## Weed interference in soybean (*Glycine max*)

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### Abstract

The interactions of 3 cultivars of soybean (Banjalong, Melrose and Valiant) with Powell's amaranth (Amaranthus powellii), paspalum (Paspalum dilatatum) and nutgrass (Cyperus rotundus) was studied using different systems. A glasshouse experiment was conducted to determine soybean response towards weeds at different density levels. Hydroponic culture was included to study the allelopathic effects of the weed extracts on soybean root growth and nodulation. A respirometer was used to study the response of soybean respiration to the weed extracts.

We found that varietal differences occurred in response to different weed species. Weed extracts significantly increased respiration rate ($P<0.01$). All weeds tested reduced soybean growth by the reduction of relative growth rate (RGR), net assimilation rate (NAR) and fresh weight-dry weight ratio (FWR). Weed extracts markedly reduced soybean nodulation and biomass production. Powell's amaranth was the most allelopathic weed species and Melrose and Banjalong were the most tolerant cultivars towards weed interference under experimental conditions.

### Keywords

Allelopathy, germination, nodulation, growth analysis, respiration

### Introduction

Soybean may interact with its neighboring plants either through resource competition or allelopathy and the combinations of both mechanisms. It is important to evaluate the relative contribution of each of the two mechanisms in most of the studies in plant interference (4). Allelopathy, also known as biochemical interactions among plants, describes any direct or indirect (harmful or beneficial) effect of a plant, including microbes, on another plant through the release of chemicals that escape into the environment (5). Allelochemicals from weeds may affect different physiological process in plants such as photosynthesis, respiration, cell division and nutrient uptake (5). There is a lack of information and understanding on the allelopathic physiological activities of Powell's amaranth, nutgrass and paspalum on soybean. The work reported here describes some physiological activities of these weeds on different cultivars of soybean.

### Methods

*Weed extract preparation*

Whole fresh weed material, both underground and aerial parts, were cut into 3 cm portions and soaked in distilled water for 24 hours at room temperature. The extract was then filtered through No. 1 Whatmann filter paper. For all experiments, soybean seeds were surface sterilized by immersing them in 70% aqueous ethanol solution for 1 minute and were then soaked in 1% of NaOCl solution for 15 minutes.

*Resource competition*

This experiment was conducted in a glasshouse from September to December 2000 with day/night temperatures of 32?C/20?C and natural light. Soybean, one plant pot$^{-1}$, was grown with either Powell's amaranth, nutgrass or paspalum at densities of 0, 2 and 10 plant(s) pot $^{-1}$, respectively. Each pot had 5 kg of soil mixture (soil : sand : peat moss = 3:2:1) with pH of 6.8. Nutricote™ fertilizer (N:P:K = 16:4.4:8.3) at 4 g pot $^{-1}$ was applied two weeks after planting (WAP). One week later and every other two weeks thereafter 0.8 g/L (w/v) Aquasol™ fertilizer (N:P:K=23:4:18) was applied at 250 mL pot$^{-1}$. After flowering, the rate of Aquasol™ was increased to 4 g/L. The experimental units were arranged in a randomized complete block design with 4 replicates. Sampling for growth analysis was taken at 3 and 4 WAP. Growth analysis calculations followed the formulas of Hunt (3).

*Hydroponic experiment*

The cultivar Melrose was used in this experiment having 4 treatments and 3 replicates arranged in a randomized complete block design. The treatments were extracts of weeds at 10% (v/v of extract) and the control. One seven-day-old soybean seedling was transferred into a one litre container filled with a modified, minus-nitrogen Hoagland's nutrient solution (2,6). For the first 15 days, the nutrient solution was supplemented with 2 mM urea. The pH of the solution was adjusted to 6.5 and the solution was aerated with air bubbles. The plants were kept in the growth cabinet with 14 hours of light and day/night temperatures of 28?C/20?C. Two sets of experiments were prepared. The first was for growth analysis and chlorophyll content determination (1) and the second was for observation of root growth and nodulation and the plants were harvested 3 weeks after the setting of the experiment.

*Respiration experiment*

Five seeds of soybean were placed in a small Petri dish and moistened with 5 mL of either 25% (w/v) weed extract or distilled water and placed in a respirometer pot. The respirometer system (Respicond$^{?}$, Sweden) used $CO_2$ evolution rate as a measure of seed respiration. In this apparatus, $CO_2$ evolution during seed respiration is absorbed by KOH and the lowering of conductivity in KOH is measured electronically. Seed respiration was measured over 4 days and was calculated as mg $CO_2$ hr$^{-1}$ for five seeds. This experiment was aimed at studying the respiration rate of germinating soybean cultivars Banjalong, Melrose, and Valiant towards the extracts of Powell's amaranth, nutgrass, and paspalum.

