THE BIOLOGY OF THE 'TAKE-ALL' WEED, *HALORAGIS ASPERA* (RASPWEED)

V.A. Osten[A], S.W. Adkins[B] and S.R. Walker[C]
[A] Queensland Department of Primary Industries, LMB 6, Emerald, Queensland 4720, Australia
[B] Department of Agriculture, The University of Queensland, Brisbane, Queensland 4072, Australia
[C] Queensland Wheat Research Institute, PO Box 2282, Toowoomba, Queensland 4350, Australia

Summary Very little was known about the biology of raspweed until this four year study was undertaken. Consequently, many previous attempts to control this perennial weed of cultivation had failed. The biology study was divided into three broad categories covering fruit and seed, root, and vegetative and floral biology. Information was measured and collected from field populations and tub grown specimens of raspweed as well as from laboratory, pot and minirhizotron experimentation. The majority of the study was undertaken on the central highlands of Queensland from early 1990 to late 1994, where extreme drought conditions were experienced during much of the period. For plant populations of arable lands, germinations were quite low, with no germinations occurring under natural conditions. Some of the conditions that promote germination have been identified and the seed appears to be highly dormant requiring a long after-ripening period. Recruitment form seed is not a major method of reproduction for raspweed populations inhabiting arable lands. Root production by individual ramets is immense but variable with season. Great reshooting potential is evident provided the root system remains fairly much intact. Root fragments below a certain size appear to lose this ability to reshoot. Reshooting can occur from considerable depth. Plant recruitment from root buds is the major short term reproductive method employed by arable raspweed populations.

The weediness of raspweed is manifested in the deep creeping root system and its ability to reshoot from depth with great fecundity and non-seasonality in central Queensland. It is the deeper sections of the root system that need to be targeted for effective weed management.

INTRODUCTION

The development and implementation of successful weed management programmes hinge on the knowledge and understanding of weed biology (Staniforth and Wiese 1985). Until very recently, little was known about the biology of the difficult-to-control native perennial weed, *Haloragis aspera* Lindley, or raspweed. A full taxonomic revision of this plant has been undertaken by Orchard (1975). This take-all weed, a member of the family Haloragaceae, is a major problem in particular areas of the north-east (Moree in New South Wales to Clermont in Queensland) grain region of Australia. It is described as a 'take-all' because where it grows, crops are unable to compete with it (McMillan and Byrnes 1985). Many past *ad hoc* attempts to control this weed have failed. While these past strategies have effectively controlled the aerial vegetative growth, they have failed to control the root system, which is capable of regenerating vegetative shoots.

This paper reports the highlights of a four year study undertaken in central Queensland on the biology of *H. aspera*. Aspects of fruit and seed; root; and vegetative and floral biology are covered. The implications of the biology to the management of this weed are also briefly inferred.

MATERIALS AND METHODS

The majority of the biology study was undertaken in Emerald in central Queensland using field populations and tub grown specimens of *H. aspera*. Many anecdotal observations were made, and much data were measured from laboratory, pot and minirhizotron experiments. The study occurred from 1990 to 1994 during an extended period of extreme drought. The biology study was divided into three broad categories covering fruit and seed, root, and vegetative and floral biology.

Fruit and seed biology studies The germination experiments used fruit capsules rather than individual seeds. The majority of these experiments were undertaken in controlled growth cabinets. Treatments varied between experiments and included a range of temperatures; illuminated or non-illuminated conditions; scarification or no scarification; and applications of gibberellic acid (GA_3) or distilled water. Germination experiments through time examined the effects of fruit age and after-ripening. After-ripening occurred at 25°C and low humidity. Natural germination studies were undertaken in pots where fruits were buried 2 cm deep in loamy sand, regularly watered to field capacity and exposed to natural conditions.

Root biology studies This study examined the reshooting potential of root fragments of various lengths and reshooting potential of intact systems. This was done

in pots, tubs and in small replicated field trials. Manipulation of the aerial vegetative shoots was used as the stimuli for reshooting in the intact systems. Depth of reshooting was also examined in pots and in the field using an enclosed barrel technique, a technique similar to that described by Pritchard (1992). Root development was examined using minirhizotrons which held a soil volume of 0.032 m^3.

Vegetative and floral biology studies Most of these studies examined the growth and development of individual ramets (aerial shoots) growing in the field under natural environmental conditions and in tubs where water was not limiting. Shoot height, flower spike length, days from emergence to flowering and fruit set were some of the attributes measured for different seasons of the year.

RESULTS AND DISCUSSION

In arable situations, *H. aspera* does not rely on reproduction from seed as the primary contributor to the short term population dynamics of the species. Regeneration by vegetative shoots produced from the root system is the major contributor to reproduction.

Reproduction from seed Germination studies carried out over time using fruits collected from a single harvest time and then stored in low humidity at 25°C for a period of four years, showed that germination peaked for fruits aged two years and then declined rapidly for older fruit. In all, 5710 fruit capsules (containing an average of 2.8 seed each) were tested with only 4.4 % germinating. Viability was estimated to be around 85 %. The seed appears to be highly dormant requiring a long after-ripening period. Germination was enhanced where GA_3 was used. Some of the germination requirements were identified as a preference for cooler temperatures (about 15°C), and illuminated conditions for older fruits (>2 years post-harvest). While scarification was not necessary, it did facilitate germination. These requirements indicate that *H. aspera* is an autumn–winter germinating species in the north-east grain region. It also would appear that older fruits need to be brought to the soil surface for exposure to light in order to germinate.

