
Final Report

as presented to the HRDC



Know-how for Horticulture™

Project No: TU012

Title: Development of ecologically based management procedures for controlling the invasion of bent grass by couch

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Horticultural Research and Development Corporation

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HRDC Research Project TU012

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Preface

This Project was carried out at the Australian Turfgrass Research Institute, Concord West, between 1 July 1990 and 30 June 1993. Funding was provided under a grant from the Horticultural Research and Development Corporation, with 50% of the total amount being subscribed through a scheme co-ordinated by the N.S.W. Golf Association.

ATRI is most grateful to the Horticultural Research and Development Corporation and the N.S.W. Golf Association for their support of this work and, in particular, wishes to express its thanks to the following clubs and organisations which responded so generously to the Golf Association's scheme: Castle Hill Country Club, Concord Golf Club, Cromer Golf Club, Elanora Country Club, Killara Golf Club, Long Reef Golf Club, Manly Golf Club, Mona Vale Golf Club, Monash Country Club, New Brighton Golf Club, New South Wales Golf Club, Oatlands Golf Club, Pennant Hills Golf Club, Pymble Golf Club, Strathfield Golf Club, The Australian Golf Club, The Royal Sydney Golf Club, Bayview Golf Club, Campbelltown Golf Club, Cumberland Golf Club, Eastlake Golf Club, North Ryde Golf Club, Coolangatta/Tweed Heads Golf Club, Toukley Golf Club, Newcastle District Golf Association, Muirfield Golf Club, Bonnie Doon Golf Club, Warringah Golf Club, Rugby League Country Club, Avondale Golf Club, and South-West Rocks Golf Club.

The Report is set out in the format required by HRDC, which means that the technical sections are relatively brief and do not include extensive sets of primary data. In accordance with normal scientific practice, the voluminous primary data has been collected into data files which have been lodged in the Institute's library in both hard copy and disc forms.

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PART 1

SUMMARY

- (a) Industry Summary
- (b) Technical Summary

1 (a) INDUSTRY SUMMARY

Couch invasion of bent grass putting greens was investigated in a 3 year research project at the Australian Turfgrass Research Institute, Concord West, between July 1990 and June 1993.

Studies of couch infestation in greens on golf courses showed that although most infestations commence near the edge of the green, maintenance operations such as coring and de-thatching, spread the infestations and that once established in the central part of the green, hole changing has the potential to spread the pest throughout the central section of the green.

Excavation studies of infestations showed that couch develops long, persistent rhizomes which often travel ahead of visible infection. These rhizomes have buds every centimetre or so along their length and each bud can develop into a new couch shoot. If the rhizome is cut or broken, even small pieces, provided they have one bud, they can develop into new plants. Use of ineffective sprays, normal hand weeding methods, cultivation practices and hole changing, all have the potential to make the couch infestation worse because they cut or break the rhizomes and leave some or all of the pieces at suitable depths for growth.

Vigilance in detecting new couch infestations, careful and complete removal of small infestations and constant attention to hygiene during renovation, cultivation and hole changing, are necessary to minimise the couch problem in bent grass greens.

Studies using herbicides and growth regulators, both separately and in combinations, on a range of couch and bent varieties led to the following conclusions:-

- (i) Tupersan[®] (Siduron), the only product currently registered for couch removal from bent, was ineffective against the majority of couch types tested. Unless the type of couch in a green is known to be highly successful, its use as a general purpose herbicide for this application should be discounted.
- (ii) Most compounds with the capacity to completely kill couch are too toxic to bent to be of practical use except as spot applications.
- (iii) Of a range of combinations of growth regulators and herbicides, the combination of Cutless[®] and Tramet[®] which has given good results in the USA was found to be relatively ineffective against Tupersan resistant strains of couch such as the locally bred "Wintergreen" type.
- (iv) The most promising combination effective against the Australian couch types was Primo[®] and Starane[®] but in the formulations and at the rates used in these experiments, discolouration of the bent and winter grass was more severe and more prolonged than would be acceptable for a green in play.

A limited trial of the effectiveness of mechanical barriers suggested that this technique may be useful in conjunction with other methods of control

1 (b) TECHNICAL SUMMARY

Couch invasion of bent grass putting greens was investigated in a 3 year research project at the Australian Turfgrass Research Institute, Concord West, between July 1990 and June 1993.

Morphological studies of couch infestations revealed that relatively limited surface infestations are accompanied by the development of an extensive network of rhizomes within the top 5cms of soil. The rhizomes have bud scales every cm or so along their length and may extend up to 40cms from the last developed shoot. Examination of old infestations which had been sprayed frequently with Siduron showed that while the central parts of the rhizome near the vertical shoots appeared dead, the distal parts of the rhizome were unaffected and it was from these sections of the rhizome that reinfestation took place about six weeks after spraying.

Given the nature of the rhizome system, any management procedure that is capable of cutting and physically moving pieces of rhizome about the green will spread the problem. Hence vigilance in detecting new infestations and complete removal before the rhizome system becomes extensive, together with basic hygiene measures during renovation, cultivation or hole-changing have been recommended as central elements in any couch management programme.

Competition studies in tubs fitted with barriers so that the effects of above and below ground colonisation could be separated suggested that the presence of soil barriers slowed up the rate of colonisation by couch.

A small trial to investigate the often heard belief in greenkeeping circles that couch infestations "grow towards the sun" (i.e. to the north) showed that circular plugs of couch have no preferred direction of new shoot growth.

Phytotoxicity trials with 9 couch varieties and 4 bent varieties were continued for nearly two years with a range of herbicides and growth regulators that had been suggested as possibly having selective phytotoxicity for couch. The findings confirmed the earlier work of Siviour and Shultz at the Institute that the efficacy of Siduron is very dependent on the variety, the Australian couch types being found to be notably resistant. No single compound was found that was totally effective against couch. The most effective compound was Fluoxypyr[®] (Stavane[®]) but it caused short lived strong discolouration to the three creeping bent varieties tested.

Finding no effective single compound, all combinations of the herbicides and growth regulators were tried to see if any synergistic effects would emerge in relation to couch kill. A field screening trial with the difficult to kill "Wintergreen" couch revealed very few effective combinations. The best of these were tested on a newly established bent green artificially infected with plugs of "Wintergreen" couch at ATRI and on an actual golf green containing bent and *Poa annua* at Manly Golf Club. It was found that a single sequential application of Fluoxypor (Starane[®]) and Triexapac-Ethyl (Primo[®]) in autumn gave almost total control of the couch without permanent damage to the bent or winter grass.

The combination of Ethofumesate (Tramat) and Flurprimdol (Cutless) recommended by U.S.A. workers Johnson and Carrow was shown to be significantly less effective on Australian couch types than the preceding combination. However, for practical purposes, the duration and intensity of the discolouration of the bent and winter grass is excessive with the Starane-Primo combination, suggesting that adjustments are needed in the balance of the two components and in the spray application technology to reduce the severity of the effects on the non-target species.

PART 2

RECOMMENDATIONS

- (a) Extension/Adoption by industry of research findings.
- (b) Directions for future research supported by HRCD.
- (c) Financial/commercial benefits of adoption of research findings.

2 (a) EXTENSION/ADOPTION BY INDUSTRY OF RESEARCH FINDINGS

The main findings of the research have already been extended to the golf industry in a series of conference papers (see Annexure I for list) and in particular at a special field day held at ATRI on 11 May 1993. The main outcomes of the research were embodied in two summary sheets handed to all delegates attending the field day (reproduced as Annexures 2 and 3 to Appendix I of this Report). It will be noted that the second of the summary sheets includes separate recommendations for greens currently without couch, for greens with moderate infestations and for greens with severe infestations. More recently (February 1994) a brief extension report summarising the findings and the recommendations was prepared for the N.S.W. Golf Association for circulation to clubs, (Annexure 4 to Appendix I of this report).

To ensure further extension and to increase adoption of the findings by industry, especially the environmentally sound approaches of vigilance and hygiene, it is recommended that ATRI provide, for a fee, training sessions based on these aspects of the research.

2 (b) DIRECTIONS FOR FUTURE RESEARCH TO BE SUPPORTED BY HRDC

The couch invasion of bent problem is a significant one for the golf industry but it is only one of a number of important greenkeeping problems confronting the industry.

While any problem can be studied in ever greater detail, the facts about the way in which couch gains a hold on greens and is subsequently spread by greenkeeping activities are now clear enough and clubs should be encouraged to put effort into these areas rather than wait for the development of new spray treatments. Further research into the general biology of the couch in connection with this problem is not recommended at present.

The best combination of herbicides and growth regulators to emerge from the extensive work of Johnson and Carrow in the U.S.A. was a mixture of Tramat[®] and Cutless[®]. Under U.S.A. conditions, on their local biotypes of couch, this gives good couch control with repeated applications with only slight effects on the bent. This mixture is insufficiently active against the hardier Australian couch biotypes and therefore, if employed locally, could well lead to a repeat of the Siduron problem which, by giving only a partial kill, has, in the long term, made the problem worse by fragmenting the infestations. Therefore, good reasons exist to explore the suggestions in the Technical Summary that refinements in relative concentration, absolute concentrations, spray technology etc may reduce the bent damage caused by the highly effective couch killing combination of Starane and Primo to acceptable levels.

The golf clubs who supported this work have already made a substantial financial contribution, as also has the HRDC, so it is recommended that the refinement of this promising combination of Starane and Primo should more appropriately be undertaken by the respective owners of the chemicals as developmental work than as research at private sector/HRDC expense.

3 (c) FINANCIAL/COMMERCIAL BENEFITS OF ADOPTION OF RESEARCH FINDINGS

When couch infestation becomes severe in a bent grass putting green, the regular roll of the ball is disrupted and the game of good players is seriously interfered with. For this reason, clubs whose greens are severely infested risk downgrading in status, loss of championship venue listing, and through player dis-satisfaction, loss of both members and visiting players. All of these undesirable consequences decrease the revenue of the club and reduce the level of services to members.

If a club, faced with the above problems, decides to remedy the situation, the infestation, if severe, can only be dealt with effectively by rebuilding the greens which costs at least \$60,000 per green, often far more. It can be seen, then, that not only does the couch problem lead to loss of revenue and progressive loss of financial security, but the remedial action is also very expensive.

By learning how to manage the problem, for example, by keeping clean greens free of the pest, by vigilantly removing any incipient infestations and by minimising introduction and spread of couch by proper hygienic measures during greenkeeping operations, golf clubs can make a major investment in their own financial security.

Finally, if the herbicidal-growth regulator approach is perfected, then clubs faced with the costs of rebuilding greens when severe couch infestation is the only major problem could be saved substantial sums of money.

In conclusion, adoption of the findings of this research by the golf industry is expected to make a direct and positive contribution to the financial stability of the industry.

PART 3

TECHNICAL REPORT

Note: The Technical Report is made up of a series of separate papers, each of which includes the headings *Introduction*, *Material and Methods*, *Results* and *Discussion*. As noted in the *Preface to the Report*, voluminous sets of primary data have been lodged on disc and in hard copy as a supporting Data File to the Report in the ATRI library.

PART 3

TECHNICAL REPORT A

THE GENERAL ECOLOGY OF COUCH INVASION OF BENT GREENS

1. Introduction

The invasion of bent-grass greens by couch-grass is a major problem for golf course superintendents in the warm-temperate areas of Australia. Currently recommended herbicide treatments give variable results, ranging from almost no effect to, at best, short term control.

McMaugh (1971) drew attention to the ability of siduron Tupersan®, applied at what were then regarded as high rates, to selectively kill warm-season grasses such as couch and kikuyu without harming the bent. Subsequent work, e.g. Siviour and Schultz (1984) demonstrated that the effects of siduron on couch varied greatly from one variety to the next, a finding which has been fully confirmed in the present work. More recently, combinations of herbicides and plant growth regulators have been examined (Johnson and Carrow {1989, 1991 and 1993}) in an attempt to secure a more uniform response across the different varieties and ecotypes of couch, and to achieve long term rather than short term control. Although the results are interesting, we still seem to be a long way from the target of permanent control of virtually any couch type without harm to the bent.

In many other areas of pest management better results have been achieved by developing strategies based on a thorough understanding of the growth patterns and adaptation of the competing species than from the use of a single chemical or non-chemical control method. Following an approach from representatives of the N.S.W. Golf Association late in 1989, ATRI commenced a three year research programme in July 1990 to develop ecologically based management practices for the control of the couch pest in bent greens. This paper provides an outline of the methods used and a selection of the principal ecological findings up to the end of the project in June 1993.

2. Methods and Materials

The general ecology of invasion of bent was studied in two different ways: (1) a survey was made of greens on fourteen golf courses, twelve of which had reported the problem and two of which, despite the presence of couch on the course, reported no invasion of the greens, and (ii) a detailed study of natural, well established invasion of the experimental bent green at the ATRI Trial Ground, Concord West. Most of the observations and conclusions in the report were first conveyed to the industry in a paper read at the 12th National Turfgrass Conference, Launceston, May 1992.

The Golf Clubs included in the survey were Concord, Manly, Rugby League (Narellan), Cumberland, Eastlake, North Ryde, Oatlands, Pymble, Avondale, Palm Meadows (Gold Coast, Queensland), Tweed Heads/Coolangatta, Pennant Hills, Killara

and Royal Sydney. The visits were carried out in the summer and early autumn of 1991 and at each club greens were inspected and construction and management history noted in relation to the intensity and patterns of infestations.

Ecological studies on the ATRI Bent Green, supplemented by some root observations on the ATRI Phytotoxicity strips were carried out in the second half of 1991 and throughout 1992. The basic technique was to mark out an area in which surface infestation of couch was visible and then having mapped the visible infestation, to remove the soil in layers of about 1cm at a time with spoons or a small trowel until the whole of the underground organs were revealed, (typically involving complete soil excavation to 10cm with selected individual fine roots being followed down to their tips). Maps were made of the rhizome pattern revealed at various levels. Thin skewers were used to support the rhizomes from the upper levels while the lower levels were being excavated. Numerous excavations were made and the results presented here are typical patterns. Excavations were made in control plots and in plots treated with Tupersan® (Siduron). Greens construction was of the 90 per cent sand-10 per cent soil type.

3. Results

(i) Survey of Golf Courses

Surveys of the problem on the twelve golf courses of the fourteen in which couch invasion was found led to the conclusions that there were three distinct types of infestations, as shown in Figure 1.

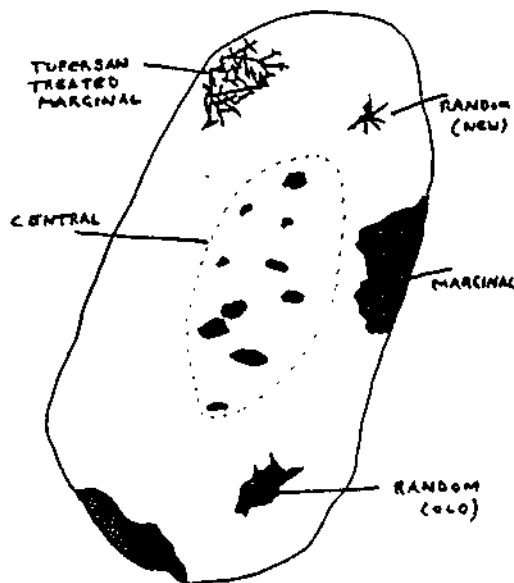


Figure 1 - Golf Green Showing the three types of infestation - marginal central and random

Marginal infestations, as the name implies, start at the edge or margin of the green and spread inwards towards the centre. This is probably the most common type of infestation. Interestingly, the general appearance and growth pattern appears similar whether the collar is comprised of couch or some other grass. These infestations are caused by varieties of couch present in the collar area growing into the green. Very old infestations usually show signs of breaking up into a lace-like pattern on the surface, a process which is greatly accelerated where Tupersan has been used.

Central infestations occur as relatively small roughly circular patches of couch in the central part of the green. In severe cases there is a tendency to grow together to form larger patches. These infestations are closely associated with the portion of the green in which the hole is located and owe their origin to the introduction of traces of couch in the plugs used to fill the holes when the "pin" is shifted. The couch is very difficult to see during the late winter when its dormant growth is overrun by a vigorous bent sward, and it seems likely that spread of the couch to start new central infestations mostly occurs at that time of the year.

Random infestations can arise at any point in the green, being the result of the chance introduction of sprigs of couch in some cases and seeds in others, followed by a favourable combination of conditions which allow the couch to become established. Probably the great majority of introductions of sprigs or seeds (by means such as machinery, players' shoes and equipment, birds or wind-drift of clippings from couch collars) do not become established, but it only takes one tiny sprig to become established in order to produce an unsightly patch by the end of the next summer.

Responses to factors such as soil type seemed to be very variable, with an apparently greater severity of infestations in older greens constructed with heavier soil mixes at some clubs being contrasted with almost the opposite experience at others. Based on the rapidity of infestation on some newly constructed sand greens, presence of couch seed or rhizome pieces in the construction material seemed to be indicated. All clubs with the infestation had tried the Tupersan treatment, some reporting moderate control but most reporting no effective long term control and several reporting that the problem had become worse with regular spraying because of the tendency of the patches to break up and re-establish as several separate infestations. It was observed at many clubs that the couch which was present after long-continued use of Tupersan has an unusually flat habit of growth, a bluish-green colour and unusually wide leaves in relation to their length. These couches appeared to be resistant to Tupersan, reportedly yellowing off after spraying but recovering completely within six weeks.

At the two clubs in the survey which did not have a couch invasion problem (Avondale, North Ryde) couch was present on the course but invasion did not seem to occur. No particular differences in management practices or physical layout were noted and at this stage no explanation can be advanced for the apparent "immunity" of their greens.

Representative results of the mapping of invasion above and below ground are covered by Figures 2 to 7, which show the situation in both control and Tupersan treated plots in plan view, and by Figure 8 which shows a representative side elevation of an individual rhizome "run" in a control plot.

