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Repellent Plants and Seed Treatments for Organic Vegetable Soybean Production

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ABSTRACT

The research was conducted to study the effect of repellent plants and seed treatments on growth and production of organically grown vegetable soybean. The experiment was carried out at Cikarawang Research Station, Bogor, from September 2005 to May 2006. The organic experiment was arranged in a split plot design using four species of companion plants as repellent plants, i.e. *Tagetes erecta*, *Cymbopogon nardus*, *Ocimum gratissimum*, *Tephrosia vogelii*, and without repellent plants as the main plot, and seed treatments i.e. galangal oil, *Pseudomonas fluorescens*, and without seed treatments as sub plot using 3 replications and conventional system (using pesticides) as control. Plants grown under conventional system had a greater fresh pod weight (6.7 kg. 10 m^{-2}) than those in organic system (4.80-5.79 kg. 10 m^{-2}), a lower insect infestation (19.17, 22.92 and 32.50%) and disease prevalence (9.17, 11.42 and 14.42%), at 6, 7 and 8 Week After Planting (WAP) respectively, than the organic system. In the organic experiment, the use of *O. gratissimum* as repellent plants resulted in a significantly lowest empty pod per plant (0.79 g). *T. erecta* and *O. gratissimum* without seed treatment, *P. fluorescens* without repellent plants, and *T. vogelii* with galangal oil seed treatment has the significant lowest insect infestation at 6 WAP of 20.67, 23.00, 26.67 and 27.33%, respectively. An organic system using repellent plants had a significantly lower insect infestation at 8 WAP (35.67-40.33%, *O. gratissimum* being the lowest) than without repellent plants (50.56%). Seed treatments on organic system had the lower disease prevalence at 8 WAP (33.87% on *P. fluorescens* and 35.47% on galangal oil) than without seed treatments (37.73%). Number of root nodules (11.6-16.7 to 7.8) and root nodules dry weight (0.068-0.101 to 0.040 g) of the organic system were greater than the conventional system. Soybean without repellent plants had a greater number of harvestable plants (137.3), but it was fewer than the conventional system (158.3).

Keywords: disease and pest control, seed treatments, organic vegetable soybean

INTRODUCTION

Soybean is an excellent source of protein, minerals and vitamines. Vegetable soybean consists of 13.60% protein, 3.34% sugar, 3.36% starch, 6.32% oil, 1.48% ash and 1.53% fiber (AVRDC, 1992). Vegetable soybean is usually consumed after boiling. Growing vegetable soybean in an organic farming system is preferable over the conventional method that uses pesticides since it will reduce the risk of pesticide residue accumulation in plant and soil.

The major constraints in organic farming in the tropics are pest and disease control. Previous studies on pest control using repellent plants and seed treatment demonstrated that repellent plants such as *Tagetes erecta, Cymbopogon nardus*, and spring onion, were effective in controlling some pests in organic soybean production (Kusheryani and Aziz, 2006). Tephrosine in the leaves, seeds and roots of *Tephrosia vogelii* function as insecticide (Lembaga Biologi Nasional, 1984). Some seed borne diseases can be controlled by seed treatment, such as *Pseudomonas fluorescens* (Dowling and O'Gara, 1994), and 0.4% galangal oil for damping off (Taufiq, 2004).

This research was aimed at studying the effect of repellent plants, i.e. *Tagetes erecta, Cymbopogon nardus, Ocimum gratissimum, Tephrosia vogelii,* and seed treatments, i.e. galangal oil and *Pseudomonas fluorescens,* on growth and production of organic vegetable soybean.

MATERIALS AND METHODS

The experiment was conducted from September 2005 to May 2006 at Cikarawang Research Station, Bogor with average rainfall of 138.3-434.2 mm $month^{-1}$ and latosol soil. Galangal oil and pure *P. fluorescens* culture from Plant Protection Department Clinic, Bogor Agricultural University, were used for seed treatment. The repellent plants used in this study were *T. erecta, C. nardus, O. gratissimum*, and *T. vogelii.* Wilis, as the soybean variety, were cultivated using green manure (25 kg ha^{-1} of *Centrosoma pubescens* and 10 ton ha^{-1} of chicken manure as nutrient source for *C. pubescens*), and 2 ton ha^{-1} of dolomite. The control was conventional system used 100 kg ha^{-1} of urea, 200 kg ha^{-1} of SP-36, and 150 kg ha^{-1} of KCl; and pesticides with bioactive

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agents of Carbofuran, Deltametrin, and Mankozeb to control pest and disease infestation.

