INTERACTIONS BETWEEN ESTABLISHING NODDING THISTLE AND PASTURE SEEDLINGS

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SUMMARY

Mixture experiments in greenhouse conditions were used to investigate interactions of nodding thistle (*Carduus nutans*) seedlings with perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) seedlings. Ryegrass exerted a mild inhibitory effect on nodding thistle productivity but the weed exerted no detectable effect on ryegrass. White clover did not influence nodding thistle productivity, but nodding thistle exerted an inhibitory effect on white clover. It is concluded that any inhibition of nodding thistle seedlings that may occur in establishing ryegrass/white clover pasture is probably due to the effects of the ryegrass component.

INTRODUCTION

Interactions between nodding thistle and pasture species occur at most stages throughout their respective life cycles. Established continuous pasture is effective in inhibiting nodding thistle seedlings (Feldman *et al* 1968; Edmonds and Popay 1983), while established bolting and flowering nodding thistle plants are very effective in inhibiting pasture growth (Thompson *et al* 1987). However, little is known about the interactions that can occur between seedling thistles and pasture grasses and clovers, especially when these grasses and clovers are themselves establishing. The aim of this study was to assess the extent of interactions between nodding thistle seedlings and ryegrass and white clover seedlings using greenhouse mixture experiments (Law and Watkinson 1987; Connolly 1986).

MATERIALS AND METHODS

Two separate greenhouse experiments were conducted, one to investigate interactions between nodding thistle and Ellett perennial ryegrass (set up in July 1989) and the other to investigate interactions between nodding thistle and Pitau white clover (set up in September 1989). For each trial, 120 polystyrene trays, measuring 332 x 202 x 85 mm deep, were set up and six replicates of 10 plant mixtures were planted. Two total densities were used, i.e. 30 or 60 seedlings/tray for perennial ryegrass/nodding thistle mixtures and 40 or 80 seedlings/tray for white clover/nodding thistle mixtures. The rate of 60 ryegrass seeds and 40 clover seeds is equivalent to the field sowing rates of 15 kg/ha and 3 kg/ha respectively. Within each total density the following proportions of seedlings were used — 100:0 (ryegrass or clover monoculture), 75:25, 50:50, 25:75 and 0:100 (nodding thistle monoculture). The planting arrangement consisted of alternating species.

The soil used for all experiments was a Horotiu sandy loam with a pH of 5.7 and 9.1% organic C. Superphosphate at concentrations corresponding to a field rate of 100 kg/ha was mixed into the soil before planting. Sufficient seeds to obtain the required densities were planted and seedlings were thinned 2-3 weeks after planting where necessary. Nutrient solutions were applied to the soil weekly after seedling emergence at levels appropriate to the soil and plant species used (Smith *et al* 1983). All treatments were kept weed free and watered as necessary for optimal growth. The greenhouse was unheated with spring temperatures of 15 ± 5 °C and summer temperatures of 25 ± 5 °C.

Proc. 43rd N.Z. Weed and Pest Control Conf. 1990: 225-228

After 8-9 weeks growth all plants were harvested at ground level and the number of plants and total dry weight of each species present in each tray was recorded. The concentrations of foliar N, P, K, S, Mg and Ca were determined for each species at specific densities.

RESULTS AND DISCUSSION

The weight per individual ryegrass plant was typically higher in the mixtures containing nodding thistle than in the pure swards (Table 1). This indicates that individual nodding thistle seedlings did not inhibit productivity of ryegrass seedlings whereas other ryegrass seedlings did. Nodding thistle seedlings had a lower productivity per seedling in the mixtures than in pure stands, especially at the higher densities (60 seedlings per tray) where total plant pressure was more intense. This indicates the importance of interspecific effects exerted by the ryegrass plants in inhibiting nodding thistle productivity. Intraspecific effects were also noted for nodding thistle, because the monocultures containing 30 seedlings per tray resulted in a higher yield per plant than did those with 60 seedlings per tray. The degree of inhibition of nodding thistle by ryegrass was generally independent of the starting ratio of the two species. The calculated 'competitive balances' also favoured ryegrass regardless of the initial starting densities confirming that ryegrass seedlings are better competitors than nodding thistle seedlings.

TABLE 1: Dry weight (g/plant) of nodding thistle and ryegrass plants at two densities in pure swards and in mixtures.

	Total density = 30 plants/tray ryegrass:thistle					Total density = 60 plants/tray ryegrass:thistle					
	100:0	75:25	50:50	25:75	0:100	100:0	75:25	50:50	25:75	0:100	MSR
ryegrass	1.24b	1.30b	1.52a	1.69a		0.69e	0.83d	1.00c	1.23b		1.14
thistle		0.66b	0.74b	0.71b	1.10a		0.24d	0.34c	0.39c	0.65b	1.34
Competitive balance[1]		0.78*	0.47	0.64*			1.11*	0.99*	0.95*		
R.Y.T.[2]		0.96	1.12	1.01			0.99	1.05	0.95		

Within each row, numbers followed by different letters are significantly different at P = 0.05 (after applying minimum significant ratio test).

[1] Competitive balance is calculated according to Wilson (1988) and is 0 if both species are evenly matched, and increasingly positive or negative if ryegrass or nodding thistle respectively have the competitive advantage; *index is significantly different to 0 at P = 0.05.