- Surface Infection

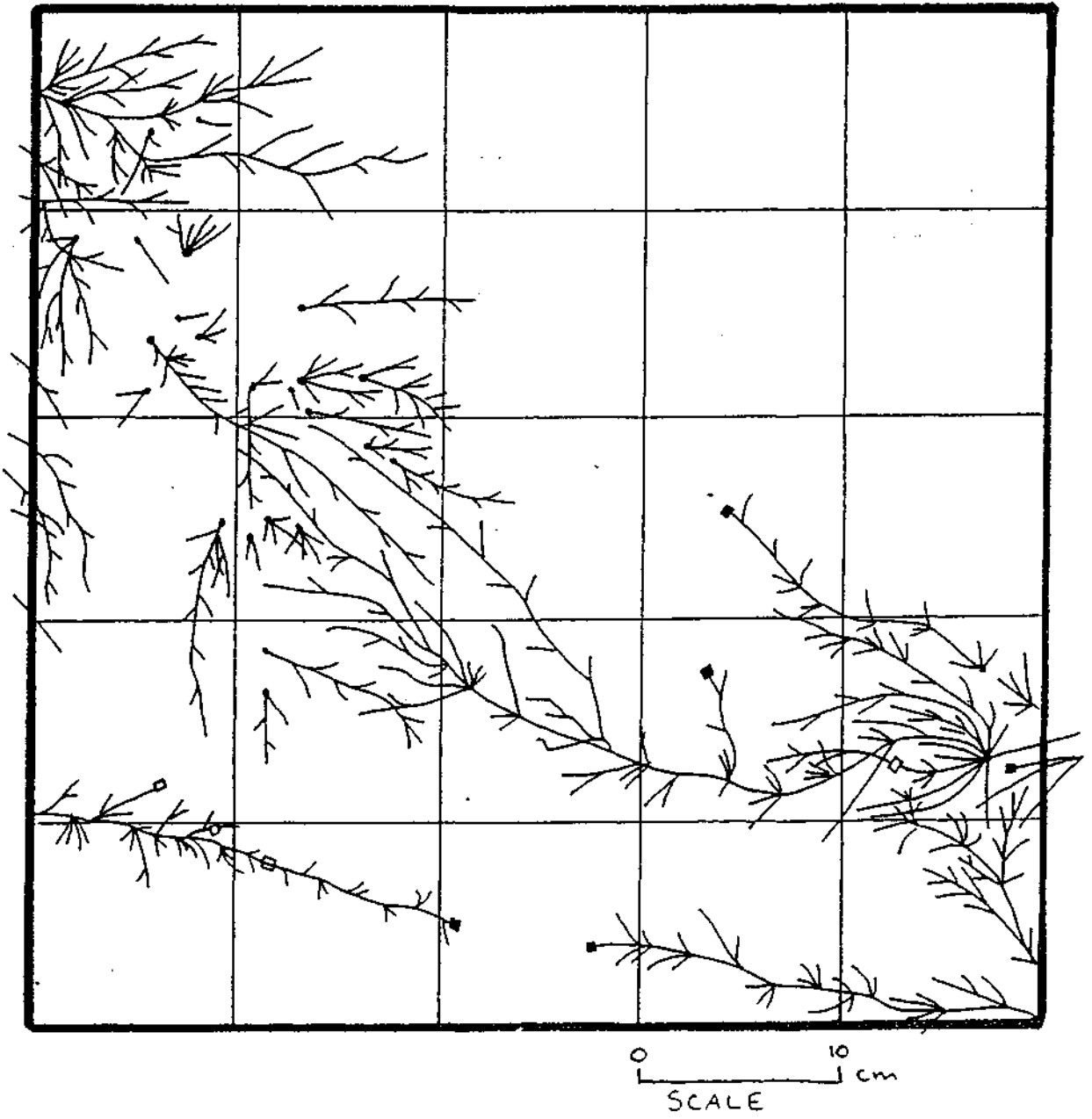


Figure 2

- Below thatch (1cm depth)

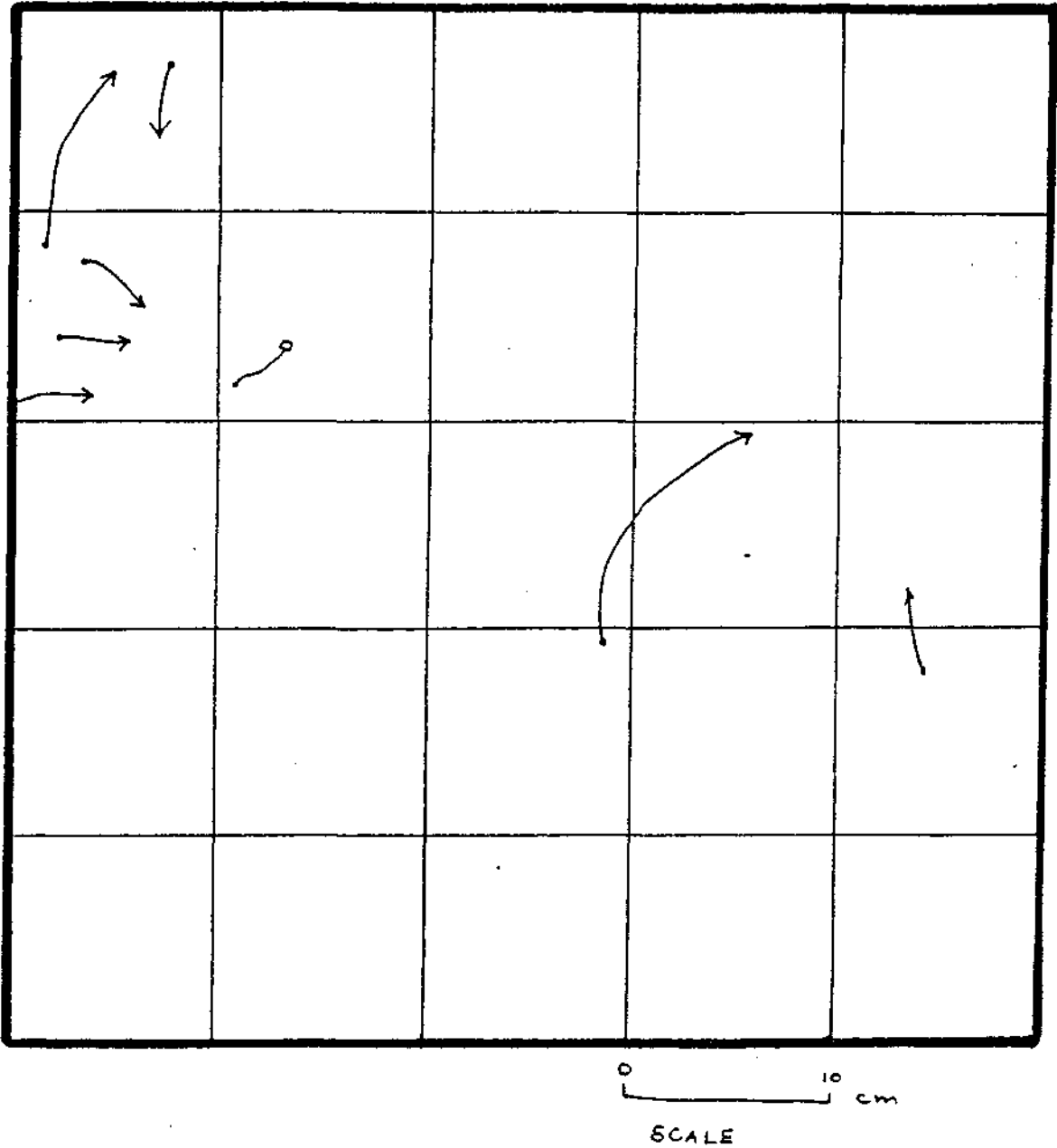
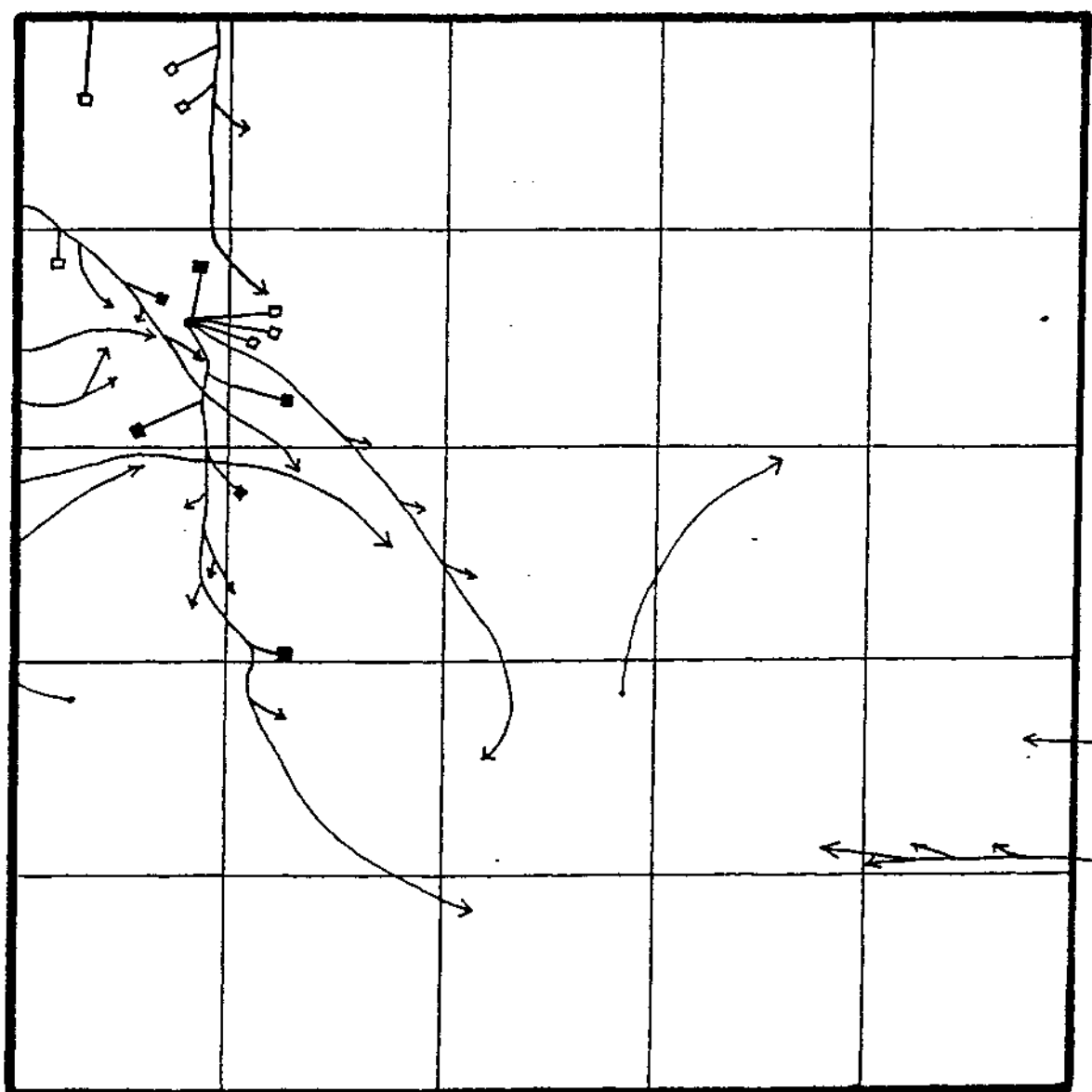


Figure 3

COUCH EVACUATION - Control

8 May, 1992

- 4cm depth



0 10 cm
SCALE

Figure 4

- Surface Infection

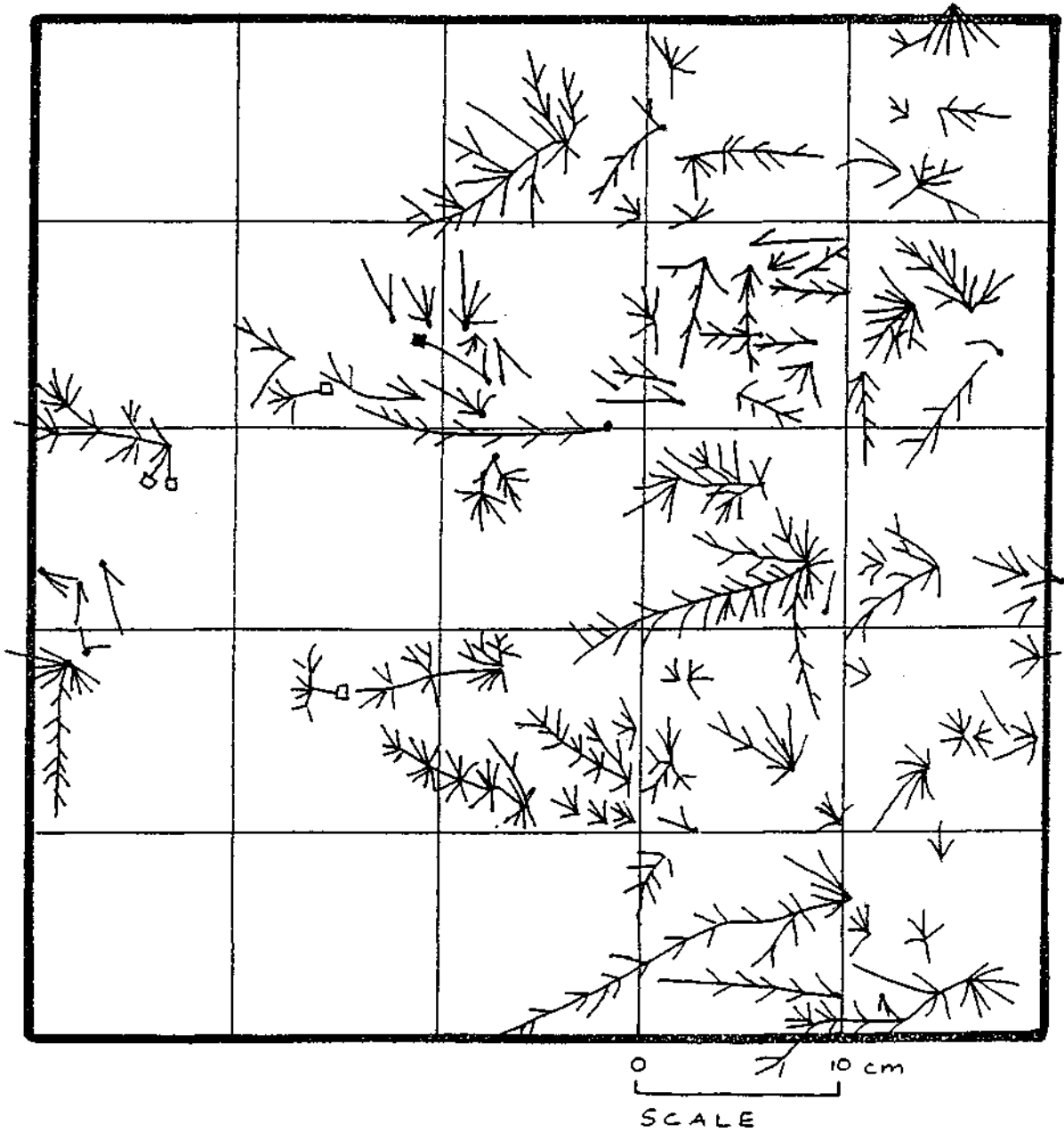


Figure 5

- Below Thatch (1cm depth)

