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Research article

Weed seed spread and its prevention: The role of roadside wash down

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ABSTRACT

Vehicles are one of the major vectors of long-distance weed seed spread. Viable seed removed from vehicles at roadside wash down facilities was studied at five locations in central Queensland, Australia over a 3-year period. Seed from 145 plant species, belonging to 34 different families, were identified in the sludge samples obtained from the wet particulate matter collection pit of the wash down facilities. Most of the species were annual forbs (50%) with small or very small seed size (<2 mm in diameter). A significant amount of seed from the highly invasive, parthenium weed was observed in these samples. More parthenium weed seed were found in the Rolleston facility and in the spring, but its seed was present in all facilities and in all seasons. The average number of viable seed found within every ton of dry particulate matter removed from vehicles was *ca.* 68,000. Thus, a typical wash down facility was removing up to *ca.* 335,000 viable seed from vehicles per week, of which *ca.* 6700 were parthenium weed seed. Furthermore, 61% of these seed (*ca.* 200,000) were from introduced species, and about half of these (35% of total) were from species considered to be weeds. Therefore, the roadside wash down facilities found throughout Queensland can remove a substantial amount of viable weed seed from vehicles, including the invasive parthenium weed, and the use of such facilities should be strongly encouraged.

1. Introduction

Weeds are unwanted plants that pose serious threats to environmental protection, native biodiversity, ecosystem stability and agricultural sustainability around the world (Bajwa, 2014; Bajwa et al., 2015a, 2016a). The plant species that are introduced in a region from outside and invade larger landscapes to disturb the native biodiversity are specified as invasive species and many of them could also be agricultural and/or environmental weeds. The introduction and spread of such invasive species have become more frequent and damaging in recent times, causing huge productivity and economic losses in different regions (Coleman et al., 2011; Graham et al., 2016). Ansong and Pickering (2013) reviewed that a large number of weed species (599 out of total 626 species studied) can disperse their seeds by cars globally. It was suggested that weed eradication on road sides and regular cleaning of cars could reduce the weed seed dispersal. In Australia, over 400 species are recognized as weeds costing over $4 billion (AUD) to the Australian economy each year (Coleman et al., 2011) and therefore, are a big point of concern for Government, environmentalists and farmers. Some weeds also pose threats to human and livestock health. For instance, parthenium weed (*Parthenium hysterophorus* L.), an invasive species, not only negatively affects pastures and livestock production but also causes severe allergies and breathing problems to people and livestock (Adkins and Shabbir, 2014). This weed has now spread to more than 40 countries, and is a Weed of National Significance (WoNS) in Australia. It was estimated to have cost $16.8 million (AUD) in lost beef production per annum in the 1970's (Chippendale and Panetta, 1994), with a predicted cost to Queensland beef producers set at $69 million (AUD) per annum in to the 2000's (Adamson, 1996). Adamson (1996) then estimated the cost to the beef industry by 2050 to be closer to $110 million (AUD) per annum. Similarly, other important weed species from different genera including, *Conyza, Chloris* and *Echinochloa* have been reported to cause significant crop yield losses and environmental degradation in Australia and other parts of the world (Bajwa et al., 2015b, 2016b).

Weed seed spread through anthropogenic activities has increased significantly with the advancements in transport and crop productions technologies (Pickering and Mount, 2010). Several studies from around the world have reported that viable weed seed

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can spread seed long distances, from infested to non-infested areas, by vehicles (Lonsdale and Lane, 1994; Zwaenepoel et al., 2006; Blackmore and Johnson, 2010; Pickering and Mount, 2010). In a study undertaken in Nigeria, Clifford (1959) reported that every 1 kg of dry mud collected from a vehicle driven in the rainy season (June), could contain as many as 100 to 180 germinable weed seeds. Zwaenepoel et al. (2006) reported that cars coming from rural areas carried significant number of viable weed seed throughout the year in Belgium. Schmidt (1989) found 3926 germinable seed, coming from 124 species, in the mud removed from a vehicle that had been driven for more than 15,000 km around Gottingen, Germany. Earlier, Sheley et al. (1996) reported that 2000 weed seed could be collected from a single vehicle when driven for very short distances in a weed infested area of Montana, the United States of America (USA). In the United Kingdom (UK), Hodkinson and Thompson (1997) found 307 germinable seed in the mud collected from car wheel arches with most being small and from weeds such as, Plantain (*Plantago major* L.) and annual bluegrass (*Poa annua* L.). Lonsdale and Lane (1994) assessed tourist vehicles that entered the Kakadu National Park (Australia) for their weed seed load and found that an individual car could carry up to 789 germinable seed from 15 different species.

