

## GENERAL DISCUSSION AND CONCLUSIONS

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### CHAPTER VI – GENERAL DISCUSSION AND CONCLUSIONS

Outside of its native range in tropical America, *P. hysterophorus* is a noxious weed and has become a menace to crop production, animal husbandry, human health and biodiversity in many countries throughout the world. Even over the two years of this study, the alarming rate at which *P. hysterophorus* can spread, and the extent of the threat it poses, is evident. Briefly defined, allelopathy is the chemical interaction between plants. Numerous bioassays have investigated the allelopathic effects of chemicals from one plant species on other test species. The challenge in these allelopathic studies is separating allelopathy and competition in plant-plant interference, and determining the phytotoxic effect of the allelochemicals, singularly and in conjunction with other allelochemicals, under completely natural conditions. In addition to direct plant-plant interactions, Inderjit & Weiner (2001) also stress the importance of allelochemicals on soil ecology processes to better understand vegetation behaviour. Parthenium plants growing on several different continents were classified into seven types by Picman & Towers (1982) according to lactone content, and parthenium plants growing in South Africa were classified into the ‘parthenin group’ which contain parthenin, coronopolin and tetraeurin A. Parthenin, a sesquiterpene lactone, is implicated as one of the primary allelochemicals in *P. hysterophorus* allelopathy (Patil & Hedge, 1988; Kohli *et al.*, 1993; Pandey, 1996; Belz *et al.*, 2006). Phenolics produced by the plant are also believed to play an important role in *P. hysterophorus* allelopathy.

A disturbed area (dumpsite) in Skukuza, Kruger National Park, which has naturally become infested with *P. hysterophorus* was used as a site for the field trial in which growth interference between *P. hysterophorus* and three indigenous grass species was studied. *P. maximum* showed best overall growth performance of the three grasses, with *E. curvula* and *D. eriantha* fairing less well. The poor performance of *E. curvula* and *D. eriantha* was attributed largely to the high soil pH which exceeded the preferences for the two grasses. Climatic factors were also implicated. *P. maximum* has a higher pH preference and is known to tolerate a wider range of climatic factors. For the first growth season (2003/2004), percentage of control data showed that *P. maximum* did not perform significantly different from *D. eriantha* at the 5 parthenium

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m<sup>-2</sup> density, but grew significantly better at the 7.5 parthenium m<sup>-2</sup> density at the P<0.075 significance level. *E. curvula* displayed the poorest growth performance at both densities. Parthenium dry mass accumulation was observed to be highly significantly less (P<0.05) when growing on *P. maximum* plots as opposed to growing on *E. curvula* or *D. eriantha* plots. No significant differences were observed for parthenium dry mass accumulation for plants growing on plots containing the latter two grass species. In the following season, parthenium control plots at the 5 parthenim m<sup>-2</sup> and 7.5 parthenium m<sup>-2</sup> densities were included in the trial in order to allow for percentage of control data analysis. In the 2004/2005 growing season, *P. maximum* once again outperformed the other two grass species. *E. curvula* and *D. eriantha* performed far better than in the previous season, however, after having become better established, showing two- and four-fold increases in dry mass accumulation, respectively. For grass dry mass accumulation percentage of control, the main species effect was found to be significant, with *P. maximum* performing significantly better than *E. curvula*. For the second growing season, *P. maximum* once again most effectively interfered with parthenium growth. Parthenium plants growing together with *P. maximum* were observed to produce less seed relative to plants growing on adjacent plots, and in some instances parthenium plant mortalities occurred. *D. eriantha* and to a lesser extent, *E. curvula*, were only able to interfere with parthenium growth significantly at the 5 plans m<sup>-2</sup> density. After the second season it was confirmed that *P. maximum* was the most suitable species to interfere with *P. hysterophorus* growth. The species can therefore potentially be used as an antagonistic species in an integrated control programme. It is unknown how well the species will establish from seed in a parthenium stand, however, and as the grass is highly palatable, it may have to be protected from grazers, initially at least, in order to allow it to become properly established.

Understanding the production of parthenin in the leaves of *P. hysterophorus* during the life-cycle of the plant is important for understanding the employment of this sesquiterpene lactone in the allelopathic interference strategy of the plant. Belz *et al.* (2006) observed differences in parthenin concentrations from leaves of the same parthenium plants harvested at different stages of growth. In this study it was observed that parthenin leaf concentration increased with plant age. At senescence, parthenium leaf dry mass was observed to contain a parthenin concentration of 34.7

