

EFFECTS OF WOOD VINEGAR AND FERMENTED LIQUID ORGANIC FERTILIZER ON SOYBEAN (SRISAMRONG 1) CULTIVATED UNDER DROUGHT CONDITIONS

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ABSTRACT

The efficiency of wood vinegar added to fermented liquid organic fertilizer to increase yields and reduce pest infestation was evaluated on a new variety of soybean (Srisamrong1) in Tumbol Rong Chang, Amphoe Muang, Phichit province during the drought season (December 2008 to March 2009). The fermented liquid organic fertilizer from herbs and wood vinegar was evaluated in 6 treatments: 1) water as control; 2) wood vinegar; 3) derris + neem seed + turmeric + molasses; 4) turmeric + tobacco + turmeric + molasses; 5) citronella grass + neem seed + turmeric + molasses; 6) citronella grass + tobacco + turmeric + molasses. Beginning at 15 days after planting, the 6 treatments were applied as foliage application at 7 days intervals for a total of 8 applications. The yields had significantly different response to the application of wood vinegar and fermented liquid organic fertilizer. Particularly, Treatment 3 and 5 showed highest and lowest efficiency in average yields with 1300 and 906.25 kg/ha (208 and 145 kg./rai) respectively. There was no significant difference among treatments on yield components such as average height, pod/plant, and 100 seeds weight. However the number of seeds/plant was significantly different in Treatment 6 which showed the highest significant efficacy to increase soil organic matter. Treatment 2 (wood vinegar) showed the highest significant efficacy with insect damage scores of 1.75 compared to an average damage score of 3.29 for the other treatments.

Key words: derris, neem seed, turmeric, molasses, citronella grass, tobacco

INTRODUCTION

Soybean, *Glycine max* (L.) Merrill is one of the most important economic plants in Thailand. The Office of Agricultural Economics, Ministry of Agriculture and Cooperatives (2006) reported that Thailand has an annual soybean production of 0.21 million tons, representing 12 percent of demand. It is well known that soybean exerts unique properties, such as excellent nutrition value, health benefits and the ability to be used in many industrial products. The important problem in soybean cultivation in Thailand is low productivity. One major cause is the outbreak of insect pests which could lead to the more applications of chemical pesticides and result in chemical residues in the environment. Therefore, using fermented liquid organic fertilizer from herbs such as derris, neem turmeric, citronella grass, tobacco and wood vinegar to substitute chemical insecticides is an alternative way of pest control to avoid the use of undesirable chemicals. It is an environmentally friendly method for soybean cultivation.

Liquid organic fertilizer is the product from bio-fermentation of vegetables, fruits, and animal wastes fermented with sugar and useful microbes. These microbes help to break down the nutrients which are valuable in terms of plant nutrients. When the nutrients are metabolized or degraded by bacteria or microorganisms, the substances are liberated, such as proteins, amino acids,

organic acids, accelerating growth hormones, vitamins, enzymes which are useful for highly efficient plant growth (Apai and Thongdeethae, 2001).

Wood vinegar is a mixture of organic compounds which is suitable for the organic farming concept. It is a byproduct from charcoal production, a condensate from the combustion of fresh wood burning in airless condition namely, Iwate kiln. Raw wood vinegar has more than 200 chemicals, such as acetic acid, formaldehyde, ethyl-valerate, methanol and tar compound. It has been used as a traditional remedy by the Japanese for over 400 years (Mu *et al.*, 2003). In addition it can be used as prebiotics (Watarai 2005). It was also found to have termicidal activity (Yatagai *et al.*, 2002), antifungal property against fungi that cause wood decay such as *Trametes versicolor* and *Tyromyces palustris* (Nakai *et al.*, 2005) and anti plant pathogenic microorganisms such as *Phytophthora capsici*, *Fusarium oxysporium*, *Ralstonia solanacearum*, and *Pythium splendens* (Hwang *et al.*, 2005). Moreover, it was also found to have antibacterial properties against dermatitis bacteria (Rakmai *et al.*, 2009). In Thailand, wood vinegar has been used in a variety of processes, such as industrial, livestock, household and agriculture products. Wood vinegar improves soil quality, eliminates pests, and accelerates or inhibits plant growth (Apai and Thongdeethae, 2001).

Therefore, the application of wood vinegar to fermented bio-fertilizer from herbs for soybean production is one organic agriculture method for reducing use of chemical pesticides and fertilizers. This study sought to evaluate the efficiency of the fermented liquid organic fertilizers of varying formulae using herbs and wood vinegar on a new variety of soybean (Srisamrong1).

MATERIALS AND METHODS

The experiments were conducted in farmer' fields in Tumbol Rong Chang, Amphoe Muang, Phichit province during the drought season (December 2008 to March 2009). The data was collected from a harvested area of 1x4 meters in experimental plots (2x5 meters) from a total of 36 plots. Soybeans (Srisamrong1) were planted by sprinkling in rows of 50cm distance. Beginning at 15 days after planting, the 6 treatments of fermented liquid organic fertilizer including water control were applied as foliage application at 7 days intervals for a total of 8 applications (60 days old). The ratio of 5:3:1:5 (kg:kg:kg:ml) was applied on Treatments 3 to 6 and were fermented in wood vinegar, 50 cc/20 liters of water including 12 g of microbial activator (LDD7). All of the treatments were diluted with water in the ratio of 1:200 before spraying.

