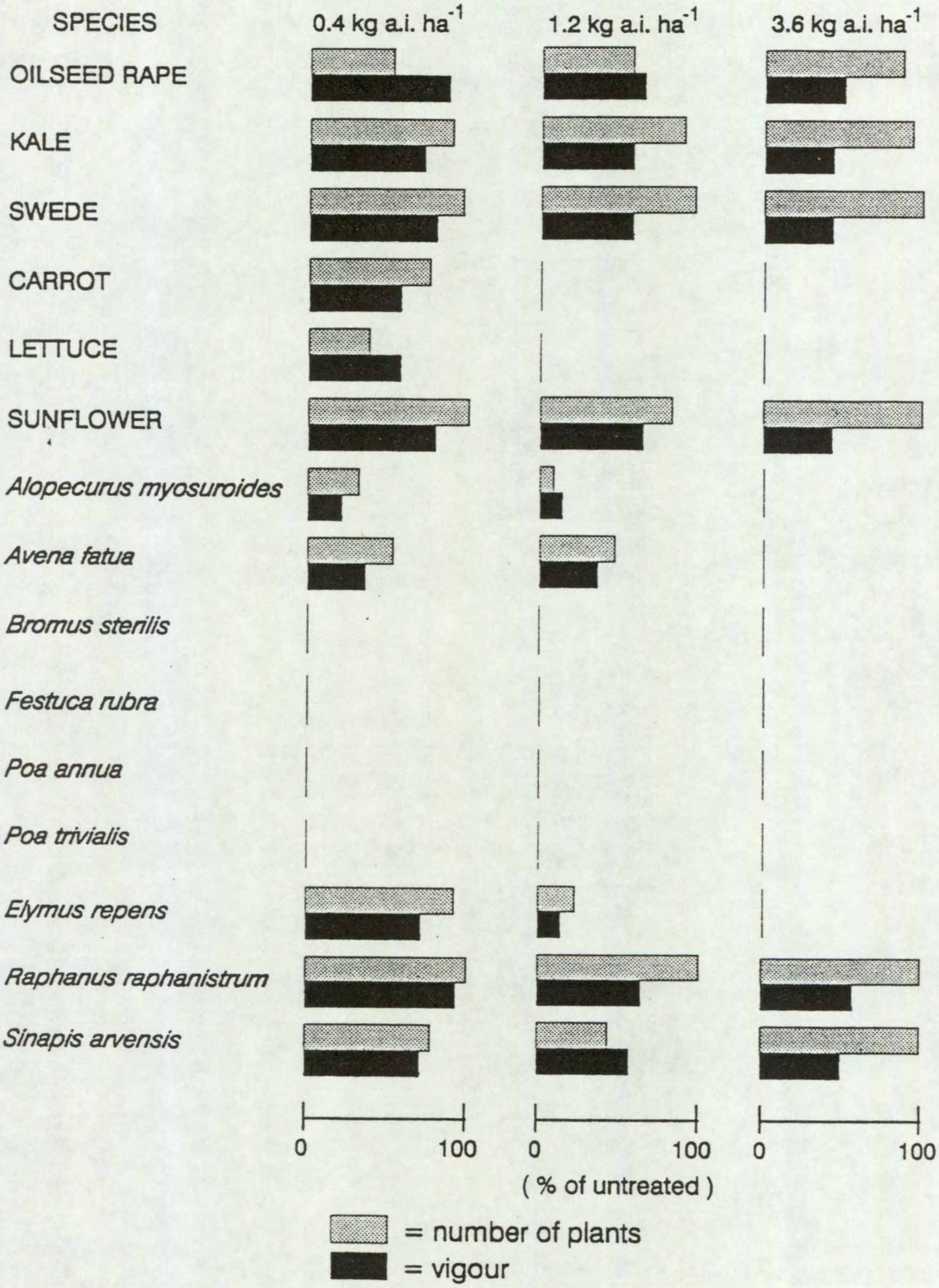
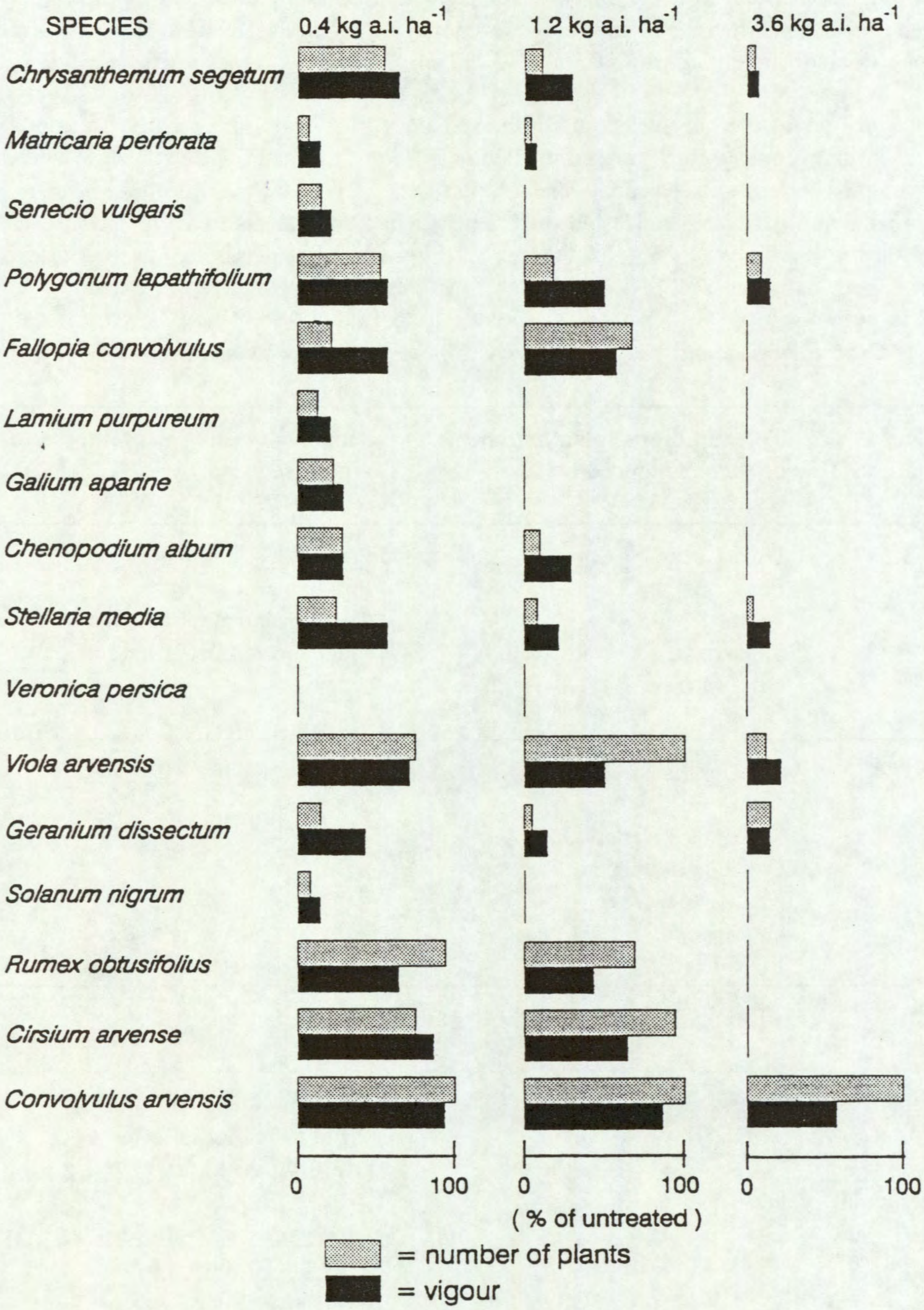


Figure 4 PRE-EMERGENCE SELECTIVITY EXPERIMENT

SAN 582 H



## 4.4 Post-emergence selectivity (Table 4 and Figures 5,6 and 7)

Post-emergence activity of SAN 582 H was much reduced compared with its pre-emergence activity. Most weed species were unaffected by SAN 582 H at 0.4 kg a.i.ha$^{-1}$ and none was adequately controlled.

