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PESTICIDES SELECTED FOR NATURAL-ENEMY EXCLUSION TRIALS IN SOUTH AFRICA DO NOT INFLUENCE THE GROWTH AND REPRODUCTION OF INVASIVE *SENECIO MADAGASCARIENSIS*

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ABSTRACT

Pesticide-based natural-enemy exclusion trials can accurately determine the efficacy of biocontrol agents on invasive weeds, provided that the chemicals have negligible effects on the plants. In an enemy-free environment, we assessed whether applications of the insecticide (imidacloprid) and fungicide (tebuconazole) affected the performance of the highly invasive Madagascar ragwort. Applications of the insecticide and fungicide, used alone and in combination, had no significant effects on the growth and flowering of Madagascar ragwort. Thus, these pesticide treatments can facilitate subsequent enemy exclusion trials used to assess the impact of established biocontrol agents on Madagascar ragwort populations in the field.

Nomenclature: Imidacloprid, tebuconazole, Madagascar ragwort, *Senecio madagascariensis* Poir.

Keywords: Fireweed, pesticide impacts, weed biological control, invasive plants.

INTRODUCTION

Senecio madagascariensis Poiret (Asteraceae; Madagascar ragwort; fireweed), native to Southern Africa and Madagascar, is a target for biological control in Australia and Hawaii (Ramadan *et al*., 2010; McFadyen and Morin, 2012). The KwaZulu-Natal region of South Africa is the origin of both the Australian and Hawaiian populations of *S. madagascariensis* (Radford *et al*., 2000). Consequently, quantitative surveys for insect natural enemies were conducted in the region (Egli and Olckers, 2015, 2020). Subsequently, natural-enemy exclusion trials on field populations of *S. madagascariensis* were planned to quantify the impact of local natural enemy communities at different localities in KwaZulu-Natal.

Natural-enemy exclusion trials typically involve pesticide treatments, in the weed's native or invaded range, and have been used to quantify the impact of natural enemies in weed biocontrol programs (e.g. Lonsdale and Farrell, 1998; Overholt *et al*., 2010; Rafter *et al*., 2011). Also, these chemical trials are used to identify the overarching role of natural enemies in regulating plant invasions (e.g. DeWalt *et al*., 2004; Cripps *et al*., 2011). Trials generally involve applications of insecticides or fungicides to remove any natural enemy effects, so that their resultant impact on plant performance traits (e.g. plant biomass) can be determined by comparing performance variables between untreated and pesticide-treated plants.

A key assumption in such natural-enemy exclusion trials was that the pesticides will have no direct effects on the plant's health. While many chemicals may have no effect, certain insecticides and fungicides have affected plant physiology in several ways that may either promote or inhibit plant growth and reproduction (e.g. Ahemad and Khan, 2012; Petit *et al*., 2012). For example, plant physiological features like chlorophyll content and levels of hormones and metabolic enzymes were affected, which influenced the rates of photosynthesis and respiration (e.g. Xia *et al*., 2006; Dhanamanjuri *et al*,. 2013). Additionally, soil residues of pesticides can be toxic to nitrogen-fixing bacteria used by crops (e.g. Madhaiyan *et al*., 2006; Ahemad and Khan, 2012; Petit *et al*., 2012) further interfering with plant growth.

These pesticide-induced effects are often dosage-dependent, with stimulatory effects at low concentrations and inhibitory effects at high concentrations (e.g. Tiyagi *et al*., 2004; Siddiqui and Ahmed, 2006; Petit *et al*., 2012;

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Dhanamanjuri *et al*., 2013) and can vary substantially between and within functional pesticide groups (Ahemad and Khan, 2012). Therefore, any chemical effects on the plant may mask the real impact of natural enemies in subsequent experiments. As such, it is important to exclude the possibility that the chemicals themselves will directly affect the plant's growth and reproductive parameters prior to the initiation of enemy-exclusion trials in the field (e.g. Overholt *et al*., 2010; Cripps *et al*., 2011; Rafter *et al*., 2011).