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mg g<sup>-1</sup>. Considering other plant parts, especially the flowers and achenes have also been observed to contain parthenin, it was calculated that under the experimental conditions, a single, mature parthenium plant has the potential of introducing an amount greater than 236.15 mg of parthenin into the environment in a single growth season. Belz *et al.* (unpublished) determined a parthenin concentration of  $16.7 \pm 1.8$  mg g<sup>-1</sup> in the dry leaves from flowering plants growing in the Kruger National Park. This corresponds with concentrations observed in this experiment for leaves from plants at the bud formation to beginning of flowering stages, indicating that parthenin levels in plants grown in greenhouses reflect those of plants growing in the wild. Attainment of highest parthenin concentration in the final three growth stages of the plant indicates a high resource allocation priority to this secondary metabolite. This accumulation of parthenin may indicate a strategy in which the plant employs residual allelopathy to inhibit or impede the recruitment of other species. Parthenin is also known for its anti-feedant and anti-microbial properties and accumulation of this compound in the plant until after the flowering process has been completed may play an important role in herbivore and pathogen defence.

For parthenin to have a direct phytotoxic effect on other plant species it must be available in the soil for plant uptake at sufficiently high concentrations. The fate and persistence of this compound in the soil will therefore be an important factor (Inderjit, 2001). Preliminary experiments showed that parthenin is easily degradable in soil, and parthenin added to the soil at concentration of 1 and 10 µg g<sup>-1</sup> degraded faster than when added at a concentration of 100 µg g<sup>-1</sup>. For the main experiment, the DT<sub>50</sub> value for parthenin added at an initial concentration of 10 µg g<sup>-1</sup> in the CS soil incubated at 20, 25 and 30°C for sterilized soil was significantly higher in all circumstances than for non-sterilized soils. This may indicate that microbes play a predominant role in parthenin degradation. Furthermore, for non-sterilized soils, parthenin degradation occurred significantly faster in soil incubated at 30°C than in soils incubated at 25 and 20°C, with DT<sub>50</sub> values of 1.44, 2.29 and 2.98 days, respectively. A significant correlation between temperature and DT<sub>50</sub> and DT<sub>90</sub> values for non-sterilized soils, but not for sterilized soils was observed. Microbial degradation may play an important role in preventing allelochemicals from reaching phytotoxic levels in natural soils (Schmidt & Ley, 1999). Analysis of parthenin degradation in different soil types showed that parthenin degradation occurred fastest in the loam soil and slowest in the

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sand. Significant difference for DT<sub>50</sub> values were observed between the loam soil (3A) (1.78 days) and the very loamy sand (CS) (3.10 days), and the loam soil and sand (2.1) (3.64 days). No significant differences in DT<sub>50</sub> values between the sandy loam (5M) (2.67 days) and any of the other soils was observed. Significant negative correlations for the 3A, 5M and 2.1 soils occurred between DT<sub>50</sub> values and water holding capacity as well as soil cation exchange capacity, but not between DT<sub>50</sub> values and soil pH and organic carbon percentage. Lack of correlation for the latter two parameters can possibly be attributed to similar pH values and low levels of carbon in the soils. Further research focuses should be aimed at determining parthenin concentrations in natural soils containing *P. hysterophorus* infestations, and investigating further concentration effects on parthenin degradation; as well as investigating the ability of varying microbial species populations found in different areas of the world on parthenin degradation.

Pure parthenin was observed to have a phytotoxic effect on *E. curvula*, *P. maximum* and *D. eriantha*. Only the sensitivity of *E. curvula* to pure parthenin had previously been assessed (Belz *et al.*, 2006). Of the three grass species, *P. maximum* was observed to be the most sensitive species regarding germination percentage and radicle growth, followed by *D. eriantha* and then *E. curvula*. ED<sub>50</sub> values for radicle length were 100.6, 144.7, and 212.9 µg ml<sup>-1</sup>, respectively. Radicle length was observed to be the more sensitive parameter than germination percentage, as has been reported for other test species (Batish *et al.*, 1997, 2002b; Belz *et al.*, 2006). For *P. maximum* and *D. eriantha* complete inhibition of germination and radicle development occurred at parthenin concentrations of 300 and 500 µg ml<sup>-1</sup>, while complete inhibition of germination did not occur for *E. curvula* across the concentration range tested. *P. maximum* displayed highest efficacy in interfering with *P. hysterophorus* growth in the field, but the relatively high sensitivity of *P. maximum* to pure parthenin may indicate that it will be challenging to establish *P. maximum* from seed in areas already infested with *P. hysterophorus*.

From work completed in this study it seems plausible that parthenin may have a phytotoxic effect on other plant species under natural conditions. Many further studies will be required to enable modelling that will more accurately determine the role of parthenin in *P. hysterophorus* allelopathy under natural conditions, however.

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Further objectives of this ongoing study are continuation of work to study the role of parthenin in *P. hysterophorus* allelopathy, and the long-term monitoring of *P. hysterophorus* spread in the Kruger National Park.