# Growth suppression by cover crops

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Many growing cover crops (CC) successfully suppress weeds. Weed control can be due to resource competition and/or allelopathy and is often associated to CC biomass development and subsequent shading, but for certain CC other factors might be implicated. We therefore studied the factors responsible for pigweed (*Amaranthus retroflexus)* growth suppression by different cover crops (CC).

## Is CC biomass negatively correlated with pigweed growth suppression?
## Is shading the primary mechanism of pigweed growth suppression by CC?

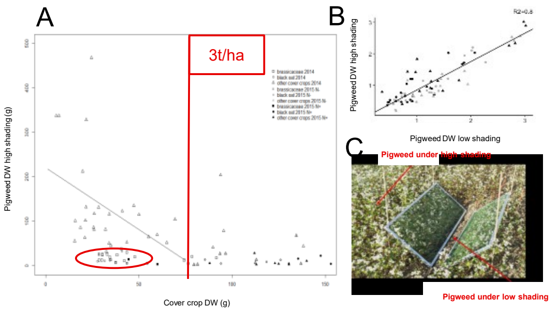


**Figure 1** Relationship between CC biomass and pigweed DW 55 days after sowing pigweed (DASP) under high shading (**A**). Linear regression is represented for CC with a biomass below 75g/0.25m² (adj-$R^2$=0.41) which corresponds to 3t/ha. Correlation between pigweed DW (high shading) and pigweed DW (low shading) (**B**). Each point represents one measure per subplot. Values of pigweed DW in mg/plant were log10 transformed. Pigweed DW was determined 31 and 55 DASP. PAR light interception (%) was measured 30 and 50 DASP. Experimental set-up for creating the two shading conditions in the field (**C**). Adapted from Gfeller et al, 2018a.

### Method

We examined the weed suppressive ability of 13 different CC on pigweed under high and low shading (figure 1C) in the field (Nyon, Switzerland) in 2014 and 2015.

### Results

- Below 3 t/ha of CC biomass, pigweed growth suppression was negatively correlated with CC biomass (figure 1A).
- Brassicaceae and black oat effectively controlled pigweed even with a low biomass (figure 1A).
- CC strongly suppressed pigweed growth through mechanisms independent from shading (figure 1B).

## Can we infer that the observed growth suppressive effects are due to allelopathy?

### Experiment 1

In order to study growth repressive root interactions in the absence of competition for light, nutrients, water and space a pot experiment was conducted under controlled conditions.

### Method

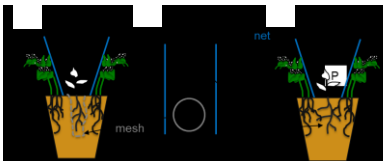


**Figure 2** CC were grown on the two outer sides of each pot. In the center 3 pigweed plants (P) were grown under complete interaction with CC plants and 3 within a mesh. 2 nets to push aside CC foliage were placed between the CC and P (net). Plants were regularly watered with a nutrient solution.

### Results

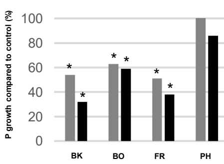


**Figure 3** Effect of root interactions with CC on pigweed growth. Pigweed was grown for 28 days (d) in the phytotron. Four CC were tested: buckwheat (*Fagopyrum esculentum*, BK), black oat (*Avena strigosa* BO), forage radish (*Raphanus sativus* var. *longipinnatus*, FR) and phacelia (*Phacelia tanacetifolia*, PH). Comparisons were made between two growth conditions: interactions between CC and pigweed with (■/interaction) and without (■/mesh) direct root interaction. Values (%) shown represent growth as compared to the control pots without CC. Values used for calculations are means of 10 replicates. Bars with an asterisk (*) are significantly different from the corresponding bare soil control ($p < 0.05$).

- Significant growth reduction ($p < 0.05$) of pigweed when grown with buckwheat, black oat and forage radish (figure 3).
- Phacelia showed no growth repressive effect on pigweed (figure 3).
- 68, 41 and 62% pigweed growth suppression by BK, BO and FR when roots were directly interacting in the soil and 46, 37 and 49 % when roots were separated by a mesh allowing movement of molecules between the two plant species but no direct root contact.

