

MECHANISMS AND EFFICACY OF BRASSICACEAE SEED MEAL-INDUCED DISEASE CONTROL

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Development and application of non-fumigant measures for the control of soilborne diseases in field level production systems is limited by the capacity to consistently predict efficacy. Although organic amendments have repeatedly been evaluated for the potential to provide an environmentally sustainable means to manage soilborne diseases, adoption of such methods has been limited to very specific environments, such as greenhouse systems, or specific soils. In many instances, failure to resolve the source of variability in efficacy stems in part from an absence of knowledge concerning the operative mechanism of disease control. Effective application of compost amendments experience further difficulties as rates of 5-20% (vol/vol) or higher are commonly required to achieve disease control even in non-complex environments such as containerized production systems. Such rates may not be economically viable or physically practical in standard field production systems. In addition, often times the amendment suffers from a lack of consistent composition, and potentially mode of action. The inability to standardize composition and quality of compost products further obscures the capacity to reliably predict disease control performance.

In Washington, apple replant disease is incited by a biological consortium of fungal pathogens and plant parasitic nematodes. Effective employment of an individual organic amendment for control of such a diverse biological complex seems improbable. For sites lacking significant lesion nematode populations, *Brassica napus* seed meal provided significant control of replant disease in field trials, but required post-plant application of mefenoxam due to the stimulatory impact of the amendment on resident populations of *Pythium* spp. Given the breadth of glucosinolates produced by brassicaceae plant species and the corresponding biological activity of the resulting isothiocyanates, it is likely that an alternative seed meal exists which will not elicit the stimulatory effect on *Pythium* populations observed in response to *B. napus* seed meal amendment. Such a material would be of value in the management of this disease syndrome in organic production systems. Goals of the current study were to 1) investigate the ability of brassicaceae seed meal amendments, or combinations thereof, to suppress replant disease; 2) examine and assess whether disease control elicited via seed meals differed mechanistically; and 3) determine the temporal nature of disease control yielded through the use of *Brassica juncea* seed meal.

Irrespective of plant source, seed meal amendment significantly improved apple growth in all orchard soils evaluated in greenhouse trials, however relative differences in pathogen suppression were observed. All seed meals suppressed root infection by *Rhizoctonia solani* AG-5, though on occasion *Brassica juncea* seed meal generated a lower level of disease control relative to other seed meal types (Table 1). When introduction of the pathogen was delayed until 4-8 weeks post-seed meal amendment, disease suppression was associated with proliferation of resident *Streptomyces* spp. and not qualitative or quantitative attributes of seed meal glucosinolate content. Using the same experimental system, pasteurization of soil prior to

pathogen infestation abolished control of *R. solani* regardless of seed meal type (Table 1). However, in the case of *B. juncea* seed meal amendment, the mechanism of *R. solani* suppression varied in a temporal manner, initially being associated with the generation of allylisothiocyanate (Table 2) and not affected by soil pasteurization. Among those tested, only *B. juncea* seed meal did not stimulate populations of *Pythium* spp. resident to orchard soils and subsequent apple root infection (Table 3). When applied in combination, *B. juncea* seed meal had the capacity to suppress *Brassica napus* seed meal-induced stimulation of *Pythium* spp. populations and subsequent apple root infection (Table 4). Suppression of soil populations and root infestation by *Pratylenchus penetrans* was dependent upon seed meal type with only *B. juncea* providing sustained nematode control.

In the field, all seed meal treatments when used in conjunction with a post-plant mefenoxam soil drench improved initial growth and yield of Gala/M26 relative to the control, and was equivalent to growth attained in Telone-C17 fumigated soil (Fig. 1). When seed meals were used independently, only *Sinapis alba* seed meal provided a growth response equivalent to that achieved through soil fumigation. Although *B. juncea* seed meal amendment did not stimulate *Pythium* spp. soil populations or root infection, tree growth in these soils was dramatically enhanced by a mefenoxam soil drench. This appeared to be in response to suppression of root infection by *Phytophthora cambivora* and *Ph. megasperma*, pathogens detected in roots of every sampled tree from PGSM treated soil grown without mefenoxam.

Although preliminary in nature, the current and previous field studies demonstrate that brassicaceae seed meal amendments have promise as an alternative strategy for control of apple replant disease, and that disease control can be realized in a predictable manner. Seed meal was applied at a rate of 8-10 t ha⁻¹, which equates to an amount ranging from <1% to 25% of that recently used in the evaluation of composts in orchard and other field production systems. Seed meal sourced from the same *Brassica* species (*B. napus*) but different cultivars or of the same cultivar over multiple years has consistently provided the same level and spectrum of disease suppression. Although these seed meals operate in part through the resident soil microbial community, a similar spectrum of pathogen control was observed in all orchard soils examined. Likewise, populations of the proposed functional microbial group active in control of *R. solani*, resident streptomycetes, were consistently amplified in these studies regardless of orchard soil. Such consistency in product in terms of both content and activity, an attribute often lacking in organic amendments, may enhance adoption of its use in commercial production systems upon repeated demonstration of function in field trials.

Table 1. Effect of brassicaceae seed meal amendment on infection of ‘Gala’ seedling roots by *Rhizoctonia solani* AG-5 in native or pasteurized orchard soils artificially infested with the pathogen

	CV native soil ^z	WVC native soil	WVC pasteurized soil
Treatment ^y	% root infection	% root infection	% root infection
Control	32c	58c	81a
BnDE	14ab	8a	89a
BnAT	10ab	- ^w	-
SaIG	9a	14ab	91a
BjPG	16b	30b	96a

^zCV, Columbia View Experimental Orchard, Orondo; WVC, Wenatchee Valley College Research and Demonstration Orchard, E. Wenatchee.

