Allelopathy in annual grasses

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Introduction

Allelopathy is a process whereby plants provide themselves with a competitive advantage by putting phytotoxins into the near environment. These chemicals can be exuded from the roots, excreted in gaseous form or be breakdown products in leachate from the previous seasons residues.

The phenomenon is common in weeds and occurs to varying extent in crop and pasture species, both broadleaf and grass. It is a significant natural process but is one which is still poorly understood, particularly in respect of how we might manage it to take advantage of it or to minimize its deleterious effects.

Most work has focused on the allelopathic capability of plant residues, largely because it is easier to research but also because there are likely to be large effects where the impact is on germination and establishment of crops or pastures. Allelochemicals function in much the same way as growth regulators, being stimulatory at low concentrations and inhibitory at high concentrations (Figure 1).

Allelopathy in grasses

There is significant literature on the effect of grasses. In terms of graminaceous crops a selection of the literature is presented in Table 1.

In the case of Purvis *et al.* (1985), a significant finding was that wheat straw encouraged the germination of wild oats (*Avena* spp.).

Literature also exists describing pasture grass effects on the growth of associated species. Tall fescue (*Festuca arundinacea* Schreb.) has been implicated in affecting germination and seedling growth (Kochhar *et al.* 1980, Rice 1984, Peters and Zam 1981). Annual ryegrass (*Lolium rigidum* Gaudin) has been recorded as affecting wheat growth whilst Leigh *et al.* (1995) have shown the allelopathic effects of senesced phalaris leaves on the germination of subterranean clover.

Silvergrass

At Charles Sturt University, we have considered the role allelopathy plays in the competitiveness of vulpia (silvergrass, rat's tail fescue, *Vulpia* spp.) in crops and pastures of the winter rainfall areas of southern Australia. Regular reports are received that wheat and lupin crops are devastated in the presence of vulpia, usually as the result of direct drilling into carryover vulpia stubble.

The initial work (Pratley 1989) showed that wheat growth was affected by vulpia stubbles collected at sowing time. This contrasted with stubbles collected at seed set the previous December and in the following July. This inferred that the chemicals are soluble breakdown products. Pratley and Ingrey (1990) showed that the breakdown products could be obtained using ultraviolet light.

Subsequent work by An (unpublished data), funded by Grain Research and Development Corporation, established a methodology for bioassay of allelopathy using radicle length of wheat (cv. Vulcan) as the test. Some aspects of note were the strong correlations between:

- extract concentration and toxicity,
- extraction time and toxicity.

Milled material was more toxic than chopped residues. *Vulpia bromoides* (L.) Gray exhibited stronger allelopathy than *V. myuros* (L.) C.C. Gmel. Shoots were the most toxic and seeds the least.

Residue extracts in bioassay remained potent for 60 days after decomposition commenced, reaching a peak after 40 days. When mixed with soil, however, toxicity declined, with potency disappearing after three to four weeks.

Two components of the toxicity at germination were observed:

- germination delay,
- germination inhibition.

The relative magnitude of these components depended on the relative phytotoxicity of the residue extracts. With strong phytotoxicity, inhibition of germination was the dominating influence, whereas with weak phytotoxicity, germination delay was most important.

The outcomes of these investigations suggest the following practical consequences:

- dry autumns with a late season break at sowing time provide the greatest risk of allelopathy to germinating crops and pastures,
- the burden of allelopathic material needs to be reduced prior to the crop establishment period through removal or, where necessary, incorporation into the soil at least three weeks prior to sowing.

Analytical research by An (unpublished data) has revealed in excess of twenty compounds with allelopathic capability present in the leachate of vulpia. There was a general inverse relationship between potency of individual compounds and their concentration. Further, there were strong synergistic allelopathic effects in the combination of chemicals relative to their singular additive contributions.

