# Competitive displacement of parthenium weed with beneficial native and introduced pasture plants in central Queensland, Australia

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**Summary** Parthenium weed (*Parthenium hysterophorus* L.) is an annual broadleaf invasive weed from the Asteraceae family. It is a threat to the pasture lands of central Queensland and has the potential to convert much traditional pasture land into parthenium-dominated communities. This study was initiated to identify beneficial pasture plants that may be able to competitively displace parthenium weed from the presently infested areas. Initial trials were undertaken in the glasshouse to select plants to be further tested at two parthenium-infested field sites in central Queensland. In the glasshouse an addition series competition trial, in several steps, was run with 20 selected grasses and legume species. Ten species were selected and were further tested in the field under natural conditions. Purple pigeon grass, guinea grass, buffel grass, Indian bluegrass, bull Mitchell grass, Kangaroo grass, pitted bluegrass and hoop Mitchell grass were all ranked as strong displacement plants in the glasshouse trial. In the field purple pigeon grass, buffel grass, butterfly pea, Kangaroo grass and bull Mitchell grass were all determined to be useful at displacing parthenium weed at the Injune site, while Rhodes grass, buffel grass, Queensland bluegrass and butterfly pea were all shown to do the same at the Monto site. These findings indicate that selected pasture species are likely to be a useful part of an integrated management plan for parthenium weed in the infested regions of central Queensland.

**Keywords** Parthenium weed, competitive plants, glasshouse and field trials.

## INTRODUCTION

Parthenium weed (*Parthenium hysterophorus* L.) is an annual broadleaf invasive weed from the family Asteraceae. Parthenium weed was introduced accidentally as a seed contaminant contained within a pasture seed lot from the USA into Clermont, Queensland in 1958 (Navie *et al*. 1996, Parson and Cuthbertson 1992). The infestation spread slowly at first but within 20 years it had covered an area of 170,000 km$^2$ in central Queensland (McFadyen 1992). Characteristics such as rapid growth, short life span, high seed production and the release of allelochemicals are thought to be some features of parthenium weed and other plants that aid their invasiveness (Baker 1974, Kohli *et al*. 2006). In Queensland, cattle production has declined by approximately 4.75 beasts ha$^{-1}$ due to this weed (Chippendale and Panetta 1994) with an associated financial loss of Aus $16.5 million per annum. Parthenium weed is also a hazard to the health of those people living in or close to the infestation sites.

Various methods have been used to manage parthenium weed worldwide but most have limited effect, or need to be re-applied constantly on an annual basis as and when the weed re-emerges from the soil seed bank. Following Ethiopian studies, Tamado and Milberg (2004) discussed the constant need to re-apply herbicides following seasonal re-emergence of parthenium weed in sorghum (*Sorghum bicolour* L.) crops. In areas where it is possible, the displacement of this weed with beneficial plants is considered to be an ideal management approach. Previously, in a glasshouse experiment, floren bluegrass (*Dichanthium aristatum* Poir.), bisset bluegrass (*Bothriochloa insculpta* cv. Bisset) and buffel grass (*Cenchrus ciliaris* L.) were all shown to be able to displace parthenium weed (O'Donnell and Adkins 2005). So, in view of these findings, this study was designed to identify other beneficial plants that may be able to displace parthenium weed in the glasshouse and then to test their effect under field conditions.

## MATERIALS AND METHODS

**Glasshouse trials** Twenty plant species, comprising 14 native grasses, four introduced pasture grasses and two legumes, were used in the displacement trials with parthenium weed in a glasshouse. The pre-germination of seeds prior to planting was used to synchronise the early growth and development of the seedlings. To do this seeds of all species were sown into 50 cm$^2$ cell trays filled with a sterile potting mix (University of California potting mix type B). The cell trays containing the seeds were then kept in a naturally illuminated glasshouse (30 ± 5/18 ± 2°C; day/night; *c*. 45% relative humidity) and watered to field capacity until seedlings were 2 days old. A typical black cracking soil was collected (from the 0 to 30 cm profile) from Injune, Queensland, and pots (25 cm diameter) were filled with 8 kg of this soil (air dried). The soil was then watered to saturation and allowed to drain for 24 h to reach a soil moisture content that was close to field capacity. The 2-day-old seedlings of parthenium weed and the test plant species were then transplanted into these pots watered to field capacity and allowed to grow together for 40 days. An addition series experimental design (Rejmanek *et al*, 1989) was used in which seedlings were sown to a total density of 4 or 6 plants pot$^{-1}$ (representing 80 or 160 plants per m$^{-2}$), each at five combinations of parthenium weed-to-test plant species (viz. 4:0, 3:1, 2:2, 1:3, 0:4) or (viz. 6:0, 4:2, 3:3, 4:2, 0:6), each replicated three times. At harvest each species was cut at soil level, dried in a dehydrator (48 h at 72°C) and their dry biomass determined. The performance of the test plants was determined using a competition index (CI) following Spitters (1983). The CI values calculated are all relative to parthenium weed whose CI value is 1.0. Plants with CI values CI >1.5, CI = 1.0–1.5 and CI <1.0 were categorised as being strong, medium or poor displacement plants, respectively, against parthenium weed.

