Ecological studies of *Hyparrhenia hirta* (L.) Stapf in northern New South Wales

Vinod Kumar Chejara
M. Sc. (Agronomy) Rajasthan Agricultural University
Rajasthan, India

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School of Environmental and Rural Science
University of New England
Armidale, New South Wales
Australia

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Declaration

I certify that the substance of this thesis has not already been submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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Abstract

Hyparrhenia hirta (L.) Stapf (Coolatai grass) is a summer active, C4 perennial grass, native to southern Africa and the Mediterranean region. In recent years its range has expanded rapidly and there are now populations of *H. hirta* in all states and Territories of Australia except Tasmania. It invades native grassy and open woodland communities, including roadsides and travelling stock routes, national parks and pastures. There is little published information on the biology and ecology of *H. hirta* in the summer rainfall environment of northern New South Wales. This study aimed to increase our understanding of key aspects of the ecophysiology, population dynamics and community ecology of *H. hirta* to assist in control and management.

The effects of various environmental factors on *H. hirta* seed germination were investigated in a series of laboratory experiments. Seed germination occurred at almost all temperature combinations from 5 to 45 ºC with peak germination at about 30/20 ºC. Germination was slightly enhanced by the presence of light, but length of photoperiod and constant vs. alternating temperatures did not affect germination. Germination was greatest at neutral pH and was moderate at pH 4 and pH 10. Germination was completely inhibited at an osmotic stress of -0.55 MPa or greater and was reduced by 50% at -0.37 MPa.

The ability of *H. hirta* to germinate under a wide range of environmental conditions provides a partial explanation for the establishment of this species throughout much of Australia and in many parts of the world. In Australia, areas with dry and cold climates such as the central part of the Northern Territory and some areas of northern NSW, respectively, are less likely to be suitable habitats for this species.

Field experiments indicated that *H. hirta* had a large viable seedbank which was dependent on the level of infestation and climatic conditions. The viable

seedbank was reduced by more than 90% in mown and herbicide treated plots over two years. Most (> 60%) of the seeds from soil beneath *H. hirta* infestations were at shallow depths (0 – 2 cm), with more at deeper depths in clay soil than sandy soil. The number of viable seeds recovered was higher in sandy soil than clay soil. Seed longevity was generally 12 months or less. Seedling emergence was greatest at the 3 cm burial depth and higher in clay soil than sandy soil, whereas at deeper depths it was higher in sandy soil. The results show that the soil seed bank for *H. hirta* is relatively shallow, short-lived and emergence is rapid, with dormancy apparently playing a negligible role. The results confirm its successful establishment in areas that have sandy soils.

Seedling population dynamics of *H. hirta* were observed at three sites on the northern NSW under different management treatments such as control, mowing and herbicide. Seedlings emerged in most months of a two year trial at three sites but the main seedling flushes were observed during the warmer months of the year, from mid summer to early autumn. The seedling survival was greater in mown and herbicide-treated plots than unmanaged plots. The seedling cohorts that emerged in the winter had a lower percentage survival than those emerging in the summer.

Intra- and inter-specific competition between young *H. hirta* and *Bothriochloa macra* a common co-occurring native species in northern NSW, plants was investigated in the glasshouse. For both roots and shoots, the relative crowding coefficient indicated a high competitive ability of *H. hirta*. *Hyparrhenia hirta* was competitively aggressive over *B. macra* and may inhibit its early growth and establishment in the field.

The allelopathic effects of *H. hirta* and *Phalaris aquatica* (well known allelopathic potential) were investigated *in vitro* on the germination and early growth

of two co-occurring native grasses, *B. macra* and *Dichanthium sericeum*. *Hyparrhenia hirta* shoot extract had a greater effect than the root extract, and the inhibition of germination was greater for the *P. aquatica* extract than for *H. hirta*. Seedling root length in *B. macra* and *D. sericeum* was similar for all extracts, although for shoot length, *D. sericeum* was more sensitive than *B. macra* to all extracts. In a pot experiment, residues reduced the seedling emergence and root/shoot ratios of both target species. Emergence of *B. macra* and *D. sericeum* was reduced by about 61% by *H. hirta* residues and 67% by *P. aquatica*. While *H. hirta* may have allelopathic potential, its effects in the field are unknown.

