ACCELERATING GIANT RAT'S TAIL GRASS (GRT) SOIL SEED BANK DEPLETION THROUGH CHEMIGATION

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ABSTRACT

The successful management of the giant rat's tail grass (GRT) is dependent on depleting the large soil seed bank reserves, preventing emerging seedlings from reaching reproductive maturity and controlling established tussocks. Though an array of integrated control options is available, control is often met with varying degrees of success due to the ten years of soil seed bank longevity. A laboratory experiment was conducted at the Ecosciences Precinct in Brisbane to investigate the efficacy of dazomet in accelerating the depletion of the GRT soil seed bank. To determine the effectiveness of dazomet, 25 glass jars were filled with a sandy loam soil to which GRT seed sachets containing 100 seeds were buried to a depth of 2 cm. Dazomet treatments consisted of 0 (control), 41.25, 82.5, 165 and 330 kg a.i. ha^{-1} were replicated five times. Following 30 days of fumigation exposure, the seeds were retrieved and tested for viability using 1% 2,3,5-triphenyltetrazolium chloride (TTC). Regardless of application rate, dazomet was effective and significantly reduced the viability rate of GRT seeds when compared to the control. A single application of dazomet killed almost 98% of the buried seed tested. Our research demonstrated that dazomet is an excellent tool for accelerating the depletion of a viable GRT soil seed bank. Further trials are planned to optimise dazomet rate and contact time, its effectiveness at destroying GRT seeds at different soil depths and how to incorporate these findings to successfully management GRT in the field.

Keywords: Giant rat's tail grass, invasive weed, seed bank, fumigation, dazomet, pot experiment.

INTRODUCTION

Weedy *Sporobolus* grasses (WSG), are highly invasive and widely distributed across Australia especially in the eastern states. These plants are a big concern to the grazing industry and natural areas as they reduce pasture productivity, exclude desirable native plants, and cause significant depletion of natural resources. (Biosecurity Queensland, 2023). Native to southern Africa, *Sporobolus natalensis* and *S. pyramidalis,* also known as giant rat's tail (GRT) grasses, are problematic perennial plants that greatly reduce the carrying capacity of pastures. GRT plants can mature within three months, forming tussocks that can grow to 60-200 cm in height (Steinrucken & Vitelli, 2023). GRT grasses are unpalatable for grazing livestock and can produce 20,000–85,000 seeds m^{-2} $year^{-1}$ with a 90% initial viability and up to ten years seed longevity (Biosecurity Queensland, 2023; Walton, 2001). GRT grass can adapt to a wide range of soils and conditions. Ecoclimatic modelling suggests giant rat's tail grass could invade 60% of Queensland which is equivalent to 108 million hectares of land. GRT grass also can grow in areas with average annual rainfall as low as 500 mm (Biosecurity Queensland, 2023). The brown tiny GRT seeds are 0.7–0.8 mm long and up to 0.6 mm wide, and are readily transported in soil, through the movement of cattle, and contaminated agricultural machinery including vehicles (Atlas of Living Australia). Targeting the large GRT soil seed bank could play an important role in the overall management of GRT to minimise seedling emergence and reduce the number of GRT plants reaching reproductive maturity to form large tussocks.

