A COMPARISON OF THE GROWTH AND PHENOLOGY OF TWO INTRODUCED BIOTYPES OF *PARTHENIUM HYSTEROPHORUS*

S.C. Navie[A], R.E. McFadyen[B], F.D. Panetta[B], and S.W. Adkins[A]
[A] Department of Agriculture, The University of Queensland, St. Lucia, Queensland 4072, Australia
[B] Department of Natural Resources, Alan Fletcher Research Station, PO Box 36, Sherwood, Queensland 4075, Australia

Summary Two biotypes of *Parthenium hysterophorus* L. have established in Australia as a result of two separate introductions from the USA. The first introduction occurred in south-east Queensland and the second in central Queensland. Nine plants from each of the biotypes were grown under a day/night temperature regime of 23/13°C and 14.5 hour photoperiod in a plant growth cabinet for a period of five months. Plants from the central Queensland biotype had a higher dry weight production, earlier stem elongation, were taller, produced larger diaspores and had a lower percentage of filled seed than the plants from the south-east Queensland population.

These differences in biology may offer an explanation why the central Queensland biotype is very aggressive while the south-east Queensland biotype is relatively well contained.

INTRODUCTION

Parthenium hysterophorus L. (parthenium weed) is an extremely prolific, annual or ephemeral, member of the Asteraceae that can reach 2 m in height (Navie *et al*. 1996). It is a serious weed throughout the beef producing areas of central Queensland where it produces dense stands and can cause a significant drop in the productivity of pastures. In heavily infested areas the carrying capacity of pastures can be reduced to negligible proportions and enforced stocking rate reductions are common, entire properties reporting a 40% reduction in carrying capacity (McFadyen 1995). It has been estimated that the cost of this weed to the beef cattle industry in central Queensland is about $A16.5 million per annum (Chippendale and Panetta 1994).

Parthenium weed is still spreading and has the potential to be a significant weed problem throughout temperate humid and sub-humid regions of Australia (Doley 1977). Southern Queensland and New South Wales are most at risk, and isolated infestations are being discovered frequently in these areas. Parthenium weed is a potentially serious environmental weed and it is also spreading into coastal cropping areas where its impact is steadily increasing. Studies have concluded that parthenium weed is allelopathic and inhibits the germination and growth of a wide variety of plant species (Adkins and Sowerby 1996). Other detrimental effects of the weed include its toxicity to stock and tainting of meat and milk. Perhaps the most serious concern is its potential effect on human health as it has the ability to cause or exacerbate contact dermatitis, asthma and hayfever (McFadyen 1995).

Parthenium weed has been introduced into Queensland from North America on two separate occasions. The most well known introduction occurred in 1958, the weed's seed being brought in with pasture grass seed imported from Texas, USA (Haseler 1976). This infestation originated north of Clermont and was not noticed as a threat until the mid 1970s when the weed spread very quickly, along roadsides in particular, throughout central Queensland. At present this infestation covers 170 000 km^2 or 10% of Queensland (Chippendale and Panetta 1994). The other introduction occurred near Toogoolawah in south-east Queensland. It has been suggested that this introduction occurred during World War II and was due to the movement of aircraft and machinery parts from the USA (Parsons and Cuthbertson 1992). This infestation has not spread anywhere near as extensively as the one at Clermont. It is not known whether the difference in the invasiveness of these two infestations is simply due to climatic differences between the two areas that are infested or whether there is a significant biotypic difference between the two infestations.

By growing plants from both populations together under the same conditions in a plant growth cabinet, we hope to detect any significant biological differences that may exist between the two populations. If differences do exist, these studies may demonstrate some of the characteristics of the Clermont introduction that cause it to be so aggressive in central Queensland. This research will also help predict the weed's potential southerly spread and be of use to control programs.

MATERIALS AND METHODS

Seed from the Clermont introduction was collected from plants at the Alan Fletcher Research Station grown from seed collected at Emerald. Seed from the Toogoolawah population was collected from plants growing on a property 5 km north of Toogoolawah, Queensland.

