Allelopathy in buffel grass (*Cenchrus ciliaris* L.) Part II Site of release and distribution of allelochemical in the soil profile

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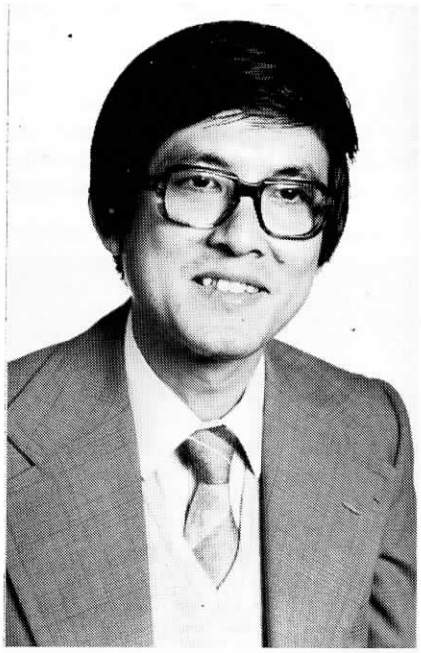

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Summary

The part of the buffel grass (*Cenchrus ciliaris* L.) root system responsible for the release of an exudate phytotoxic to calotrope (*Calotropis procera* (Ait.) W.T.Ait.) seedlings was investigated in a specially designed potting system. Decreasing suppression with increasing depth was noted, resulting in the accumulation of the phytotoxic principle in the topmost layer of the soil profile. The ecological significance and practical implications of the results are discussed.

Introduction

The possible production of root exudates by the important pasture species buffel grass (*Cenchrus ciliaris* L.) in suppressing the growth of calotrope (*Calotropis procera* (Ait.) W.T.Ait.), a weed of the East Kimberley of Western Australia, has been discussed by Cheam (1984).

Buffel grass has a large, strong root system capable of growing to depth (Humphreys, 1974; Bogdan, 1977), so that it is possible that the release of the allelochemical varies along the root system causing an uneven distribution in the soil profile. The study reported here investigated the site of release of the allelochemical and its overall phytotoxicity at different levels of the soil profile.

Materials and methods

Pipe experiment

A specially designed potting system was used to determine which part of the buffel grass root is the main site of release of the allelochemical. Twenty pots were made from pieces of PVC irrigation pipe each 80 cm long with a diameter of 16 cm. Four equally spaced 10 cm×11 cm windows were cut in each pipe, with the PVC pieces held in place in each window with masking tape prior to filling the pipes with 50:50 v/v sand and sawdust mixture. The lower end of each pipe was covered with a piece of 'Sarlon' cloth, held in place by a clamp. Five pregerminated seeds of buffel grass were sown in each of ten treated pipes at a uniform depth of 13 mm. Ten control pipes remained unsown. The pipes were kept in a glass house in an upright position under natural light and maintained at 28/21°C for each 12/12 hour day. After 10 weeks of growth, by which time the roots had reached the bottom of the pipe, all the buffel grass shoots were removed leaving only the intact roots in the pipe. The PVC pieces were removed from each window and the pipes arranged horizontally at random along a bench with the windows facing upwards. The four windows along each pipe were marked A, B, C and D (four levels of the soil profile, top to bottom). Eight pregerminated calotrope seeds were sown into each window of five of the treated pipes that contained intact buffel grass roots and five of the control pipes without buffel grass roots. After 1 week the calotrope seedlings were thinned to five per window and all seedlings were allowed to grow for 8 weeks.

Pot experiment

The remaining five treated and five control pipes from the above experiment were carefully sawn off at equal intervals to remove the soil and buffel grass roots from the four levels of the soil profile. A portion of the collected soil from each level of the treated pipes was transferred into an 8.5 cm diameter plastic pot. For the control, a bulked sample from the four levels of the control pipe was found to be adequate. The buffel grass roots collected from each of the four levels of the treated pipes were washed, their fresh weights determined, and then separately mixed with control soil in 8.5 cm diameter pots. The treatments therefore consisted of the treated soil collected from levels A, B, C and D, control soil containing buffel grass roots collected from each of these four levels of soil, and the control. The nine treatments were arranged in a randomized complete block design of five replicates. Eight pregerminated calotrope seeds were sown into each pot, and after 1 week thinned to five per pot. The seedlings were allowed to grow for 8 weeks.

