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Damage to *Senecio jacobaea* by the Rust Fungus *Puccinia expansa*

G. Alber, G. Défago, L. Sedlar and H. Kern

Institute of Phytomedicine, Swiss Federal Institute of Technology, ETH CH-8092 Zurich, Switzerland.

Abstract

Plants of *Senecio jacobaea* (ragwort) were repeatedly infected by the rust fungus *Puccinia expansa* in greenhouse experiments. Dry weight of rusted plants, harvested approximately 80 days after seed, was 50% less than that of healthy plants. Reduction of number of assimilating leaves was about 46%. Dry weight of rusted plants, harvested approximately 110 days after seed, was 62% less than that of healthy plants. Reduction of number of flowers/plant was about 42%. The rust had no significant influence on initiation of stem elongation. These results show that *P. expansa* could be of value in biocontrol of *S. jacobaea*, especially in combination with the insects *Tyria jacobaeae* and *Longitarsus jacobaeae*.

Dommage causé au *Senecio jacobaea* par la rouille *Puccinia expansa*

Dans des expériences en serres, des plantes de *Senecio jacobaea* ont été infectées de façon répétée avec la rouille *Puccinia expansa*. Le poids à sec des plantes rouillées, moissonées 80 jours environ après la montée en graine, n'atteignait que 50% de celui des plantes saines. La réduction du nombre de feuilles assimilantes était de 46% environ. Le poids à sec des plantes rouillées, moissonées 110 jours environ après la montée en graine, était 62% moins élevé que celui des saines. La réduction du nombre de fleurs d'une plante infectée était de 42% environ. La rouille ne pas influencé, de fac??on significative, l'initiation de la croissance des tiges. Ces résultats indiquent que le *P. expansa* pourrait être utile dans la lutte contre le *S. jacobaea*, surtout en combinaison avec les insects *Tyria jacobaea* et *Longitarsus jacobaeae*.

Introduction

Senecio jacobaea L. (ragwort; Compositae) is a serious weed on pastures in many parts of the world. According to Schmidl (1972*a*) in Victoria (Australia) more than half a million dollars (Australian) are spent annually on control of ragwort; in Oregon the minimum economic loss/year is estimated about 1.5 million U.S. dollars (Isaacson 1978). *S. jacobaea* spreads rapidly and decreases production of pastures. Moreover it contains pyrrolizidine alkaloids, which are toxic to cattle and horses. The plant is often present at various growth stages at the same time (as seedlings, rosettes of various ages, in full flower or in seeding stage). This makes chemical control often unreliable (Harper and Wood 1957; Schmidl 1972*a*). Therefore biological methods for control of ragwort, such as introducing exotic insects, have been investigated by different laboratories (Schmidl 1972*b*; Cullen and Moore 1981).

The lepto-rust *Puccinia expansa* Link (= *P. glomerata* Grev.) (Uredinales) attacks and deforms leaves and flowering stems of *S. jacobaea*. In greenhouse experiments two strains of the rust, collected on *S. alpinus* L. in Switzerland, did not infect any beneficial plants outside the genus *Senecio*. Therefore *P. expansa* could be considered specific enough to be a biological control agent against *Senecio* weeds (Alber *et al.* 1984).

The object of this study was to determine the influence of *P. expansa* on growth of *S. jacobaea* under greenhouse conditions; in particular, effect on number of leaves and flowers, and on dry weight of plants.

Materials and Methods

Plant Material

Seeds of *S. jacobaea* were collected at Sonnenberg (800 m), near Lucerne, Switzerland in 1981.

Rust Material

Teliospores of *P. expansa* (strain Se-9) were collected on *S. alpinus* in Justistal (1200 m), Switzerland, in 1982. Since then the strain was maintained and propagated in the greenhouse.

Table 1. Time table of inoculations and harvests of plants in the experiments I and II.

	Days after seed		Quantity of spore suspension, 10^5 spores/ml
	I	II	I and II
1. Inoculation	35	40	150 ml
2. "	49	54	150 ml
3. "	63	68	200 ml
First harvest of plants	77	78	–
4. Inoculation	77	78	200 ml
5. "	91	88	200 ml
6. "	105	98	200 ml
Second harvest of plants	119	108	–

Methods

Plants were grown from seeds and individually potted in clay pots (height 14 cm, diam. 12 cm) in sterilized soil (Potgrond Topferde, De Baat, Netherlands) mixed with Perlit (PePe, granular mineral of quartz expanded by heating) in proportion 5:1. For experiments, plants were divided into two groups of 30 plants (15 control, 15 treatment) and maintained in separate greenhouse chambers under the same conditions (8 h dark at 15°C and 16 h light at 20°C; 80% r.h.). Once a week plants were fertilized with 125 ml/plant of 0.1% Lonzin (16% N, 16% P_2O_5, 16% K_2O and trace elements).