The experiment was arranged in a split plot design with repellent plants as main plot, i.e. *T. erecta, C. nardus, O. gratissimum, T. vogelii*, and without repellent plants, and seed treatments as sub plots, i.e galangal oil, *Pseudomonas fluorescens*, and without seed treatments, with 3 replications. The conventional system (using synthetic pesticide) was used as control but the data were not included in the statistical analysis. The data that arranged in the split plot design was analyzed using ANOVA, and Duncan Multiple Range Test (DMRT) at 95% confidence level.

Plot size was 5 m x 2.5 m for organic farming (with one of the rows in the middle planted with a type repellent plant according to the treatment), and 5 m x 5 m for conventional system. Dolomite and chicken manure were applied at 2 weeks before planting *C. pubescens* as green manure. *C. pubescens* was harvested at 3 months after planting and left for decomposition in the soil for 2 months. Repellent plants were planted 2 months before soybean in the middle row and at the fringe of each plot, circling the whole plots.

Seed were soaked for 15 minutes in either 250 mL kg^{-1} of galangal oil seed mix with 0.1% Tween-80 as emulsifier; or in pure culture of *P. fluorescens* at 10^8 cfu mL^{-1} population.

The soybean planting space was 50 cm x 10 cm, with 2 seeds per hole. The soybean was harvested at 70 days after planting (DAP) when the pods are still green, and 2/3 of older leaves have already senescence (stage R_6-R_7).

Observation was conducted on number of plants per plot (10 m^2 as the plot harvest), plant height, number of branches, productive nodes, filled and empty pods, weight of roots nodules, fresh pod and seeds per plant, 100 seeds fresh and dry weight, and number of harvestable plants in 10 sample plants per plot. Insect infestation and disease prevalence were scored on 20 sample plants per plot. Level of damage on sample plants were calculated using a method developed by Sinaga (2003).

RESULTS AND DISCUSSION

Overall Condition

Soil pH (5.43) and CEC (14.41) were low and percent base saturation was high (48.16%). The soil was dry at the time *C. pubescens*, repellent plants and soybean planting. The average biomass weight of *C. pubescens* was 11.44 kg. 10 m^{-2}. In the early growth stages, the soybean was infected by *Aspergillus flavus.* The dry condition made the soybean was susceptible to pest and diseases such as *Oxya* sp. (grasshopper) and *Lamprosema indicata* (caterpilar) and rust (*Phakopsora pachyrrhizi*) and resulted in low number of plants per plot (52.31-65.19%). Therefore replanting was necessary and carried out at 1 Week After Planting (WAP). Soybean flowered at 5 WAP.

Results

Repellent plants affected plant height at 7 WAP, percentage of insect infested plants at 8 WAP, and the number of harvestable plants. Seed treatments decreased disease prevalence at 8 WAP. Interaction between repellent plants and seed treatments significantly affected percentage of insect infested plants at 6 WAP and empty pod weight per plant.

Plant heights in organic system were 22-27% and 11-21% shorter than the conventional system, whereas number of root nodules and dry weight of root nodules were 115-324% and 70-152% greater, and number of branches and number of productive nodes were 26-35% and 20-21% at 7 and 10 WAP, respectively. Variables in organic system were not affected by the treatments (Table 1). The lowest insect infestation at 6 WAP in organic system (Table 2) was found on *T. erecta* without seed treatments (20.67%) and the highest was found on the combination of *C. nardus* with *P. fluorescens* (34.33%) which had higher percentage of insect infested plants than in the conventional system (19.17%). Combination of repellent plants and seed treatments in the organic system was not effective in reducing insect infestation compared to the conventional system that used pesticides.