Bromus sterilis was the only weed susceptible to SAN 582 H at 1.2 kg a.i.ha$^{-1}$ and poa spp. and Lamium purpureum were controlled at 3.6 kg a.i.ha$^{-1}$. Pea, dwarf bean, white clover, sugar beet and oilseed rape were tolerant to 3.6 kg a.i.ha$^{-1}$, while field bean, onion, maize and oat were unaffected by 1.2 kg a.i.ha$^{-1}$. Wheat plants from seed treated with NA were unaffected by SAN 582 H at 1.2 kg a.i.ha$^{-1}$ but plants from seed not dressed with NA were damaged at this dose.

Table 4 Crop tolerance and weed sensitivity to post-emergence treatments of SAN 582 H

| Dose (kg a.i.ha$^{-1}$) | Tolerant crops (plant number or vigour reduced by less than 15%) | Sensitive weeds (plant number or vigour reduced by 70% or more) |
|---|---|---|
| 3.6 | Dwarf bean<br>Pea<br>White clover<br>Sugar beet<br>Oilseed rape | Poa annua<br>Poa trivialis<br>Lamium purpureum<br>(plus species listed below) |
| 1.2 | (species listed above plus)<br><br>Wheat + safener<br>Oat ± safener<br>Maize ± safener<br>Onion<br>Field bean | Bromus sterilis |
| 0.4 | All crops tolerant | No weeds sensitive |
| Sensitive crops (severe damage or kill at 0.4 kg a.i.ha$^{-1}$)<br><br>Perennial ryegrass | | Tolerant weeds (no or only slight to moderate effects at 3.6 kg a.i.ha$^{-1}$)<br><br>Alopecurus myosuroides<br>Agrostis stolonifera<br>Many dicotyledonous weeds |

Figure 5 POST-EMERGENCE SELECTIVITY EXPERIMENT

SAN 582 H

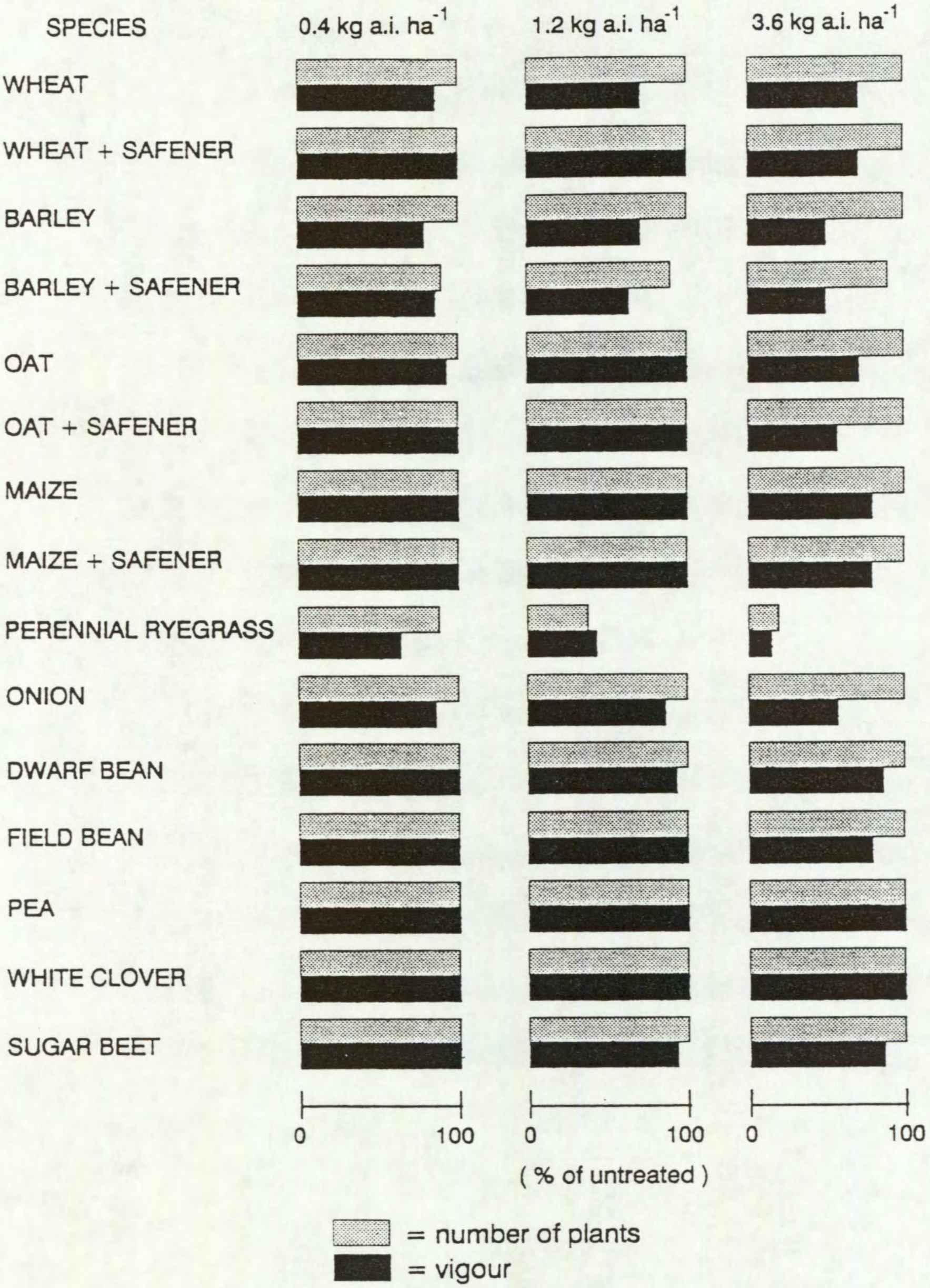
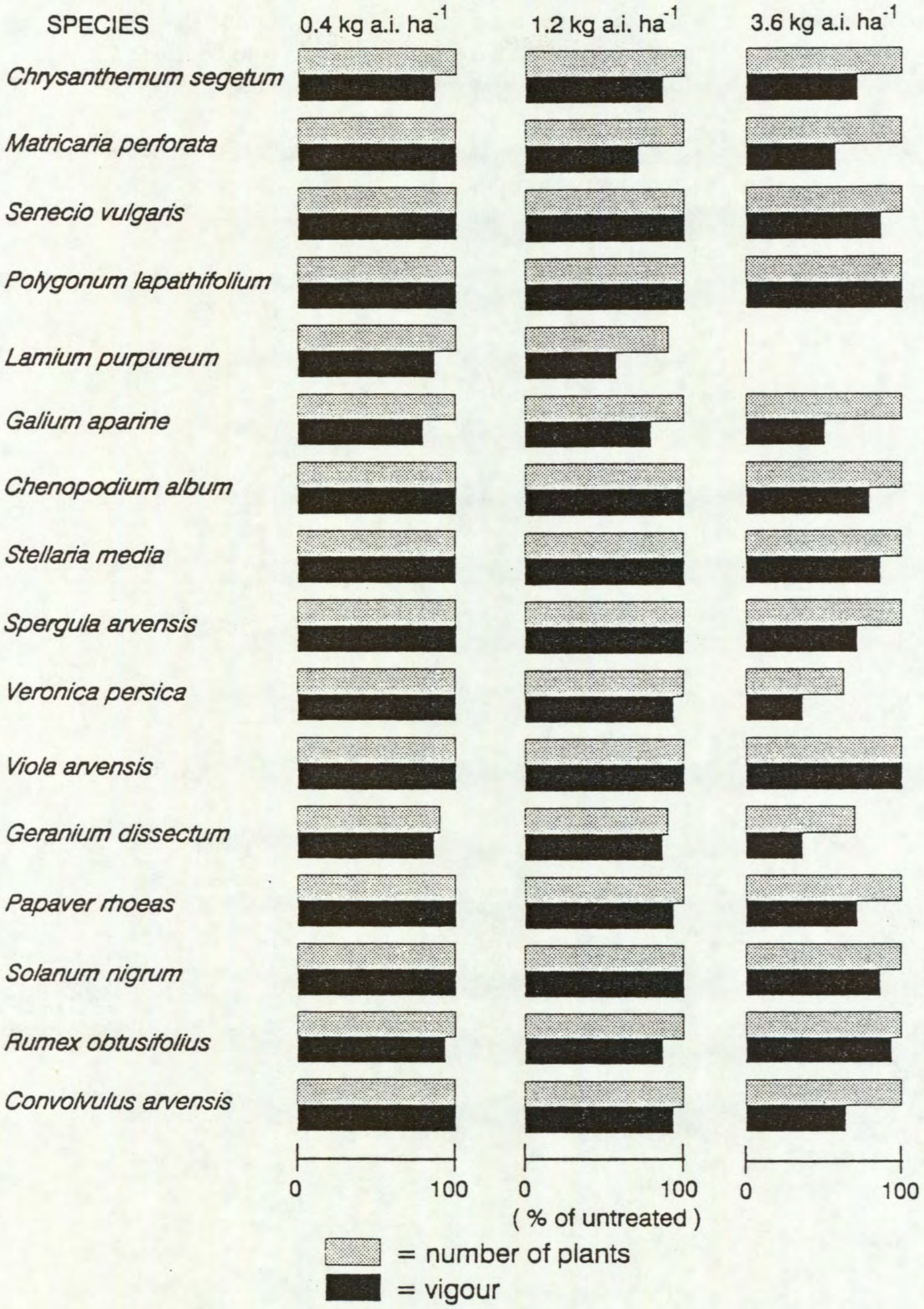