[2] R.Y.T. is the relative yield total (De Wit and van den Bergh 1965). This index is 1.0 if both species use the same resources and above 1.0 if they use partially different resources. *index is significantly different to 1.0 at P = 0.05.

Visual observations (for both high and low total density) showed that where there were more ryegrass plants present than nodding thistle plants, the leaves of nodding thistle seedlings were etiolated. When the proportion was 50:50, although still etiolated, some leaves reached the top of the grass canopy and developed hard prickly tips. When the proportion of thistles exceeded ryegrass, the thistles were greener in colour and produced larger prickly leaves which were more visible at the top of the canopy but did not dominate the mixture. Thus although nodding thistle seedlings were inhibited by ryegrass seedlings they still persisted, grew and became established, and were therefore still potentially capable of completing their life cycle.

None of the calculated 'relative yield totals' were significantly different from 1.0, indicating that the two species were using the same resources (Wilson 1988). Attempts to determine the relative importance of the interspecific and intraspecific inhibitory effects through fitting inverse non-linear competition models to the data (Firbank and Watkinson 1985; Law and Watkinson 1987) were made, but lack of fit of these models

TABLE 2: Dry weight (g/plant) of nodding thistle and white clover plants at two densities in pure swards and in mixtures.

	Total density = 30 plants/tray white clover:thistle					Total density = 60 plants/tray white clover:thistle					
	100:0	75:25	50:50	25:75	0:100	100:0	75:25	50:50	25:75	0:100	MSR
clover	0.62a	0.50ab	0.41b	0.38b		0.42b	0.31bc	0.30c	0.27c		1.26
thistle		2.29a	1.42b	1.15b	1.04b		1.12b	0.72c	0.54c	0.54c	1.36
Competitive balance		-0.97*	-0.73*	-0.80*			-1.00*	-0.66*	-0.54		
R.Y.T.		1.24	1.12	1.10			1.09	1.09	1.04		

Legend as for Table 1; positive and negative competitive balance values indicate that white clover and nodding thistle respectively have the competitive advantage.

did not justify their use. The poor fit may have been overcome if a wider range of total densities was used.

In the clover/nodding thistle study, nodding thistle inhibited productivity of individual white clover plants at both densities (Table 2). Nodding thistle had lower productivity in the pure stand than in mixtures with clover, probably because intraspecific inhibition in nodding thistle was occurring.

Where the number of clover plants dominated the mixture, the thistles were large, healthy and visually unaffected, whereas the clover petioles became very elongated in order to reach the thistle canopy. Where thistles dominated the mixture, the clover seedlings were mostly smothered, and very few clover leaves reached the top of the canopy. These observations support the calculated 'competitive balances' which significantly favoured nodding thistle as the superior competitor over clover, except at the 75% thistle mixture (high total density) where intraspecific inhibitory effects were probably starting to occur.

The 'relative yield totals' were not significantly different from 1.0, making it unlikely that the two species were using different resources. As in the ryegrass/nodding thistle interaction study, attempts to fit inverse non-linear competition models to these data sets were unsuccessful.

In both experiments the nutrient content analysis of the foliar tissue indicated that, for each species, nutrient uptake was independent of whether monocultures or mixed cultures were used. Thus the interspecific effects which occurred were not due to restricted nutrient uptake. Competition may have been for light.

Successful pasture establishment is known to be effective in reducing the emergence and survival of nodding thistle seedlings (Popay and Thompson 1980; Edmonds and Popay 1983). The present study suggests that ryegrass is effective at inhibiting nodding thistle and it is probably the component of ryegrass/white clover pastures that is most responsible for inhibiting nodding thistle establishment. Whether these effects are due primarily to resource competition or allelopathic mechanisms is currently under investigation.

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REFERENCES

Connolly, J., 1986. On difficulties with replacement series methodology in mixture experiments. *J. Appl. Ecol. 23:* 125-137.

De Wit, C.T. and van den Bergh, J.P., 1965. Competition between herbage plants. *Netherlands J. Agric. Sci. 13:* 212-221.

Edmonds, D.K. and Popay, A.I., 1983. Effect of pasture competition on the survival and flowering of nodding thistle. *Proc. 36th N.Z. Weed and Pest Control Conf.:* 89-93.

Feldman, I., McCarty, M.K. and Scrifes, C.J., 1968. Ecology and control studies of musk thistle. *Weed Sci. 16:* 1-4.

Firbank, L.G. and Watkinson, A.R., 1985. On the analysis of competition within two species mixtures of plants. *J. Appl. Ecol. 22:* 503-517.

Law, R. and Watkinson, A.R., 1987. Response surface analysis of two-species competition: an experiment on *Phleum arenarium* and *Vulpia fasciculata. J. Ecol. 75:* 871-886.

Popay, A.I. and Thompson, A., 1980. Nodding thistle: its growth and control. *Ruakura Farmers Conf.:* 63-69.

Smith, G.S., Johnson, C.M. and Cornforth, I.S., 1983. Comparison of nutrient solutions for growth of plants in sand culture. *New Phytol. 94:* 537-548.

Thompson, A., Saunders, A.E. and Martin, P., 1987. The effect of nodding thistle (*Carduus nutans* L.) on pasture production. *Proc. 40th N.Z. Weed and Pest Control Conf.:* 222-225.

Wilson, J.B., 1988. Shoot competition and root competition. *J. Appl. Ecol. 25:* 279-296.