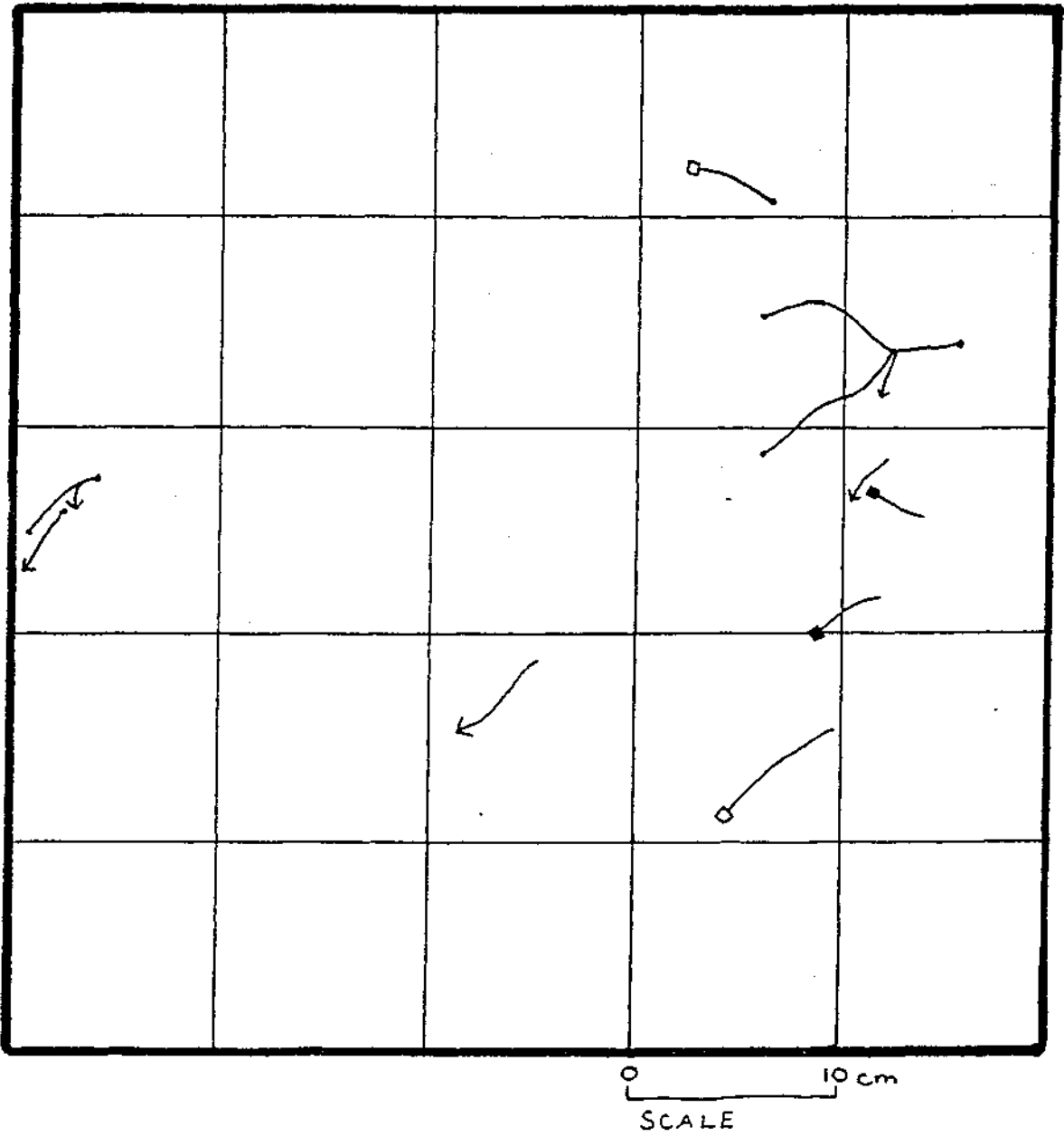


Figure 6

COUCH EVACUATION - Tapersan

13 May, 1992

- 6-10cm depth

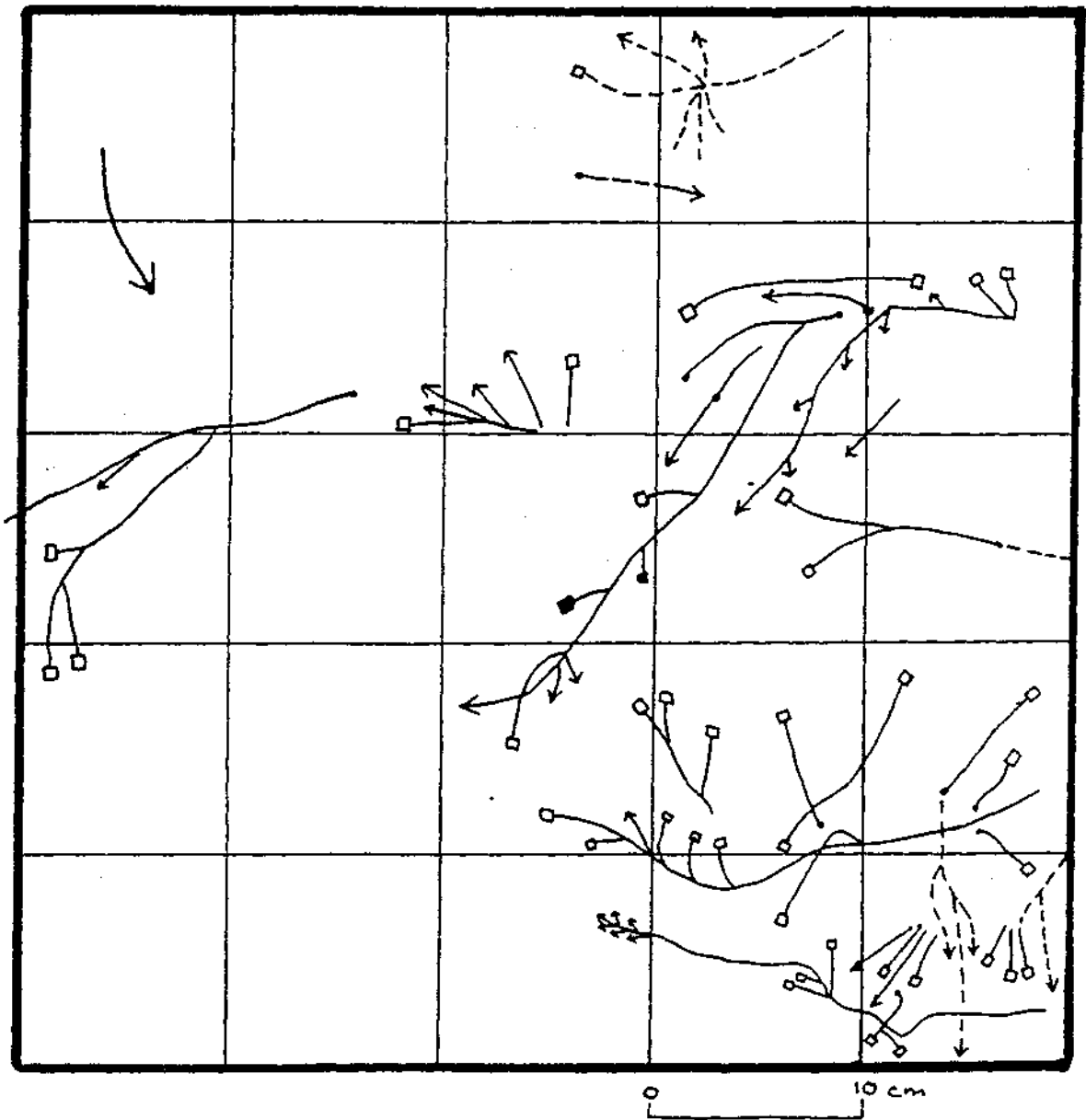


Figure 7

The maps show extremely interesting points, both in general and in relation to the treatment effects. Figure 2 (Control) shows that the infestation in the 50cm x 50cm grid was composed of a moderate number of long runners many of which continued beyond the borders of the map. In contrast, the Tupersan treated material (Figure 3) showed a large number of short runners, almost none of which extended beyond the plot nor were they connected together in large surface networks. These tendencies were marked characteristics of the sprayed plots. In both cases, the surface runners showed fine roots coming from most of the nodes except those near the shoot tips, but connections to the underground rhizome system were confined to the points of emergence in the control and seemed to have decayed in many cases in the Tupersan treatments.

Figures 4 and 5 show the respective situations at 1cm depth in the soil, revealing that very few rhizomes were found at that level. Further excavation to four centimetres revealed the main rhizome system below the central plots (Figure 6) with nothing found at greater depths except for fine adventitious roots which penetrated vertically to about 25cms. In contrast, the Tupersan treated plots (Figure 7) had the main rhizome system at a slightly greater depth, mostly at 6cms with a few rhizomes forming a deeper system at 10cms. No rhizomes were found beneath this depth, only fine adventitious roots descending vertically to about 25cms. On comparing the two main rhizome diagrams (Figs 6 and 7) it will at once be recognised that the patterns are very different, the large number of blind ends (as distinct from active rhizome tips - squares versus arrows in the diagram) being a notable feature of the treated plots. If the surface and deep patterns are compared, it will be noted that there is little correspondence between the two in the control plot, suggesting that the scale of organisation in the untreated invading couch is considerably greater than the grid size adopted here, whereas the greatly broken up (smaller scale) pattern in the sprayed plots leads to a much closer correspondence between above and below ground patterns with the mapping scale used here.

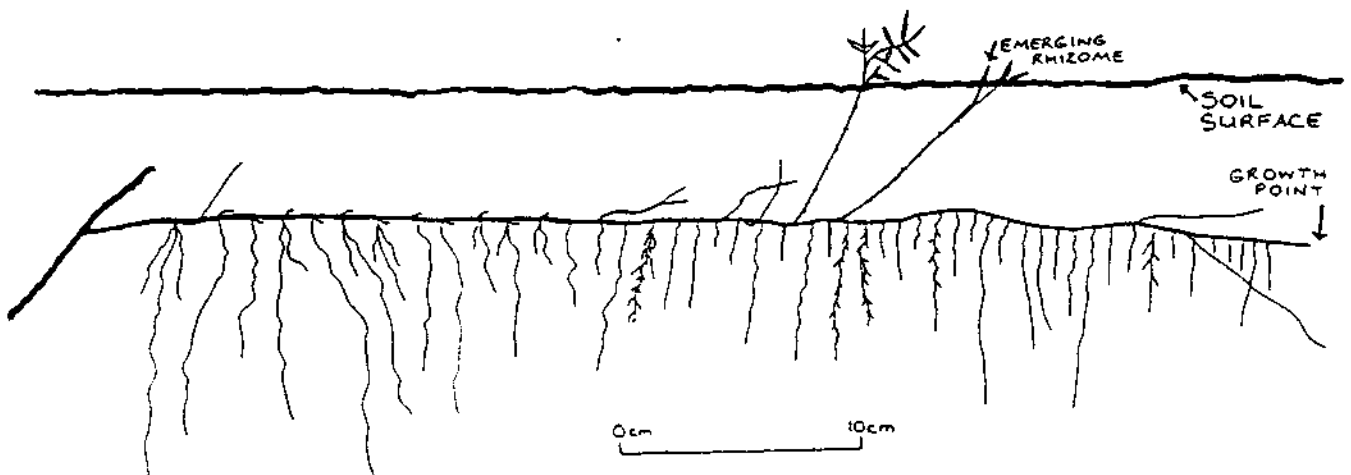


Figure 8 - Part of a rhizome system of an invading couch plant

The profile view of a typical control plot rhizome shown in Figure 8 is notable in showing the extreme length of the rhizomes and the paucity of above ground exposures when the rhizome remains intact.

4. Discussion

The survey of golf clubs, while failing to find any management explanation for the apparent "immunity" of the greens at two of the fourteen clubs, none the less brought to light the fact that the majority of the infestations away from the borders of the green are caused by couch pieces moved about during the process of hole changing. This suggests that the prevention of central infestation in greens which are currently either free of couch or only lightly infected is in the hands of the Superintendent and involves careful attention to vigilance and hygiene, especially in the cooler months when the couch is more difficult to see.

The mapping work has provided an ample explanation of the field observations that spraying of non-susceptible types of couch with Tupersan actually increases the density of the surface infestation and incidentally confirms the previously uncorroborated observations of McMaugh (1971) that Tupersan causes break up of the rhizomes into shorter segments. The maps show that while considerable break-up is caused a surprising number of rhizome tips remain alive, and in some cases these are stimulated to produce multiple growing points (see Figure 7, lowest central grid square). This means that the search for an effective herbicidal treatment must pay close attention to translocation to rhizome tips if proper control is to be achieved.

In terms of control by hand weeding, Figure 8 provides a complete explanation of the ineffective nature of weeding in which the emergent shoots are dug up: the sole effect of this is to break up the rhizome and stimulate multiple infestations. The invading rhizome characteristics are also interesting in showing the tendency to travel through the soil for tens of centimetres in advance of any visible activity at the surface and also for the fact that the system develops its greatest expression at an intermediate depth rather than close to the surface as one often finds in pure stands of couch or at the great depths often mentioned in gardeners' tales (which usually relate to isolated rhizomes negotiating some physical barrier or entrapment). The rhizome system in the invading couch situation accounts for the majority of the dry matter of the couch and represents the major strategy by which couch maintains its status as one of the most difficult weeds found in bent greens.

5. References

- Johnson, B.J. and Carrow, R.N. (1989). *Bermudagrass Encroachment into Creeping Bentgrass as Affected by Herbicides and Plant Growth Regulators*. *Crop Science*, 29 : 1220-1227.
- Johnson, B.J. and Carrow, R.N. (1991). *Frequency of Flurprimidol-Herbicide Treatments on Bermudagrass (Cynodon spp.) Encroachment into Creeping Bentgrass (Agrostis stolonifera)*. *Weed Science*, 39 : 221-226.
- Johnson, B.J. and Carrow, R.N. (1993). *Bermudagrass (Cynodon spp.) Suppressions in Creeping Bentgrass (Agrostis stolonifera) with Herbicide-Flurprimidol Treatments*. *Weed Science*, 41 : 120-126.
- McMaugh, P.E. (1971). *Control of Encroachment of Agrostis spp. Swards by Warm Season Turf Grasses*. *Journal of the Sports Turf Research Institute*, 47 : 33-40.
- Siviour, T.R. and Schultz, G.F. (1984). *Response of Bermudagrass (Cynodon dactylon) to Siduron*. *Weed Science* 32 : 178-180.

PART 3

TECHNICAL REPORT 'B'

COUCH - BENT COMPEITION STUDIES AND COUCH RUNNER ORIENTATION TRIAL

1. Introduction

As reported in the previous chapter (Technical Report 'A'), couch invasion of bent greens is a major problem in the golf industry, both in Australia and the United States of America. During the discussions with course superintendents, four matters related to couch as a competitor arose which seemed worthy of experimental investigation viz:

- (i) does couch invasion take place mainly across the surface or by underground means;
- (ii) how seasonal is the competitive ability of couch - some superintendents were of the view that bent was able to invade the couch during the winter months;
- (iii) is it true, as suggested by some superintendents, that "couch runners grow towards the sun for preference" (i.e. towards the north); and,
- (iv) can soil or surface barriers assist in controlling couch invasion from the collars of the greens.

An extensive literature on plant competition has been ably summarised by Harper (1977) in his famous book "Population Biology of Plants", and it is not intended to cover the same ground here. A useful summary of more recent work, involving a helpful critique of methodology will be found in Cousens (1992), while a considerable amount of the background relevant to comparative studies such as those to be described in the first part of this chapter has been provided by Grime, Hodgson and Hunt (1988) in the introductory chapters of their major work "Comparative Plant Ecology". More specific applications to amenity grassland problems will be found in Grime (1980).

After several alternative approaches had been considered, it was decided that the method of Donald (1958), which allows one to separate the effects of above ground and below ground competition, would assist greatly in answering questions (i), (ii), and (iv) above, while the simple method of growing small cores (plugs) of turf in large, orientated pots would supply the data needed to cover question (iii).

The general growth patterns of couch and bent, recently summarised by Cooper (1994) and Parker (1994) respectively, lead one to the conclusion that for much of the warmer part of the year in Sydney, bent is well above its preferred range of temperatures for growth, whereas the reverse is true during the cooler months, with the couch slowing down and eventually becoming dormant when night temperatures fall much below 10°C. These considerations suggested that there could be some substance to the suggestion from the field that the bent actually invades the couch in the cold months, so it was decided to observe the competition experiment throughout the year.

In relation to the possible role of physical barriers, considerable interest was generated in this approach while the work was being carried out as a result of advertisements for a product known as the "Greens Encroachment Barrier Systems" in the U.S. periodical "Golf Course Management", p.140, April, 1991, and vigorous promotion by a local turf maintenance company in 1991 and 1992.

This barrier system, made of plastic, is designed to be placed slightly below the soil surface, thereby overcoming problems of ball-contact (see Foy, 1991) associated with earlier systems which came right to the surface.

Since two different experiments were conducted to address these issues, the first experiment, on competition, covering questions (i), (ii) and (iv) will be reported first, followed by the orientation trial to cover question (iii).

2. Materials and Methods - Competition Trial

Aim: To investigate the use of physical barriers in an integrated management program for the control of couch grass in bent grass greens.

Method: The trial was located at the Australian Turfgrass Research Institute (A.T.R.I.), Concord West. Couch grass and bent grass were evenly divided into plastic tubs 60cm long by 35cm wide by 19cm deep. For treatments A, B and C plastic 3mm thick and held in place with gaffer tape was used to form physical barriers dividing the couch from the bent. Both the couch and the bent grass were regularly trimmed using scissors or hedge clippers to a height of approximately 10mm. Each plastic tub was fertilised approximately every 2 weeks with 'Aquasol' (Total Nitrogen 23%, Phosphorus 4%, Potassium 18%) made up at the label concentration and applied at the rate of 1 litre per tub.

Following insertion of the plastic barriers, the tubs were filled to within about 5cm of the top with a standard 90 sand/10 soil turf growing medium. The grasses were established by placing squares of cut turf (trimmed to the size of exactly half the size of the tub) on the soil surface and firmly pressing down to ensure contact of turf and soil. Varieties used were "Penncross" creeping bent supplied by Strathyr Instant Lawn, Victoria, and "Wintergreen" couch supplied by Qualturf, Richmond. Establishment took place in early February 1992.

The experimental arrangement was as shown below in Figure 1, providing situations for no competition (A), above ground competition (B), below ground competition (C) and full competition (D).

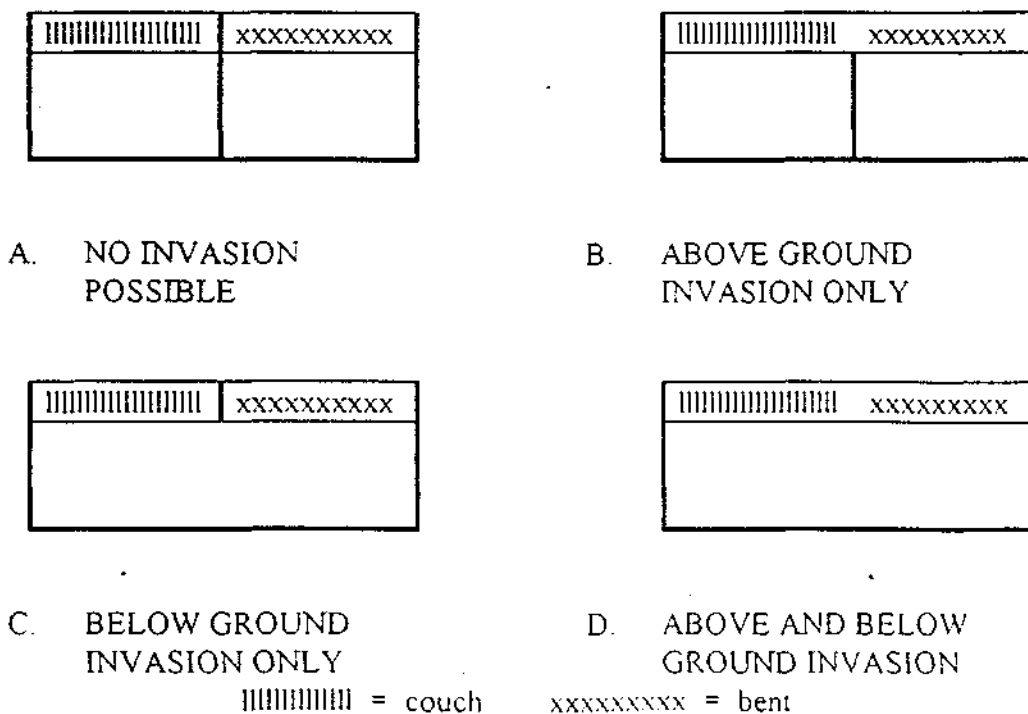


FIGURE 1 - Arrangement of Dividers in Tubs for Competition Experiments

As originally planned, harvests were to be conducted on three occasions spaced over a period of 18 months, with observations on a regular basis throughout. There were four replicates of each competition treatment, giving 48 tubs in all (4 treatments x 4 replicates x 3 harvest dates = 48). However, the experience of the first harvest, in June 1992, showed that the effects of the invasions were not great in terms of dry matter yields, given the large bulk of material (comparatively) introduced with the turf as well as that later developed. Accordingly, subsequent work concentrated on observational recording, both above and below ground, which was continued until June 1993. An attack of Argentine Stem Weevil led to the removal of some tubs from the trial in January 1993.

Observations made on a routine basis included mapping of the distribution of the two species (using a grid system) and periodic washing out of some tubs to observe the root masses. The harvest consisted of clipping off all the green material ("verdure" of the American workers) and reporting this as tops and surface stolons, and then washing away all the sand and separating the roots and deep rhizomes from the thatch layer by cutting with scissors. The thatch layer as here defined consists of a compact layer of non-green stems and leaf bases, stolons and shallow rhizomes. Although sounding somewhat mixed morphologically, in practice it is an easily recognised, distinct and natural layer in the turf system. The three fractions (as free of sand as possible) were dried in a forced draught oven at 70°C, weighed, ignited to burn off the organic matter, and the residue of sand weighed. By subtraction, the true weight of the organic matter in the tops, thatch and roots was thus found.

3. Results of Competition Study

Harvest Results

A full harvest was carried out on 22 July 1992, 5 months after establishment. No gross effects of competition were found, a full statistical analysis failing to reveal any significant differences in dry matter yields attributable to treatments. It did, however, show that couch maintained a significantly larger amount of dry matter per unit area than bent.

Although some invasion effects were observable at the time of harvest (see below for details) the amount of dry matter associated with the invading rhizomes or stolons was far too small (only one percent or less) in comparison with the total mass to be important in this approach to growth analysis. However, the dry matter data, representing the results of a study in which full corrections had been made for entrained sand, do reveal the interesting fact that the great bulk of the dry matter of both couch and bent is in the thatch layer rather than the tops or the true roots. This is clearly shown in Figure 2, (for primary data and statistical analysis see Data File 1)

Observational Results

As expected, treatment A, in which there was complete separation above and below ground, showed no invasion of any kind.

Treatment B, which allowed above ground invasion only, showed little change in the first summer, with invasion only becoming significant by January 1993 (i.e. approx 12 months after planting - see Figure 2). Left unchecked, this invasion then rapidly worsened, giving an extensive coverage of the bent surface by mid Autumn, 1993. By that stage the couch runners had started to develop traces of a rhizome system in the bent section and from these set up new, independent, centres of invasion

It was noted in June to August 1992 and again in June 1993, that it was very difficult to detect the couch runners in the vigorously growing bent even though their positions were known on the grid from previous mapping.