Our trial was conducted to demonstrate that neither treatment with the selected insecticide (imidacloprid; Confidor® 70 WG), fungicide (tebuconazole; Folicur® 250 EW), nor a combination of the two, would directly affect the growth, biomass accumulation and floral production of *S. madagascariensis* plants during subsequent enemy-exclusion trials. Both chemicals are systemic pesticides that are effective against a broad range of insects and pathogens (e.g. Cripps *et al*., 2011).

MATERIALS AND METHODS

The trial was conducted in the Botanical Garden of the University of KwaZulu-Natal, Pietermaritzburg, South Africa. For experiment *Senecio madagascariensis* seedlings were obtained by germinating seeds in an open shade house over a 2-week period in early 2014. Similar-sized seedlings were individually transferred into 20 cm diameter pots, watered and left to recover for 48 hours. Then, the plants were placed on a metal table inside a 2.4 × 2.3 × 2m walk-in cage erected inside a greenhouse to exclude natural enemies. Five plants for each of the four treatments were arranged on the table according to a randomized block design. The treatments comprised an untreated control, insecticide treatment, fungicide treatment and a dual treatment (insecticide and fungicide). Individual plants were treated outside the cage to prevent contamination of adjacent plants and then returned to their original position.

Insecticide-treated plants each received 100ml of imidacloprid (0.5g/ l water) that was poured into the soil around their roots. For consistency, fungicide-treated plants also received 100 ml of water around their roots and 100ml of tebuconazole (1ml/ l water) applied to their foliage with a spray pump. Dual-treated plants received both insecticide and fungicide applications in the same manner. The control plants received 100 ml of water around their roots and 100 ml of water applied to their foliage with a spray pump. The plants were treated every two weeks for the duration of the 10-week trial period and were watered (500ml per plant) three times a week.

At the termination of the trial, the height, canopy diameter, canopy radius (i.e. measured perpendicular to the diameter) and numbers of floral structures (open and closed capitula) were recorded for each plant. The volume of each plant was determined by the product of its height, canopy diameter and canopy radius. The plants were harvested, oven dried (48 hours at 60^{o}C) and then weighed to determine their dry mass. The data sets met the assumptions of normality and homogeneity of variances (P>0.05) and comparisons of plant height, volume, biomass and floral production between the four treatments were conducted using one-way Analysis of Variance.

RESULTS AND DISCUSSION

After 10 weeks of exposure to the pesticide treatments, there were no significant differences between the control and pesticide-treated plants (Fig. 1) in relation to their mean height ($F_{3,16}$= 1.763; P = 0.195), foliar volume ($F_{3,16}$= 0.720; P = 0.555), dry mass ($F_{3,16}$= 3.076; P = 0.058) and floral production ($F_{3,16}$= 2.098; P = 0.141).Therefore, there was no evidence that the selected insecticide (imidacloprid), fungicide (tebuconazole) or combination of the two significantly affected the growth and reproduction of *S. madagascariensis* plants. Earlier studies involving other plant species where imidacloprid was used in insect-exclusion trials (DeWalt *et al*., 2004; Overholt *et al*., 2010; Cripps *et al*., 2011; Rafter *et al*., 2011) and tebuconazole was used in fungal-exclusion trials (Cripps *et al*., 2011) also reported a lack of phytotoxic or growth-enhancing effects on the test plants. Therefore, we considered imidacloprid and tebuconazole to be appropriate for the proposed natural-enemy exclusion trials, which were initiated later on *S. madagascariensis* in South Africa.