Considering this low dependence on reproduction from seed, much energy/growth is devoted to seed production. One ramet can produce more than 100 aerial shoots in a year. The average proportion of total shoot height attributed to flowering stem irrespective of season is about 54 %. The average number of fruit set per centimetre of flowering stem is approximately 4.5.

All flowers examined were hermaphrodite with the male organs maturing and senescing prior to female organ maturity within the same flower. Levels of floral maturity decreased with progression up the spike. Self-fertilization within the same flower is impossible. Flowering occurred at all times of the year. Days to flowering was quickest in summer (about 30 days) and longest in winter (about 60 days). In central Queensland, the (annual) life cycle of aerial shoots was 60 days in summer and greater than 100 days in winter.

Vegetative reproduction *Haloragis aspera* possesses a root system similar in structure to that of skeleton weed (*Chondrilla juncea* L.) as depicted schematically by Cuthbertson (1972). New aerial shoots arise from both the vertical and lateral sections of the root system. These shoots are adventitiously initiated and their numbers are not predetermined. The reshooting studies have shown that new shoots can be produced form considerable depth in the soil (as deep as 50 cm). Root fragments less than 20 cm in length do not readily reshoot if at all. Intact root systems show the greatest reshooting potential. The removal of all or most aerial vegetative material with minimal disturbance to the roots stimulated prolific reshooting.

Root production over the summer period is immense. The minirhizotron studies showed that within four months, a single transplanted ramet can produce up to 7.5 m of root thicker than 0.5 mm (diameter). While the root system is establishing, shoot fecundity is much reduced particularly if this process occurs in winter, but once established, reshooting becomes prolific irrespective of the season. One ramet transplanted in early summer produced 28 new shoots within three months. The same ramet produced a further 88 new shoots during the following winter. In contrast, a ramet transplanted in winter produced only four new shoots during the establishment phase. In central Queensland, reshooting from the roots appears to be non-seasonal for established root systems.

Implications to weed management Unlike many other perennial weeds of cultivation, *H. aspera* tends to infest paddocks in isolated patches. Weed control practices therefore only need to focus on the patches, however the efforts required will be more intensive than an overall paddock approach. Individual vegetative flushes need to be controlled as appear. Allowing a flush to complete its life cycle results in an expansion of the root system and replenishment of the soil seed bank. Many of the past *ad hoc* attempts to control this weed have successfully controlled the aerial vegetative shoots and roots located in the upper soil zones, but have failed to control the plant outright. This is failure is related to the size and depth of the root system. The majority of these attempts have been

herbicide based (2,4-D applied at 2 L ha^{-1} being the most cost-effective) and it would appear that the herbicides are not reaching the roots at depth and are acting too quickly resulting in death of the top growth before the herbicide is translocated deep enough. Ideally, herbicides which are highly phloem mobile but slow acting may penetrate to these roots at depth.

It is unlikely that cultivation spreads *H. aspera* across paddocks due to the plant's inability to reshoot from root fragments shorter than 20 cm in length. Cultivation is therefore an option for controlling the aerial growth as well as the roots in the upper soil zone (surface to 40 cm soil depth). Cultivation should not be undertaken on wet soils in case the roots do not sever into fragments less than 20 cm. Longer segments capable of reshooting may end up being transplanted across the paddock.

It is the roots located at soil depths greater than 40 cm that pose the management problem. These roots are capable of reshooting. Conventional management methods have proved inadequate for these deep roots. Innovative approaches will be necessary and these are yet to be developed and tested. Clearly, the management of this weed will require an integrated and intensive approach.

ACKNOWLEDGMENTS

This research was funded by the Grains Research and Development Corporation, the Queensland Department of Primary Industries and The University of Queensland. We are grateful for the technical assistance provided by Lynda Broom, Jacqui Willcocks, Andrea Adkins and Leisa Armstrong.

REFERENCES

Cuthbertson, E.G. (1972). *Chondrilla juncea* in Australia. IV. Root morphology and regeneration from root fragments. *Australian Journal of Experimental Agriculture* 12, 528-34.

McMillan, M.G. and Byrnes, P.J. (1985). Take-all weeds. *The Australian Cotton Grower* 6, 30-1.

Orchard, A.E. (1975). Taxonomic revisions in the family Haloragaceae 1. The genera *Haloragis, Haloragodendron, Glischrocaryon, Meziella* and *Gonocarpus. Bulletin of the Auckland Institute and Museum* No. 10, pp. 299. (The Council of the Auckland Institute and Museum, New Zealand).

Pritchard, G.H. (1992). Some aspects of the biology of creeping knapweed (*Acroptilon repens*) in Victoria. *In* 'Proceedings of the First International Weed Control Congress', Volume 2, pp. 407-9. (Weed Science Society of Victoria Inc.).

Staniforth, D.W. and Wiese, A.F. (1985). Weed biology and its relationship to weed control in limited-tillage systems. *In* 'Weed Control in Limited Tillage Systems', Monograph Series No. 2, ed. A.F. Wiese, pp. 15-25. (Weed Science Society of America, Illinois, USA).