Treatment C, which allowed underground invasion, was slower to show signs of invasion (e.g. very little observable in December 1992) but a few months later in the Autumn of 1993 showed much more severe infestation of the bent than Treatment B.

Treatment D, which had no barriers, allowed rapid invasion of the bent, some encroachment being obvious after five months, and one year after planting as shown in Figure 3, invasion was extensive and reached to the far end of the bent.

In the treatments which allowed surface movement of the grasses (Treatments B and D) bent was observed to grow a small distance into the couch in both winters. In some, but not all of these tubs, small patches of the winter-invading bent from the 1992 winter were still present in the couch in the 1993 summer (see, for example, Figure 3).

Couch out of Bent Competition - Harvest 1

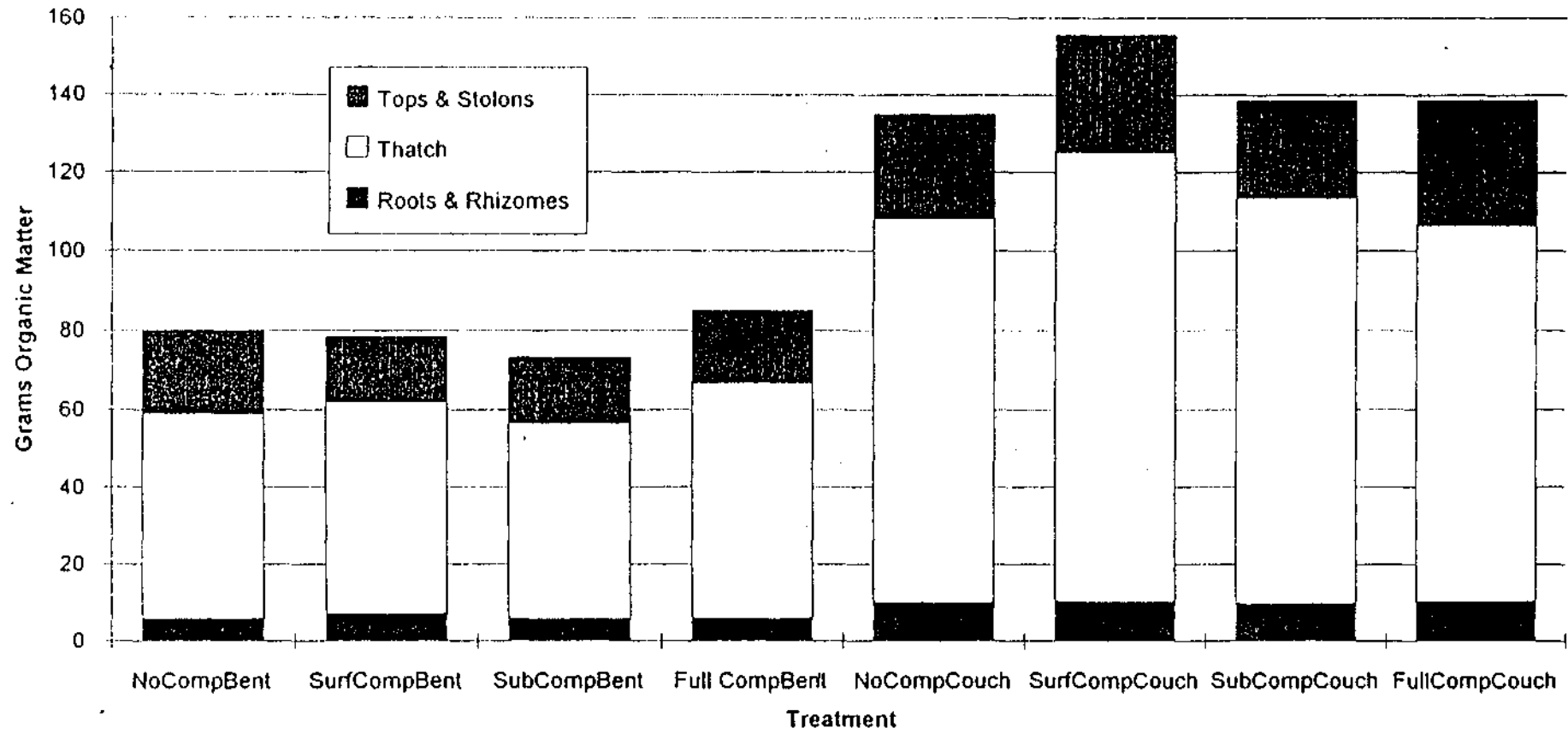


Figure 2

Competition Bins

Date: 7/1/93

Box No: II B3

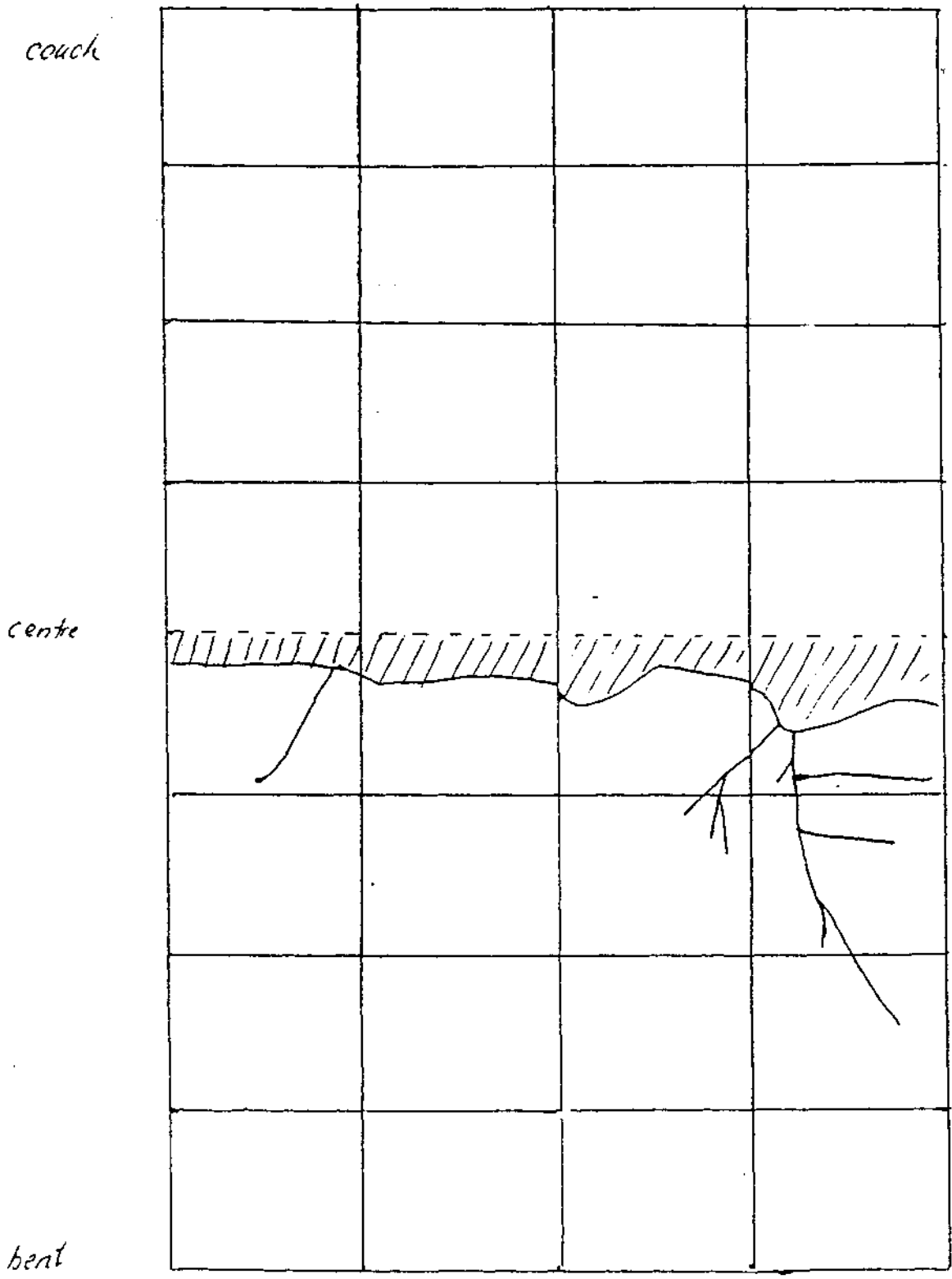


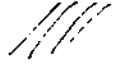
Figure 3 - Treatment B

Competition Bins

Date: 14/1/93

Box No: III D1

Couch in bent



Bent in couch



couch

ente

bent

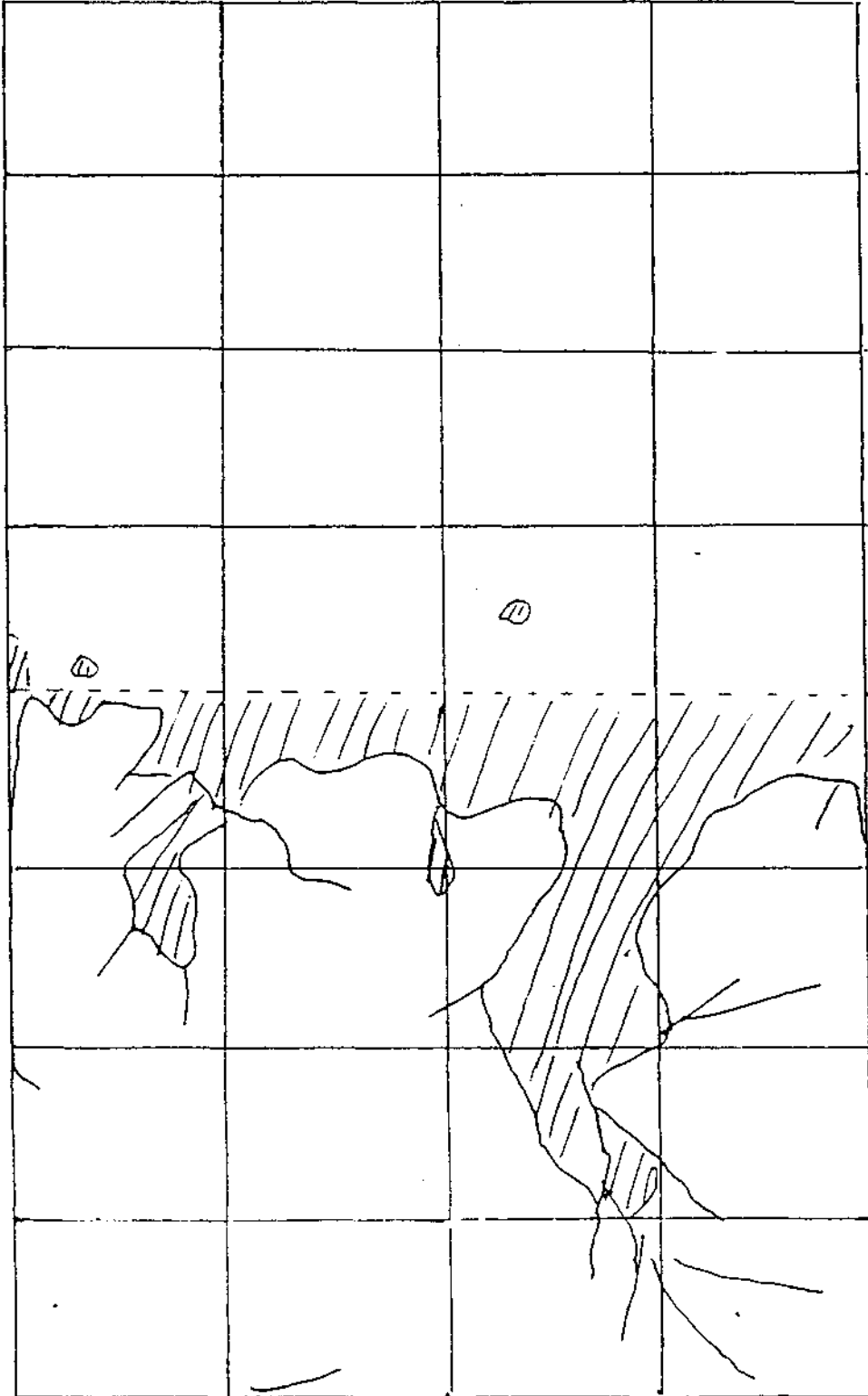


Figure 4 - Treatment D

4. Discussion of Competition Studies

The method of Donald (1958) allowed a convenient separation of above and below ground invasion and showed clearly that in the early stages of growing side by side, surface invasion is the most significant route of invasion. Over a longer time span (e.g. 12-14 months) underground invasion is also very important. Where invasion was uncontrolled, extensive occupation of the adjoining bent surface took place within 12 months (Figure 3).

Excavation of the root systems showed that rhizomes heading in the direction of the bent, on striking an underground barrier, typically turned horizontally and grew towards the side of the tub, rather than plunging down vertically in an attempt to get under the barrier.

These results and observations suggest that in the absence of any barriers or control measures, well developed established couch established a significant presence in an adjoining bent area in less than 18 months. The results also show that barriers are effective in reducing spread but that underground barriers alone will only be effective in the longer term if accompanied by a programme of cutting or spot spraying of the surface growth. It should be noted that the promoters of the plastic barrier systems stress that it is only effective if regularly supplemented by cutting of any surface invading runners by a vertical cutting apparatus working round the green in a special groove formed on the top of the submerged barrier.

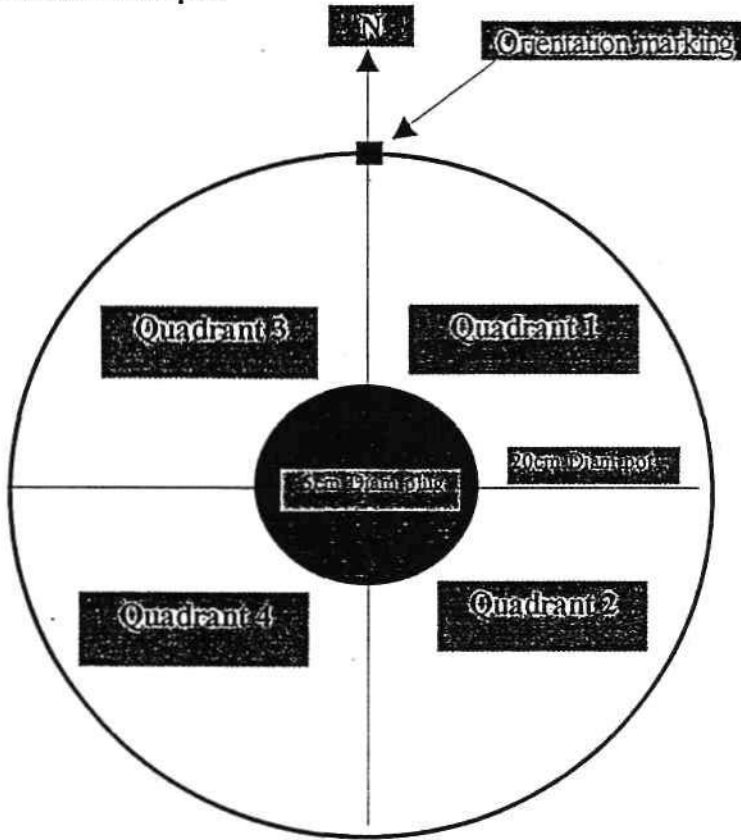
5. Methods and Materials - Runner Orientation Trial

Two couch grass varieties were chosen for use in this trial, Santa Ana couch grass and ATRI C-17 couch grass (* reason)

Six by 5cm plugs of each couch variety were randomly taken from strips at ATRI. These plugs were transplanted into 20cm black plastic pots containing a sandy turf soil.

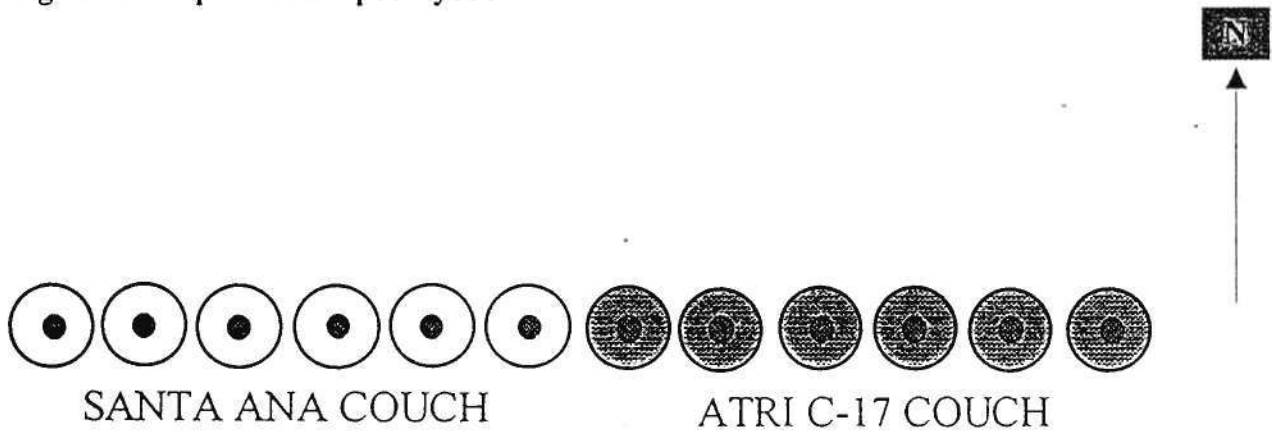
Each pot was marked to indicate how it should be orientated for the duration of the trial.

Figure 5 Runner initiation trial pot



For each of the two couch grass varieties there were six replicates. - These pots were placed in full sunlight and were not moved for the duration of the trial. The pot layout is shown below.

Figure 6 Experimental pot layout



Each of the couch pots was watered regularly and received 250 ml of Aquasol fertiliser every two weeks at the concentration recommended on the label.

Table 1 TABLE OF OPERATIONS

DATE	ACTIVITY
12/2/1992	Couch plugs transplanted into pots
26/2/1992	Observations - runner no., direction and proportion of long vs short
4/3/1992	Observations - runner no., direction and proportion of long vs short
18/3/92	Observations - runner no., direction and measurement of runner length. - Long runners cut off near growing point and tied with coloured string
1/4/1992	Observations - runner no., direction and proportion of long vs short
8/4/1992	Observations - runner no., direction and proportion of long vs short
14/4/1992	Observations - runner no., direction and proportion of long vs short
29/4/1992	Observations - runner no., direction and proportion of long vs short
6/5/1992	Observations - runner no., direction and proportion of long vs short
20/5/1992	Observations - runner no., direction and proportion of long vs short
13/6/1992	Observations - runner no., direction and proportion of long vs short
22/7/1992	Observations - runner no.
26/8/1992	Observations - runner no.