Figure 6 POST-EMERGENCE SELECTIVITY EXPERIMENT

SAN 582 H

Figure 7 POST-EMERGENCE SELECTIVITY EXPERIMENT

SAN 582 H

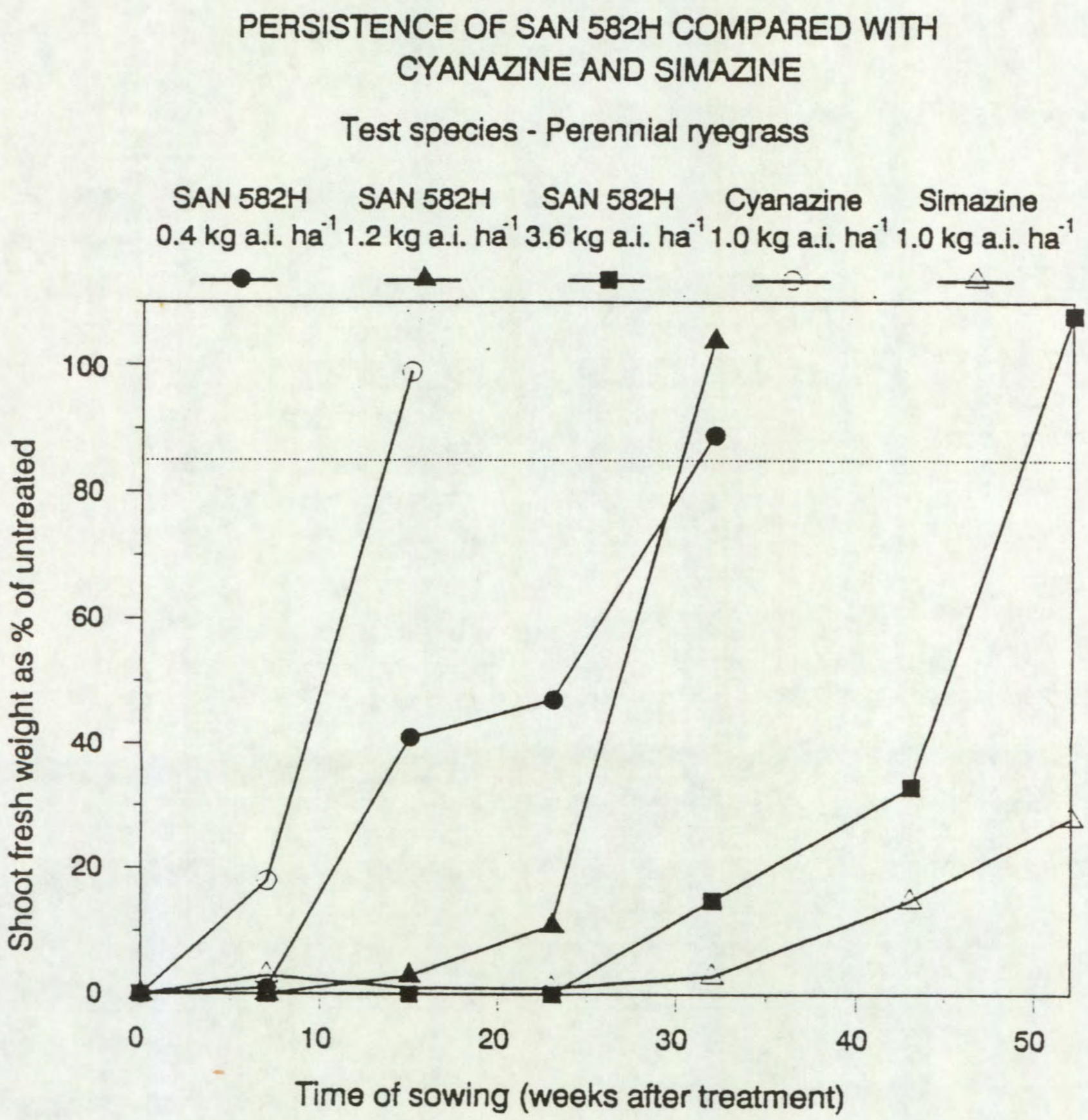


4.5 Soil persistence (Figure 8)

A moderate period of soil persistence was found for SAN 582 H at 0.4 and 1.2 kg a.i.ha$^{-1}$, perennial ryegrass being unaffected when sown into treated soil 30 weeks after spraying. However, 3.6 kg a.i.ha$^{-1}$ caused damage to perennial ryegrass up to 43 weeks after spraying although no phytotoxicity was seen at the 52-week bioassay.