In both experiments all treatments were adequately watered with demineralized water daily and complete nutrient solution added twice a week to ensure that both factors were non-limiting. Eight weeks after sowing the height and total leaf area of each plant was determined and the leaf, stem and root dry weight recorded.

Results

Pipe experiment

Results on the bioassay of the allelochemical at various levels of the control and treated soils are shown in Plate 1 and Figure 1.

All the growth parameters measured showed a definite trend of decreasing suppression with increasing depth in the treated soil. There was a significant linear relationship showing a significant difference between positions within the treated pipes.

Pot experiment

Plate 2 and Figure 2 show that soil collected from level A which previously supported the growth of buffel grass was consistently the most toxic, resulting in the greatest suppression of calotrope seedlings. Soil from level B also showed considerable toxicity, but no toxicity was detected in the soil of levels C and D. This was probably due to the small quantity of soil used for detecting the allelochemical but could also be due to the effect of dilution resulting from mixing of the soil before obtaining a portion of the soil for testing.

The results in Figure 2 also show that control soil containing incorporated buffel grass root collected from the various soil levels did not inhibit the growth of calotrope, thus suggesting that decaying buffel grass root does not contribute to the overall phytotoxicity.

Discussion

The definite trend of decreasing suppression with increasing depth indicates that the allelochemical was exuded mainly by the upper portion of the root system. No rhizome was involved because the West Australian cultivar of buffel grass is a non-rhizomatous type (Whiteman, 1980). This could mean that there was a relationship between the amount of root present at the various soil levels and the degree of toxicity, but a comparison of the fresh weight data of the root fragments collected from the various soil levels showed that such a relationship did not exist. It is likely that the number of root meristematic points accounted for the greater production and accumulation of the allelochemical in the upper layer of the soil profile. Typical of a grass, the fibrous root system of buffel grass appeared to have a higher concentration of meristematic points near the soil surface. In the present case it is assumed that the meristematic point is actively producing the allelochemical.

The production of the allelochemical is dependent upon the living buffel grass plant *in situ*. Decaying roots and shoots did not contain the allelochemical. This differs from some of the examples given in the literature. For example, Fisher *et al.* (1978) found that root exudates of *Solidago* and *Aster* are not as effective against sugar maple (*Acer saccharum* Marshall) as the compounds released upon decomposition. It is often difficult to separate chemicals produced by higher plants and released during decomposition from chemicals produced by micro-organisms responsible for decomposition. In the present work, any role played by micro-organisms was not investigated.

A much more thorough investigation will be necessary to determine the behaviour of the allelochemical in buffel grass. Its effects on other plants have to be examined and attempts to isolate and identify the allelochemical should be made. Regardless of the future work, the current results suggest that the concentration of the allelochemical in the topmost layer of the soil profile has important ecological significance since calotrope seeds are found mainly in the top soil under natural field situation. The germinating seed is thus placed at a very great disadvantage. The continuous production of the allelochemical by the perennial buffel grass is therefore an excellent example of a biological control system going on in nature. In practical terms it means that proper management of the pastoral areas, including prevention of over-grazing and the planting of buffel grass, will prevent calotrope growing in areas that are now free of this weed. Planting of buffel grass on land already infested with calotrope should lead to a steady decline in the vigour and density of the weed.