Plants in treatment groups were inoculated three or six times with *P. expansa* in intervals of 14 and 10 days respectively (Table 1). Inoculation occurred by regularly spraying a teliospore suspension (150 or 200 ml; see Table 1) of 10^5 spores/ml tap water containing 0.05% Etalfix (adhesive Maag AG, Switzerland). Teliospores were pretreated by storing for 21 days on water agar at 8°C (Alber *et al.* 1984). At the moment of each inoculation a germination test of the spore suspension on water agar was made.

Plants in control groups were sprayed with the same amount of tap water containing 0.05% Etalfix. After treatment, plants were incubated for 72 h under a plastic tent. Ten to fourteen days after the third inoculation, half of the plants of both groups were harvested (Table 1). Harvesting included cutting the plants 1 cm above the soil surface. The number of assimilating leaves was counted. Dry weight was determined after drying the plant material for 24 h at 105°C. Ten to fourteen days after the sixth inoculation the second harvest occurred by cutting the whole plants 1 cm above the soil surface (Table 1). Number of flowers (including buds, flowers and faded flowers) was counted, and dry weight of whole plants determined. Time of stem elongation was also assessed. The whole experiment was repeated on two different days (experiment I and II).

Statistical Analysis

Data from each harvest were analysed separately using Student's t-test. Statistical differences with a significance level of $P < 0.01$ are indicated with three stars (***), those with a significance level of $P < 0.10$ with one star (*) (Figs. 1–4). The difference between means of control and treatment expressed in percent of the mean of controls gives the reduction by the rust infection (Table 2).

Results

The average percent germination of teliospore suspensions was always 50–70%. In general, first infection symptoms (light-green spots) occurred 7–9 days after inoculation. Numerous pustules developed on leaves, leaf stems, flowering stems and peduncles 2–3 days later.

Damage to S. jacobaea *at First Harvest*

In both experiments *P. expansa* reduced dry weight of plants and the number of assimilating leaves significantly ($P < 0.01$). Mean dry weight of rusted plants was 50% of that of healthy plants (Table 2, Fig. 1). The reduction of number of leaves was by 46% (Table 2, Fig. 2).

Damage to S. jacobaea *at Second Harvest*

In both experiments the rust reduced dry weight of plants significantly ($P < 0.01$). Mean dry weight of rusted plants was 62% less than that of healthy plants (Table 2, Fig. 3). Reduction of flowers/plant was by 42%, but in experiment I only significant at $P < 0.10$ and in experiment II not significant (Table 2, Fig. 4).

Influence of the Rust on Stem Elongation of S. jacobaea

The rust had no significant influence on the beginning of stem elongation. In control and treatment groups, 74 days after seed (experiment II: 57 days) stem elongation was first observed.

Discussion

Basidiospores (produced by teliospores) of rust fungi need dew or raindrops to infect their host plants. Unfavourable moisture conditions and the absence of wind in the greenhouse prevented a reinfection of *S. jacobaea* by spontaneously germinating teliospores. For this reason plants were repeatedly inoculated to imitate favourable natural conditions.

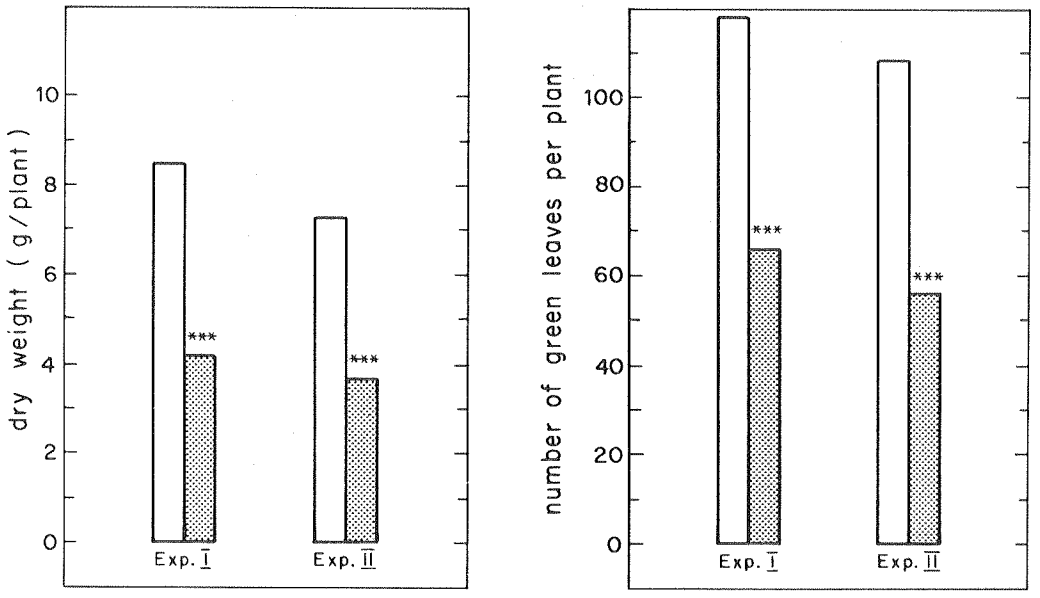

Fig. 1. (Left) Effect of *Puccinia expansa* Link on dry weight of *Senecio jacobaea* L.; plants harvested approximately 80 days after seed (first harvest). Means based on 15 plants. ***, significant at $P < 0.01$; *, significant at $P < 0.10$; n.s., not significant; ☐ control; ▒ treatment.