6 RESULTS - Runner Orientatin Trial

See Data File 2 for full Data Set

Figure 7 MEAN RUNNER NUMBER IN EACH QUADRANT Santa ANA COUCH

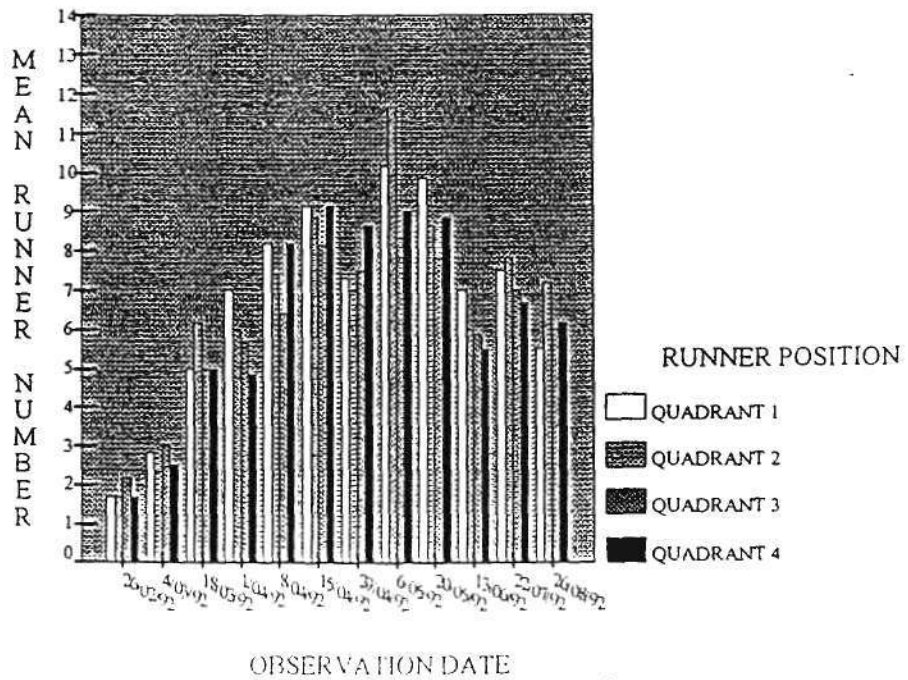
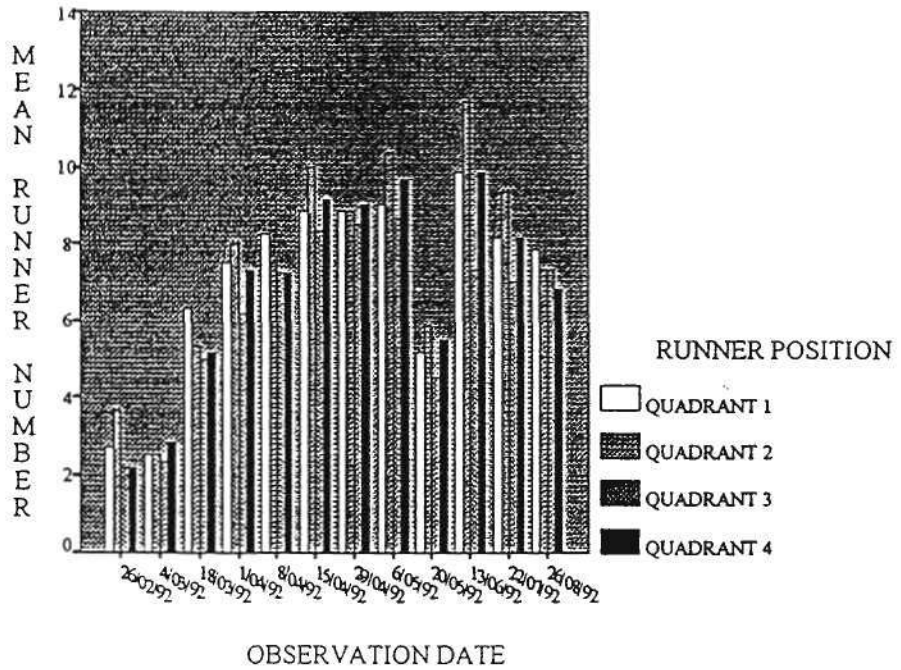


Figure 8 MEAN RUNNER NUMBER IN EACH QUADRANT
 ATRI C-17 COUCH



The above graphs illustrate both the differences between runner numbers on different observation dates and the similarity between runner numbers in each quadrant on individual observation dates. Over the entire trial period, the proportion of runners in each quadrant appears to be similar.

Figure 9 MEAN RUNNER NUMBER IN EACH QUADRANT OVER TRIAL PERIOD
 SANTA ANA

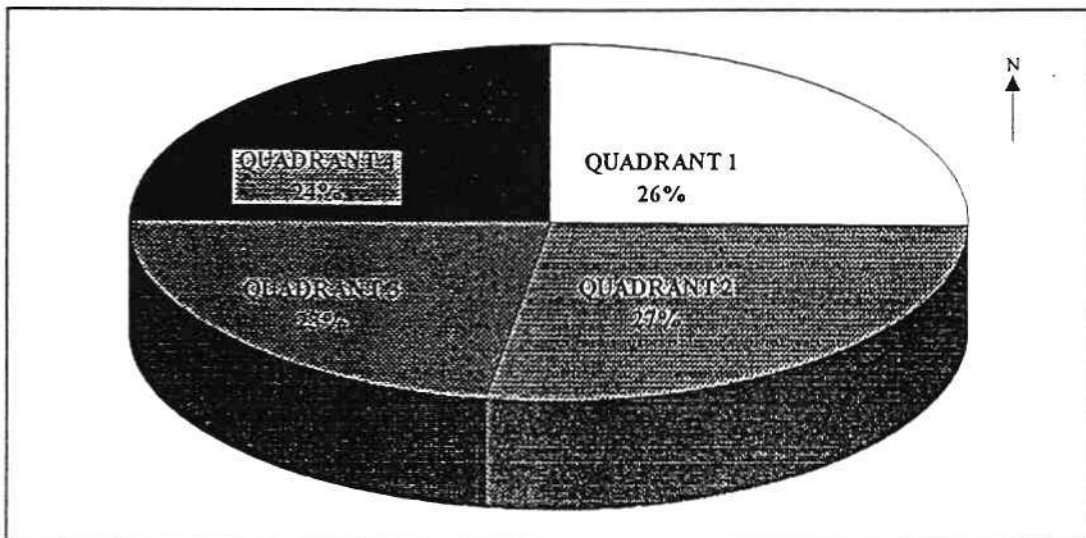
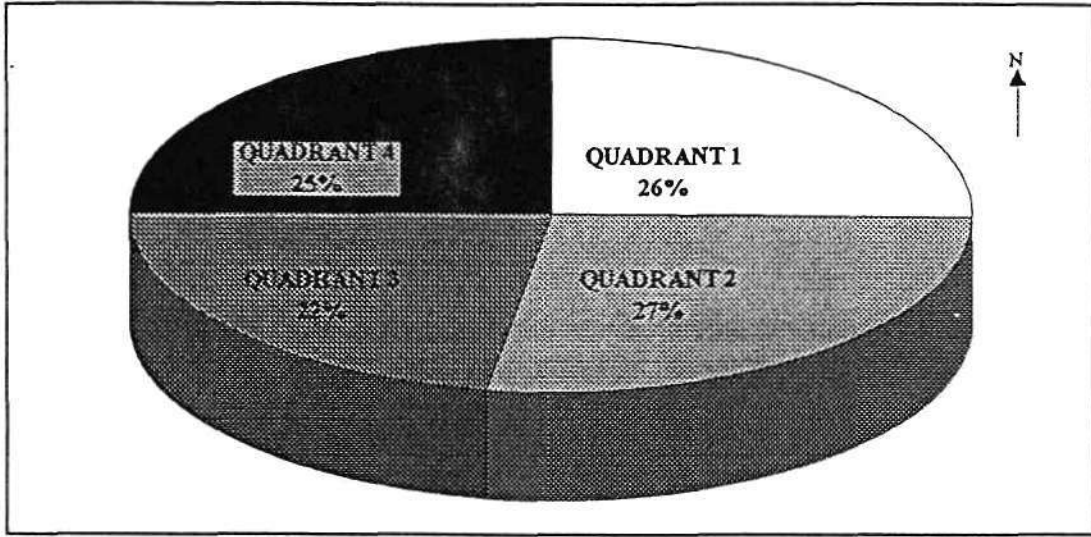


Figure 10 MEAN RUNNER NUMBER IN EACH QUADRANT OVER TRIAL PERIOD ATRI C-17 COUCH



A description of the data for each quadrant of each variety is shown in Data File 2. Statistical analysis of the data showed a significant difference at the 5% significance level between mean runner numbers of the different couch varieties (Data File 2) therefore the two varieties need to be considered separately in the remaining analysis. A highly significant difference was seen in the mean runner number from one observation date to the next: this is partly due to the natural initiation and senescence pattern of the couch runners, and the large time period between some observations.

Findings from the above analysis indicated the data should be segregated so that the desired hypothesis could be analysed. It was decided to analyse each couch variety separately for each observation date.

From this analysis it was found that a significant difference between runner number in each quadrant occurs on only one observation date for each variety. These were; 6/5/92 for Santa Ana couch and 13/6/92 for ATRI C-17. By looking at the original data, it can be seen that the difference shown in each of these cases is probably due to a small number of case which show high values compared to the rest of the observations. To test whether this is so, an analysis of variance was done with the high numbers removed (these are shown bolded in the table below), the analysis showed, in both varieties, that the mean difference between quadrants was not significant. It was therefore reasoned that these high values resulted in a significant difference between quadrant means; as they are outliers, it is reasonable to exclude them from the analysis. (Full statistical data in Data File 2).

Table 2 Santa Ana Couch sample data

6/05/1992 Sample 1	6/05/1992 Sample 2	6/05/1992 Sample 3	6/05/1992 Sample 4	6/05/1992 sample 5	6/05/1992 Sample 6
11	9	12	12	7	10
11	10	14	13	12	10
10	6	8	7	9	10
6	10	12	10	9	7

Table 2 ATRI C-17 Couch sample data

13/6/1992 Sample 1	13/06/1992 Sample 2	13/6/1992 Sample 3	13/6/1992 Sample 4	13/6/1992 Sample 5	13/6/1992 Sample 6
8	14	9	10	8	10
12	11	11	9	16	11
9	7	6	7	9	6
12	7	10	11	9	10

7. Discussion

Through analysis of the experimental data it was found that couch runners of the varieties Santa Ana and ATRI C-17 do not show a preferred initiation and elongation direction. We can therefore conclude that there is no truth in the "old greenkeepers' assertion" that couch runners grow towards the sun, meaning that invasion of the green from the collar is equally likely from any point of the compass, other factors being equal.

References for Technical Report 'B'

- Cooper, R.F. (1994). **A Study of Winter Oversewing of Couchgrass Sportsturf with Ryegrass Infected with Acremonium Endophyte**, M.Agr.Thesis, University of Sydney.
- Cousens, R.F. (1991) *Aspects of the Design and Interpretation of Competition (Interference) Experiments*, **Weed Technology** 5:666-673
- Donald, C.M. (1958). *The Interaction of Competition for Light and for Nutrients*, **Australian Journal of Agricultural Research** 9 : 421-435.
- Foy, J.H. (1991). *Controlling the Battle of Bermudagrass*, **Green Section Record**, Nov-Dec. pp. 13-16.
- Grime, J.P. (1980). *An Ecological Approach to Management*, in: **Amenity Grasslands: An Ecological Perspective**, ed. Rorison, I.H. and Hunt, R, pp. 13-55. Wiley, Chichester, U.K.
- Grime, J.P., Hodgson, J.G., & Hunt, R. (1988). **Comparative Plant Ecology**, Urwin-Hyman, London.
- Harper, J.L. (1977) **Population Biology of Plants**, Academic Press, London.
- Parker, M. (1995). **Comparison of Rooting Potential of Washed and Unwashed Creeping Bent Turf**, M.Agr. Thesis, University of Sydney.

PART 3

TECHNICAL REPORT C

RELATIVE PHYTOTOXICITY OF SELECTED GROWTH REGULATORS AND HERBICIDES TO COUCH AND BENT VARIETIES

1. Introduction

The problem of couch grass (*Cynodon dactylon*) invasion of bent grass (*Agrostis* spp.) golf greens is well known within the turfgrass industry. In early summer, when the growth rate of bent grass is slowing down, couch grass begins active growth and disturbs the appearance and playing quality of golf green.

McMaugh (1971) reported that Siduron adequately controlled invading couch grasses, however others have found that control using Siduron is inadequate and temporary (Siviour & Schultz 1984), leaving couch grass to regrow in less than six weeks (Johnson and Carrow 1989). In addition, Siviour & Schultz (1984) found that Siduron efficacy varied markedly with different strains of couch grass.

Many researchers have investigated the use of herbicides and growth regulators to kill or retard the growth of couch grass (Johnson 1989). Often the control of couch grass is described as adequate at 2 to 3 weeks after treatment, however by six weeks full recovery is seen (Johnson and Carrow, 1991). Some have investigated interactions between various herbicides, growth regulators and fertilisers. The majority of such work is conflicting and inconclusive (Kaufmann 1989, Kelly *et al* 1983, Johnson and Carrow 1991 and 1993).

This work formed part of a wider study of the problem of couch invasion which was carried out at ATRI between July 1990 and June 1993. The aim of this section was to evaluate the potential of a range of herbicides and growth regulators used singly and in combinations for the selective management of couch in bent.

2. Material & Method

2.1 Candidate Compounds

Substances reported in the references already cited as having activity towards couch together with certain compounds selected because of similarities in molecular structure and a Ciba-Geigy experimental plant growth regulator coded CG163935 (recently released as "Primo[®]") were chosen for detailed trial. The ten substances used were as follows:-

Herbicides

Siduron	Tupersan) ¹
Triclopyr	(Garlon) ¹
Clopyralid	(Lontrel) ¹
Fluoxypyr	(Starane) ¹
Ethofumesate	(Tramat) ¹

Growth Regulators

Melfluidide	(Embark) ¹
Flurprimidol	(Cutless) ¹
Amidochlor	(Limit) ¹
Chlormequat	(Cycocel) ¹
Trinexapac-Ethyl	(Primo) ¹

Registered Trade Name

2.2 *Application Methods*

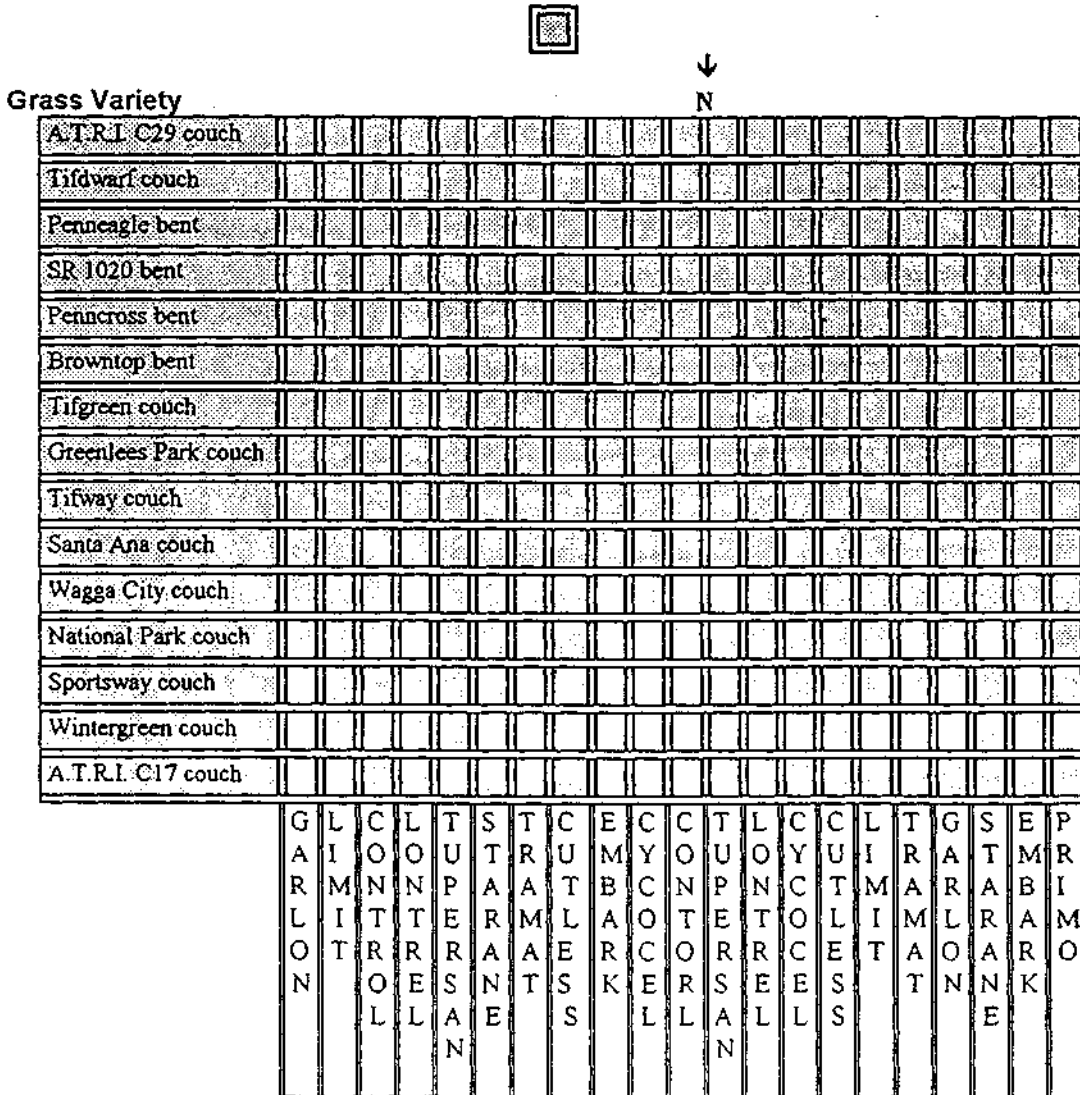
The compounds were applied using a Hardi boom sprayer with 4110-30 (red) nozzles at 25 PSI pressure, to produce a spray droplet size ranging from 200-520 μ m. The standard application rates used were the highest recommended label rates for turf or if no label rates for turf were present, rates were determined using past experience or on the basis of reports in the technical literature. (See Attachment I for list of rate references). The application volume used was 987L/ha. Where Tupersan was sprayed the plots treated with it were hand watered after all the other treatments had been applied.

2.3 Trial Layout

The trial was located on the phytotoxicity test strips at the trial grounds of the Australian Turf Grass Research Institute, Concord West. The ten compounds previously listed were tested on eleven varieties of couch and four of bent. Although essentially exploratory in nature, the trial was done in duplicate on all varieties of grass except for "Wintergreen" couch, "Tifgreen" couch and "Penneagle" bent and for all chemicals except Primo, in which cases the additional space required was unavailable because of the use of parts of these strips in other ATRI trials.

The general layout of the trial is shown below:-

Figure 1 Experimental layout for Phytotoxicity Trials
Each plot measures 1m x 1m with 0.25m borders



Spraying was carried out in summer and autumn, 1992 and again in summer and autumn 1993. Weather data for the whole of the trial period as registered at the ATRI weather station will be found in Data File 3.