**Field trials** A field trial replicated five times using a completely randomised design was undertaken in the field at Injune (S 25°46'18", E 148°21'06") with a similar trial being carried out at Monto (S 24°88', E 151°27'19") in central Queensland. The mean annual rainfall in Injune is 630.3 mm and the mean annual temperature is 27.5°C (max)/11.7°C (min) while the mean annual rainfall in Monto is 731.9 mm and the mean annual temperature is 27.3°C (max)/12.9°C (min). Five plant species were selected from the present glasshouse studies and an additional five from the previous glasshouse studies of O'Donnell and Adkins (2005) for these trials. At each location seven species were planted. The plot sizes were both 45 m$^2$ and seeds of all the plant species were sown (using the recommended sowing rates) into a well prepared seed bed that was evenly infested with parthenium weed. One plot of parthenium weed alone was kept as a control plot. Management of all other weeds was carried by hand removal at several times throughout the trial. The above ground shoot biomass of the test plant species and parthenium weed was harvested after 160 days of growth, from five randomly thrown quadrats (1 m$^2$) in all plots. The samples, following separation into species were then dried in a dehydrator (48 h at 70°C) and weighed. The percentage reduction of parthenium weed dry biomass by each test species was then calculated.

## RESULTS

**Displacement ability in the glasshouse** Out of 20 plant species, three (viz. purple pigeon grass, *Setaria incrassate* (Hochst.) Hack.; buffel grass, *Cenchrus ciliaris* L.; and guinea grass, *Panicum maxicum* Jacq. var. Maximum) gave >1.5 CI values, five (Indian bluegrass, *Bothriochloa pertusa* L.; bull Mitchell grass, *Astrebla squarrosa* C.E.Hubb.; kangaroo grass, *Themeda triandra* Forssk.; and pitted bluegrass, *Bothriochloa decipens* (Hack.) C.E.Hubb.) gave CI values between 1.0 and 1.5, and 12 species (lablab, *Lablab purpureus* L.; silky browntop, *Eulalia aurea* (Bory.) Kunth.; red grass, *Bothriochloa macra* (Steud.) S.T.Blake; centurion, *Centrosema pascuorum* Mart. ex Benth.; curly Michell grass, *Astrebla lappacea* (Lindl.) Domin; wallaby grass, *Austrodanthonia richardsonii;* black spear grass, *Heteropogon contortus* (L.) Roem. & Schult.; cotton panic grass, *Digitaria brownii* Roem. & Schult.; weeping grass, *Microleana stipoides* (Labill.) R.Br.; dessert bluegrass, *Bothriochloa ewartiana* (Domin.) C.E.Hubb; curly windmill grass, *Enteropogon acicularis* (Lindl.) Lazarides; and forest bluegrass, *Bothriochloa bladhii* cv. Swann.) gave <1.0 CI values. These species were ranked as either being strong, medium and poor displacement plants against parthenium weed, respectively.

**Dry biomass reduction under field conditions** At the Injune field site, compared to the control, purple pigeon grass, buffel grass, butterfly pea, kangaroo grass and bull Mitchell grass were all found to be good at displacing parthenium weed, suppressing growth while producing large amounts of palatable biomass (Figure 1). These plant species reduced the parthenium weed biomass by 82, 74, 70, 67 and 61%, respectively. Indian bluegrass and Seca stylo competed less well (Figure 1), reducing biomass of parthenium weed by 49 and 39% respectively. At the Monto site, Rhodes grass, buffel grass, Queensland bluegrass, butterfly pea and creeping bluegrass suppressed parthenium weed growth while producing large amounts of palatable biomass (Figure 2). These plant species reduced the parthenium weed shoot dry biomass by 79, 71, 69, 68 and 62%, respectively. Digit grass and Indian blue grass competed less well than the other pasture plant species (Figure 2), reducing biomass only by 50 and 35% respectively.