Soil persistence of SAN 582 H was between that obtained for the two "standard" herbicide treatments. No effects of cyanazine were found after 15 weeks, whereas simazine was appreciably phytotoxic 52 weeks after soil treatment.

Figure. 8



## 5. DISCUSSION

Work by Harr et al. (1991), investigating the mode of action of SAN 582 H, found the herbicide was almost exclusively active via uptake through the plant coleoptile. This is in agreement with our results which showed that soil-applied treatments were active, even when applied early post-emergence, while treatments restricted to the foliage were virtually inactive.

SAN 582 H, applied pre-emergence, is known to have excellent potential for control of warm climate weed species in maize and soyabean (Harr, 1991). Our experiments showed that pre-emergence application of SAN 582 H also shows potential for selective control of a range of temperate weed species, especially annual grasses, in some temperate crops. The tolerance of dwarf bean, field bean and pea, at a dose to which several important annual weeds were sensitive, is of particular interest. However, poor activity against polygonaceous and cruciferous weed species suggests that SAN 582 H would need to be part of a sequence or mixture with other herbicides to give broad spectrum control.

Maize was the most tolerant crop tested to SAN 582 H and this tolerance was further increased by seed dressing with the safener naphthalic anhydride (NA). The increased tolerance of oat to pre-emergence treatments of SAN 582 H when seed was dressed with the safener is also of special interest as this herbicide had good activity against grass weeds including the wild oat (Avena fatua). Further work to determine the level of selectivity between cultivated and wild oat would be worthwhile.

Also of interest was the tolerance of wheat plants from seed dressed with the safener (NA) to post-emergence treatment of SAN 582 H at 1.2 kg a.i.$ha^{-1}$. Bromus sterilis, a particularly difficult weed problem of winter wheat in the UK, was susceptible to this dose. Again, further investigation is suggested.

The moderate period of soil persistence, indicated from our experiment, should prove advantageous in the field for control of later-germinating weeds without causing residual phytotoxicty problems in subsequent crops.

## 6. ACKNOWLEDGEMENTS

I am most grateful to Mr R.J. Tutcher, Mr R.F. Hughes and his staff for practical assistance, and to Mrs M.D. Griffin and Mrs A. Berry for their help in typing this report. Special thanks go to Sandoz Crop Protection Ltd for supplying the experimental herbicide sample. This work was funded by MAFF.

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Richardson, W.G. and Dean, M.L. (1974) The activity and post-emergence selectivity of some recently developed herbicides : oxadiazon, U-29722, U-27628, metflurazone, norflurazone, AC 50191, AC 84777 and iprymidam. Technical Report Agricultural Research Council Weed Research Organization, 32, pp. 74

# APPENDICES

**APPENDIX 1.** Species Information for Activity Experiment

| Species | Cultivar (source) | N° of seeds or plants pot$^{-1}$ | | Depth of planting | Growth stage of untreated plants at:- | | |
|---|---|---|---|---|---|---|---|
| | | pre-em | post-em | (cm) | Spraying post-em | Assessment pre-em | post-em |
| Dwarf bean (Phaseolus vulgaris) | The Prince (Finney Lock) | 3 | 2 | 2 | 1 trifoliate expanding | 3 trifoliates flowering | 3 trifoliates flowering |
| Kale (Brassica oleraceae acephala) | Marrowstem (Finney Lock) | 10 | 5 | 0.5 | 2-2.5 leaves | 4 leaves | 6 leaves |
| Polygonum amphibium (amphibious bistort) | WRO* Clone 1 | 6 | 5 | 1.5 | 3-4 leaves | 12 leaves | 11 leaves |
| Perennial ryegrass (Lolium perenne) | Melle (British seedhouses) | 12 | 8 | 0.5 | 3 leaves | 5 leaves, 7 tillers | 5 leaves, 5 tillers |
| Avena fatua (wild oat) | WRO* 1980 | 12 | 5 | 1 | 3 leaves | 6 leaves | 7 leaves, 2 tillers |
| Elymus repens (common couch) | WRO* Clone 31 | 6 | 4 | 1 | 3 leaves | 6 leaves, 1 tiller | 8 leaves, 2 tillers |

* WRO denotes seed or rhizome collected from stockbed plants originally propagated at the Weed Research Oganization, Oxford, but now maintained at Long Ashton Reseach Station

**APPENDIX 2.** Species Information for Pre-emergence Experiment

| Species | Cultivar or source | No. pot$^{-1}$ | Depth of planting (cm) | Growth stage of untreated controls at assessment |
|---|---|---|---|---|
| Wheat (Triticum aestivum) | Avalon | 8 | 1 | 5 leaves, 1 tiller |
| Wheat + NA safener | Avalon | 8 | 1 | 5 leaves, 1 tiller |
| Barley (Hordeum vulgare) | Igri | 8 | 1 | 5 leaves, 1 tiller |
| Barley + NA safener | Igri | 8 | 1 | 5 leaves, 1 tiller |
| Oat (Avena sativa) | Peniarth | 8 | 1 | 6 leaves |
| Oat + NA safener | Peniarth | 8 | 1 | 6 leaves |
| Maize (Zea mays) | LG 11 | 4 | 2 | 5 leaves |
| Maize + NA safener | LG 11 | 4 | 2 | 5 leaves |
| Perennial ryegrass (Lolium perenne) | Melle | 12 | 0.5 | 6 tillers |
| Onion (Allium cepa) | White Lisbon | 15 | 0.5 | 3 leaves |
| Dwarf bean (Phaseolus vulgaris) | The Prince | 3 | 2 | 2 trifoliates |
| Field bean (Vicia faba) | Maris Bead | 4 | 4 | 8 leaves |
| Pea (Pisum sativum) | Meteor | 4 | 4 | 8 leaves, flowering |
| White clover (Trifolium repens) | Huia | 15 | 0.5 | 15 leaves |
| Sugar beet (Beta vulgaris) | Samson | 8 | 1 | 6 leaves |
| Oilseed rape (Brassica napus oleifera) | Jet Neuf | 12 | 0.5 | 4 leaves |
| Kale (Brassica oleracea acephala) | Marrowstem | 12 | 0.5 | 4 leaves |
| Swede (Brassica napus) | Marian | 12 | 0.5 | 4 leaves |

