NFLUENCE OF TEMPERATURE ON THE ALLELOPATHIC POTENTIAL OF VULPIA RESIDUES

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Abstract The impact of environmental temperature on the phytotoxicity of vulpia residues was evaluated on the seedling growth of wheat (*Triticum aestivum* cv. Vulcan) and subterranean clover (*Trifolium subterraneum* cv. Junee). The aqueous extract of vulpia residues severely depressed the seedling growth of wheat and subclover. The extent of the inhibition depended upon the extract concentration and temperature regimes. Vulpia extracts exerted stronger phytotoxicity at both 15°C and 35°C than at 25°C . At 50% strength of vulpia extract, the inhibition was 72%, 46% and 84% at 15°C, 25°C and 35°C for wheat radicle growth, and was 77%, 13% and 35% at 15°C, 25°C and 35°C for the seedling growth of subclover, respectively. This study suggests that vulpia allelopathic activity could be enhanced by environmental temperatures.

INTRODUCTION

Silvergrasses (*Vulpia* spp.) have become important weeds of pasture and cereal crops in southern Australia (McIntyre and Whalley 1990). Recent research has shown that the allelopathic potential of vulpia residues can severely reduce the dry matter production of winter crops (Pratley and Ingrey 1990) and can lead to total failure of pasture establishment (An *et al.* 1996). The degree of phytotoxicity of vulpia residues appears to depend on factors such as the weathering status of residues, including ultraviolet light and moisture pretreatment of the residues (Pratley 1989; Pratley and Ingrey 1990), and the ratio of residues to soil (An *et al*. 1993)

Evidence has accumulated that the magnitude of allelopathic effects not only depends on the types of allelochemicals and their concentrations, but also on the associated growth environments, particularly stressful conditions (Einhellig 1995). So far, only a few studies have been done on the influence of environmental conditions on the allelopathic activity. The objective of the present study was to determine whether temperature variation affected the allelopathic activity of vulpia residues.

MATERIALS AND METHODS

The bioassay procedure described previously (An *et al*. 1997) was employed in the present study.

Test species and pre-germination Wheat (*Triticum aestivum* cv. Vulcan) and subterranean clover (*Trifolium subterraneum* cv. Junee) were used as test species for assessing the phytotoxicity of aqueous extracts of vulpia residues. Seeds of both species were pre-germinated at 25°C in the dark for 24 h for Vulcan wheat and 43 h for subclover.

Preparation of aqueous extract of vulpia residues Shoot residues of vulpia (*Vulpia myuros* L. Gmel) were collected from the field and oven-dried at 40°C for 72 h and then stored in dry conditions prior to the commencement of the experiments. The residues were ground in a Wiley mill to pass through a sieve of 0.1 mm. An aqueous extract was prepared by soaking 100 g of ground residues in a 2 L Erlenmeyer flask filled with 1000 mL of distilled water. The flask was sealed, wrapped with aluminium foil and incubated in the dark at 25°C for 4 days. The resulting mixture was filtered and squeezed through 4 layers of cheesecloth. The filtrate was further vacuum-filtered through Whatman #1 filter paper and collected in plastic jars (about 100 mL for each jar). This filtrate was expressed as the full strength (100%) of the aqueous extract of vulpia residues and placed in a storage freezer in preparation for the experiments.

Bioassays on seedling elongation A concentration series was made up from the 100% strength of vulpia extract into 100, 75, 50, 25, 12.5, 1, 0.01 and 0% (water control). Twenty pre-germinated seeds of each test species were uniformly selected and separately sown onto petri dishes (9 cm in diameter) lined with one layer of Whatman #1 filter paper. For each concentration, 5 mL of extract for wheat or 4 mL for subclover was added to each petri dish. Control treatments received distilled water only, 5 mL for wheat or 4 mL for subclover. The petri dishes were covered, wrapped with aluminium foil, and then maintained in dark incubators at desired temperature regimes. The petri dishes were arranged in a randomised complete block design with three replicates. Radicle and shoot length of wheat and mean seedling length (root + shoot) of subclover were recorded after the growth of the two species in incubators for 48 hours.

Environmental temperature regime settings After preliminary experiments, growth temperature of 25°C was selected for the optimal growth of both wheat and subclover. Temperatures 15 and 35°C were selected to monitor the growth of these two species under varied temperature conditions.

Statistical analysis Data were subjected to the analysis of variance and treatment means were tested separately with least significant difference (LSD) at 1% level of probability. The percentage of growth inhibition was calculated as (control data – treatment data)/ control data*100.

RESULTS

Allelopathic effects of aqueous extracts of vulpia residues on the growth of test species at optimal temperature The seedling growth of wheat cv. Vulcan and subclover cv. Junee was significantly inhibited by the aqueous extract of vulpia residues at 25°C (Figure. 1). Increasing strength of aqueous extract of vulpia residues linearly reduced the seedling growth of wheat, showing the characteristic growth response to extract concentrations. Coleoptile growth of wheat was less inhibited than radicle growth by the aqueous extract. The seedling growth of subclover was less affected by the vulpia extract in comparison with wheat growth.