Plant husbandry The experiment was conducted in a plant growth cabinet at the University of Queensland. The temperature was set at 23(±1)°C during the day and

13(±1)°C at night and the photoperiod was 14.5 hours. Plants were grown in 20 cm pots in a soil mixture made up of equal parts of heavy black clay soil and sand. Seed was sown on the 16th of July 1995 and the date of emergence of the first seedling in each pot recorded. All subsequent seedlings that germinated were removed. Nine plants from both the 'Emerald' and 'Toogoolawah' biotypes, as they will be referred to henceforth, were studied in the experiment and were placed randomly in the cabinet. Plants were watered daily and soil moisture kept to field capacity.

Data collection The phenology of the plants was studied by recording the time to stem elongation, and appearance of first flower, anthesis, and first mature fruit. The height of the plants was measured 20 days after sowing and thereafter at 10 day intervals until 150 days had elapsed. The length of the longest leaf was also measured. A record of mature flower production was kept over the duration of the experiment, until 150 days after each plant had emerged. At this stage the plants were harvested and separated into roots, stems, leaves, capitula and diaspores and the dry weight of each of these parts was recorded. At harvest the number of immature flowers was also counted. The percentage of filled seed was determined by observation of 100 seed from each plant, and lastly the weight, length and width of 50 filled diaspores from each plant was determined.

Statistical analysis T-tests were performed on the data to determine if any of the measured characters differed significantly between biotypes. The percentage seed filled data was arc-sign transformed prior to analysis as most of the Toogoolawah values were greater than 75%. In the phenology study the test for normality often failed because one of the Emerald plants was an outlier, in these cases a Mann-Whitney Rank Sum Test was conducted.

RESULTS

The overall phenological differences between the two populations were not large (Figure 1), however one major difference was that the stems of seven out of the nine Emerald plants elongated prior to flowering while eight out of the nine Toogoolawah plants flowered before stem elongation commenced. This resulted in a significant difference, between the two biotypes, in the time to stem elongation (P=0.04) while the times to first flower, anthesis and first mature fruit were not significantly different. The time between stem elongation and any other phenological event was always different for the two biotypes (elongation and first flower: P=0.0015, elongation and anthesis P=0.002, elongation and first mature fruit P=0.013), while the time between any other two

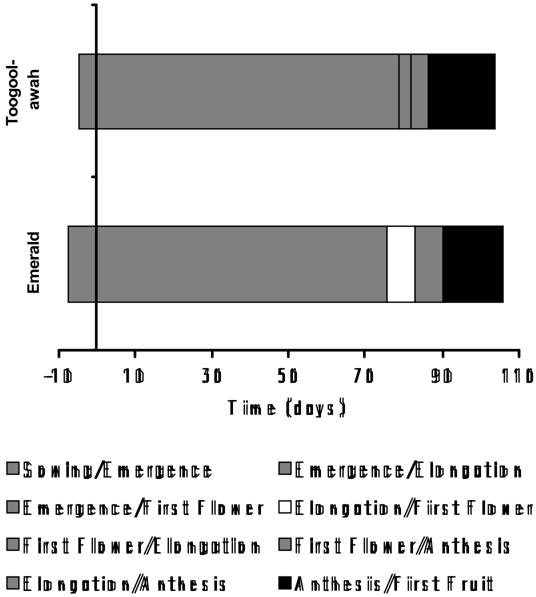

Figure 1. Phenology of plants of the Emerald and Toogoolawah biotypes when grown under a 23/13°C day/night temperature regime and a 14.5 hour photoperiod. The bars represent the averages of nine plants.

events (e.g. first flower and first mature fruit) did not differ between biotypes. There was no significant difference between biotypes in the time from sowing to seedling emergence.

