

Using Essential Oils as Sprout Inhibitors and Their Effects on Potato Seed Tubers Performance

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Introduction

Increasing concerns regarding the safety and environmental impact of traditional sprout inhibitors, such as chlorophoram, (Kleinkopf *et al.*, 2003) has stimulated interest in finding alternate sprout inhibitors, including essential oils.

Objectives: a) examine the impact of dose and duration of dill weed, spearmint and clove (Bio-C[®]) essential oil treatment on potato sprout growth; b) evaluate the yield potential of seed tubers when treated with essential oils.

Materials and Methods

Dose and Duration Effects

The Dose Effect: dill weed and spearmint oil was applied as a vapor to non-dormant 'Russet Burbank' tubers in 1-L jars at 0, 0.5, 5, 15, 50 and 200 mg/L airspace. The tubers were ventilated 4 days after the treatment applied. Sprout measurements were taken after tubers were stored at room temperature for 29 days.

The Duration Test: non-dormant 'Piccolo' tubers were treated with one application of dill weed, spearmint and Bio-C[®] at 0, 15, 30, 60, 120 and 200 mg/L airspace in 1-L jars at 10°C in the dark. All tubers were stored for 19 weeks and ventilated every 7 days (Figure 1A). Sprouting time was visually evaluated daily and the weight was measured at the end of 19 weeks.

The content of the active compound, carvone, in dill weed oil and spearmint oil were determined by GC analysis.

Seed Tuber Performance

Seed tubers were planted in 1-L pots in a growth chamber after being treated with any one of the 3 types of essential oils at 0, 15, 30, 60, 120 and 200 mg/L airspace for 7 days. Growing conditions were set at: 13 hrs photo period, 23/18°C day/night temperature, 240 μmol*m⁻²*s⁻¹ PAR, weekly fertilization at 250 mg/L with 20:20:20. Harvest was conducted 100 days after planting.

Results

Dose and Duration Effects

After treatment, necrosis occurred on the emerging bud tissue and the surrounding region under high doses of essential oils (Figures 1B and C).



Figure 1A. 'Piccolo' tubers in 1-L jars being ventilated; B. comparison of emerging sprouts of control tubers and the necrosis on tubers treated with 120 mg/mL Bio-C[®] for 7 days; C. necrosis on tubers treated with 240 mg/mL dill weed oil for 6 weeks.

A dose response analysis, using a log-logistic model (Eq. 1, Seefeldt *et al.*, 1995), showed that a dose of 32.5 mg/L airspace for dill weed oil and 21.5 mg/L airspace for spearmint oil would produce a 50% reduction in sprout growth within 29 days treatment period after dormancy break.

$$y = f(x) = C + \frac{D - C}{1 + (x / I_{50})^b} = C + \frac{D - C}{1 + \exp[b(\log(x) - \log(I_{50}))]} \quad (\text{Eq. 1})$$

Equation 1. Log-logistic non-linear regression model for dose analysis, where C = lower limit (i.e. the sprout growth mean of the highest dose); D = upper limit (i.e. the sprout growth mean of the control); b = the slope; I₅₀ = the dose giving 50% response (i.e. the dose results in 50% of sprout growth reduction).

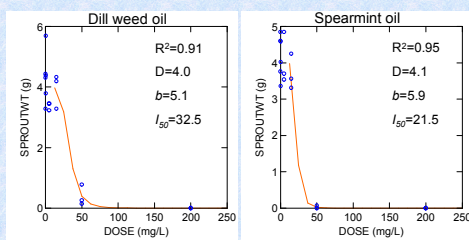


Figure 2. Dose response analysis curves of 'Russet Burbank' tuber sprout weight responding to essential oil treatments.

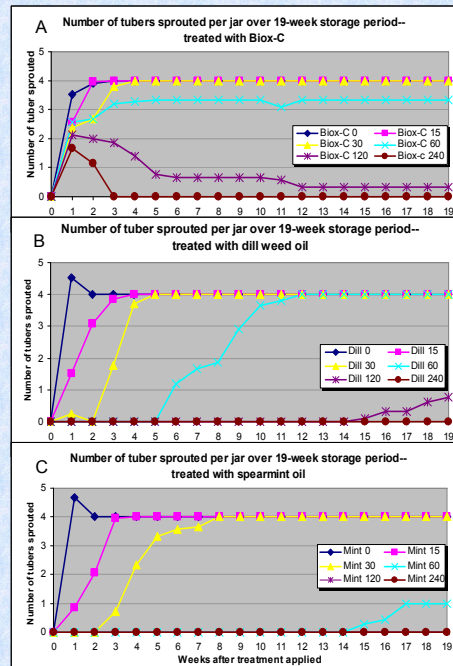


Figure 3. Time of sprouting of tubers treated with different essential oils at various doses.

Most tubers treated with Bio-C[®] sprouted within the first week. However, due to the necrosis of the newly emerging sprouts on tubers treated with 120 or 240 mg/mL of Bio-C[®], the numbers of sprouted tubers decreased in the following weeks (Figure 3 A). The major active compound in Bio-C[®] is eugenol (Kleinkopf and Frazier, 2002), and the delayed effect of Bio-C[®] may have an association with its slow evaporation rate based on visual observations.

With a single application, dill weed and spearmint oils suppressed sprouting effectively for at least 5 weeks when the treatments were higher than 30 mg/mL (Figs. B, C). The difference in the duration of suppression between these two essential oils could largely be due to the content of the effective compound carvone (30.5% by weight in dill weed oil and 82.3% in spearmint oil).

Seed Tuber Performance

The essential oil treatments, especially at high doses, delayed the emergence (data not showing); however, the tuber yield were not significantly different from the control (Table 2).

Table 2. The mixed model RCBD analysis of the essential oil (E.O.) and dose effects on the total weight and the number of 'Piccolo' tubers produced per plant (p<0.05).

Effect	Degree of Freedom	Total Weight		Number of Tubers	
		F Value	Pr>F	F Value	Pr>F
E.O.	2	1.93	0.15	0.11	0.90
Dose	5	2.09	0.07	1.08	0.37
E.O. x Dose	10	0.87	0.56	1.33	0.22

Summary

- The doses of the essential oils have significant effect on suppressing sprout growth, but at levels <15 mg/mL the sprout suppression effect was not significant;
- After dormancy break, a dose of 32.5 mg/L airspace for dill weed oil and 21.5 mg/mL for spearmint oil would result in a 50% reduction in sprout growth over a period of one month in 'Russet Burbank' tubers;
- The duration of the sprout growth suppression is dependent on the dose and the essential oil applied;
- The 7 day essential oil treatments on 'Piccolo' seed tubers did not cause significant difference in tuber yields, although the seed emergence for treated tubers were delayed compared to control.

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