**APPENDIX 2.** (cont'd) Species Information for Pre-emergence Experiment

| Species | Cultivar or source | No. pot$^{-1}$ | Depth of planting (cm) | Growth stage of untreated controls at assessment |
|---|---|---|---|---|
| Carrot (Daucus carota) | Chantenay Red Cored | 12 | 0.5 | 5 leaves |
| Lettuce (Lactuca sativa) | Webbs Wonderful | 15 | 0.5 | 6 leaves |
| Sunflower (Helianthus annuus) | Frankasol | 7 | 1.5 | 3 pairs leaves |
| Alopecurus myosuroides (blackgrass) | Herbiseed | 20 | 0.25 | 5 tillers |
| Avena fatua (wild oat) | WRO | 10 | 1 | 5 leaves |
| Bromus sterilis (barren brome) | Herbiseed | 8 | 1 | 4 leaves, 3 tillers |
| Festuca rubra (red fescue) | Herbiseed | 20 | 0.5 | 5 leaves, 4 tillers |
| Poa annua (annual meadow grass) | Herbiseed | 20 | 0.25 | 8 tillers |
| Poa trivialis (rough meadow grass) | Herbiseed | 16 | 0.25 | 8 tillers |
| Elymus repens (common couch) | WRO Clone 31 | 6 (3cm rhizomes) | 1 | 7 leaves, 1 tiller |
| Raphanus raphanistrum (wild radish) | Herbiseed | 10 | 0.5 | 7 leaves |
| Sinapis arvensis (charlock) | B & S | 15 | 0.5 | 6 leaves |
| Chrysanthemum segetum (corn marigold) | B & S | 25 | surface | 13 leaves |
| Matricaria perforata (scentless mayweed) | Herbiseed | 25 | surface | 12 leaves |
| Senecio vulgaris (groundsel) | Herbiseed | 15 | surface | 7 leaves, flowering |
| Polygonum lapathifolium (pale persicaria) | Herbiseed | 20 | 0.25 | 9 leaves |
| Fallopia convolvulus (black bindweed) | Herbiseed | 20 | 0.5 | 12 leaves |

**APPENDIX 2.** (cont'd) Species Information for Pre-emergence Experiment

| Species | Cultivar or source | No. pot$^{-1}$ | Depth of planting (cm) | Growth stage of untreated controls at assessment |
|---|---|---|---|---|
| Lamium purpureum (red dead nettle) | Herbiseed | 20 | 0.5 | 6 pairs leaves, flowering |
| Galium aparine (cleavers) | Herbiseed | 16 | 0.5 | 8 whorls, + axillaries |
| Chenopodium album (fat hen) | Herbiseed | 15 | 0.25 | 9 leaves, flowering |
| Stellaria media (chickweed) | Herbiseed | 20 | 0.5 | 10 pairs leaves, several branches |
| Veronica persica (common field speedwell) | Herbiseed | 20 | 0.25 | 10 leaves, + axillaries |
| Viola arvensis (field pansy) | Herbiseed | 25 | 0.25 | 6 leaves |
| Geranium dissectum (cut-leaved cranesbill) | Herbiseed | 10 | 0.5 | 6 leaves |
| Solanum nigrum (black nightshade) | Herbiseed | 15 | 0.25 | 8 leaves |
| Rumex obtusifolius (broad-leaved dock) | Herbiseed | 15 | 0.25 | 6 leaves |
| Cirsium arvense (creeping thistle) | WRO Clone 1 | 6 (3 cm roots) | 1 | 10 leaves |
| Convolvulus arvensis (field bindweed) | Herbiseed | 20 | 0.5 | 8 leaves |

**APPENDIX 3.** Species information for Post-emergence Experiment

| Species | Cultivar or source | No. plants pot$^{-1}$ | Growth stage of untreated controls | |
|---|---|---|---|---|
| | | | At spraying | At assessment |
| Wheat (Triticum aestivum) | Avalon | 5 | 3 leaves | 7 leaves, 4 tillers |
| Wheat + NA safener | Avalon | 5 | 3 leaves | 7 leaves, 4 tillers |
| Barley (Hordeum vulgare) | Igri | 5 | 3 leaves | 7 leaves, 5 tillers |
| Barley + NA safener | Igri | 5 | 3 leaves | 7 leaves, 5 tillers |
| Oat (Avena sativa) | Peniarth | 5 | 2.5 leaves | 6 leaves, 6 tillers |
| Oat + NA safener | Peniarth | 5 | 2.5 leaves | 6 leaves, 6 tillers |
| Maize (Zea mays) | LG 11 | 3 | 3 leaves | 8 leaves |
| Maize + NA safener | LG 11 | 3 | 2.5 leaves | 7 leaves |
| Perennial ryegrass (Lolium perenne) | Melle | 8 | 3 leaves, 1 tiller | 10 tillers |
| Onion (Allium cepa) | White Lisbon | 5 | 3 leaves | 5 leaves |
| Dwarf bean (Phaseolus vulgaris) | The Prince | 2 | 1 trifoliate | 6 trifoliates |
| Field bean (Vicia faba) | Maris Bead | 3 | 3 leaves | 15 leaves, flowering |
| Pea (Pisum sativum) | Meteor | 3 | 4 leaves | 7 leaves |
| White clover (Trifolium repens) | Huia | 5 | 3 leaves | 25 leaves |
| Sugar beet (Beta vulgaris) | Samson | 5 | 4 leaves | 12 leaves |
| Oilseed rape (Brassica napus oleifera) | Jet Neuf | 5 | 2.5 leaves | 7 leaves |
| Kale (Brassica oleracea acephala) | Marrowstem | 5 | 2.5 leaves | 7 leaves |

**APPENDIX 3.** (cont'd) Species information for Post-emergence Experiment (contd)

| Species | Cultivar or source | No. plants pot$^{-1}$ | Growth stage of untreated controls | |
|---|---|---|---|---|
| | | | At spraying | At assessment |
| Cabbage (Brassica oleracea capitata) | Golden acre | 5 | 3 leaves | 12 leaves |
| Carrot (Daucus carota) | Chentenay Red Cored | 5 | 3 leaves | 7 leaves |
| Parsnip (Pastinaca sativa) | White Gem | 3 | 2 leaves | 5 leaves |
| Lettuce (Lactuca sativa) | Webbs Wonderful | 5 | 3.5 leaves | 10 leaves |
| Sunflower (Helianthus annuus) | Frankasol | 3 | 4 leaves | 10 leaves |
| Alopecurus myosuroides (blackgrass) | Herbiseed | 5 | 3 leaves, 1 tiller | 12 tillers |
| Avena fatua (wild oat) | WRO | 5 | 2.5 leaves | 6 leaves, 2 tillers |
| Bromus sterilis (barren brome) | Herbiseed | 5 | 2.5 leaves | 8 tillers |
| Poa annua (annual meadow grass) | Herbiseed | 8 | 3 leaves, 1 tiller | 16 tillers |
| Poa trivialis (rough meadow grass) | Herbiseed | 8 | 3 leaves, 1 tiller | 20 tillers |
| Agrostis stolonifera (creeping bent) | Herbiseed | 5 | 3 leaves, 4 tillers | 15 tillers |
| Elymus repens (common couch) | WRO Clone 31 | 5 | 3 leaves | 5 leaves, 3 tillers |
| Raphanus raphanistrum (wild radish) | Herbiseed | 5 | 3 leaves | 7 leaves, flowering |
| Sinapis arvensis (charlock) | B & S | 5 | 3.5 leaves | 7 leaves, flowering |
| Chrysanthemum segetum (corn marigold) | B & S | 4 | 4 leaves | 17 leaves, flowering |
| Matricaria perforata (scentless mayweed) | Herbiseed | 5 | 4 leaves | 15 leaves, axillaries, flowering |
| Senecio vulgaris (groundsel) | Herbiseed | 5 | 3 leaves | 8 leaves, flowering |