^yBnDE=*Brassica napus* cv. Dwarf Essex; BnAT=*B. napus* cv. Athena; SaIG=*Sinapis alba* cv. IdaGold; BjPG=*Brassica juncea* cv. Pacific Gold.

^xMeans in a column followed by the same letter are not significantly different.

^w (-) indicates not determined.

Table 2. Effect incubation period between *Brassica juncea* seed meal amendment and pathogen introduction on infection of ‘Gala’ seedlings grown in Columbia View orchard soil artificially infested with *Rhizoctonia solani* AG-5

Treatment	<i>R. solani</i> infection frequency (%)
Control	79a ^z
<i>B. juncea</i> 0 h incubation	13b
<i>B. juncea</i> 24 h incubation	62a
<i>B. juncea</i> 4 wk incubation	28b

^zMeans in a column followed by the same letter are not significantly different.

Table 3. Effect of brassicaceae seed meal amendment on percent root infection by resident *Pythium* spp. for ‘Gala’ seedlings grown in replant orchard soils

Treatment ^y	CV ^z	GC	WVC
Control	12.5a ^x	13.0a	15.0a
BnDE	45.0b	43.5b	55.5b
BnAT	51.0b	68.5c	68.5bc
SaIG	49.5b	77.5c	78.0c
BjPG	7.0a	11.0a	20.5a

^z CV, Columbia View Experimental Orchard, Orondo; GC, commercial orchard, Manson; WVC, Wenatchee Valley College Orchard, E. Wenatchee.

^yBnDE=*Brassica napus* cv. Dwarf Essex; BnAT=*B. napus* cv. Athena; SaIG=*Sinapis alba* cv. IdaGold; BjPG=*Brassica juncea* cv. Pacific Gold.

^xMeans in a column followed by the same letter are not significantly different.

Table 4. Effect of *Brassica napus* cv. Dwarf Essex, *Brassica juncea* cv. Pacific Gold, and composite seed meal amendments on populations of *Pythium* spp. (propagules g soil⁻¹) recovered from replant orchard soils.

Treatment	CV orchard ^z				GC orchard			
	Day 0	Day 3	Day 7	Day 14	Day 0	Day 3	Day 7	Day 14
Control	25a ^y	25a	0a	75a	0a	50a	25a	25a
<i>B. napus</i>	25a	525b	400b	275b	0a	2425b	3500b	3525b
<i>B. juncea</i>	0 ^x a	0a	0a	0a	0a	0	50a	0a
<i>B. n+B.j.</i> 1:1	0a	0a	0a	0a	0a	125a	125a	25a
<i>B. n+B.j.</i> 1:2	0a	25a	0a	0a	0a	75a	0a	75a
<i>B. n+B.j.</i> 2:1	0a	75a	25a	25a	50a	50a	0a	150a

^zCV, Columbia View Experimental Orchard, Orondo; GC, commercial orchard, Manson.

^yMeans in a column followed by the same letter are not significantly different.

^xLimit of detection for any individual soil sample equals 100 propagules g soil⁻¹.

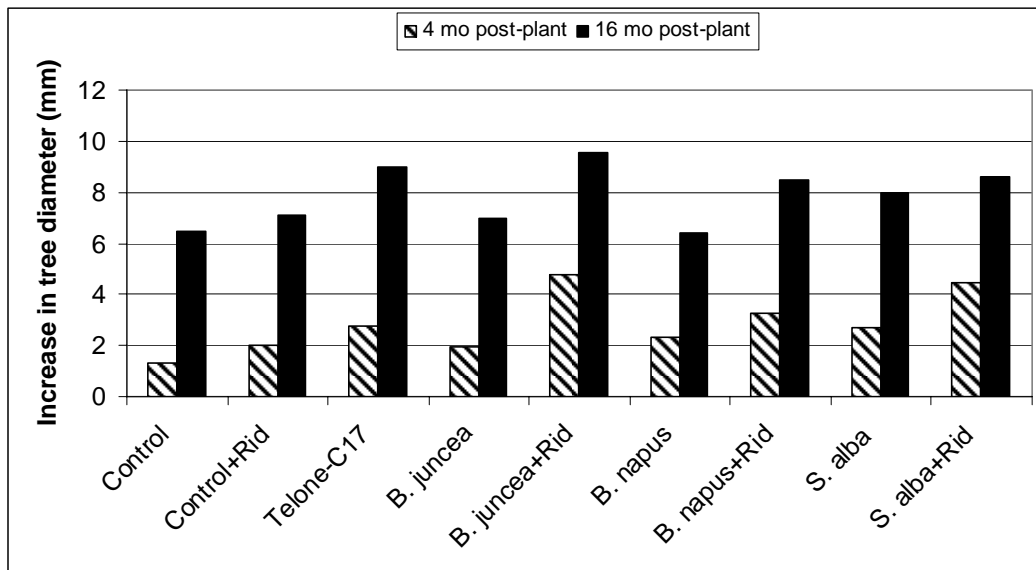


Fig. 1. Effect of brassicaceae seed meal treatments with or without post-plant Ridomil drench on increase in trunk diameter for Gala/M26 apple grown at CV orchard, Orondo, WA.