Phytotoxic effects were noted in accordance with the standard ATRI rating scale (see below), and other observations made as necessary.

Table 1.
Phytotoxicity Rating Scale

% Rating	Effects
0	None evident.
10	Negligible damage ; slight discolouration.
20	Slight damage ; some discolouration, distortion and/or stunting visible.
30	Moderate damage; moderate discolouration, marked distortions and/or stunting. Recovery expected.
40	Substantial damage; much discolouration, marked distortions and/or stunting. Some damage probably irreversible.
50	Majority of plants damaged, some irreversibly; some necrosis; discolouration and distortions severe.
60	Nearly all plants damaged, many irreversibly, some plants killed (40%); substantial necrosis and distortion.
70	Severe damage, substantial number of plants killed (40-60%); severe necrosis and distortion.
80	Very severe damage, majority of plants killed (60-80%); remainder show much necrosis and wilting.
90	Extreme damage, remaining live plants (20%) severely discoloured and distorted permanently or desiccated.
100	Complete loss of plant and/or crop yield.

3. Results

3.1 Introduction

This experiment involved the observation of the short and longer term effects of five herbicides and five growth regulators applied separately to eleven couch varieties and four bent varieties. The compounds were applied at intervals to the same strips so the cumulative effects of multiple applications could be observed.

The main method of assessment was by phytotoxicity ratings using the ATRI Standard Turf Scale (Table 1). This gives numerical (percentage) scores which were entered into the data base. Assessments took place at approximately weekly intervals for six weeks following a spraying and then at approximately monthly intervals until the next spraying. The accumulation of about 15,000 data points is not included in this report, but is available at the Institute's Library as Data File 4.1-4.4 and Data File 5.1-5.8 for this Project.

The raw data was submitted to graphical analysis in two different ways to highlight relationships.

The first set of graphs were prepared to show the response of single grass varieties to the chemicals used, plotted against observation date over a period of about two months following application. This allows one to see the degree of response and the time - course of damage and recovery for each compound, variety by variety, for each of the four spraying dates. Study of such graphs is useful in showing factors such as the gradual reduction in the impact of same compounds with response between summer and autumn applications (sixty graphs).

The second set is also presented variety by variety, but plots response against chemical used for a series of observation dates. This form of presentation tends to highlight the comparative performance of the compounds and is probably the more useful of the two methods (sixty graphs).

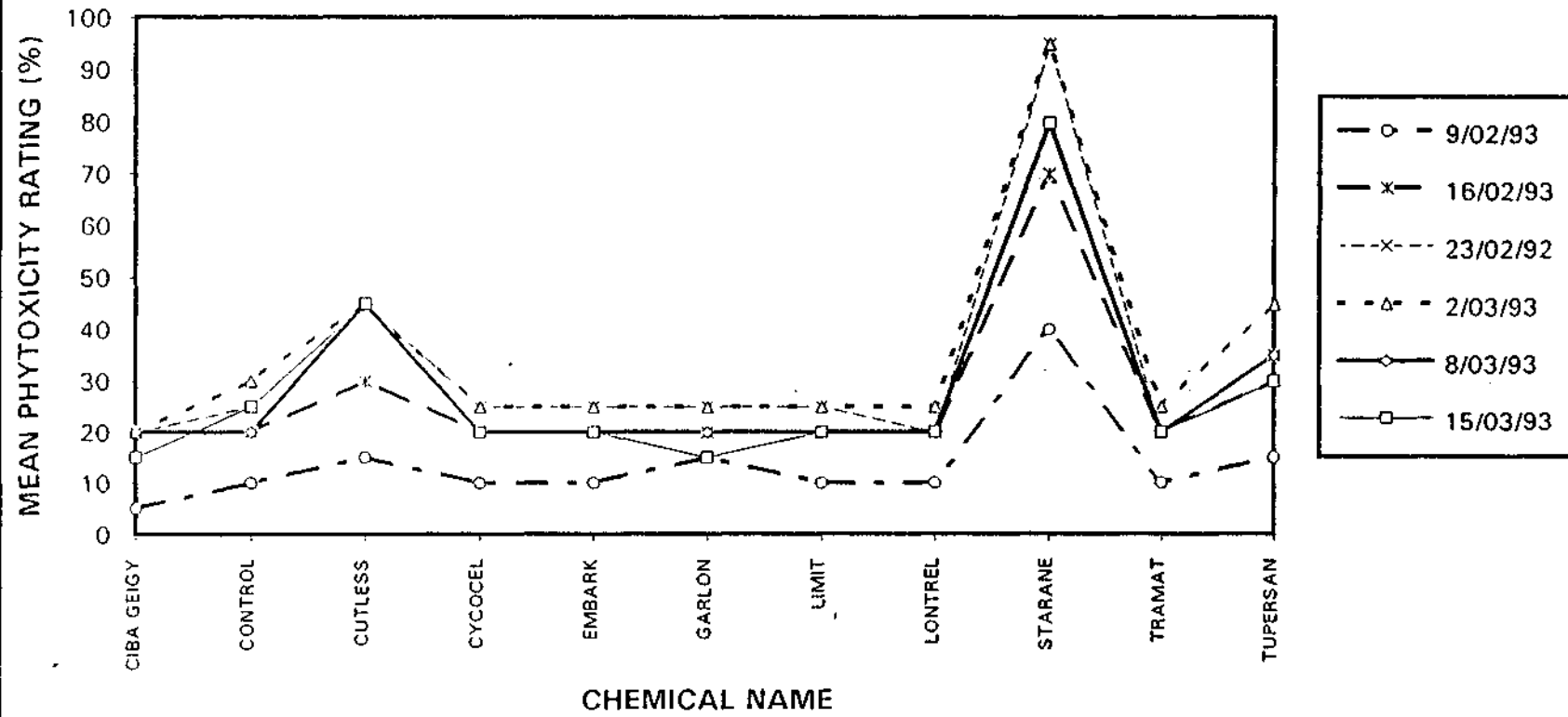
Because of the large number of graphs (120 in all) they are not presented here, but are included in full as Data File 5 of the Data Volume held at ATRI. Examples of the second type of graph are presented as Figures 2 and 3, and show at a glance the greater sensitivity of Tifgreen couch to compounds such as Cutless and Starane than couch variety Greenlees Park.

3.2 *Results in Detail*

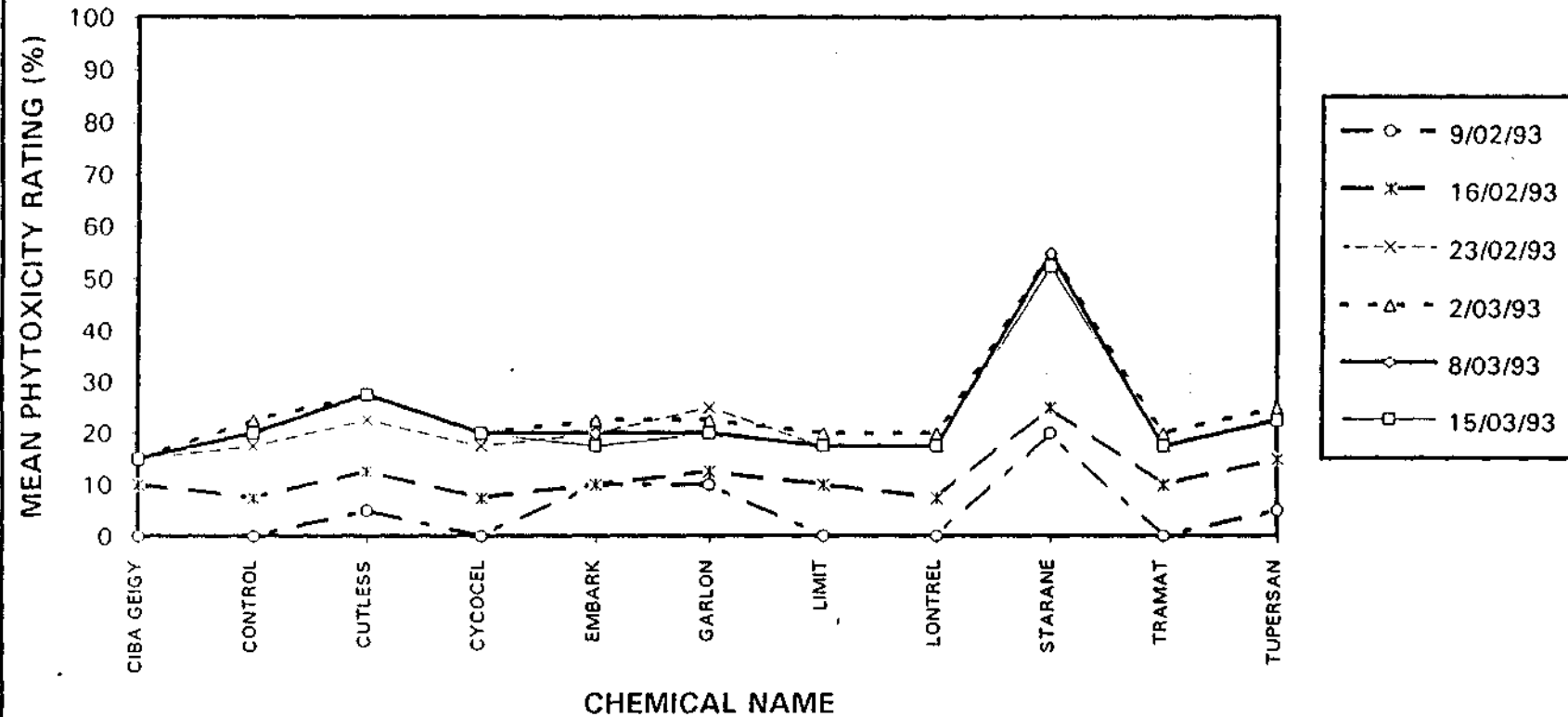
Analysis of the enormous amount of data generated by this experiment showed the following main trends:-

- (a) There were marked variations between couch varieties in sensitivity to the compounds used, varieties such as "Tifgreen" and "Santa Ana" being much more susceptible in general than the Australian varieties (see charts below).

**PHYTOTOXIC EFFECTS ON TIFGREEN COUCH GRASS - SUMMER
 SPRAYING 29/1/1993**



**PHYTOTOXIC EFFECTS ON GREENLEES PARK COUCH GRASS - SUMMER
 SPRAYING 29/1/1993**



- (b) No single compound gave 100% phytotoxicity, even after four applications to the same plants over two years;
- (c) Autumn applications produced more severe effects than the summer sprayings in many couches;
- (c) The compound most consistently active against couch varieties was Starane (long term effect);
- (d) Some couch varieties showed moderate susceptibility to either Garlon or Primo. A few were susceptible to Tramat, and Cutless occasionally produced a small peak; and
- (f) The effect of Topersan (Siduron) on couch declined as the experiment progressed: high short-term phytotoxicities in the summer 1992 series (up to 60%) were replaced by lower ratings averaging about 20% in the autumn 1993 series (fourth spraying); and
- (g) Effects on bent varied with variety. The cumulative effects over the four sprayings were small and short-lived for all compounds with "Browntop" bent, whereas "Penneagle" showed short-lived 40-50% sensitivity to Starane and to a lesser extent to Primo, while "SR1020" and "Pencross" responded similarly but in addition showed a passing response to Garlon at the 35% level.

4. Discussion

Comparing the two grass species (couch and bent) the effects of Starane were greater in intensity and much longer in duration with couch than bent. Although Starane gave a greater degree of control of couch than any other compound, it was relatively less effective on some varieties. In addition, the occasional high activity of other substances could not be ignored. As a result, it was decided that a further trial examining the interactions of the various compounds be carried out to explore the possibility of synergistic interactions giving a level of control not achievable with single compounds.

5. References

- Johnson, B.J. & Carrow, R.N. 1989. *Bermudagrass Encroachment into Creeping Bentgrass as Affected by Herbicides and Plant Growth Regulators*. *Crop Sci.* 29: 1220-1227.
- Johnson, B.J. & Carrow, R.N. 1991. *Frequency of Flurprimidol-Herbicide Treatments on Bermudagrass (Cynodon spp.) Encroachment into Creeping Bentgrass (Agrostis stolonifera)*. *Weed Sci.* 39: 221-226.
- Johnson, B.J. & Carrow, R.N. 1993. *Bermudagrass (Cynodon spp.) Suppression in Creeping Bentgrass (Agrostis stolonifera) with Herbicide - Flurprimidol Treatments*. *Weed Sci.* 41: 120-126.
- Kaufman, J.E. 1989. *How Turfgrass Biology Affects Responses to Growth Regulators*. The 6th International Turfgrass Research Conference, Tokyo, July 3-August 5, 1989.
- Kelly, C.A., Walker, K.L., Abernathy, J.R. and Wendt, C.W. 1983. *The Influence of Growth Regulators on Common Bermudagrass*. *Texas Turfgrass Research*. PR-4168, 111-125.
- McMaugh, P. 1971. *Control of Encroachment of Agrostis spp. Swards by Warm Season Turf Grasses*. *J. Sports Turf Res. Inst.* 47: 33-40.
- Siviour, T.R. & Schultz, G.F. 1984. *Response of Bermudagrass (Cynodon dactylon) to Siduron*. *Weed Sci.* 32: 178-180.

ATTACHMENT 2

Technical Report C

1. References for Rates of Herbicides and Growth Regulators

Beard, J.B. et al., *Chemical Growth Regulator Evaluations on Bermudagrass, Texas P.R. 3493*

Canaway, P.M. & Peel, C.H., *Control of Poa annua using Ethafumesate in Renovated Swords of Lolium perenne Subjected to Football Type Wear, J. Sports Turf Res. Inst. 61 pp-52-58.*

Johnson, Billy J., (1988) *Influence of Nitrogen on the Response of "Tifway" Bermudagrass (C. dactylon) to Flurprimdol, Weed Technology 2, pp53-58*

Johnson, Billy J. (1989) *Response of Tall Fescue (Festuca arundinacea) to Plant Growth Regulator Application Dates. Weed Technology 3 pp.408-413*

Johnson, Billy J. (1989) *Response of Bermudagrass (Cynodon spp.) to Plant Growth Regulators. Weed Technology 3 pp.440-444*

Kavanagh, T. *The Effect of three Grass Growth Retardant Chemicals Species Composition of Lawn Turf. J. Sports Turf Res. Inst. 62, pp 172-181*

Kelly, C.A. et al., *The Influence of Growth Regulators on Common Bermudagrass, Texas P.R. 4168*

Marshall, E.J.P. (1983) *A Feasibility Study of the Use of Chemicals for Rural Amenity Areas. Technical Report No. 71, Weed Research Organisation, Oxford (Melfluidide)*

Neal, Joseph C. (1990) *Non-Pherioxy Herbicides for Perennial Broadleaf Weed Control in Cool Season Turf Weed Technology 4 pp.555-559.*

ATTACHMENT 2
Technical Report C

2. Spray Data

Date of first spraying : 15/1/1992

Weather Conditions			
Spraying time	Temperature (9.00am)	Relative humidity (%)	Cloud cover
10.00am-4.00pm	19.5	80	full

Date of second spraying : 6/4/1992

Weather Conditions					
Spraying time	Temperature (3.00pm) dry bulb	Temperature (3.00pm) wet bulb	Relative humidity (%)	Wind speed	Cloud cover
9.00am-3.00pm	27.5	21.5	56	breezes 3 knots	nil

Date of third spraying : 29/1/1993

Weather Conditions				
Spraying time	Temperature	Relative humidity (%)	Wind speed	Cloud cover
9.00am	24.5	72	up to 3 knots	nil
11.00am	30.0	55	up to 4 knots	nil
3.00pm	31.0	55	up to 6 knots	nil

Date of fourth spraying : 6/4/1993

Weather Conditions					
Spraying time	Temperature dry bulb	Temperature wet bulb	Relative humidity (%)	Wind; speed, direction	Cloud cover
8.50am	24.5	17.5	48	less than 3 knots, West	nil
10.10am	26.0	19.0	49	3-4 knots, West	nil
11.45am	29.5	21.0	45	less than 2 knots, West	nil

ATTACHMENT 3
Technical Report C

3. Chemical Information

Chemical Information					
	Pesticide Name	TradeName	Company Name	Application Rate	Pesticide Manual No.
Herbicides	Siduron	Tupersan ®	Du Pont	50kg ai/ha	10720
	Triclopyr	Garlon 600 ®	Dow Elanco	0.6kg ai/ha	12020
	Clopyralid	Lontrel ®	Dow Elanco	0.18kg ai/ha	3215
	Fluroxypyr	Starane ®	Dow Elanco	0.8kg ai/ha	6650
	Ethofumesate	Tramat ®	Schering AG	0.4kg ai/ha	5750
Plant Growth Regulators	Melfluidide	Embark ®	3M Company	0.5kg ai/ha	7890
	Flurprimidol	Cutless ®	Dow Elanco	1.0kg ai/ha	6660
	Amidochlor	Limit ®	Monsanto	1.2kg ai/ha	*25
	Chlormequat Chloride	Cycocel 77A ®	BASF Ag	10.0kg ai/ha *1.7kg ai/ha	2420
	CGA163935	Ciba-Geigy	Ciba Geigy	1.0kg ai/ha *2.0kg ai/ha	5793

Trade Name	Active Ingredient
Tupersan ®	Wettable powder, 500g/kg Siduron
Garlon 600 ®	600g/L Triclopyr present as the butoxyethanol ester
Lontrel*L ®	300g/L Clopyralid present as the monoethanolamine salt
Starane ®	300g/L Fluroxypyr present as the methylheptyl ester
Tramat ®	200g/L Ethofumesate, Solvent-557g/L Xylene
Embark ®	240g/L Melfluidide
Cutless ®	50% Flurprimidol- α -(1-methylethyl)- α -[4-(trifluoromethoxy)phenyl]-5-pyrimidinemethanol
Limit ®	41.6% N-Acetamidomethyl-2-chloro-2',6'-diethylacetanilide
Cycocel *77A ®	77g/L 2,2-chloroethyltrimethylammoniumchloride
Ciba-Geigy	250g/L cimecT acarb, [ethyl 4-cyclopropyl(hydroxy)methylene-3,5-dioxocyclohexanecarboxylate]

PART 4

TECHNICAL REPORT D

FIELD TRIAL OF HERBICIDES AND GROWTH REGULATORS, ALONE AND IN COMBINATION, FOR THE MANAGEMENT OF COUCH INVASION OF BENT GREENS

1. Introduction

The general background to the problem, together with relevant references, has been provided in the introduction section of Technical Report C. The experiments discussed here follow on from the phytotoxicity trials of the previous section and included a large scale check for synergistic reactions between the five herbicides and five growth regulators in a field trial at Richmond. The most promising combination from this trial were then used in two field trials: one on an artificially couch infected bent green at the ATRI Trial Grounds, Concord West, and the other on portion of the 11th Green at Manly Golf Club. The three experiments will be described in sequence.