Fig. 2. (Right) Effect of *Puccinia expansa* Link on number of assimilating leaves of *Senecio jacobaea* L.; plants harvested approximately 80 days after seed (first harvest). Means based on 15 plants (see Fig. 1).

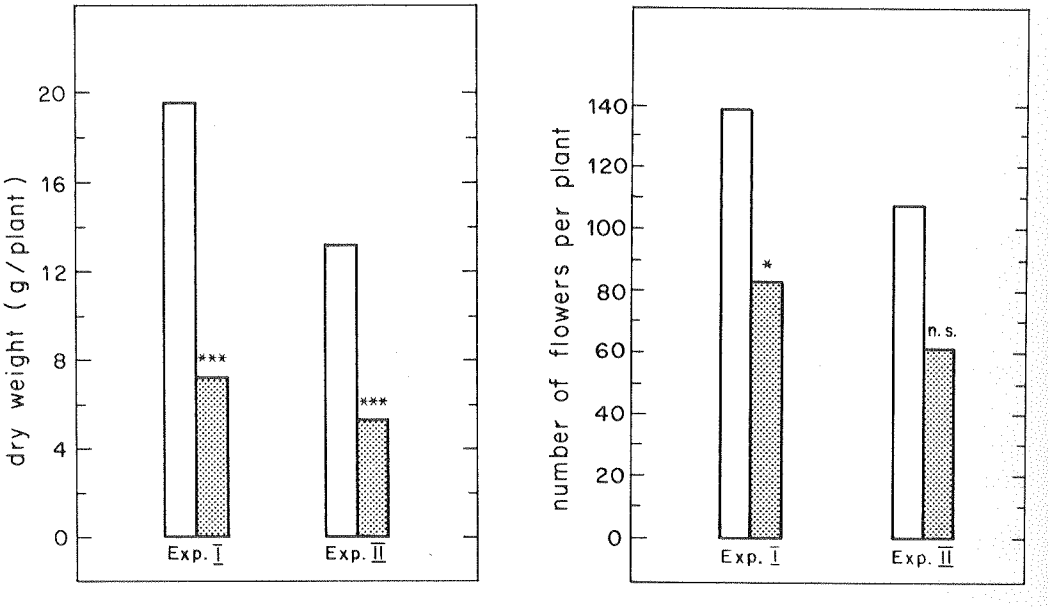

Fig. 3. (Left) Effect of *Puccinia expansa* Link on dry weight of *Senecio jacobaea* L.; plants harvested approximately 110 days after seed (second harvest). Means based on 15 plants (see Fig. 1).

Fig. 4. (Right) Effect of *Puccinia expansa* Link on number of flowers/plant (*Senecio jacobaea* L.); plants harvested approximately 110 days after seed (second harvest). Means based on 15 plants (see Fig. 1).

S. jacobaea is normally a biennial plant (Harper and Wood 1957). Therefore, in the greenhouse not all plants had formed flowering stems and flowers by the second harvest, resulting in several values of zero. For this reason the standard deviation of the values was too high, and thus reduction of number of flowers/plant not statistically significant.

Loss of dry weight described in this paper is similar to that observed by other authors working with fungal pathogens or insects. Hasan (1974) showed that in field experiments the rust fungus *Puccinia xanthii* Schw. reduced dry weight of *Xanthium strumarium* L. (Compositae) by 37%. Schmidl (1972*b*) found that in field experiments the cinnabar moth *Tyria jacobaeae* L. (= *Callimorpha jacobaeae* L.) (Lepidoptera: Arctiidae) reduced dry weight of *S. jacobaea* by 58%, and number of flowers by 64%. *T. jacobaeae* has already been successfully used as a biocontrol agent in Oregon (Isaacson 1978).

Table 2. Reduction of dry weight, number of green leaves and flowers/plant of *Senecio jacobaea* L. due to infection by *Puccinia expansa* Link, expressed in percent of healthy plants. Means based on 15 plants.

	Harvest 1: 80 days after seed			Harvest 2: 110 days after seed		
	Experiment					
	I	II	*	I	II	*
Dry weight (g)	49.8%	49.9%	50%	63.1%	60.5%	62%
No. of green leaves/plant	43.9%	48.2%	46%	—	—	—
No. flowers/plant	—	—	—	40.7%	43.3%	42%

* Average of both experiments.

According to Schmidl (1981), successful biological control of a weed usually requires a number of interacting organisms. Besides *P. expansa*, he also mentions the insects *T. jacobaeae* and *Longitarsus jacobaeae* (Waterhouse) (Coleoptera: Chrysomelidae) for ragwort control.

The results of this paper show that *P. expansa* has good control potential in the greenhouse, but further experiments under field conditions are necessary.

Acknowledgments

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