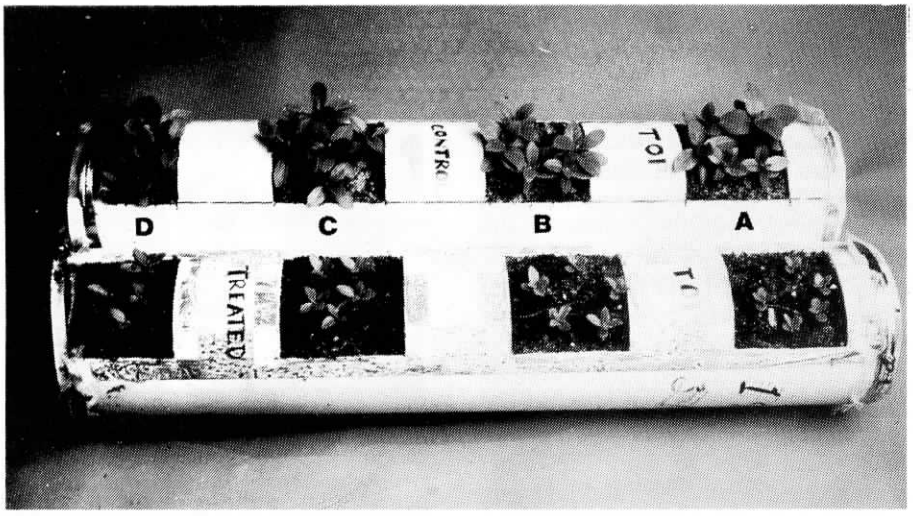

Plate 1 Growth resonses of calotrope seedlings after growing for 8 weeks in control and treated soil at various levels of the soil profile (A, B, C and D top to bottom)

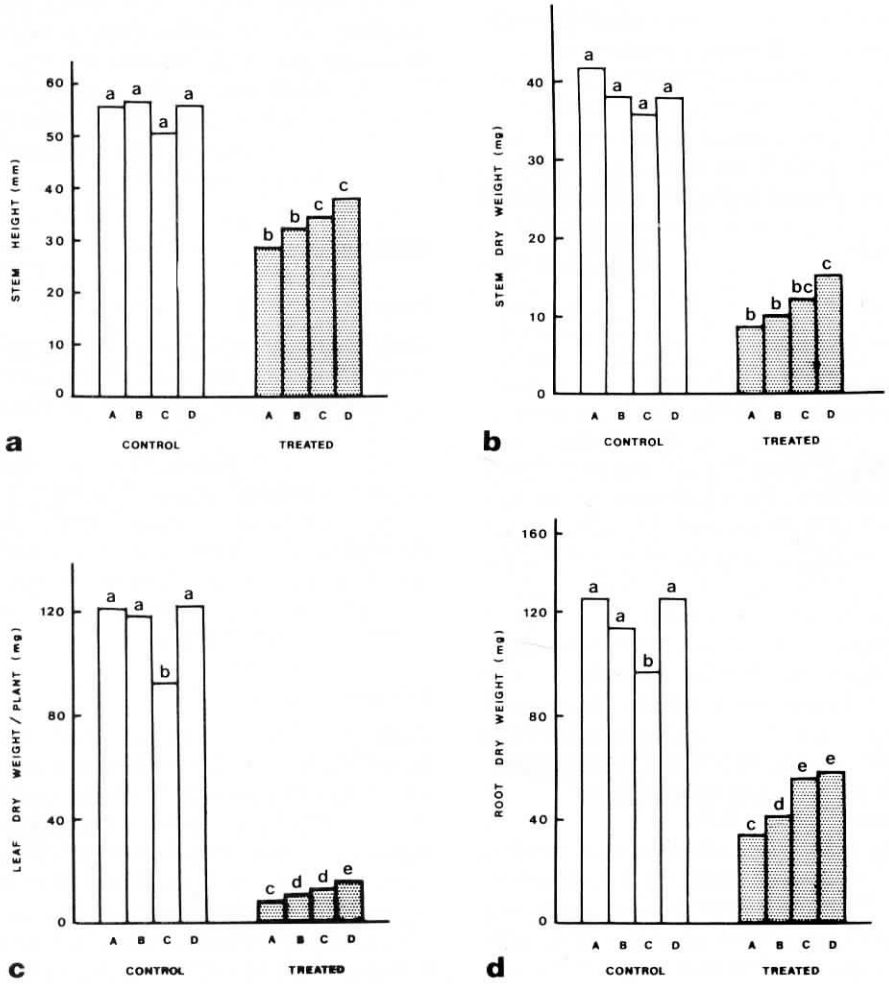

Figure 1 Assay for allelochemical in control and treated soil at various levels of the soil profile (A, B, C and D top to bottom), using calotrope as the bioassay species. Stem height (a), stem dry weight (b), leaf dry weight per plant (c) and root dry weight (d) were taken as measures of phytotoxicity 8 weeks after interaction. Any two columns not marked with the same letter within a particular growth parameter measured are significantly different at the 5% level of probability.