2. Herbicide and Growth Regulator Interaction Trials on Couch

2.1 Method

Two major trials involving all possible combinations of the ten selected substances were laid down at "Qualturf" Turf Farm, Richmond. The first trial was commenced in December, 1991, on an area of "Greenlees Park" Couch. This trial was abandoned following severe flood damage in February, 1992. A second trial was set up in April, 1992 on an area of well established "Wintergreen" couch and remained under observation until May, 1993. Trial layout was as shown below in Figure 1:-

other observations (e.g., tendency to produce runners) were assessed as necessary.

The varieties of couch selected for these trials were chosen because the Phytotoxicity Trials (see Technical Report 'C') had shown that these were amongst the types most difficult to damage with the chemicals under test.

The range of chemicals used and the phytotoxicity scale employed were the same as these detailed in Technical Report 'C'.

The trial was regularly hand mown during the growing period using a 2-stroke Victa rotary mower set to level 6 (lower edge of cutting bar 4cms. above the level of hard standing). On the actual trial this produced an effective grass length above "solid" thatch of about 2.5cms. Weeds within plots were regularly removed by hand, and, except when required for runner growth assessments, the border strips were kept weed free by applications of Roundup® at the label rate. During runner assessment periods, border strips were kept clear by hoeing.

After the Autumn 1992 spraying, only general observations were made, but after the Summer and Autumn 1993 sprayings, phytotoxicity ratings were made for each plot at approximately weekly intervals for six weeks and following the Summer and Autumn sprayings in 1993, additional observations were made of the tendency to produce invasive runners by growth into the border strips.

Weather conditions at the time of spraying of the unflooded trial were as follows:

Richmond No.2 Trial

Date of first spraying : 29/4/1992

Weather Conditions					
Spraying time	Temperature dry bulb	Temperature wet bulb	Relative humidity (%)	Wind;speed,	Cloud cover
8.00am-3.30pm	23.0	16.0	47	3-8 knots gusts up to 8-9 knots	nil

Date of second spraying : 3/2/1993

Weather Conditions					
Spraying time	Temperature dry bulb	Temperature wet bulb	Relative humidity (%)	Wind; speed, direction	Cloud cover
8.30am	24.5	22.5	80	less than 2 knots Northwest	medium-full cover
10.45am	28.5	24.0	68	3-4 knots, Northwest	thin- half cover
12.45am	29.5	24.0	62	less than 2 knots, Northwest	thin 20%cover

Date of third spraying : 31/3/1993

Weather Conditions					
Spraying time	Temperature dry bulb	Temperature wet bulb	Relative humidity (%)	Wind; speed, direction	Cloud cover
10.30am	23.0	15.5	44	up to 4 knots South-Southwest	nil
2.00pm	24.5	16.0	39	0 knots	nil
5.15pm	20.5	14.5	51	up to 4 knots Southeast	nil

2.2 Soil at the Richmond Site

The soils in the area used are influenced to some extent by the regular applications of poultry manure. Information from the farm manager is that 25-50 cubic metres (50 cubic metres weighs 7-8 tonnes) of lightly composed deep litter poultry manure is applied annually, usually split into two or three doses applied after cutting of the turf.

The soil is dark grey to black at the surface, with a clay loam texture (0-10cm), passing into a light clay which extends to beyond 1 metre. It is an alluvial deposit, the fine particle size reflecting its distance from the river. pH* ranges from 6.0 at the surface to 6.5-7.0 at depth. Salinity is low (E.C.** value 0.04 dS/m).

* determined in the field by C.S.I.R.O. Colour Kit.
 ** 1:5 soil:water ratio

The plot area had been topdressed in early summer (i.e. in November-December of both 1991-1992). The vigorous growth of couch through the experimental period showed that soil fertility was high. Plots were irrigated during prolonged dry spells. During soil examination, couch roots were found down to 1.7 metres.

3. Results

The primary data is too extensive for presentation here. As with previous reports, the results are available in the ATRI Library in the Primary Data File Volume as Data Files 6.1 to 6.3. Most of the treatments had negligible effects on the relatively herbicide resistant Wintergreen couch and it was considered that because of the nature of the design and the small number of strong reactions, statistical analysis would yield nothing of value. Instead, the few effective single and combined treatments were noted. The average values for these treatments are set out below:

- (a) Overall, the highest phytotoxicities were associated with Starane.
- (b) The best combinations were Starane x Starane (80%), Garlon x Starane (60%), Starane x Primo (50%), and Starane x double strength Primo (70%).
- (c) A combination of Cutless and Trammat, as recommended by Johnson and Carrow (1989), was found to be ineffective (10%) under these conditions.
- (d) Runner suppression was marked in all treatments mentioned in (b) above, and also in the Primo x Primo treatments at both regular and double strength levels.

4. Discussion

Given the obviously enhanced effects of the treatments listed in (b) against the relatively difficult to control 'Wintergreen' couch, growing as a well established solid turf, it was decided to test these particular combinations on greens infested with couch.

5. Pest Management Trials: Effect of Selected Compounds and Combinations on Couch in Bent Grass and Bent/Winter Grass Greens.

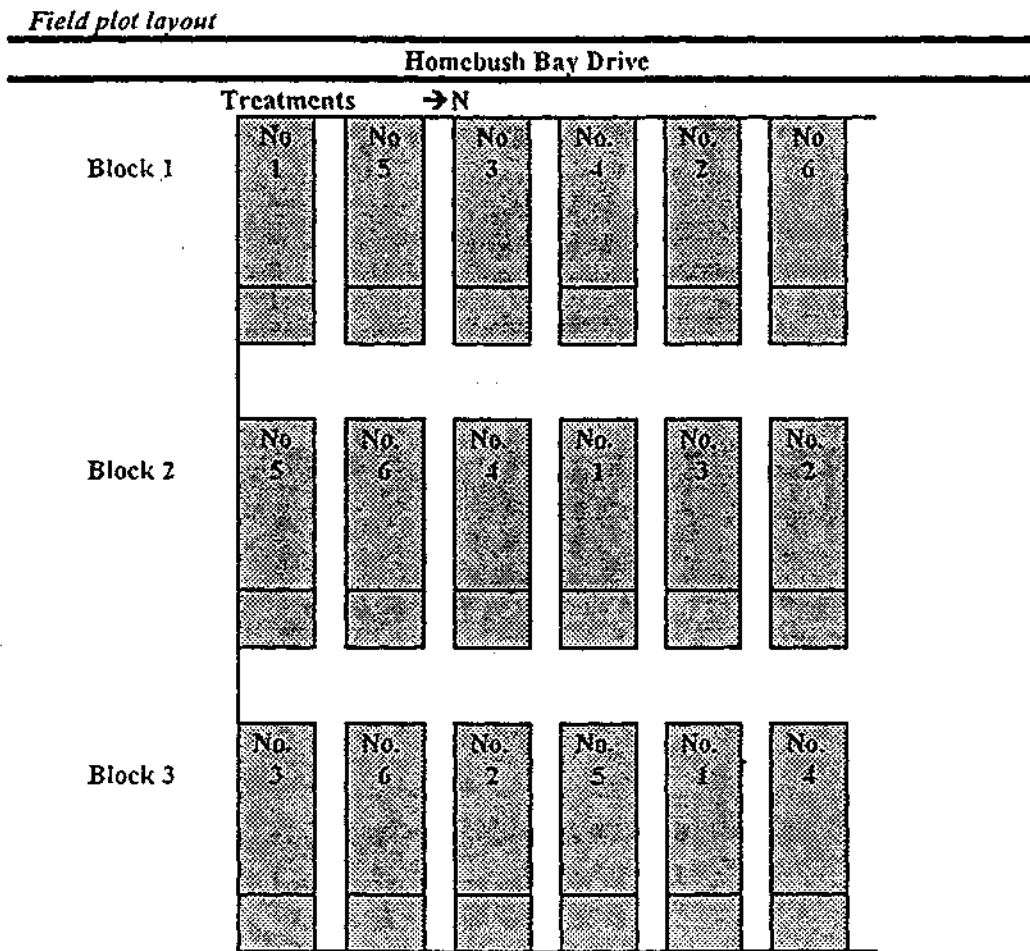
5.1 *Trial A - Couch in pure Penncross Bent*

- 5.1.1 *Method.* The trial was located on a green of pure Penncross Bent growing on a 90% sand profile at the trial grounds of the Australian Turfgrass Research Institute, Concord West. The green was cut every three days at a height of 7 mm and was kept in active growth by regular fertilizer applications. Untreated cores of "Wintergreen" couch turf, 100 mm in diameter, were introduced into the plots of bent prior to spraying. The aim was to observe the effects on both couch and bent. Treatments and application rates were as follows:

Treatments	Application Rates
No. 1 Water(control)	Cutless - 0.8kg ai/ha
No. 2 Cutless + Trammat	Tramat - 1.7kg ai/ha
No. 3 Double Strength Primo	Primo - 1.0kg ai/ha
No. 4 Double Strength Starane	Starane - 0.8kg ai/ha
No. 5 Starane + Primo	Garlon - 0.6kg ai/ha
No. 6 Garlon + Starane	Primo x2 - 2.0 x kg ai/ha Starane x2 - 1.6kg ai/ha

The trial was laid out in a randomised complete block design with three replications as shown in the diagram below. Effect of the treatments was assessed by phototoxicity ratings at approximately weekly intervals for a period of eight weeks following application, and thereafter at monthly intervals. The scale used was the standard ATRI scale described in Technical Report 'C'.

Figure 2.
Pest Management Trial, Experimental Bent Green, ATRI, Concord West



Each plot measures 3m x 1m with a 0.4m border between plots within a block and a 1m access path between blocks. Three 100mm couch cores were placed in each plot in the area indicated by the small rectangle.

5.1.2 Results

Detailed results are available in Data File 2.

Marked effects were produced on both bent and couch by some of the treatments. The following phytotoxicity data on dates approximately 4, 8 and 13 weeks after spraying give a good idea of the range of responses.

Table 2
Experimental Bent Green, ATRI, Concord West
Percent phytotoxicity scores, averages of the three replications

Species	Date	Treatment					
		1. Water (control)	2. Cutless + Tramet	3. Primo x2	4. Starane x 2	5. Starane + Primo	6. Garlon + Starane
Bent	30/4/93	5	7	15	83	73	87
	25/5/93	3	15	30	92	82	77
	28/6/93	0	7	20	92	63	62
Couch	30/4/93	9	18	35	30	38	33
	25/5/93	7	46	57	84	88	86
	28/6/93	2	60	71	98	96	97

5.1.3 Discussion

The results show that the three treatments involving Starane were all highly active against couch, the phytotoxicity scores after 13 weeks showing that an almost 100% kill had been attained, despite the relatively small response to standard doses of Starane in the variety "Wintergreen" as found in earlier trials. The Cutless + Tramet combination performed much better under the conditions of this trial than it did on pure swards of the same couch variety, but none the less it was significantly less effective than the Starane combinations, as was the double-strength Primo. Of treatments 4, 5 and 6, the double strength Starane caused severe and persistent damage to the bent (92% after 13 weeks) and therefore cannot be regarded as useful in this situation. Treatments 5 and 6 (Starane + Primo and Garlon + Starane respectively) were equally as effective against the couch as double strength Starane, but were significantly less toxic to the bent at 13 weeks. Observations were continued on this trial in a general way after the end of the official research on 30/6/93 until October 1993, and showed that no recovery of couch took place in Treatments 4, 5 and 6, whereas the bent in treatments 5 and 6 recovered almost completely by the fifth month after spraying.

These results show great promise for the Starane + Primo and Garlon + Starane combinations as a means of controlling couch in fine bent greens provided the severity and duration of the damage to the bent surface can be reduced to acceptable levels (e.g., less than 20% score within six weeks of application). A degree of selectivity combined with excellent efficacy against the couch has been demonstrated. Further development of the combinations requires

exploration of the proportions of the components and a careful study of spray technology factors to decrease deposition on and/or absorption by non-target species.

5.2 Trial B - Couch in a predominantly Winter Grass Golf Green

5.2.1 *Method.* The treatment and application rates given for Trial A were tested on an area of the 11th Green at Manly Golf Club in which the original bent turf had been almost completely replaced by a perennial form of winter grass and in which there was a serious degree of natural couch invasion by a Tupersan tolerant ecotype. The green, which was cut daily at 4 mm remained in play during the trial period. Spraying took place on 22/4/93 and phytotoxicity observations continued until the end of June, 1993. The main reason for undertaking this trial was the need to evaluate the effect of the selected combinations on winter grass because of its very widespread presence in greens, particularly at the autumn spraying time which this work has suggested as the most effective time.

5.2.2. Results and Discussions

Full results are presented in the Data File 8.

A summary of results for couch and winter grass are presented in Table 3, below. The amount of bent remaining in the selected portions of the green was too small to allow for meaningful observations to be made. Results are provided for times approximately two and seven weeks after spraying.

Table 3
11th Green, Manly Golf Club
Percent phytotoxicity scores, averages of the four replications

Species	Date	Treatment					
		1. Water (control)	2. Cutless + Tramal	3. Primo x2	4. Starane x 2	5. Starane + Primo	6. Garlon + Starane
Winter Grass	4/5/93	0	46	45	87	71	67
	9/6/93	0	33	6	95	47	67
Couch	4/5/93	0	15	18	92	80	88
	9/6/93	0	88	28	100	100	100

The results show that complete kill of the couch was achieved by the seventh week in Treatments 4, 5 and 6, i.e., the treatments involving Starane. However, unlike the previous trial on "Wintergreen" couch, the native couch present on this green proved fairly susceptible (phytotoxicity score of 88% after seven weeks) to the Cutless + Tramal combination (Treatment 2) which was less damaging to the winter grass than the treatments including Starane. Despite this, Treatment 2 is considered to have limited applicability because most of the couch types examined in the phytotoxicity trials (see Part 3, above) were not responsive to either Cutless or Tramal when applied separately.

Of treatments 4, 5 and 6, the double-strength Starane shows no potential because of its excessive phytotoxicity towards the winter grass, while Starane + Primo, although as used in this trial undesirably damaging to the winter grass, was, after seven weeks, significantly less so than the Garlon + Starane combination.

5.2.3 Discussion

PRIMO®. The goal of this work was to find a herbicide or growth regulator or combination of any two which would selectively control virtually any form of couch in bent greens. Since in practice bent greens usually include a proportion of winter grass, a subsidiary goal was to ensure that any treatment developed was not highly active against that species.

As described in the proceeding sections, a number of treatments were identified which were reasonably effective against a known "hard to kill" couch variety (Wintergreen) growing as a well established pure stand on a turf farm, and these were subsequently tested on "Wintergreen" couch in an experimental bent green and on a natural couch infestation on an in-play golf green consisting largely of a perennial ecotype of winter grass.

The results of these trials, considered in terms of selective removal of couch from the green with minimal damage to the bent or winter grass, showed that none of the treatments as currently formulated or applied actually achieved the goal, the problem being an unacceptably strong and prolonged discolouration of the bent and/or winter grass. However, it has been shown that a single autumn application of either Starane + Primo or Starane + Garlon gave almost total control of both a native couch and a relatively herbicide resistant cultivar without permanently damaging the bent or winter grass.

Based on the overall results of the whole project, it is considered that of the two favoured combinations, the one most likely to prove effective against virtually any couch is the Starane (herbicide) and Primo (growth regulator) combination. Taken in conjunction with indications of less persistent discolouration of winter grass, it is concluded that the sequential application of Starane and Primo is the most promising combination of the large number examined, but adjustments are needed in the balance of the two components and in the application technology to reduce the effects on the non-target species.

ANNEXURES

ANNEXURES

CONTENTS:

- | | | |
|-----------------|----------|--|
| Annexure | 1 | Extension and Publicity |
| | 2 | ATRI Field Day Programme |
| | 3 | Field Day Information Sheets |
| | 4 | Brief Extension Report prepared for circulation
to Golf Clubs in N.S.W. |

ANNEXURE 1

EXTENSION & PUBLICITY

List in chronological order:-

- October, 1991. Australian Society of Horticultural Science, 1st National Conference, Sydney. "Management of Couch grass invasion of bent grass greens: factors in the design of an ecologically based research programme".
- 12 November, 1991. NSW Golf Association Headquarters, Sydney. Seminar for representatives of supporting clubs: "Couch in Bent: the Constant Invasion".
- December, 1991. Golf in New South Wales, magazine of the NSW Golf Association - two page report and summary of the above seminar.
- 12 March, 1992. Toukley Golf Club Seminar for delegates from Clubs in the Gosford and Central Coast Districts: "An Ecological Approach to Couch Control in Bent Greens". (Talk followed by field inspection/demonstration).
- 16 May, 1992. 3rd Australian Turf Researchers' Seminar, Launceston. "Couch - Bent Research Report".
- 17 May, 1992. 12th National Turfgrass Conference, Launceston. "Turfgrass Invasion of Bent Grass Greens: An Integrated Pest Management Approach to its Control".
- 2 June, 1992. Report to Supporting Golf Clubs, "ATRI Research Report: Couch Invasion of Bent Grass".
- 11 May, 1993. Field Day ATRI. Theme: "Couch Invasion of Bent Greens". (A major event consisting of Lectures, trial inspection and practical demonstrations. See annexures 1, 2 and 3 (attached) for programme and Summary Sheets 1 and 2, respectively).
- 9 February, 1994. Final short report to NSW Golf Association for distribution to Clubs who had supported the project. "HRDC Research Project TU012. Development of Ecologically Based Management Procedures for Controlling the Invasion of Bent Grass in Golf Greens by Couch Grass: Summary of Project and Practical Outcomes". (Attached as Appendix 4).
- May, 1994. "Herbicide-Growth Regulator Combinations for the Management of Couch Invasion of Bent Grass Greens". Proceedings of the 1st ATRI Turf Research Conference, pages 71-87

ANNEXURE 2

ATRI FIELD DAY

COUCH INVASION OF BENT GREENS

(HRDC Research Project)

May 11, 1993

PROGRAMME

REGISTRATION (Marquee)	10.00 am	Registration of delegates
SESSION I (Marquee)	10.30 am	Welcome by Mr. Ian McIver, Director ATRI
	10.35-11.10 am	Couch - one of the world's worst weeds invading your greens. Background talk by Dr. Peter Martin.
MORNING TEA	11.10-11.30 am	
SESSION II (Behind Glasshouse)	11.30-12.10 pm	Couch Control (a) Mechanical Barriers - do they work? (b) Removal by digging out - the right and wrong way. (Outdoor demonstrations - project staff)
LUNCH	12.10-1.30 pm	At 1.00 pm during luncheon break two optional activities will be available to those interested. (i) Turflite Information Service - computer demonstration (David Drane) (ii) Laboratory Methods (Maria Guerrero)
SESSION III (Bent green)	1.30-2.10 pm	Couch Management - the Chemical Approach (Dr. Peter Martin and Mr. Adrian Sands)
AFTERNOON TEA	2.10-2.25 pm	
SESSION IV (Marquee)	2.30-3.00 pm	An integrated approach to managing the couch pest in bent greens - recommendations for - (i) New Greens free of couch (preventive measures). (ii) Mildly infested greens. (iii) Severely infested greens. (A summary sheet of provisional recommendations will be issued at the conclusion of this session). (Dr. Peter Martin and Mr. Adrian Sands)

ATRI Publications will be on display and for sale in the marquee throughout the day.