Parthenium weed seed spread by vehicles has been reported in several studies (Jayachandra, 1971; Parsons and Cuthberson, 2001; Blackmore and Johnson, 2010; Khan, 2012). Jayachandra (1971) reported that parthenium weed seed by this mechanism appears to be one of the main modes of its dispersal for this species, especially over long distances. Parsons and Cuthbertson (2001) also stated that long-distance spread of parthenium weed seed in Australia is likely to be within the mud carried on vehicles, including cars, trucks and farm machinery. Currently, in Australia most new infestations of parthenium weed are first identified along main roads and their side tracks, and therefore it has been concluded that seed spread to these locations must have been by the movement of vehicles and machinery along these pathways. Blackmore and Johnson (2010) reported that the source of all new roadside outbreaks of parthenium weed in New South Wales (NSW) was from vehicles travelling south from Queensland. Nearly 70% of the new and recurring infestations of parthenium weed in NSW were to be found along the main highway corridors coming south from Queensland (Blackmore and Johnson, 2010).

Given the view that significant weed seed spread occurs on vehicles, an emphasis has been placed on the concepts of “weed hygiene practices”, “weed seed spread prevention”, and “weed seed containment” in some developed countries, especially Australia (Blackmore and Johnson, 2010; Graham et al., 2016; DAF, 2017). Many road-side wash down facilities have now been built in Queensland, Australia with an expectation in reducing the spread of weed seed on vehicles travelling in the rural areas (Ouellet-Plamondon et al., 2009; DAF, 2017). Agricultural and other machinery and motor vehicles that are passing through, or are coming from infested areas are expected to be cleaned at these facilities before they move on into non-infested areas (Parsons and Cuthbertson, 2001; DAF, 2017). However, no research has been published on how effective wash down is in removing seed from vehicles, or to determine the kinds of seed removed, and if it is necessary to undertake the wash down process outside of the weed seed production season.

A better understanding of weed seed spread by vehicles is a crucial prerequisite for the prevention of establishment in new areas and for the long-term management of weeds, including highly invasive weed species such as parthenium weed. Road side wash down has been recognized as an effective way to reduce the weed seed spread. Although several studies have looked at the magnitude of seed dispersal by vehicles, the information on weed seed dynamics at the road side wash down facilities and therefore, the effectiveness of such facilities is lacking in the literature. The present study investigated the number and diversity of weed seed that collected within the particulate matter found inside a number of different vehicle wash down facilities in Queensland. This will be useful in determining the value of vehicle wash down as a technique for preventing weed seed spread, as well as determining whether the facilities need to be operated throughout the year and if some geographic locations are more important than others.

2. Materials and methods

2.1. Wash down facilities

The wash down facilities included in this study were not identical but were similar in basic structure and function. These facilities varied in age, support infrastructure and their geographic location. They incorporated various designs and standards depending on the breadth of the intended users. A typical wash down facility studied serviced a wide range of vehicles types including, private cars, four-wheel drive vehicles, farm machinery, caravans and construction machinery (Ouellet-Plamondon et al., 2009). Details on structure, operations and regulations of these wash down facilities are described by DAF (2017). Wet particulate matter samples were collected from each of the five wash down facilities (Clermont, Rolleston, Springsure, Injune and Monto) in central Queensland on four separate occasions throughout the year (i.e. in summer, January to March; autumn, April to June; winter, July to September and spring, October to December) during a 3-year period (2007–2009; Table 1). The sites were all *ca.* 400 km from Brisbane. All sampled facilities were on the south west edge of the main parthenium weed infestation in Queensland, and in locations that would pick up vehicles moving out of this region into less or un-infested regions.

2.2. Seed sample collection

The wet particulate matter samples (*ca.* 1–2 kg wet) were collected at random from the first sump pit (the pit that receives the water and debris directly from the vehicle wash down process) using a spade and bucket. It was then transferred into large zip-lock plastic bags and brought back rapidly (usually within 5–6 h) for analysis at the University of Queensland, Brisbane. Upon arrival at the University of Queensland all samples were allowed to drain off all free water, then were weighed and divided into seven equal portions based on weight. Six of which were then spread thinly over a 2 cm layer of sterilized compost (University of California potting compost) contained within shallow germination trays (25 × 20 × 6 cm; l/w/d) that were distributed randomly over a number of benches in the glasshouse. Two control trays were then placed among the experimental trays to monitor for any seedlings that did not belong to the samples. The glasshouse conditions varied depending upon when the study was done, and as it took a number of months to complete each trial, the germination conditions for all species should have been met at some point in the study.

All the germination trays were watered daily to maintain their soil moisture content at or close to field capacity. The trays were observed regularly for newly emerging seedlings. All seedlings were marked and initially recorded as either being parthenium weed, ‘other broadleaf species’ or ‘grass or sedge species’ as they emerged. Once the seedlings were large enough to be visually identified, they were identified and removed, or in the case of