Allelopathic effects of aqueous extracts of vulpia residues on the growth of test species at different temperatures Environmental temperature had significant impacts on the allelopathic activity of vulpia residues on the growth of wheat and subclover (Figure 2 and 3). The combined effect of temperature and vulpia extract was greater than either effect alone on the growth inhibition of the tested species. At an optimal temperature of 25°C , 85% strength of the aqueous extract of vulpia residues was required to achieve 67% inhibition on the radicle growth of wheat in comparison with water control, however only 12.5 to 25% strength of the vulpia extract was required to achieve the same level of growth inhibition at 15°C . In order to achieve 75% of growth inhibition on radicle length of wheat, about 94% strength of vulpia extract was required at 25°C and only 12.5% strength of the extract was needed at 35°C . At 50% strength of vulpia extract, the inhibition for the radicle growth of wheat was only 46% at 25°C, but 72% and 84% at 15°C and 35°C , respectively. Similarly, 67% strength of the aqueous extract of vulpia residues was required to obtain 24% inhibition on the seedling growth of subclover at 25°C , however only 12.5% strength of the extract was sufficient to reach the same level of growth inhibition at 35°C . At 50% strength of vulpia extract, the inhibition for the seedling growth of subclover was only 13% at 25°C , but 77% and 35% at 15°C and 35°C , respectively.

DISCUSSION

This study showed that allelopathic activity could be affected by environmental temperatures. Steinsiek *et al*. (1982) found that the allelopathic potential of aqueous extract of wheat (*Triticum aestivum*) straw was more severe on the inhibition of germination and growth of selected weed species at 35°C than at 25°C or 30°C . Einhellig and Echrich (1984) claimed that grain sorghum (*Sorghum bicolor*) and soybean (*Glycine max*) were more susceptible to ferulic acid when they were grown at higher temperatures. Stamp and Osier (1997) also reported that the allelopathic inhibition of chlorogenic acid or tomatine was greater at 26/ 22°C (day/night) than at 26/14°C on the growth of an insect herbivore, *Manduca sexta* (L.).

In nature, plants are regularly subjected to many biotic and abiotic conditions that are less than optimal. Temperature, moisture, nutrient, disease and herbicide stresses are common and these stresses may collectively regulate the allelopathic activities in the field. Such stresses play dual roles in regulating the allelopathic activity. On one hand, donor plants under stressful conditions usually increase the production and exudation of secondary metabolites (Tang *et al*. 1995), thereby resulting in higher concentrations of allelochemicals in the growth environment. On the other hand, receiver plants under stressful conditions are more vulnerable and sensitive to the allelochemicals (Einhellig 1989). Thus, the active concentrations of allelochemicals for growth inhibition will be lower than normally expected. Hence, the joint effect of allelopathic activity with environmental stresses could be the ultimate determinant for the degree of phytotoxicity imposed on the receiver plants.

Temperature, water and acid stresses are common in current farming conditions in Australia. In the field, wheat and subclover would experience temperature of 15°C or low on a regular basis and hence the allelopathic effects of vulpia during winter would be enhanced. Crop plants under stressful conditions are more vulnerable to allelochemicals derived from vulpia

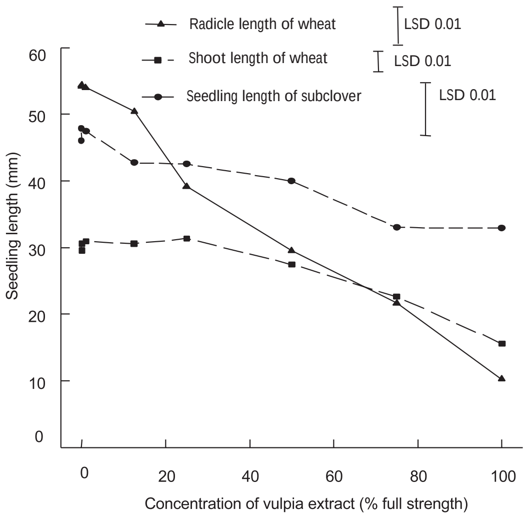

Figure 1. Dose response of test species to the aqueous extract of vulpia residues at 25°C

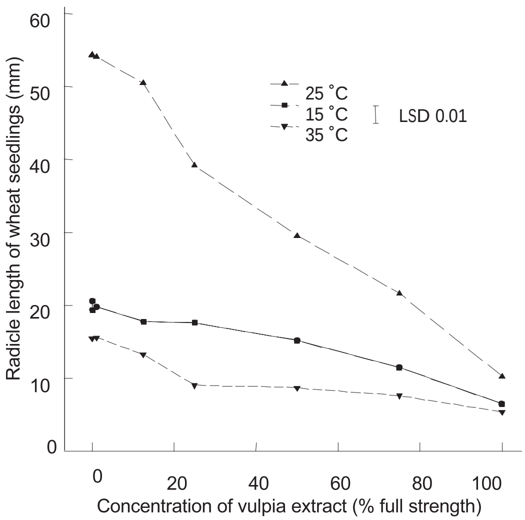

Figure 2. Characteristic responses of wheat seedlings to aqueous extracts of vulpia residues at different temperature regimes

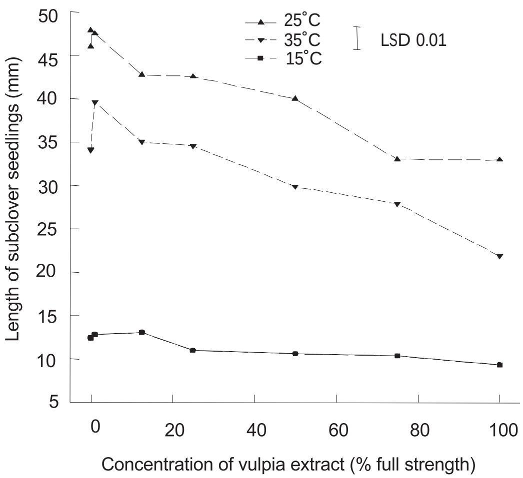

Figure 3. Characteristic responses of subclover seeds to the aqueous extracts of vulpia residues at different temperatures

than those grown in normal environments. Various environmental stresses may augment the allelopathic effects of vulpia on the growth of cereal crops and other pasture species.

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