ANNEXURE 3

COUCH INVASION OF BENT GREENS

FIELD DAY, MAY 11, 1993 - SUMMARY SHEET 1

KNOW YOUR ENEMY

The grass Australians call COUCH (*Cynodon dactylon*) is found in most of the warm temperate parts of the world.

Couch is widely used as a pasture grass and as a lawn grass.

However, couch often turns up where it is not wanted. It is extremely difficult to control, so much so that couch is included near the top of the official list of the world's worst weeds!

In agriculture, couch is mainly found as a pest in frequently cultivated areas such as market gardens and orchards.

Couch can be spread by seed, runners or rhizomes, but the secret of its success as a weed is in the way its rhizomes work.

Couch rhizomes usually occur in the top 5-7.5cms (2-3 inches) of soil.

Couch rhizomes have buds every centimetre or so along their length. Each of these buds can develop into a new couch shoot. If the rhizome is broken or cut, even the small pieces, provided they are buried and have at least one bud, can form new plants!

Ineffective sprays worsen the infestation because the unkilld parts of the rhizomes form vigorous new plants. One plant becomes many.

Turf cultivation practices spread couch by cutting up the rhizomes and "planting" the pieces at suitable depths for growth.

Couch is frequently spread around the inner part of the green during the process of moving the hole.

Couch rhizomes often travel ahead of the visible infection.

Couch is a tough and clever weed. It is extremely difficult to kill completely. Bent is a refined and delicate grass easily damaged by chemicals and readily killed outright. By taking shelter in the bent, couch sets us a very tricky problem.

Couch is like a cancer in the green: the smallest bit of rhizome left alive in the green can easily reinfest the whole green in two years.

COUCH INVASION OF BENT GREENS

FIELD DAY, MAY 11, 1993 - SUMMARY SHEET 2

PRACTICAL OUTCOMES OF THE RESEARCH PROJECT

WARNING. These research findings are reported for the interest of those attending the field day. Many of the chemicals used are experimental compounds or are not registered in NSW for us on turf. Research findings involving the use of chemicals not currently registered for use on turf do not constitute ATRI recommendations for the use of those compounds. ATRI takes no responsibility for individuals or organisations who make improper use of this information in relation to their obligations under the Pesticides Act and other applicable legislation.

1. GREEN WITHOUT COUCH. "Prevention is better than cure"

Constant vigilance is necessary to keep the green free of couch.

- a. Inspect the green in detail at least fortnightly during the warmer weather and ever six weeks during the cooler weather. To improve prospects of spotting couch, do this when the surface is dry and recently mown and the sun is shining across the green at an angle. View the surface systematically like a pilot scanning the sky in sectors before take-off.
- b. Request players to report any couch they may see on these greens.
- c. If couch is found, dig it out completely in the way demonstrated. It is better to make a slightly larger hole to be certain you have got it all than to leave the rhizome tip behind to reinfect the green. No chemical method is as effective as surgical removal, provided you know exactly what you are looking for and do a thorough job.
- d. Screen all topdressing material to ensure that it contains no pieces of couch rhizome.
- e. Avoid use of couch collars. If couch collars must be used consider installing soil barriers, but-remember that to be fully effective the soil barrier must be used in conjunction with periodic surface treatments.
- f. Thoroughly clean any machinery which has been used on couch or couch infested greens before letting it on to a couch-free green. Pay particular attention to machines which could be contaminated with rhizome pieces or which have the capacity to bury seeds, clippings or rhizome pieces which could shake out or fall off during use.
- g. Think about the problem and take such other measures as seem necessary at your course. Couch is a clever weed, but it can be beaten provided you get it early enough.

2. GREEN WITH MODERATE COUCH INFESTATION

- a. Stop using ineffective chemicals because they actually cause the patches to increase in size and usually lower the vigour of the bent.
- b. Avoid spreading couch to clean sections of the central green by examining the plug before insertion every time you change the position of the hole. Remember to examine for surface growth and for rhizomes which can be present even if surface growth is absent.
- c. Follow basic hygiene measures (d) and (f) as set out in the preceding section.
- d. Replace couch collars or consider a soil barrier as discussed in (e) above.
- e. Three weeks before renovating, dethatching or carrying out any form of cultivation which could cut the rhizomes or spread and bury shoots and rhizomes, spot spray the couch patches with a combination of growth regulator and herbicide to kill as much of the couch as possible and to reduce the likelihood of the surviving pieces taking root if moved or of putting out runners if not moved. Experimentally, combinations of Starane and an unreleased Ciba-Geigy growth regulator are showing promise in this application. These treatments seem to be more effective in spring and autumn than in summer. Regrowth of bent is also faster at those times.
- f. Do not fertilize heavily when the bent is growing slowly during periods of high temperature. To do so is simply feeding the couch when it can grow best. Similarly, in (e) above, fertilize when the chemicals are still affecting the couch but the bent has recovered from any temporary set back.
- g. Spot spraying of the couch affected areas with herbicide combinations such as Garlon and Starane have shown promise experimentally when applied in the cooler weather but while the couch is still active.
- h. When the couch is reduced to a small number of scattered infestations, experimental work suggests that application to the couch alone (e.g. by painting on) of higher levels of Starane or a combination of Starane and the Ciba-Geigy growth regulator will kill the couch almost completely. Any small remaining living fragments can then be dug out by the method demonstrated.
- i. Marginal patches of couch in an otherwise clean green can be prevented from spreading by spot spraying every six weeks or so during the couch growing season with a growth regulator. Our experiments suggest that the unreleased Ciba-Geigy product is more effective in this role than substances such as Cutless, Limit and Embark.
- j. Managing the couch pest where you have a moderate infestation requires a great deal of thought and planning. Some of the measures mentioned above stop it from getting worse, while others, if you have the time available, can be used to gradually reduce the infestation. On current indications it could take two or three years to reduce the problem to negligible proportions.

3. GREEN SEVERLY INFESTED WITH COUCH

TREATMENT OPTION

- a. There is no effective couch killer known to us which is suitable for general spraying over a whole green on a more or less routine basis. However, if you are desperate, cannot afford to regrass or rebuild the green, and can persuade your members to live with severely discoloured bent (and winter grass as well) for periods of four to six weeks in the autumn and spring, some of the treatments as demonstrated on the small bent green at Concord are capable of killing a great deal of the couch.
- b. Although repeated treatment over two years could well eliminate the couch, we do not have enough information on the long term effects on the bent as yet to be confident that this is a practical approach.

REGRASSING OPTION

- a. A proper regrassing operation should get rid of the couch completely and allow you to make a fresh start. By following the methods set out in section 1 you should then be able to keep the new green clean.
- b. However, be warned! The wily couch is an incredibly tough weed and its rhizomes are hardly ever all killed by one gassing and never all killed by one application of a total herbicide such as Glyphosate. After the initial treatment it does not pay to be in a hurry. stir the ground to stimulate any surviving pieces of rhizome into action, irrigate if the weather is dry and allow several weeks to go by before re-poisoning by either a general application or spot treatment. Repeat as necessary until no more couch regenerates. Avoid applying these treatments when the couch is dormant or about to go into dormancy because you will have to wait for the spring "green-up" to find out whether your treatment has been effective.
- c. If the aim is to get rid of couch and start again, there is no point in regrassing until you are absolutely sure all couch has gone. This takes at least four weeks, often much more.

ANNEXURE 4

HRDC RESEARCH PROJECT TU 012

"Development of Ecologically Based Management Procedures for Controlling the Invasion of Bent-Grass Golf Greens by Couch Grass"

Summary of Project and Practical Outcomes

A. SUMMARY

Background

During 1989 the N.S.W. Golf Association identified couch invasion of bent greens as one of the major problems in the maintenance of quality greens in this state. After discussions with ATRI a research grant submission was made to the Horticultural Research and Development Corporation for a three year project to investigate the nature of the problem in biological terms and to seek improved procedures for its management.

The project, which was wholly conducted by ATRI, commenced in July 1990 and concluded in June 1993, although ATRI continued some unfunded observations on one trial until early October 1993. The project could not have been undertaken without the generous financial support of numerous individual golf clubs, the N.S.W. Golf Association and the Horticultural Research & Development Corporation.

Field Observations

The project commenced with greens inspections and discussions with Course Superintendents at fourteen metropolitan and near metropolitan clubs in order to gain a first hand understanding of the nature of the problem. Degrees of infestation varied considerably but apart from a tendency for the problem to be more severe on greens built with sand than those with heavier soils, no obvious causes for the variations were detected. However, it was soon observed that infestation on greens fell into three types, (i) on the edge of the green, usually as an extension of fairway or collar couch, (ii) circular infestations in the central part of the green, broadly within the hole-changing area, and (iii) random infestations in other parts of the green. It was also observed that the couch patches which are so obvious during the warmer months become almost invisible in the winter because of the tendency of the bent to grow over them at that season. It was concluded that infestations of the kind mentioned in (ii) above have their origin in hole-changing operations during the cooler weather when it is very difficult to see whether the plug about to be used to fill a hole contains couch or not.

The field survey also served to confirm what has been widely suspected for many years, namely that "Tupersan", the only currently registered chemical for couch control in bent, varies widely in effectiveness on different types of couch with some kinds surviving repeated applications over several years.

Growth Habit of Invading Couch

A small bent grass green at the ATRI trial ground at Concord West had become infected with two different kinds of couch some years before this project commenced. The infestations were mainly of the class (i) type, i.e. invading from the margins. Detailed observation of surface growth in relation to underground development in areas sprayed and not sprayed with "Tupersan" led to a number of important findings about the way couch successfully invades bent grass and also showed that many types of couch resist eradication by "Tupersan".

The work by the ATRI team has highlighted the vitally important role of the root and rhizome system of couch in its ability to invade bent grass greens and in making it difficult to control. The root system of clumps of invading couch has been shown in this work to often weigh more and to cover a larger area than the surface growth.

Once established in the green, the presence of the rhizomes (long, deep, horizontal underground shoots with buds every centimetre or so) means that renovation operations such as slicing or coring actually increase the severity of the infestation by breaking up the rhizomes into shorter pieces and stimulating the buds to develop into surface shoots.

In experiments with Tupersan we have found that the degree of control of top growth depends very much on the variety of couch - some are quite susceptible, others fairly resistant. However, even in the susceptible varieties, we have observed that the rhizomes are not completely killed despite repeated applications. The result, once again, is that what was one plant of couch becomes several separate infestations, each with the potential to form a large clump.

Competition Studies and Mechanical Barriers

Studies in which couch and bent were established in large tubs from squares of washed turf were used to investigate the significance of above and below ground invasion by use, in different tubs, of no barriers, below ground barriers, above ground barriers and complete barriers.

The tubs without barriers showed that in the course of twelve months of observation, as expected, the couch actively invades the bent during the warmer weather but from about April till September the process is reversed to some extent and, although the couch in the bent section does not disappear, the bent actually invades the couch section to a limited extent. Underground invasion was shown to be the more effective of the two invasion pathways, the vast majority of the invading "roots" taking the form of rhizomes within the top 5cms of the soil.

On the basis of this work it would seem likely that soil barriers 15 or 20cms deep supplemented by periodic trimming or spraying to remove surface stolons will prove effective in greatly reducing the frequency of marginal (type (i)) infestations.

Experiments with Herbicides and Growth Regulators

The studies reported so far shows that once established in the green couch is very difficult to eradicate by normal cultural methods, indeed, its spread is probably hastened by such methods. Clearly then an effective chemical control is needed.

While there are many herbicides with proven activity against couch, the majority of these are strongly toxic to bent and in many cases to Poa annua (winter grass) which often makes up a fair proportion of "bent" greens.

Given that some growth regulators have been shown to slow down the growth of couch more than that of bent, it was decided to include growth regulators in the search for a more effective chemical. It is well known that combinations of chemicals are often more effective than single chemicals, so the experiments conducted included a wide range of combinations of herbicides, of growth regulators and of herbicides and growth regulators. A large number of field trials, some on an extensive scale, were conducted at ATRI and on a turf farm at Richmond during the second half of the project. Full details are provided in the main report, but in brief, of the five selected herbicides and five selected growth regulators (shown in Table I below), tested singly and in all possible combinations, the treatment to show most promise as an effective couch killer that allowed survival of bent and Poa was a combination of "Starane" herbicide and the newly-released Ciba-Geigy growth regulator "Primo". (During the experimental work this growth regulator had not been released and was known only by the code name CG163935.)

Table I

Selected Chemicals Tested Singly & in Combinations

Trade Name	Chemical Common Name
HERBICIDE	
Tupersan	Siduron
Garlon	Triclopyr
Lontrel	Clopyralid
Starane	Fluoxypyr
Tramat	Ethofumesate
GROWTH REGULATORS	
Embark	Melfuidide
Cutless	Fluprimidol
Limit	Amidochlor
Cycocel	Chloremequat
Primo	Trinexapac-Ethyl

The "Starane"- "Primo" combination used at the lower of our two experimental rates (0.8kg active ingredient per hectare of "Starane" and 1.0kg active ingredient per hectare of "Primo") gave excellent couch kill from a single early autumn application, but there was extensive yellowish discolouration of the Penncross bent which was still unacceptably yellow six weeks later. A fully normal appearance did not return until the spring. Observations during this period suggested that the level of "Primo" used in the combination was too high.

B. PRACTICAL OUTCOME

The practical significance of the work done in this project was explained and demonstrated to representatives of the Golf Association and the supporting clubs at a special field day held at ATRI on 11 May 1993, shortly before formal conclusion of the project. The notes which follow have been adapted from the material presented to representatives attending the field day. They are of a strictly practical nature and are divided into sections reflecting three different field situations, e.g.

1. Green without any couch invasion - how to keep it that way
2. Green with moderate couch invasion - how to reduce the amount of couch
3. Green severely infested with couch - the pros and cons of treatment versus regrassing.

WARNING: Research findings involving the use of chemicals not currently registered for use on turf do not constitute ATRI recommendations for the use of those compounds. ATRI takes no responsibility for individuals or organisations who make improper use of this information in relation to their obligations under Pesticides Act and other applicable legislation.

1. GREEN WITHOUT COUCH. "prevention is better than cure"

Constant vigilance is necessary to keep the green free of couch.

- a. Inspect the green in detail at least fortnightly during the warmer weather and every six weeks during the cooler weather. To improve prospects of spotting couch, do this when the surface is dry and recently mown and the sun is shining across the green at an angle. View the surface systematically, like a pilot scanning the sky in sectors before take-off.
- b. Request players to report any couch they may see on these greens.
- c. If couch is found, dig it out completely, including the rhizome tips. It is better to make a slightly larger hole to be certain you have got it all than to leave the rhizome tip behind to re-infect the green. No chemical method is as effective as surgical removal, provided you know exactly what you are looking for and do a thorough job.
- d. Screen all topdressing material to ensure that it contains no pieces of couch rhizome.
- e. Avoid use of couch collars. If couch collars must be used consider installing soil barriers, but remember that to be fully effective, the soil barrier must be used in conjunction with periodic surface treatments.
- f. Thoroughly clean any machinery which has been used on couch or couch infested greens before letting it on to a couch-free green. Pay particular attention to machines which could be contaminated with rhizome pieces which could shake out or fall off during use.
- g. Think about the problem and take such other measures as seem necessary at your course. Couch is a clever weed, but it can be beaten provided you get it early enough.

2. GREEN WITH MODERATE COUCH INFESTATION

- a. Stop using ineffective chemicals because they actually cause the patches to increase in size and usually lower the vigour of the bent.
- b. Avoid spreading couch to clean sections of the central green by examining the plug before insertion every time you change the position of the hole. Remember to examine for surface growth and for rhizomes which can be present even if surface growth is absent.
- c. Follow basic hygiene measures (d) and (f) above.
- d. Replace couch collars or consider a soil barrier as discussed in (e) above.

- e. Three weeks before renovating, dethatching or carrying out any form of cultivation which could cut the rhizomes or spread and bury shoots and rhizomes, spot spray the couch patches with a combination of growth regulator and herbicide to kill as much of the couch as possible and to reduce the likelihood of the surviving pieces taking root if moved or of putting out runners if not moved. Experimentally, combinations of Starane and Primo have shown promise in this application. These treatments seem to be more effective in spring and autumn than in summer. Regrowth of bent is also faster at those times.
- f. Do not fertilise heavily when the bent is growing slowly during periods of high temperature. To do so is simply feeding the couch when it can grow best. On areas sprayed to control the couch, fertilise when the chemicals are still affecting the couch but the bent has recovered from any temporary set back.
- g. When the couch is reduced to a small number of scattered infestations, experimental work suggests that application to the couch alone (e.g. by painting on) of higher levels of Starane or a combination of Starane and Primo, will kill the couch almost completely. Any small remaining living fragments can then be dug out ensuring that the rhizome tips are removed.
- h. Marginal patches of couch in an otherwise clean green can be prevented from spreading by spot spraying every six weeks or so during the couch growing season with a growth regulator. Our experiments suggest that Primo is more effective in this role than substances such as Cutless, Limit and Embark.
- i. Managing the couch pest where you have a moderate infestation requires a great deal of thought and planning. Some of the measures mentioned above stop it from getting worse, while others, if you have the time available, can be used to gradually reduce the infestation. On current indications, it could take two or three to reduce the problem to negligible proportions.

3. GREEN SEVERELY INFESTED WITH COUCH

TREATMENT OPTION

- a. There is no effective couch killer known to us which is suitable for general spraying over a whole green on a more or less routine basis that does not lead to discolouration of the bent. However, if you are desperate, cannot afford to regrass or rebuild the green, and can persuade your members to live with severely discoloured bent (and winter grass as well) for periods of four to six weeks (and some discolouration for much longer), a combination of Starane and Primo could be used in the Autumn and then in the Spring..

REGRASSING OPTION

- a. A proper regrassing operation should get rid of the couch completely and allow you to make a fresh start. By following the methods set out in section 1, you should then be able to keep the new green clean.
- b. However, be warned! The wily couch is an incredibly tough weed and its rhizomes are hardly ever all killed by one gassing and never all killed by one application of a total herbicide such as Glyphosate. After the initial treatment, it does not pay to be in a hurry. Stir the ground to stimulate any surviving pieces of rhizome into action, irrigate if the weather is dry and allow several weeks to go by before re-poisoning by either a general application or spot treatment. Repeat as necessary until no more couch regenerates. Avoid applying these treatments when the couch is dormant or about to go into dormancy because you will have to wait for the spring "green-up" to find out whether your treatment has been effective.
- c. If the aim is to get rid of couch and start again, there is no point in regrassing until you are absolutely sure all couch has gone. This takes at least four weeks, often much more.

Professor Peter Martin

9/2/94