Chemigation is a control strategy used independently or integrated to effectively reduce soil weed populations and various soil organisms such as fungi, bacteria, and nematodes in golf courses, nurseries, turf sites, and potting soils (Bearss, 2020). Dazomet (Basamid ®) is a soil fumigant that decomposes into a gaseous form releasing methyl isothiocyanate (MITC) when in contact with moist soil with a half-life of less than 24 hours (Ren *et al.*, 2022; Fritsch & Huber, 1993; Smelt & Leistra, 1974). Dazomet's efficacy in controlling soil borne pests is strongly influenced by temperature, moisture, incorporation depth, target organism, and the time it is present as a gas within the soil profile (Zheng *et al.*, 2006; Fritsch & Huber, 1993; Smelt & Leistra, 1974). Previous research has shown the effectiveness of dazomet in controlling large scale infestations of branched broomrape (*Orobanche ramosa*) and red witchweed (*Striga asiatica*) soil seed bank. Less than 10% of *O. ramosa* seed remained viable after a dazomet applications of 112.8 to 338.4 kg ha^{-1} at soil moisture content from 0.05 to 0.15 g g^{-1} (Prider & Williams, 2014). The red witchweed surface seed bank declined to <9% after a single application of dazomet at 330 kg a.i. ha^{-1} (Williams *et al.*, 2022). Dazomet effectively controlled an annual bluegrass seed infestation in a turfgrass system by supressing the seedling emergence in both loamy sand and sandy clay loam soil types in different seed placement depths, regardless of the rate of fumigation (Green, 2020). Though an array of effective integrated control options are available for managing GRT. While flupropanate supply is currently limited in Australia's herbicide market, dazomet may provide an alternative option for accelerating the soil seedbank depletion of GRT and could be a key management strategies. Dazomet is effective in controlling weed seed banks but there is no published data on the efficacy and application rate required for managing GRT. To address this knowledge gap, we conducted an experiment in glass chambers to analyse the efficacy of dazomet at four different concentrations and evaluate the viability rate of GRT seeds after a chemigation treatment.

MATERIALS AND METHODS

A laboratory experiment was conducted in May 2023 at the Ecosciences Precinct, Dutton Park, Queensland, Australia to assess the efficacy of dazomet (Basamid ®) in accelerating the depletion of a GRT soil seed bank. *Sporobolus. natalensis* seeds were collected from a nursery stock cultivated in a glasshouse and stored in glass jars in a low humidity environment in the lab. Only seeds >425 μm were used to maximize the germination viability (84 %) of the seed cohort. One hundred seeds were counted and then transferred to 30 mm × 40 mm 62 mm precision woven polyamide (nylon) mesh tubes (SAATIFIL PA 62/40 PW WH) with the ends sealed using self-adhesive nylon tape (PSP Spinnaker Repair Tape). The sachets were buried at 2 cm depth in ~ 90 mL glass jars containing 3 cm of sieved sandy loam soil and capped with a lid throughout the duration of the experiment.

The dazomet granular was surface applied at either 41.25, 82.5, 165 or 330 kg a.i. ha^{-1} and immediately incorporated to the top one centimetre of the soil profile. A negative control (no fumigation) was also used. All treatments were replicated five times. Irrigation was then applied to achieve a moisture level of ~50% field capacity to activate dazomet through hydrolysis. Jars were then sealed with a plastic lid and placed in a growth chamber set to 18° C during the day and 10° C at night. The jars were subjected to a cycle of 12 hours light and dark for 30 days. Seed sachets were then retrieved and washed to remove the exterior soil. The contents of the sachet were then transferred to 90 mm petri dishes and covered with a Whatman® number 1 filter paper and moistened.

The petri dishes were stored in a temperature and humidity chamber set at 30°C day/ 25°C night in 12 hours light and dark cycle. After seven days the germinated seeds were counted and removed from petri dishes and non-germinated seeds transferred to 2 ml eppendorf tubes. Seeds were then immersed in 600 µl of 1 % 2,3,5-triphenyl tetrazolium chloride (TTC) and stored in the dark at 35° C for four days. Viability testing was performed as per Moore (1976) to determine the effects of dazomet on seed mortality. Embryos turning red to pink in colour were considered viable. ANOVA and TukeysHSD tests were used to determine treatment differences. Statistical analysis was carried out in R (v4.0.5, The R Foundation).

RESULTS

Dazomet significantly reduced germination of GRT seeds compared to the control (ANOVA: $F = 504.2$, $df=4$, $p<0.0001$), but there was no difference in seed viability between the different dazomet concentrations (Figure 1). Irrespective of concentration, dazomet treated seeds failed to germinate in the petri dishes, however, 63.3% of the seeds in control treatments germinated in seven days. Viability of buried GRT seeds was significantly reduced after dazomet application. regardless of concentration, only 2.4% of dazomet treated seeds were viable, however, non-treated seeds were 84.8% viable. Even at lowest rate of 41.25 a.i. ha^{-1}, dazomet killed 98.6% of the buried GRT seeds. The differences in viability between the different dazomet treatments were not significant (Figure 1).