**APPENDIX 3.** (cont'd) Species information for Post-emergence Experiment (contd)

| Species | Cultivar or source | No. plants pot$^{-1}$ | Growth stage of untreated controls | |
|---|---|---|---|---|
| | | | At spraying | At assessment |
| Polygonum lapathifolium (pale persicaria) | Herbiseed | 5 | 4 leaves | 11 leaves, flowering |
| Lamium purpureum (red dead-nettle) | Herbiseed | 5 | 2 pairs leaves | 7 pairs leaves, axillaries, flowering |
| Galium aparine (cleavers) | Herbiseed | 5 | 2 whorls | 12 whorls on branches + axillaries |
| Chenopodium album (fat hen) | Herbiseed | 5 | 4 leaves | 12 leaves, flowering |
| Stellaria media (chickweed) | Herbiseed | 5 | 3 pairs leaves | 9 pairs on branches, axillaries, flowering |
| Spergula arvensis (corn spurrey) | Herbiseed | 5 | 2 whorls | 7 whorls, axillaries, flowering |
| Veronica persica (common field speedwell) | Herbiseed | 4 | 5 leaves | 15 leaves, axillaries, |
| Viola arvensis (field pansy) | Herbiseed | 4 | 4 leaves | 9 leaves, axillaries, flowering |
| Geranium dissectum (cut-leaved cranesbill) | Herbiseed | 5 | 2 leaves | 16 leaves |
| Papaver rhoeas (common poppy) | Herbiseed | 5 | 4 leaves | 11 leaves, axillares, flowering |
| Solanum nigrum (black nightshade) | Herbiseed | 5 | 3 leaves | 7 leaves, axillaries, flowering |
| Rumex obtusifolius (broad-leaved dock) | Herbiseed | 5 | 3 leaves | 5 leaves |
| Convolvulus arvensis (field bindweed) | Herbiseed | 5 | 3 leaves | 8 leaves |

**APPENDIX 4** Addresses of seed suppliers

B & S Weed Seed Suppliers
Little Orchard
Main Street
Whatton in the Vale
Nottingham
England
NG13 9EP

British Seedhouses
Portview Road
Avonmouth
Bristol
England

Finney Lock Seeds Ltd
Avenue Road
Witham
Essex
England
CN18 2DX

Herbiseed
The Nurseries
Billingbear Park
Wokingham
England
RG11 5RY

## APPENDIX 5 ABBREVIATIONS

| | | | |
|---|---|---|---|
| acid equivalent | a.e. | minute | min |
| active ingredient | a.i. | more than | > |
| approximately equal to | ≈ | organic matter | o.m. |
| centimetre | cm | page | p. |
| cultivar (s) | cv. | pages | pp. |
| degree centigrade | °C | part per million | ppm |
| emulsifiable concentrate | EC | per | $^{-1}$ |
| equal to | = | percent(age) | % |
| gramme | g | plus or minus | ± |
| hectare | ha | postemergence | post-em |
| hour | h | pre-emergence | pre-em |
| hydrogen ion concentration | pH | relative humidity | r.h. |
| kilogramme | kg | second | s |
| less than | < | soluble liquid | SL |
| litre | l. | species (singular) | sp. |
| maximum | max | species (plural) | spp. |
| metre | m | sub-species | ssp. |
| micrometre | μm | temperature | temp |
| milligramme | mg | varietas | var |
| millilitre | ml | volume per volume | v/v |
| millimetre | mm | water dispersible granule | WG |
| minimum | min. | wettable powder | WP |

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CROP AND ENVIRONMENTAL SCIENCES DEPARTMENT

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6. The botany, ecology, agronomy and control of Poa trivialis L. rough-stalked meadow-grass. November 1966. G P Allen. Price £0.25

7. Flame cultivation experiments 1965. October 1966. G W Ivens - Price £0.25

8. The development of selective herbicides for kale in the United Kingdom. 2. The methylthiotriazines. Price £0.25

10. The liverwort, Marchantia polymorpha L. as a weed problem in horticulture; its extent and control. July 1968. I E Henson. Price £0.25

11. Raising plants for herbicide evaluation; a comparison of compost types. July 1968. I E Henson. Price £0.25

12.* Studies on the regeneration of perennial weeds in the glasshouse; I. Temperate species. May 1969. I E Henson. Price £0.25

13. Changes in the germination capacity of three Polygonum species following low temperature moist storage. May 1969. I E Henson. Price £0.25

14. Studies on the regeneration of perennial weeds in the glasshouse. II. Tropical species. May 1970. I E Henson. Price £0.25

15. Methods of analysis for herbicide residues. February 1977. (second edition). Price £5.75

16. Report on a joint survey of the presence of wild oat seeds in cereal seed drills in the United Kingdom during spring 1970. November 1970. J G Elliott and P J Attwood. Price £0.25

17. The pre-emergence selectivity of some newly developed herbicides, Orga 3045 (in comparison with dalapon), haloxydine (PP 493), HZ 52.112, pronamide (RH 315) and R 12001. January 1971. W G Richardson, C Parker and K Holly. Price £0.25

18. A survey from the roadside of the state of post-harvest operations in Oxfordshire in 1971. A Philipson. Price £0.25

19.* The pre-emergence selectivity of some recently developed herbicides in jute, kenaf and sesamum, and their activity against Oxalis latifolia. December 1971. M L Dean and C Parker. Price £0.25

20.* A survey of cereal husbandry and weed control in three regions of England. July 1972. A Philipson, T W Cox and J G Elliot. Price £0.35

21. An automatic punching counter. November 1972. R C Simmonds. Price £0.30

22. The pre-emergence selectivity of some newly developed herbicides: bentazon, BAS 373OH, metflurazone, SAN 9789, HER 52.123, U 27,267. December 1972. W G Richardson and M L Dean. Price £0.25

23. A survey of the presence of wild oats and blackgrass in parts of the United Kingdom during summer 1972. A Philipson. Price £0.25

24. The conduct of field experiments at the Weed Research Organization. February 1973. J G Elliott, J Holroyd and T O Robson. Price £1.25

25. The pre-emergence selectivity of some recently developed herbicides: lenacil, RU 12068, metribuzin, cyprazine, EMD-IT 5914 and benthiocarb. August 1973 W G Richardson and M L Dean. Price £1.75

26. The post-emergence selectivity of some recently developed herbicides: bentazone, EMD-IT 6412, cyprazine, metribuzin, chlornitrofen, glyphosate, MC 4379, Chlorfenprop-methyl. October 1973. W G Richardson and M L Dean. Price £3.31

27. Selectivity of benzene sulphonyl carbamate herbicides between various pasture grasses and clover. October 1973. A M Blair. Price £1.05