**Results**

*Resource competition*

All weed species at all densities reduced soybean growth and seed weight (P<0.001) (Table 1). Regardless of soybean cultivars, Powell's amaranth at 2 plants pot$^{-1}$ reduced 58, 70 and 38% of RGR, NAR and FWR, respectively and 64% of seed weight. There was no significant interaction between soybean cultivars and weeds on seed weight. Melrose produced higher seed weight (40.5 g plant$^{-1}$) than other cultivars (27.9 g plant$^{-1}$ for Banjalong and 30.26 g plant$^{-1}$ for Valiant) (data meaned across weed treatments). Powell's amaranth caused a reduction in vegetative growth causing low seed weight yields in all cultivars. Maximum reduction in seed weight (72%) occurred in the presence of Powell's amaranth at density of 10 plants pot$^{-1}$ whilst minimum reduction (42%) was observed in soybean grown in association with 2 plants pot$^{-1}$ of nutgrass. There was significant difference between cultivars (P<0.001) indicating a difference in competitive ability between cultivars towards the weeds.

*Hydroponic experiment*

Weed extracts had significant effects on chlorophyll content (P<0.05). Powell's amaranth reduced the chlorophyll content by 17.24% of the control treatment. Powell's amaranth also reduced biomass production as indicated by a 54.5% dry weight reduction (Table 2). All weed treatments significantly reduced dry weight of soybean cv. Melrose. Soybean receiving nutgrass extract had the lowest plant dry weight in this experiment because roots did not develop extensively (see Figures 1 and 2 for comparison). This may in part contribute to soybean response to allelopathic effects of nutgrass.

Significant differences (P=0.004) were also found in nodule dry weight (Table 2). Soybean from the control treatment group developed many small nodules along the roots in addition to the crown nodules. Other treatment groups, in contrast, only had crown nodules on their primary roots. All these data demonstrated the inhibiting effects of the weeds on the growth of soybean except for the chlorophyll content in response to nutgrass extracts.

*Respiration rate*

There were significant difference between cultivar (P=0.006) and weed extract (P=0.008) treatments. Melrose and Banjalong had higher respiratory activity than Valiant (Figure 3). Seeds in extracts of

**Table 1. Soybean growth and yield in response to different weed species**

| Cultivars | Weed density (plant(s) pot$^{-1}$) | RGR (week$^{-1}$) | NAR (mg cm$^{-2}$ week$^{-1}$) | FWR | Seed weight (g plant$^{-1}$) |
|---|---|---|---|---|---|
| Banjalong | Control | 1.66 $^{A\ a}$ | 13.25 $^{A\ a}$ | 8.63 $^{A\ a}$ | 56.92 $^{A\ a}$ |
| | Amaranth 2 | 0.35 $^{A\ b}$ | 2.25 $^{A\ ef}$ | 4.56 $^{A\ f}$ | 21.93 $^{AB\ bc}$ |
| | Amaranth 10 | 0.51 $^{A\ c}$ | 1.60 $^{A\ f}$ | 5.26 $^{A\ c}$ | 15.87 $^{AB\ c}$ |
| | Nutgrass 2 | 1.07 $^{A\ d}$ | 6.63 $^{A\ c}$ | 6.72 $^{A\ c}$ | 29.05 $^{B\ b}$ |
| | Nutgrass 10 | 0.69 $^{A\ c}$ | 3.27 $^{A\ de}$ | 6.51 $^{A\ cd}$ | 22.93 $^{C\ bc}$ |
| | Paspalum 2 | 1.27 $^{A\ f}$ | 6.93 $^{A\ b}$ | 6.43 $^{A\ d}$ | 24.59 $^{B\ b}$ |
| | Paspalum 10 | 0.69 $^{A\ c}$ | 4.27 $^{A\ d}$ | 7.28 $^{A\ b}$ | 24.53 $^{B\ b}$ |
| Melrose | Control | 1.34 $^{B\ a}$ | 6.55 $^{B\ a}$ | 8.16 $^{B\ a}$ | 64.71 $^{B\ a}$ |
| | Amaranth 2 | 0.86 $^{B\ b}$ | 3.35 $^{B\ d}$ | 5.33 $^{B\ f}$ | 29.36 $^{A\ c}$ |
| | Amaranth 10 | 0.88 $^{B\ b}$ | 5.17 $^{B\ b}$ | 5.67 $^{B\ c}$ | 22.81 $^{A\ c}$ |
| | Nutgrass 2 | 0.83 $^{B\ b}$ | 4.13 $^{B\ cd}$ | 7.44 $^{B\ c}$ | 44.09 $^{A\ b}$ |
| | Nutgrass 10 | 0.64 $^{A\ c}$ | 3.32 $^{A\ d}$ | 7.00 $^{B\ d}$ | 42.26 $^{A\ b}$ |