Tolerance or susceptibility to vulpia allelopathy varies considerably between species. Our work has shown that cocksfoot, *V. myuros*, *V. bromoides*, subterranean clover, canola, medics and phalaris were relatively tolerant whereas lupins, barley, wheat and field peas were most

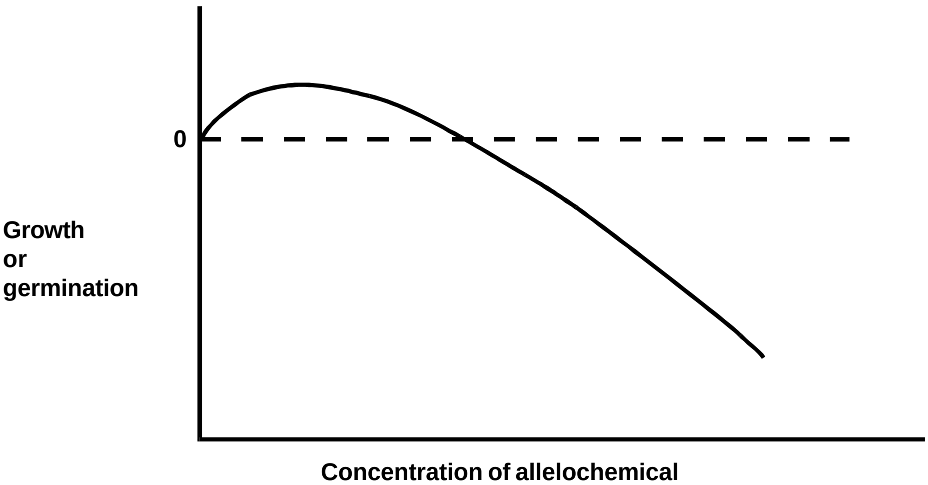

Figure 1. Theoretical plant response curve to allelochemical concentration.

Table 1. Graminaceous crops and their allelopathic effects.

Crop	Target species	Reference
Cereal rye	Lettuce, proso millet	Barnes and Putnam 1985
Wheat, oats	Corn, wheat, sorghum	Guenzi and McCalla 1962
Wheat	Wheat, oats	Kimber 1967
Rice	Rice	Chou and Lin 1976
Wheat, sorghum	Broadleaf vs. grass weeds	Purvis *et al.* 1985

Table 2. Susceptibility of wheat and subterranean clover cultivars to vulpia toxicity as measured by the inhibition index (An *et al*. 1996b).

	Sensitivity	Cultivar	Inhibition index[A]		
			Germination	Root	Overall[B]
Wheat	Tolerant	Ford	26.9 b	27.9 a	27.8 a
		Darter	6.4 a	36.6 b	32.2 ab
		Dollarbird	4.8 a	41.2 bc	35.9 b
		Rosella	1.5 a	44.2 bc	38.0 b
		Janz	4.1 a	48.1 cd	41.7 bc
	Sensitive	Vulcan	11.0 ab	53.5 d	47.3 c
Subterranean clover	Tolerant	Trikkala	9.0 a	9.3 a	9.3 a
		Seaton Park	15.8 a	31.2 b	28.9 b
		Karridale	9.0 a	34.7 bc	31.0 bc
		Clare	16.1 a	39.1 c	35.7 bc
		Woogenellup	16.1 a	39.3 c	35.9 bc
	Sensitive	Junee	12.8 a	41.9 c	37.6 c

[A] Means identified in the same column by the same letter are not significantly different at the 5% level, Duncan's new multiple-range test.
[B] Weighted average of germination and root inhibition indices. The weight is 14.6% for germination, 85.4% for root.

susceptible. It is important to record that most farmer inquiries relate to those species identified as being most susceptible.

There is also considerable variation between varieties in terms of susceptibility, as shown in Table 2 for wheat and subterranean clover.

Evidence suggests that there is an allelopathic effect from vegetative vulpia. Observations during pasture establishment (An *et al*. 1996a) showed that chemical spraying (using paraquat) released chemicals into the soil which interfered with establishment of direct drilled pasture species. In two years, subsequent regeneration of vulpia resulted in failure of pasture establishment. In year 3, the sprayed vulpia residue was incorporated by cultivation, with sowing taking place some three weeks later to enable decomposition to occur. Successful establishment of cocksfoot, phalaris and subterranean clover was achieved.

Another aspect worthy of consideration is the capability of vulpia residues to predispose associated plants to infection. Pratley (unpublished data) has observed the presence of substantial root rot in subterranean clover in the presence of vulpia whereas control pots without vulpia showed no overt symptoms of the disease.

In summary, there is no doubt that allelopathic effects are occurring in the field and are of sufficient magnitude to decimate crop establishment under the appropriate conditions. Such effects are likely to be spasmodic and vary in significance from year to year.

Acknowledgment

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