The percentage of insect infested plants in plots with repellent plants were lower than without repellent plants at 8 WAP (10.23-14.89%) (Table 3), whereas seed treatments reduced disease prevalence significantly at 8 WAP than without seed treatments (2.26 and 3.86%). Percentage of insect infested plants and disease prevalence increased with time both in conventional system and organic system, with conventional system were lower than the organic system. Percentage of insect infested plants at 6, 7, and 8 WAP in conventional system were 8-13, 9-18, 3-8% lower than the organic system, respectively. While disease prevalence at 6, 7, and 8 WAP in conventional system were 8-14, 10-19, 17-23%, respectively.

Planting *O. gratissimum* alone reduced the empty pod weight per plot considerably, much lower than other treatments, including the conventional system. Conventional system had a higher empty pod weight per plant than the organic system with the range between 25-275%.

Plots without repellent plants had a higher number of harvestable plants (137.33) in the organic system (Table 4), but lower than the conventional system (158.33). In the conventional system, the number of harvested plants, fresh pod weight per plant and fresh pod weight per plot were greater than those in the organic system (15-53, 103-144, and 15-39%, respectively).

Discussion

Soybean plants in plot with *C. nardus* as repellent plants were significantly taller than plants of other treatments

Table 1. Growth response of soybean to repellent plants and seed treatments

Treatments	Plant height (cm)		Number of root nodules	Dry weight of root nodules (g)	Number of branches	Number of productive nodes
	7 WAP	10 WAP				
Organic system						
Repellent plants						
T. erecta	43.57b	46.31	16.1	0.088	2.5	8.8
C. nardus	47.14a	50.20	14.6	0.101	2.3	9.1
O. gratissimum	42.68b	47.04	11.6	0.068	2.5	8.8
T. vogelii	43.64b	47.13	16.7	0.101	2.4	8.7
Without repellent plants	43.10b	48.94	13.4	0.097	2.6	9.4
Seed treatments						
Galangal oil	44.51	48.25	14.7	0.086	2.5	9.2
P. fluorescens	44.08	46.98	12.9	0.096	2.5	8.9
Without seed treatments	43.49	48.54	15.9	0.091	2.4	8.7
Conventional system	54.47	56.07	7.8	0.040	3.5	10.6

Note: Numbers followed by the same letter in the same columns are not significantly different based on DMRT at level α = 5%; WAP = Week After Planting

Table 2. Effect of repellent plants and seed treatments on percentage of insect infested plants at 6 WAP (%)

Treatments	Galangal Oil	*P. fluorescens*	Without seed treatments
Repellent plants			
T. erecta	28.67ab	33.33a	20.67bc
C. nardus	30.67ab	34.33a	33.00a
O. gratissimum	28.33ab	28.67ab	23.00bc
T. vogelii	27.33abc	29.67ab	29.33ab
Without repellent plants	31.67a	26.67abc	32.33a
Conventional system		19.17	

Note: Numbers followed by the same letter in the same rows and columns are not significantly different based on DMRT at level α = 5%

Table 3. Percentage insect infested plants and disease prevalence as affected by repellent plants and seed treatments[a)]

Treatments	Percentage of insect infested plants (%)			Disease prevalence (%)		
	6 WAP	7 WAP	8 WAP	6 WAP	7 WAP	8 WAP
Organic system						
Repellent plants						
T. erecta	27.56	35.11	37.67b	17.78	22.33	31.56
C. nardus	32.67	37.44	40.33b	19.44	24.78	35.89
O. gratissimum	26.67	32.78	35.67b	19.22	29.56	36.22
T. vogelii	28.78	35.11	38.11b	23.67	30.89	36.11
Without repellent plants	30.22	41.00	50.56a	22.11	27.00	38.67
Seed treatments						
Galangal oil	29.33	35.60	40.27	19.07	25.00	35.47b
P. fluorescens	30.53	37.73	41.07	21.07	28.93	33.87b
Without seed treatments	27.67	35.53	40.07	21.20	26.80	37.73a
Conventional system	19.17	22.92	32.50	9.17	11.42	14.42

Note: Numbers followed by the same letter in the same columns are not significantly different based on DMRT at level α = 5%; a) = data analysis on all numbers in the table used Arc Sin transformation; WAP = Week After Planting

(Table 1). *C. nardus* grew fast, because of prolific growth, and competed for light with soybean. Leaves of *C. nardus* created shading for soybean plants and resulted taller soybean plants than un-shaded plants (in other treatment).