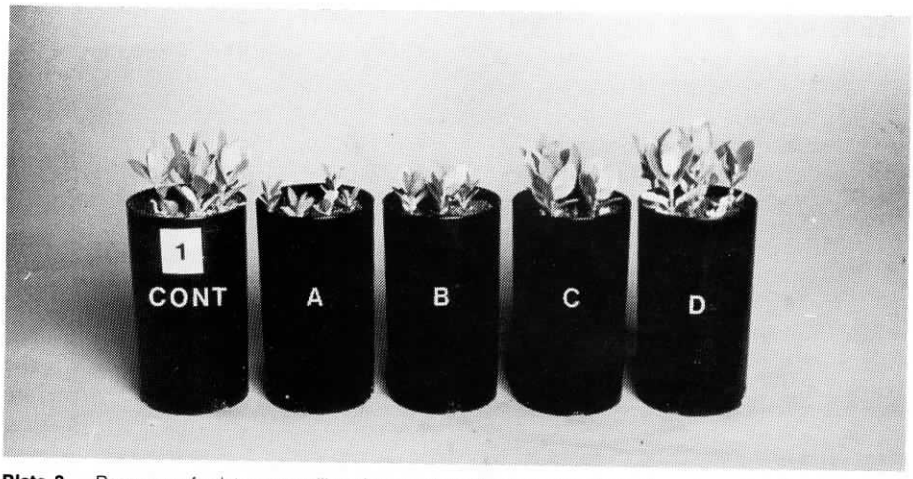

Plate 2 Response of calotrope seedlings in control and treated soil collected from the various levels of the soil profile (A, B, C and D top to bottom at 20 cm intervals) in which buffel grass had grown previously and from which all buffel grass remains had been removed before testing. Pots from left to right: control, level A, B, C and D soils.

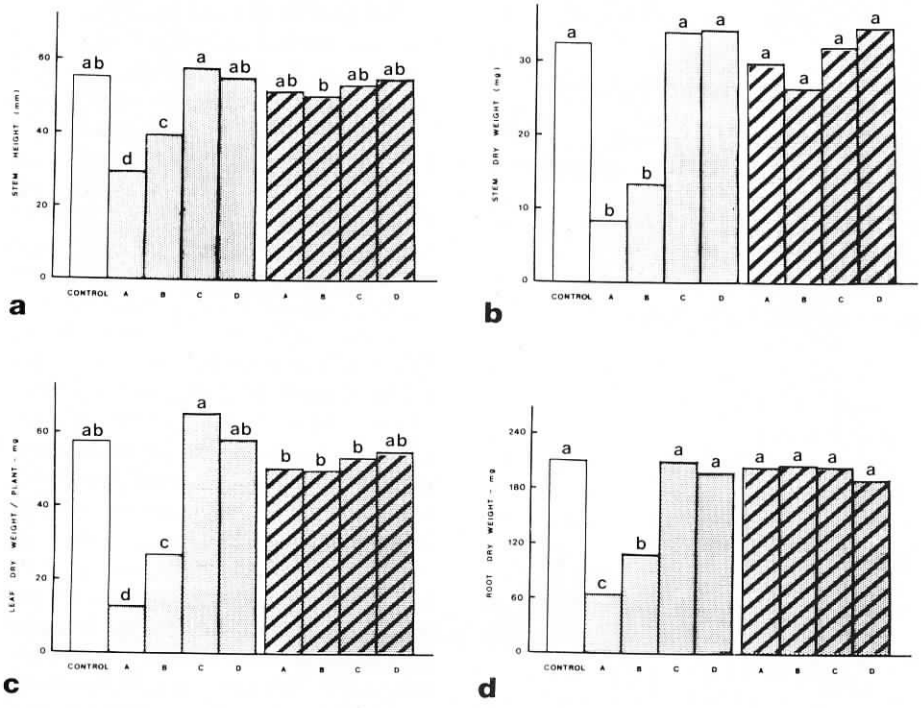

Figure 2 Bioassay of soil collected from the various levels of the soil profile (A, B, C and D top to bottom at 20 cm intervals) from which buffel grass had been removed before testing (stippled columns) and bioassay of control soil containing root fragments collected from the various soil levels (hatched columns). (a) stem height, (b) stem dry weight, (c) leaf dry weight per plant and (d) root dry weight of calotrope were taken as measures of phytotoxicity 8 weeks after interaction. Any two columns not marked with the same letter within a particular growth parameter measured are significantly different at the 5% level according to Duncan's new multiple range test.

Acknowledgements

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References

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