28. The post-emergence selectivity of eight herbicides between pasture grasses: RP 17623, HOE 701, BAS 3790, metoxuron, RU 12068, cyprazine, MC 4379, metribuzin. October 1973. A M Blair. Price £1.00

29.* The pre-emergence selectivity between pasture grasses of twelve herbicides: haloxydine, pronamide, NC 8438, Orga 3045, chlortoluron, metoxuron, dicamba, isopropalin, carbetamide, MC 4379, MBR 8251 and EMD-IT 5914. November 1973. A M Blair. Price £1.30

30. Herbicides for the control of the broad-leaved dock (Rumex obtusifolius L.). November 1973. A M Blair and J Holroyd. Price £1.06

31. Factors affecting the selectivity of six soil acting herbicides against Cyperus rotundus. February 1974. M L Dean and C Parker. Price £1.10

32. The activity and post-emergence selectivity of some recently developed herbicides: oxadizon, U-29,722, U-27,658, metflurazone, norflurazone, AC 50-191, AC 84,777 and iprymidam. June 1974. W G Richardson and M L Dean. Price £3.62

33. A permanent automatic weather station using digital integrators. September 1974. R C Simmonds. Price £0.63

34. The activity and pre-emergence selectivity of some recently developed herbicides: trifluralin, ispropalin, oryzalin, dinitramine, bifenox and perfluidone. November 1974. W G Richardson and M L Dean. Price £2.50

35. A survey of aquatic weed control methods used by Internal Drainage Boards, 1973. January 1975. T O Robson. Price £1.39

36. The activity and pre-emergence selectivity of some recently developed herbicides: Bayer 94871, tebuthiuron, AC 92553. March 1975. W G Richardson and M L Dean. Price £1.54

37. Studies on Imperata cylindrica (L.) Beauv. and Eupatorium odoratum L. October 1975. G W Ivens. Price £1.75

38. The activity and pre-emergence selectivity of some recently developed herbicides: metamitron, HOE 22870, HOE 23408, RH 2915, RP 20630. March 1976. W G Richardson, M L Dean and C Parker. Price £3.25

39. The activity and post-emergence selectivity of some recently developed herbicides: HOE 22870, HOE 23408, flamprop-methyl, metamitron and cyperquat. May 1976. W G Richardson and C Parker. Price £3.20

40. The activity and pre-emergence selectivity of some recently developed herbicides: RP 20810, oxadiazon, chloronitrofen, nitrofen, flamprop-isopropyl. August 1976. W G Richardson, M L Dean and C Parker. Price £2.75

41. The activity and pre-emergence selectivity of some recently developed herbicides: K 1441, mefluidide, WL 29226, epronaz, Dowco 290 and triclopyr. November 1976. W G Richardson and C Parker. Price £3.40

42. The activity and post-emergence selectivity of some recently developed herbicides: KUE 2079A, HOE 29152, RH 2915, triclopyr and Dowco 290. March 1977. W G Richardson and C Parker. Price £3.50

43. The activity and pre-emergence selectivity of some recently developed herbicides: dimefuron, hexazinone, trifop-methyl, fluothiuron, buthidazole and butam. November 1977. W G Richardson and C Parker. Price £3.75

44. The activity and selectivity of the herbicides: ethofumesate, RU 12709 and isoproturon. December 1977. W G Richardson, C Parker and M L Dean. Price £4.00

45. Methods of analysis for determining the effects of herbicides on soil micro-organisms and their activities. January 1978. M P Greaves, S L Cooper, H A Davies, J A P Marsh and G I Wingfield. Price £4.00

46. Pot experiments at the Weed Research Organization with forest crop and weed species. February 1978. D J Turner and W G Richardson. Price £2.70

47. Field experiments to investigate the long-term effects of repeated applications of MCPA, tri-allate, simazine and linuron - effects on the quality of barley, wheat, maize and carrots. July 1978. J D Fryer, P D Smith and J W Ludwig. Price £1.20

48. Factors affecting the toxicity of paraquat and dalapon to grass swards. March 1978. A K Oswald. Price £2.90

49. The activity and post-emergence selectivity of some recently developed herbicides: NP 48, RH 5205 and Pyridate. May 1978. W G Richardson and C Parker. Price £2.50

50. Sedge weeds of East Africa - II. Distribution. July 1978. P J Terry. Price £1.50

51. The activity and selectivity of the herbicides methabenzthiazuron, metoxuron, chlortoluron and cyanazine. September 1978. W G Richardson and C Parker. Price £2.20

52. Antidotes for the protection of field bean (Vicia faba L.) from damage by EPTC and other herbicides. February 1979. A M Blair. Price £1.35

53. Antidotes for the protection of wheat from damage by tri-allate. February 1979. A M Blair. Price £2.00

54. The activity and pre-emergence selectivity of some recently developed herbicides: alachlor, metolachlor, dimethachlor, alloxydim-sodium and fluridone. April 1979. W G Richardson and C Parker. Price £3.00

55. The activity and selectivity of the herbicides carbetamide, methazole, R 11913 and OCS 21693. May 1979. W G Richardson and C Parker. Price £1.80

56. Growing weeds from seeds and other propagules for experimental purposes. July 1979. R H Webster. Price £1.10

57. The activity and pre-emergence selectivity of some recently developed herbicides: R 40244, AC 206784, pendimethalin, butralin, acifluorfen and FMC 39821. December 1979. W G Richardson, T M West and C Parker. Price £3.55

58. The tolerance of fenugreek (Trigonella foenumgraecum L.) to various herbicides. December 1979. W G Richardson. Price £1.55

59. Recommended tests for assessing the side-effects of pesticides on the soil microflora. April 1980. M P Greaves, N J Poole, K H Domsch, G Jagnow and W Verstraete. Price £2.00 (Amended version to be printed in 1986)

60. Properties of natural rainfalls and their simulation in the laboratory for pesticide research. September 1980. R C Simmonds. Price £1.25

61. The activity and post-emergence selectivity of some recently developed herbicides: R 40244, DPX 4189, acifluorfen, ARD 34/02 (NP 55) and PP 009. November 1980. W G Richardson, T M West and C Parker. Price £3.75

62. The activity and pre emergence selectivity of some recently developed herbicides: UBI S-734, SSH-43, ARD 34/02 (NP 55), PP 009 and DPX 4189. February 1981. W G Richardson, T M West and C Parker. Price £3.50

63. The activity and post-emergence selectivity of some recently developed herbicides: SSH-41, MB 30755, AC 213087, AC 222293 and Dowco 433. May 1981. W G Richardson, T M West and C Parker. Price £3.50

64. The activity and pre-emergence selectivity of some recently developed herbicides: chlomethoxynil, NC 20484 and MBR 18337. March 1982. W G Richardson, T M West and C Parker. Price £3.00

65. A system for monitoring environmental factors in controlled environment chambers and glasshouses, June 1982. R C Simmonds. Price £1.50

66. The activity and pre emergence selectivity of some recently developed herbicides: AC 213087 and AC 222293. December 1982. W G Richardson, T M West and C Parker. Price £2.00

67. The activity and post-emergence selectivity of some recently developed herbicides: trifopsime, glufosinate, RH 8817,MBR 18337 and NC 20484. December 1982. W G Richardson, T M West and C Parker. Price £3.25