The CLIMEX modelling package was used to investigate the global distribution of *H. hirta* on the basis of its ecology and climate profile and the impacts of climate change. While cold stress is the primary limiting factor, hot and dry stress prevent its establishment in the Sahara, inland Australia and parts of the Middle East. Areas of particular invasion risk include Central and South America, sub-Saharan Africa, coastal Queensland, most of parts of NSW, Mexico, the Caribbean and the south-eastern USA. The world-wide potential distribution of *H. hirta* under current climatic conditions includes suitable optimal habitat covering much of the tropics and subtropics. Under a moderately warmer scenario (CSIRO-Mk2a), a 41% increase in the potential distribution of *H. hirta* compared to its potential distribution under current climatic conditions suggests that the range of *H. hirta* is likely to expand into areas that are currently too cold. Under the more extreme scenario (HadCM3), the 45% decrease in potential distribution shows that it's range is likely to contract overall if hot and dry stresses become too severe.

Hyparrhenia hirta has a large, shallow seedbank with short viability. Therefore control techniques that enhance its germination and deplete the soil

seedbank should be used in management. Removing the existing infestation using mowing and herbicides can reduce seed fall. Application of recommended herbicides towards the end of the active period for emergence and growth during summer and autumn could help control infestations and prevent spread.

The effect of environmental factors on germination, competitive interactions of *H. hirta* with native species, and allelopathic potential needs to be confirmed in the field situations. The timing and amount of seed production also needs to be assessed under a range of biophysical conditions.

Publications arising from this thesis

Journal articles

Chejara, V. K., Kristiansen, P., Whalley, R. D. B., Sindel, B. M. and Nadolny, C. (in press 2008). Factors affecting seed germination of Coolatai grass (*Hyparrhenia hirta*). *Weed Science*.

Chejara, V. K., Kristiansen, P., Whalley, R. D. B., Sindel, B. M. and Nadolny, C. (under review). Vertical distribution and viability of *Hyparrhenia hirta* seeds and seedling emergence in soils of different textures. *Weed Science*.

Chejara, V. K., Kristiansen P., Sindel, B. M., Nadolny, C., and Whalley, R. D. B. (to be submitted). Seedbank and seedling dynamics in *Hyparrhenia hirta* as affected by management factors. *Journal of Ecology*.

Chejara, V. K., Kristiansen, P., Whalley, R. D. B., Sindel, B. M. and Nadolny, C. (under review). Density based competition between Australian native grass *Bothriochloa macra* and introduced grass *Hyparrhenia hirta*. *Journal of Arid Environments*.

Chejara, V. K., Kristiansen, P., Whalley, R. D. B., Sindel, B. M. and Nadolny, C. (under review). Effect of *Hyparrhenia hirta* and *Phalaris aquatica* aqueous extracts and plant residues on two native grasses. *Plant Ecology*.

Chejara, V. K., Kriticos, D. J., Kristiansen, P., Sindel, B. M., Whalley, R. D. B., and Nadolny, C. (to be submitted). The current and future potential geographical distribution of *Hyparrhenia hirta*. *Weed Research*.

Conference abstracts

Chejara, V. K., Kristiansen, P., Whalley, R. D. B., Nadolny, C. and Sindel, B. M. (2007). Allelopathic potential of *Hyparrhenia hirta* (L.) Stapf on native grasses. In: "Organising Committee (ed.) 9th International Conference on the Ecology and Management of Alien Plant Invasions". Program and Abstract Book. 17-21 September 2007, Hyatt Regency, Western Australia. Congress West, Wembley. p. 212.

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