## DISCUSSION

**Displacement ability in the glasshouse** The suppression of parthenium weed growth by purple pigeon grass, buffel grass, guinea grass, Kangaroo grass, bull Mitchell grass, pitted bluegrass and hoop Mitchell grass in the glasshouse trial may be attributable to

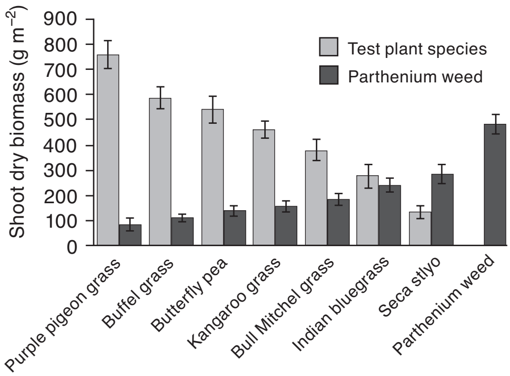


**Figure 1.** The above ground dry biomass of seven test species and parthenium weed when grown together at the Injune field site. The data sets are the means ± standard error for measurements taken from five replicate plots.

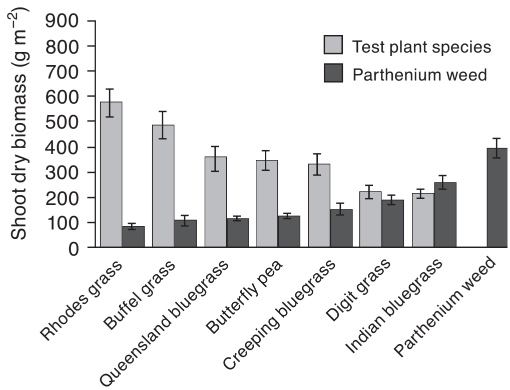


**Figure 2.** The above ground dry biomass of seven plant species and parthenium weed when grown together at the Monto field site. The data sets are the means ± standard error for measurements taken from five replicate plots.

the fact that these plant species are able to extract soil nutrients and water more efficiently and/or grow more rapidly than parthenium weed. These observations are in accordance with findings by O'Donnell and Adkins (2005) where it was reported that a number of improved, introduced plant species were able to displace parthenium weed in a glasshouse study. These plants may inhibit the growth of parthenium weed through competition or through an allelopathic interference. These features of faster growth or interference may be the characteristics of these species that makes them useful for the displacement of parthenium weed.

**Dry biomass reduction under field conditions** Out of seven plant species, five (purple pigeon grass, buffel grass, butterfly pea, kangaroo grass and bull Mitchell grass) were good at displacing parthenium weed in the field at Injune. At the Monto field site, five species (Rhodes grass, buffel grass, Queensland bluegrass, butterfly pea and creeping bluegrass) were good at displacing parthenium weed. The displacement ability of the native plant species in the field may be due to the fact that they are better adapted to the environmental conditions of central Queensland than parthenium weed. Unsupported observations suggest that many of the native grasses had a good tillering ability and rapid growth pattern in the field, producing an extensive root system and leaf canopy quite early after emergence from the soil. These findings are in agreement with those of Bowen *et al*. (2007), who found two native grasses (Queensland bluegrass and tall windmill grass; *Chloris ventricosa* R.Br.) to be able to displace parthenium weed in the field. As mentioned earlier, many of the introduced plant species trialled are known to germinate, establish and grow rapidly. They have been selected by the pasture producers as they can produce good biomass rapidly. Such plants are able to shade parthenium weed at an early stage of growth, resulting in suppressed growth and lower shoot biomass production in the weed. The strong root systems of both the introduced and native plant species may be another factor that boosted their displacement ability against the weed. In India, Kandasamy and Sankaran (1997) have found that field crops that formed canopies early (viz. maize, *Zea mays* L.; sorghum, *Sorghum bicolor* L.; and sunflower, *Helienthus annuus*) effectively suppressed the population and biomass of parthenium weed. These plants were able to extract water and nutrients more efficiently than parthenium weed. The native grasses selected for these studies were also well adapted to the central Queensland climatic and soil conditions (e.g. tolerance to frost and drought), which may be further reasons why these plants did well in the trial. It is evident from these results that introduced and native pasture species could be useful as part of an integrated management plan for parthenium weed in central Queensland in the future.

ACKNOWLEDGMENTS

We acknowledge the Higher Education Commission Islamabad-Pakistan, The University of Queensland, Brisbane, the Queensland Murray Darling Committee and Burnett Mary Regional Group for various inputs in these studies.

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