68. The activity and pre-emergence selectivity of some recently developed herbicides: WL 49818, WL 82830, WL 83627, WL 83801 and DPX 5648. December 1982. W G Richardson, T M West and C Parker. Price £4.00

69. The activity and late post-emergence selectivity of some recently developed herbicides: AC 252925, DOWCO 453, HOE 33171 and HOE 35609. March 1983. W G Richardson, T M West and G P White. Price £3.25

70. The potential of various herbicides for selective control of weed grasses and Stellaria media in newly sown ryegrass/clover leys and ryegrass seed crops. May 1983. F W kirkham. Price £1.75

71. A feasibility study of the use of chemicals for rural amenity areas. Sponsored by the Countryside Commision. September 1983. E J P Marshall. Price £5.00

72. The activity and late post-emergence selectivity of FBC 32197. November 1983. W G Richardson, T M West and G P White. Price £1.25

73. Paraquat persistence - statistical analysis of the WRO long term trial. January 1984. R J Hance, T H Byast, P D Smith and T M Weight. Price £1.00

74. The activity and post-emergence selectivity of some recently developed herbicides: AC 252214, DPX-T6376 and chlorazifop. February 1984. W G Richardson, T M West and G P White. Price £2.00

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77. Experiments on the effects of the herbivorous fish, grass carp (Ctenopharyngodon idella Val.) on aquatic vascular plants, algae, zooplankton and phytoplankton and the importance of water temperature on the success of weed control. September 1984. M C Fowler. Price £3.50

78. The activity and post-emergence selectivity of some recently developed herbicides: MCPA-thioethyl, MT-124, tridiphane, aclonifen and RST 20024 H. October 1984. W G Richardson and T M West. Price £5.40

79. A preliminary study on the effect of some agricultural herbicides on a range of field margin flora. November 1984. J E Birnie. Price £2.50

80. The activity and pre-emergence selectivity of some recently developed herbicides: imazaquin, isoxaben, metsulfuron-methyl, aclonifen and orbencarb. December 1984. W G Richardson and T M West. Price £6.50

81. The side effects of alloxydim sodium, sethoxydim, acifluorfen and fluazifop-butyl on legume growth and nodulation. January 1985. J M Bebb, M P Greaves and W G Richardson. Price £3.00

82. An IRGA system for continuous monitoring of $CO_2$ and $H_2O$ vapour exchange in replicate plants growing in controlled environments. January 1985. C R Merritt and R C Simmonds. Price £3.00

83. A laboratory pot sprayer for use with controlled environment chambers. February 1985. R C Simmonds and J A Drinkwater. Price £2.50

84. Maps of the changes in the weeds of Boddington Barn field over twenty years (1961-1981). March 1985. R J Chancellor. Price £4.50

85. The use of bentazone and pyridyl herbicides alone and in mixtures for the control of creeping thistle (Cirsium arvense L.) in grassland. April 1985. W G Richardson, A K Oswald and T M West. Price £1.50

86. The activity and pre-emergence selectivity of some recently developed herbicides: metazachlor, butamifos, MT-124, tridiphane, MK 616 and prodiamine. May 1985. W G Richardson and T M West. Price £7.00

87. The potential use of grass growth retardants at Sullom Voe terminal, Shetland. A report prepared for W J Cairns and Partners, 16 Randolph Crescent, Edinburgh, Environmental Consultants to BP Petroleum Development Ltd as Operators of Sullom Voe Terminal. May 1985. E J P Marshall. Price £3.00

88. A further study of the effect of six cereal herbicide treatments on a range of broad-leaved field margin plants. June 1985. J E Birnie. Price £2.50

89. The activity, pre- and post-emergence selectivity of diflufenican. December 1985. W G Richardson and T M West. Price £3.00

90. The pre-emergence selectivity in warm-climate species of some recently developed herbicides: imazaquin, AC 263499, cinmethylin and isoxaben. January 1986. C Parker and A K Wilson. Price £2.60

91. The activity, pre-emergence selectivity and persistence of some recently developed herbicides: DOWCO 453, quizalofop-ethyl, BAS 517 00H, cinmethylin, AC 263499 and RST 20024H. W G Richardson and T M West. Price £6.20

92. The activity and post-emergence selectivity of some recently developed herbicides: SMY 1500, PPG 884, PPG 1259 and DPX-M 6316. W G Richardson and T M West. February 1986. Price £4.20

93. The pre-emergence selectivity in warm-climate species of some recently developed herbicides: metazachlor, RST 20024H, orbencarb and diflufenican. C Parker and A K Wilson. February 1986. Price £2.70

94. Screening strawberries for tolerance to 96 herbicides and growth regulators applied to the foliage and roots. D V Clay. February 1986. Price £5.00

95. Grass growth retardant use at Sullom Voe Terminal, Shetland 1985 Programme Report. (A report prepared for W J Cairns & Partners, 16 Randolph Crescent, Edinburgh, Environmental Consultants to BP Petroleum Development Limited as Operators of Sullom Voe Terminal). E J P Marshall. August 1986. Price £2.50

96. Studies of the flora in Arable Field Margins. E J P Marshall. October 1986. Price £3.50

97. The post-emergence selectivity in warm-climate species of some recently developed herbicides: SMY 1500, PPG 884, PPG 1259 and DPX-M 6316. A K Wilson and C Parker. February 1987. Price £3.75

98. The activity, pre-emergence selectivity and persistence of some recently developed herbicides: SMY 1500, PPG 884, PPG 1259, DPX-M 6316 and FMC 57020. T M West and W G Richardson. November 1987. Price £6.00

99. The pre-emergence selectivity in warm-climate species of some recently developed herbicides: SMY 1500, PPG 884, PPG 1259, DPX-M 6316 and FMC 57020. A K Wilson and C Parker. August 1988. Price £5.00

100. The post-emergence selectivity in warm-climate species of some recently developed herbicides: AC 263499, BAS 514, CGA 131036, DPX L5300, and DPX A7881. A K Wilson. August 1988. Price £3.50

101. The pre-emergence selectivity in warm climate species of some recently developed herbicides: CGA 131036, DPX L5300, DPX A7881 and BAS 514. A K Wilson. August 1988. Price £3.50

102. The post-emergence selectivity in warm-climate species of two recently developed herbicides: FD 4026 (PP604) and BAS 51700H. A K Wilson. August 1988. Price £3.50

103. Assessment of amenity grass mixtures for use in low-maintenance situations. G Donaldson, G M Arnold and M Perry. February 1988. Price £6.00

104. The activity and post-emergence selectivity of some recently developed herbicides: imazethapyr, BAS 51800H, DPX-L5300, triasulfuron and DPX-A7881. T M West. June 1988. Price £6.00

105. Further assessments of amenity grass mixtures for use in low maintenance situations. G Donaldson, G M Arnold and S Cooper. March 1989. Price £6.00

106. The activity, pre-emergence selectivity and persistence of some recently developed herbicides: BAS 51800H, DPX-L5300, triasulfuron, DPX-A7881 and fluroxypyr. T M West. November 1989. Price £6.00

107. Pre-emergence and post-emergence selectivity and persistence of the herbicide UBI C4874. T M West. August 1992. Price £4.00