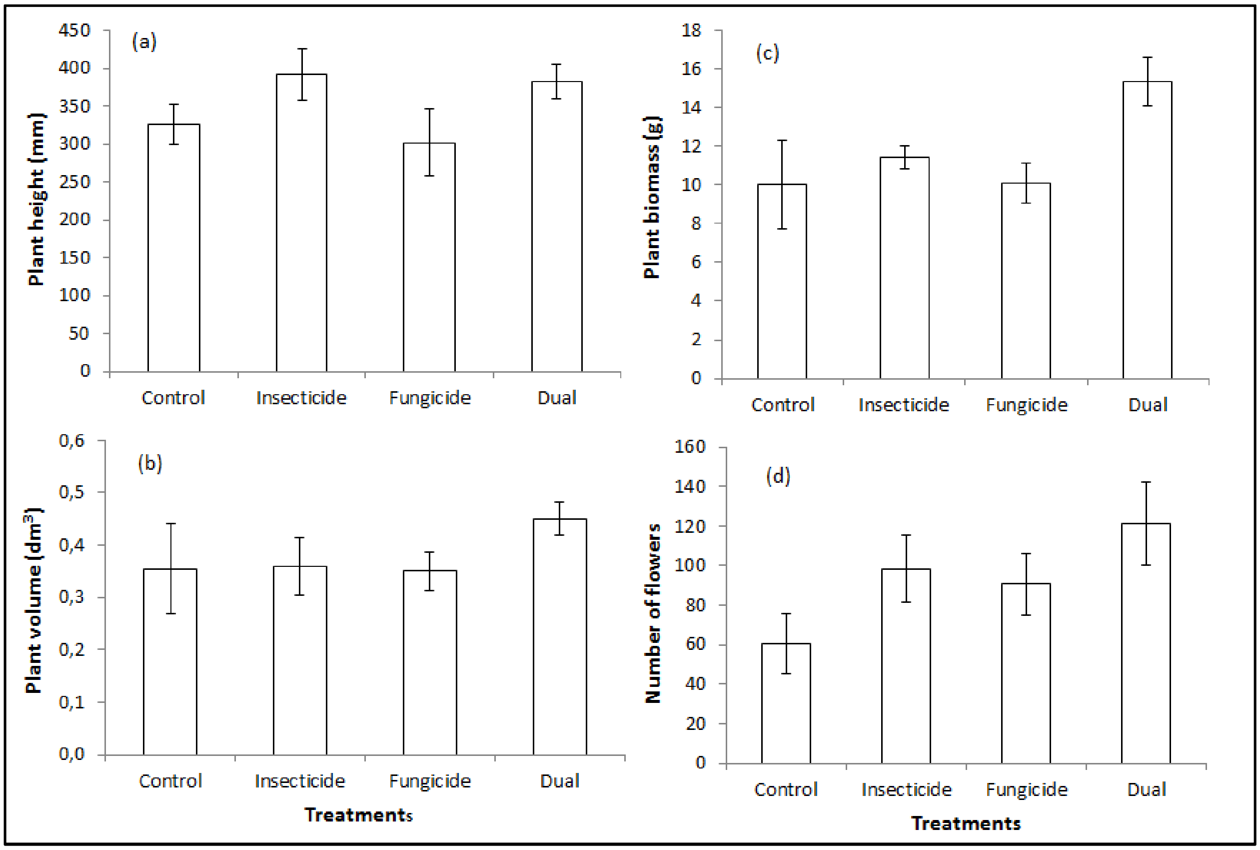

Fig. 1. Mean (± S.E.) final height (a), volume (b), dry mass (c) and floral production (d) of *Senecio madagascariensis* plants that were treated with insecticide, fungicide and both chemicals (dual) relative to untreated controls.

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REFERENCES

Ahemad, M. and Khan, MS. 2012. Effects of pesticides on plant growth promoting traits of *Mesorhizobium* strain MRC4. J. Saudi Soc. Agric. Sci. 11:63-71.

Cripps, MG., Bourdôt, GW., Saville, DJ., Hinz, HL., Fowler, SV. and Edwards, GR. 2011. Influence of insects and fungal pathogens on individual and population parameters of *Cirsium arvense* in its native and introduced ranges. Biol. Invasions 13:2739-2754.