| | | | | | |
|---|---|---|---|---|---|
| | Paspalum 2 | $1.10^{\text{B d}}$ | $4.13^{\text{B cd}}$ | $7.78^{\text{B b}}$ | $39.31^{\text{A b}}$ |
| | Paspalum 10 | $0.65^{\text{A c}}$ | $4.77^{\text{A c}}$ | $5.36^{\text{Bf}}$ | $40.23^{\text{A b}}$ |
| Valiant | Control | $1.58^{\text{C a}}$ | $8.00^{\text{C a}}$ | $7.93^{\text{C a}}$ | $60.96^{\text{AB a}}$ |
| | Amaranth 2 | $0.73^{\text{A d}}$ | $2.80^{\text{A d}}$ | $5.52^{\text{B c}}$ | $15.36^{\text{B c}}$ |
| | Amaranth 10 | $0.54^{\text{A d}}$ | $2.23^{\text{A d}}$ | $5.18^{\text{A f}}$ | $13.92^{\text{B c}}$ |
| | Nutgrass 2 | $1.18^{\text{A b}}$ | $6.25^{\text{A b}}$ | $6.54^{\text{A c}}$ | $32.84^{\text{B b}}$ |
| | Nutgrass 10 | $1.08^{\text{B c}}$ | $4.57^{\text{B c}}$ | $6.08^{\text{C d}}$ | $30.82^{\text{B b}}$ |
| | Paspalum 2 | $1.31^{\text{A b}}$ | $6.73^{\text{A b}}$ | $7.31^{\text{C b}}$ | $29.33^{\text{B b}}$ |
| | Paspalum 10 | $0.52^{\text{B d}}$ | $2.65^{\text{B d}}$ | $5.39^{\text{B ef}}$ | $27.91^{\text{B b}}$ |

Values within the same column followed by same small letters are non significant within the same soybean cultivar. Values sharing the same capital letters are non significant between soybean cultivars for the corresponding treatment at 5% LSD.

**Figure 1. Roots of soybean, control**

**Figure 2. Roots of soybean + nutgrass extract**

nutgrass, paspalum and water had similar respiration rates. These treatments were all significantly lower than the seed respiration rate in Powell's amaranth extract (P=0.001) (Figure 4). There was no significant interaction between cultivar and extract treatments. The weeds tested interfered with the respiration of germinating soybean under the experimental conditions.

**Table 2. Soybean cv. Melrose response to weed extract in hydroponic experiment**

| Weed | Chlorophyll content | Plant dry weight | Nodule dry weight |
|---|---|---|---|
| | (g mg$^{-1}$ leaf) | ------- (mg plant$^{-1}$) ------- | |
| Amaranth | 0.24 a | 2518.1 a | 71.5 ab |
| Nutgrass | 0.37 b | 2314.7 a | 92.2 a |
| Paspalum | 0.26 a | 4055.5 b | 55.0 b |
| Control | 0.29 c | 5530.2 c | 246.7 c |

Values within the same column sharing the same letters are not significant at 5% LSD

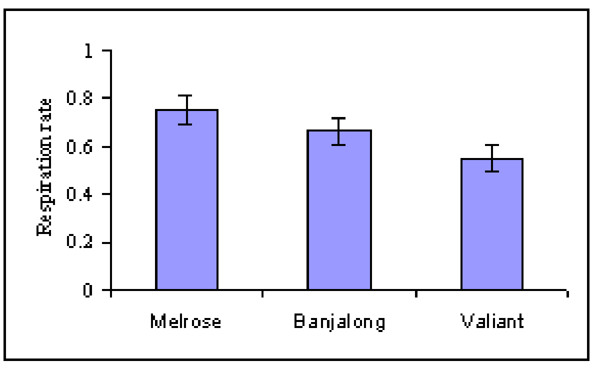


**Figure 3. Respiration (mg $CO_2$ hr$^{-1}$) of different cultivar of soybean. Error bars indicate standard error of means.**

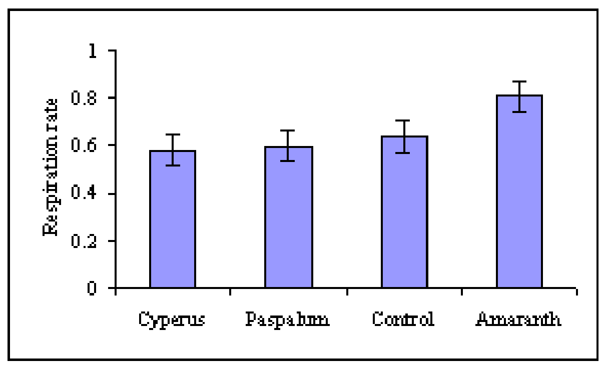


**Figure 4. Weed effect on soybean respiration (mg $CO_2$ hr$^{-1}$). Error bars indicate standard error of means.**

## Conclusions

All weed species studied here showed allelopathic effects on the growth and yield of soybean. *Amaranthus powellii* is the most allelopathic weed and Melrose and Banjalong are the most tolerant cultivars towards interference with the weeds tested. This suggests important soybean varietal differences in response to weeds; it further suggests that even in relatively low weed densities Powell's amaranth can severely affect soybean growth and yields. Consequently, Powell's amaranth should be given a high priority for control when soybean field is infested by Powell's amaranth, nutgrass and paspalum. Different physiological responses may in part explain some of the negative interference between weed species and soybean growth.

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