The effectiveness of repellent plants on controlling insect infestation and disease prevalence varied with species, and affected the number of harvested plants. The number of plants per plot indicated the plants that survived until harvest and produced filled pod with the effectiveness of repellent plants in controlling insect infestation and disease prevalence. The effectiveness of *T. erecta*, *T. vogelli*, and without repellent plants were similar in controlling pest and disease as indicated by the number of harvested plant of each repellent treatment were 120.6, 122.1, and 137.3, respectively (Table 4). Seed growth percentage on plots without repellent plant was the lowest, but replanting made the plot had the highest number of plants per plot. At the other plots with repellent plants, *A. flavus* inocula might still be in the soil and affected the number of plants per plot and replanting could not make the population back to 100%. The other possibility of the low number of plants per plot was the negative influence of the repellent plants. Eartheasy (2010) reported that secretions from the roots of growing *T. erecta,* as one of the Compositae family, have an insecticidal effect on the soil, effective against nematodes and to some extent against keeled slugs. The flower petals also have nematicidal properties and can attract and harbor beneficial insects. When plantings are mixed with *T. erecta*, pests are less likely to spread throughout a crop.

In general, empty pod plant^{-1} was lower in organic system than in conventional system. The highest weight of empty pod plant^{-1} was from combination between without repellent plant and galangal oil (Table 5). On plots without repellent plants, insect infestation was higher on plant leaves, but there was no infestation on the pods. The high empty pod plant^{-1} was caused by low nutrient and leaf damages. Leaves damages caused by insect decreased the photosynthesis, then decreasing the photosynthate and in the end disturbed the seed development (Milthorpe and Moorby, 1974), so the seed filling process was disturbed, and increasing the empty pod weight.

Table 4. Effect of repellent plants and seed treatments on the number of harvested plants, fresh pod weight per plant and fresh pod weight per 10 m^2

Treatments	Number of harvested plants	Fresh pod weight	
		per plant (g)	per 10 m^2 (kg)
Organic system			
Repellent plants			
T. erecta	120.6ab	12.016	4.80
C. nardus	103.0b	14.467	5.79
O. gratissimum	114.8b	12.332	4.93
T. vogelii	122.1ab	12.226	4.89
Without repellent plants	137.3a	13.020	5.21
Seed treatments			
Galangal oil	120.7	12.943	5.18
P. fluorescens	117.7	12.380	4.95
Without seed treatments	120.2	13.113	5.25
Conventional system	158.3	29.42	6.70

Note: Numbers followed by the same letter in the same columns are not significantly different based on DMRT at level α = 5%

Table 5. Effect of repellent plants and seed treatments on empty pod weight per plant (g)

Treatments	Galangal oil	*P. fluorescens*	Without seed treatments
Repellent plants			
T. erecta	1.03cd	1.40bcd	1.52abcd
C. nardus	1.43bcd	1.08cd	1.20cd
O. gratissimum	1.68abcd	2.23ab	0.79d
T. vogelii	1.78abc	0.98cd	1.84abc
Without repellent plants	2.37a	1.11cd	2.15ab
Conventional system		2.97	

Note: Numbers followed by the same letter in the same rows and columns are not significantly different based on DMRT at level α = 5%

The lowest insect infestation at 6 WAP was found at combination of *T. erecta* as repellent plant and without seed treatment combination (Table 2). This finding is in line with Kusheryani and Aziz (2006), who reported that insect infestation on *T. erecta* as repellent plant was the lowest at 8 and 11 WAP (33.50 and 30.00%, respectively) on soybean planting. The insect infestation was also the lowest on *T. erecta* as repellent plant at 6 WAP (Table 3). Seed treatments galangal oil or *P. fluorescens* had little influence on insect infestation, but they were effective as fungal disease control.