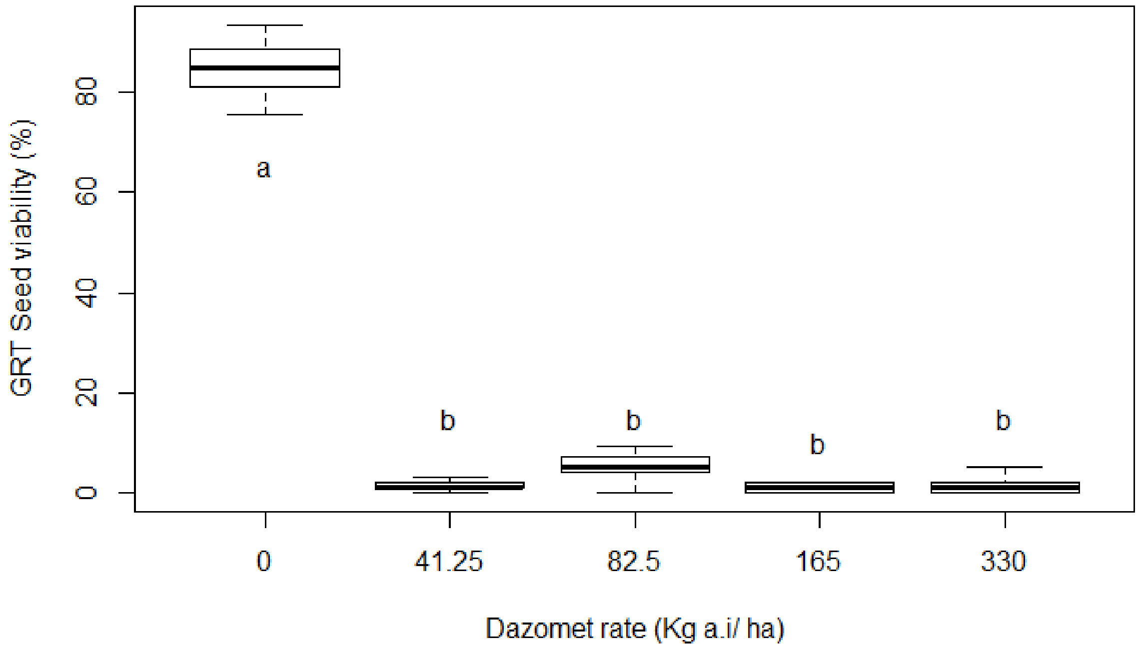

Figure 1. GRT seed viability 30 days after different dazomet application rates. Lettering indicates a statistically significant difference at $p<0.05$ (TukeyHSD).

DISCUSSION

Our research demonstrated that dazomet is an excellent tool for destroying GRT seeds. How we translate this to an accelerated soil seed bank depletion in natural Australian grasslands, pastures, disturbed sites, and woodlands will require additional research. This study demonstrated that there was no statistical difference in seed mortality (94.9% – 99.0%) between the four dazomet concentrations tested, and the small variability observed could be the result of uneven contact of the seeds inside the sachets with the MITC gas released from dazomet hydrolysis. The study of Prider (2014) showed that dazomet was also effective in soils with low moisture content but the release of MITC gas after dazomet application in the first seven days was slow and often occurred over a longer period of 30 days. The result of this experiment also confirmed the release of MITC gas over 30 days in dazomet treatments significantly reduced viability of GRT seeds by 97.6%. Another study found dazomet to effectively control annual bluegrass (ABG) seedling emergence in turfgrass systems in both loamy sand and sandy clay loam soils at 3 and 6 cm placement depths, regardless of application rate (Green, 2020). Our research demonstrated the effectiveness of dazomet in controlling GRT soil seed bank in top 3 cm depth of sandy loam soils in all treatments except control. In the absence or limited supply of flupropanate, dazomet may provide an alternative to controlling GRT seedlings and accelerating the soil seedbank depletion of GRT in key management systems. Further studies are needed to evaluate the impact of exposure time with dazomet, seed placement depth, soil type, and moisture content on accelerating the depletion of a GRT soil seed bank.

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