DeWalt, SJ., Denslow, JS. and Ickes, K. 2004. Natural-enemy release facilitates habitat expansion of the invasive tropical shrub *Clidemiahirta*. Ecology. 85(2):471-483.

Dhanamanjuri, W., Thoudam, R. and Dutta, BK. 2013. Effect of some pesticides (fungicides) on the germination and growth of seeds/seedlings of some crop plants, (i.e. *Cicer arietinum* and *Zea mays*). Middle East J. Sci. Res. 17(5):627-632.

Egli, D. and Olckers, T. 2015. Abundance across seasons of insect herbivore taxa associated with the invasive *Senecio madagascariensis* (Asteraceae), in its native range in KwaZulu-Natal, South Africa. Afr. Entomol. 23(1):147-156.

Egli, D. and Olckers, T. 2020. Insect herbivores associated with the invasive herb *Senecio madagascariensis* (Asteraceae) in its native range in KwaZulu-Natal, South Africa and their potential as biological control agents in invaded countries. Biocontrol Sci. Techn. 30:243-255.

Lonsdale, WM. and Farrell, GS. 1998. Testing the effects on *Mimosa pigra* of a biological control agent *Neurostrotagunniella* (Lepidoptera: Gracillaridae), plant competition and fungi under field conditions. Biocontrol Sci. Techn. 8(4):485-500.

Madhaiyan, M., Poonguzhali, S., Hari, K., Saravanan, VS. and Sa, T. 2006. Influence of pesticides on the growth rate and plant-growth promoting traits of *Gluconacetobacter diazotrophicus*. Pestic. Biochem. Physiol. 84:143-154.

McFadyen, REC. and Morin, L. 2012. *Senecio madagascariensis* Poir. - fireweed. In: Biological Control of Weeds in Australia. Eds. Julien, MH., McFadyen, REC. and Cullen, JM. CSIRO Publishing, Melbourne, Australia. 526-536.

Overholt, WA., Diaz, R., Markle, L. and Medal, JC. 2010. The effect of *Gratianaboliviana* (Coleoptera: Chrysomelidae) herbivory on growth and population density of tropical soda apple (*Solanum viarum*) in Florida. Biocontrol Sci. Techn. 20(8):791-807.

Petit, A., Fontaine, F., Vatsa, P., Clément C. and Vaillant-Gaveau, N. 2012. Fungicide impacts on photosynthesis in crop plants. Photosynth. Res. 111:315-326.

Radford, IJ., Muller, P., Fiffer, S. and Michael, PW. 2000. Genetic relationships between Australian fireweed and South African and Madagascan populations of *Senecio madagascariensis* Poir. and closely related *Senecio* species. Aust. Syst. Bot. 13:409-423.

Rafter, MA., Palmer, WA. and Walter, GH. 2011. Assessing the biological control potential of an adventitiously-established “pest”, *Scirtothrips aurantii* (Faure), on a weed, *Bryophyllum delagoense* (Eckl. & Zeyh.), in Queensland. Biol. Control. 58:346-353.

Ramadan, MM., Murai, KT. and Johnson, T. 2010. Host range of *Secusio extensa* (Lepidoptera: Arctiidae), and potential for biological control of *Senecio madagascariensis* (Asteraceae). J. Appl. Entomol. 135: 269-284.

Siddiqui, ZS. and Ahmed, S. 2006. Combined effects of pesticide on growth and nutritive composition of soybean plants. Pak. J. Bot. 38(3):721-733.

Tiyagi, SA., Ajaz, S. and Azam, MF. 2004. Effect of some pesticides on plant growth, root nodulation and chlorophyll content of chickpea. Arch. Agron. Soil Sci. 50(6):529-533.

Xia, XJ., Huang, YY., Wang, L., Huang, LF., Yu, YL., Zhou, YH. and Yu, JG. 2006. Pesticides-induced depression of photosynthesis was alleviated by 24-epibrassinolide pretreatment in *Cucumis sativus* L. Pestic. Biochem. Physiol. 86:42-48.

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