Repellent plants significantly reduced insect infestation at 8 WAP, but the effects were insignificantly different between repellent plants treatments. The repellent plants secreted aromas disliked by the insect, or the leaves and/or flower color that disliked by the insect (Dadang, 1999), thus the insect repelled from the plant plots. On the other hand there is a possibility that repellent plants to be the habitat of natural enemies of the pest that can control the pest population naturally. Multiple cropping systems tend to have more diversity of natural enemies of the pest than monoculture (Reijntjes *et al.,* 1999). This is due to favorable conditions, such as the food and water availability on the specific times and places, as well as the availability of micro habitats for specific needs, such as soil protection for the predators at the nights.

Seed treatments reduced disease prevalence at 8 WAP. *P. fluorescens* resulted in the lowest disease prevalence, but it was not significantly different from those treated with galangal oil (Table 3). It is possible that roots colonization by *P. fluorescens* increased at 8 WAP, therefore increased the soybean tolerance to diseases. Plant can defend itself from plant pathogen through structural formation that hampered pathogen invasion and through biochemistry reaction inside the cell and plant tissues and toxic compound production (Agrios, 1997). The other possibilities that blocked pathogen invasion by bacteria are through (a) Fe (III) competition, (b) volatile compound production, (c) resistance inside the plant, and (d) roots colonization (Defago *et al.,* 1990). At 8 WAP there was a possibility of the increasing plant resistance to pathogen because *P. fluorescens* applied to soybean seeds.

At 6 and 7 WAP disease prevalence in plants seed-treated with galangal oil was lower than *P. fluorescens*, but at 8 WAP insignificantly higher than *P. fluorescens*. The condition probably caused by the decreasing antifungal activity of galangal oil with the increasing plant age. Peroxidase activities can be increased by galangal oil for 1 week after seed treatment, but after that the influence will decrease (Taufiq, 2004). One of the peroxidase functions is as an oxidative polymerization as the last enzymatic step in lignin biosynthesis involves oxidative polymerization of free radicals catalyzed by cell wall peroxidase in plants as observed in Arabidopsis (Ezaki *et al*., 2001). The increasing peroxidase on the cell wall made the plant resistance to the cell wall degradation enzymes produced by the pathogen, and in the end it will increase the plant resistance to the pathogen.

Rust caused by *Phakopsora pachyrhizi* was a major pathogen during experiment. Seed treatment method supposedly influenced the seed treatment efficacy. Seed treatment assumed to be effective to control soil-borne disease, but for shoot diseases, probably leaf treatment will be more effective.

Organic plots yields in the (4.81-5.79 kg plot^{-1}) were lower than those in the conventional plots (6.70 kg plot^{-1}); this might be related to the lower nutrient availability on the organic plots from manure and green manure applied to the organic plots. In addition, decomposition of these organic materials might still occur during the experiment and further reduced the nutrients availability for the soybean plants, as previously reported by Melati dan Andriyani (2005). The low CEC on the organic matter because of the incomplete decomposition process also caused the lower nutrient availability.

The conventional plots had higher soybean yields, yet it has the negative sides since the use of inorganic pesticides might potentially harm the environment and human health. On the other hand, even though yield in the organic plots was lower, growing organic soybean is still recommended, particularly due to the growing concerns on healthy vegetables and increasing demands for organic vegetables in Indonesia, particularly West Java.

CONCLUSIONS

Very general should be more spesific. The use of galangal oil or *P. fluorescens* as seed treatments had little influence on insect infestation, but it was effective on disease control. Repellent plants only affected plant height at 7 WAP; *T. erecta* or *O. gratissimum* without seed treatment had significantly lowered insect infestation at 6 WAP. Seed treatmens decreased disease prevalence at 8 WAP. Fresh pod weight per plot and fresh pod weight per plant in organic system were lower than those in the conventional system. The fresh pod weight per plot (10 m^2) of conventional system (6.7 kg) was higher than organic system (4.80-5.79 kg).

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