### Experiment 2

By considering the theory on costs of plant defense in stressful environments, predicting that costs should increase when competition is intense, we further hypothesized that buckwheat changes its root exudation profile in the presence of weeds in order to suppress their growth.

### Method

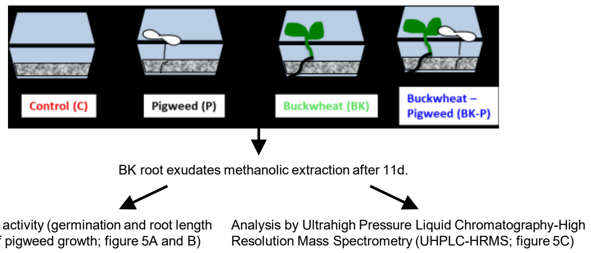


**Figure 4** Experimental set-up of the root exudate biological activity and metabolomic analysis: Root exudates were obtained from 11d old glass sand cultures of buckwheat (BK), pigweed (P), and a buckwheat/pigweed mixed culture (BK-P). Biological activity was tested by diluting root exudates to 1%. Whatman paper in a petri dish (12 cm x 12 cm) was humidified with 4 mL of diluted root exudates, measurements were performed after 5d on 24 pigweed seeds per petri dish.

### Results

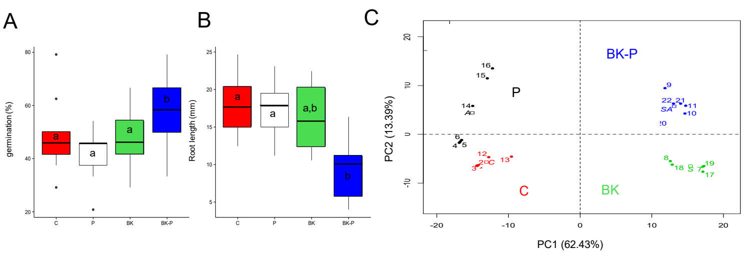


**Figure 5** Percentage germination of pigweed seeds (**A**) and root length (**B**) in petri dishes 5d after sowing (DAS) in the presence of root exudates obtained from 11 d old glass sand cultures of control boxes without plants (C), with pigweed (P), with buckwheat (BK) and with a buckwheat/pigweed mixed culture (BK-P). N=9, Tukey's HSD, P-value < 0.05. Principal component analysis (PCA) on descriptors obtained from the different root exudates from sand culture and separated by UHPLC-HRMS (**C**). Adapted from Gfeller et al, 2018b.

- Root exudate extracts from BK-P caused a higher germination rate for pigweed and strongly reduced pigweed root growth (figure 5A and B).
- In total, a list of 3506 different markers was generated after analysis of root exudate extracts by UHPLC-HRMS.
- Principal component analysis differentiated between the root exudation composition of the 4 experimental conditions (figure 5C).

## Conclusions

- Weed suppression by cover crops (CC) is not always related with a high CC biomass development.
- With two shading levels, pigweed biomass was similar, demonstrating that light interception by CC was not the primary mechanism responsible for pigweed growth suppression.
- Below a threshold of 3 t/ha of CC biomass, pigweed growth suppression was negatively correlated with CC biomass.
- Brassicaceae and black oat did not follow this relation and effectively controlled pigweed even with a low biomass.
- Allelopathic root exudates can be studied independently from resource competition in soil.
- Forage radish, black oat and buckwheat suppressed pigweed growth by allelopathic root exudates.
- Buckwheat changed its root exudation profile after heterospecific neighbor recognition and induced pigweed root growth inhibition.

## References

Gfeller, A., et al. (2018). "Fagopyrum esculentum Alters Its Root Exudation after Amaranthus retroflexus Recognition and Suppresses Weed Growth." Frontiers in Plant Science **9**(50).
Gfeller, A., et al. (2018). "Explanations for Amaranthus retroflexus growth suppression by cover crops." Crop Protection **104**: 11-20.