At the conclusion of the experiment the Emerald plants were, on average, 44% taller than the Toogoolawah plants (Figure 2). This difference between the two biotypes was statistically significant (P=0.0008), as it also was on days 70, 80, 130 and 140. The average length of the longest leaf on the Emerald plants was 13.9 cm, while on the Toogoolawah plants it was 11.5 cm. T-test analysis showed this difference to be significantly different (P=0.0007).

The average total dry weight of the Emerald plants (35.8 g) was 42% higher than for the Toogoolawah plants (25.3 g). There was no difference between biotypes in the dry weight of roots, capitula and diaspores (Figure 3). However, there was a significant difference in the dry weights of stems (P=0.0002) and leaves (P<0.0001), which resulted in a difference in the total dry weight (P=0.002).

There was no difference between biotypes in the number of capitula (either mature, young or total) produced by the end of the experiment (Table 1). The size of individual diaspores differed between the two biotypes with the Emerald diaspores being 8% longer and 12% wider than the Toogoolawah diaspores (Table 1).

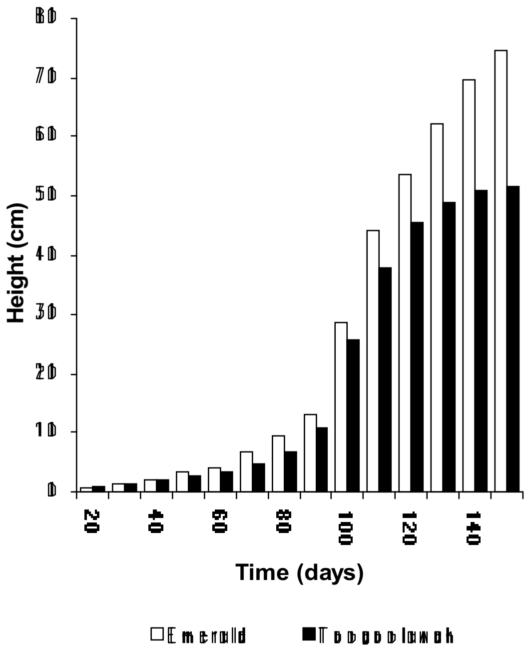

Figure 2. Graph of average plant height over time for plants from two parthenium weed biotypes. Heights are the average of nine plants.

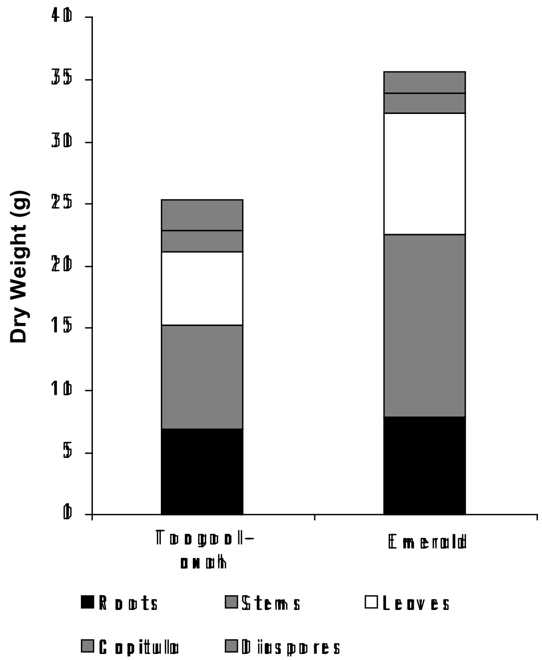

Figure 3. Graph of plant dry weight showing the contribution of the different plant parts for the two biotypes. Data given is the mean of nine plants.

However, there was no distinction between the two biotypes in the weight of individual diaspores. Another significant difference between biotypes was that while nearly all of the Toogoolawah seed was filled, less than two-thirds of the Emerald seed was filled (Table 1).

DISCUSSION

The results from the phenology and height studies indicate that plants of the Emerald biotype display earlier stem elongation and faster growth. This may give them a much greater advantage in the field when in competition with other species and is possibly one of the reasons why this biotype has been so aggressive. The time from the appearance of the first capitula to the production of the first mature seed seems to be more rigid for both biotypes under the conditions in which they were grown in the plant growth cabinets.

The Emerald plants were significantly taller than the Toogoolawah plants during the middle period of the experiment and then again towards the end of the experiment, but not on days 90–120. Days 70 and 80 match the time when the Emerald plants started elongating ahead of the Toogoolawah plants. The difference in height apparent at that time was subsequently reduced as the Toogoolawah plants started to flower. On these plants capitula were borne on thin branches that kept pace for a time with the much thicker-stemmed and larger-leaved Emerald plants. Once these branches reached their final height, at about 120 days, there was little further growth in height for the remainder of the experiment. However, the thicker main stem of the Emerald plants had the strength to support larger branches at a greater height, which were still reaching upwards and out over the Toogoolawah plants at the completion of the experiment.

Table 1. Reproductive and diaspore characters of two biotypes of parthenium weed. Results are the average of nine plants.

Character	Emerald	Toogoolawah
Capitula production		
Young	838	760
Mature	589	627
Total	1427	1387
Diaspore characters		
Length (mm)	2.23[A]	2.06[A]
Width (mm)	1.81[B]	1.62[B]
Weight (mg)	0.93	0.96
Percentage seed filled	62[C]	94[C]

[A] P=0.002, [B] P=0.0005, [C] P=0.006. All other differences were non-significant.

The dry weight data is consistent with these findings and shows that the Emerald plants allocate a larger proportion of resources to stem and leaf production (69%) than the Toogoolawah plants (55%). The Toogoolawah plants, however, allocate twice the percentage of resources into production of diaspores (10%) than the Emerald plants (5%) and were able to match the flower production of these much larger plants.

Even though the Emerald diaspores were larger than the Toogoolawah diaspores there was no difference in diaspore weight between the two biotypes. This suggests that either the Emerald seed have a lower density or that they possess larger accessory structures. This difference may affect the dispersal of seed under certain conditions. Parthenium weed seed is known to be spread short distances by both wind and water, this being especially apparent in central Queensland where the weed advances along waterways (Parsons and Cuthbertson 1992). This spread along waterways is nowhere near as apparent around Toogoolawah, in south-east Queensland, and a difference in the structure of the diaspore may be one reason for this difference.

Studies on the pollination and fertilization of parthenium weed have produced conflicting results. Lewis *et al.* (1988) concluded that wind must be the main method of pollen dispersal, while Gupta and Chanda (1991) suggested that parthenium weed was insect pollinated, or at most amphiphilous (pollen dispersed mainly by insects and partially by wind). It is likely that there is a difference in the suitability, and hence relative contribution, of wind and insect pollination to different biotypes of parthenium weed. The fact that the Toogoolawah flowers had a higher percentage of filled seed than the Emerald flowers may indicate such a difference in pollination requirements. There was a significant amount of air movement throughout the growth cabinet but very few insects were present. It may be that the Emerald biotype relies more on insect pollination and this is the reason why the percentage of seed filled was lower on these plants. It is also possible that self-pollination was occurring in the Toogoolawah plants and not in the Emerald plants.

This study has highlighted some differences in the biology of two biotypes of parthenium weed that may be reasons for the large difference in the relative invasiveness of those biotypes in disturbed environments in Queensland. As the conditions simulated in the growth cabinet are equivalent to those present in Victoria in the summer, and as the Emerald biotype grew more vigorously in these conditions it suggests that this biotype will be a much greater problem than the Toogoolawah infestation if it spreads into south-eastern Australia. Further comparison of the growth and phenology of the two biotypes will be carried out under a broader range of temperatures in order to determine whether the growth advantage of the Emerald biotype is more general.

It is also evident, when assessing the potential threat of alien weed species to a particular area, that more than just one population of that species needs to be considered.

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