The experiment was in RCBD (randomized complete block design) with 3 replications and 6 treatments as follows:

1. Water (control)
2. Wood vinegar
3. FLO* formula 1 (derris + neem seed + turmeric + molasses)
4. FLO* formula 2 (turmeric + tobacco + turmeric + molasses)
5. FLO* formula 3 (citronella grass + neem seed + turmeric + molasses)
6. FLO* formula 4 (citronella grass + tobacco + turmeric + molasses)

* FLO= Fermented Liquid Organic Fertilizer

The soil nutrient levels prior to planting and after harvest were analyzed. The yield components of 10 soybean plants, chosen randomly were recorded in terms of height (cm), limb, node length, seed number, pod number, 100 seeds weight (g) and yield (kg/rai). The rating score of insect pest infestation on soybean was measured using the following criteria.

- Score 1 = leaves area were infested (damaged leaves) <25%
2 = leaves area were infested (damaged leaves) between 26 to 50%
3 = leaves area were infested (damaged leaves) between 51 to 75%
4 = leaves area were infested (damaged leaves) between 76 -100%

The data was analyzed for ANOVA in Randomized Complete Block Design (RCBD) and by Duncan's multiple range test (DMRT) by Sirichai's statistics program.

RESULTS

Effect of wood vinegar and fermented liquid organic fertilizer treatments

Yields of soybean (Srisamrong1) in response to the application of wood vinegar and fermented liquid organic fertilizer were significantly different (Table 1). Treatment 3 and 5 showed the highest and lowest yields compared to the other treatments with 208 and 145 kg/rai (1300 and 906 kg/hectare), respectively. Although there were no significant effects for all treatments on the yield components (height, and 100 seeds weight and pod/plant), significant differences were noted on the number of seeds/plant. In particular, treatment 6 (formula 4: citronella grass + tobacco + turmeric + molasses) showed the significantly highest number of seeds/plant, 33.60 (Table 2).

Table 1. Effects of wood vinegar and fermented liquid organic fertilizer on average yield (kg/rai) of soybean (Srisamrong1) during the drought season in Phichit (December 2008 -March 2009).

Treatments	Yield (kg/rai)
1. Control (water)	185.33 ± 21.71 ^{ab}
2. Wood vinegar	174.67 ± 1.85 ^{ab}
3. FLO formula 1	208.00 ± 2.19 ^a
4 FLO formula 2	193.33 ± 2.87 ^{ab}
5. FLO formula 3	145.33 ± 2.16 ^b
6. FLO formula 4	176.00 ± 2.33 ^{ab}
F-test	*
CV (%)	15.65

* = significant difference at level of confidence 95 % by DMRT method (LSD .05 = 51.37)
Mean in a column followed by the same letter are not significantly different at the level by DMRT.

Table 2. Effects of wood vinegar and fermented liquid organic fertilizer on height, node and pod on soybean (Srisamrong1) during the drought season in Phichit (December 2008 -March 2009).

Treatments	Yield components				
	Height (cm)	Node/plant	Pod/plant	No. of seeds/plant	100 seeds weight (g)
1. Control (water)	32.90 ± 1.17	7.13 ± 0.35 ^a	15.47 ± 4.85	27.23 ± 7.50 ^{ab}	13.77 ± 0.62
2. Wood vinegar	32.83 ± 4.38	6.97 ± 0.15 ^a	14.43 ± 4.33	26.27 ± 9.01 ^{ab}	14.53 ± 0.56
3. FLO (formula 1)	32.07 ± 1.35	7.06 ± 0.40 ^a	14.40 ± 1.85	28.03 ± 4.20 ^{ab}	14.29 ± 0.73
4 FLO (formula 2)	31.20 ± 1.01	6.63 ± 0.49 ^{ab}	14.50 ± 1.83	26.97 ± 1.62 ^{ab}	14.70 ± 0.67
5. FLO (formula 3)	28.27 ± 2.15	6.37 ± 0.32 ^b	14.50 ± 3.25	23.27 ± 7.75 ^b	13.96 ± 0.37
6. FLO (formula 4)	30.40 ± 2.00	6.90 ± 0.52 ^a	18.97 ± 6.34	33.60 ± 9.85 ^a	14.76 ± 0.35
F-test	ns	*	ns	*	ns
CV (%)	7.48	3.95	18.33	22.14	4.36

ns = non significant difference

* = significant difference at level of confidence 95 % by DMRT method (LSD .05 = 0.49)

Means in a column followed by the same letter are not significantly different at the level by DMRT.

Pest infestation evaluation

The results of the score evaluation rate on disease and insect pest infestations are shown in Table 3. Wood vinegar showed the highest efficiency on insect pest control resulting in a highly significant difference in the insect damage score of 1.75 compared to an average damage score of 3.29 - 4 for the other treatments (Table 3).

Table 3. Insect pest infestation in treated soybean.

Treatments	Scores of insect pest infestation on soybean
1. Control (water)	3.75 ^a
2. Wood vinegar	1.75 ^b
3. FLO (formula 1)	3.50 ^a
4. FLO (formula 2)	4.00 ^a
5. FLO (formula 3)	3.50 ^a
6. FLO (formula 4)	3.25 ^a
F-test	*
CV (%)	22.81

* = significant difference at level of confidence 99 % and 95 % by DMRT method

Means in a column followed by the same letter are not significantly different at the level by DMRT.

Soil Analysis

The physical and chemical properties of the soil were determined prior to planting and after harvest in all treatments (Table 4).

Table 4. Nutrient levels in soil before planting and after harvest (December 2008 - March 2009).

Soil Samples	Nutrient content in treated soil samples (ppm)						
	pH	% OM	N	P	K	Ca	Mg
Pre harvest							
Guard row	6.15	1.29	0.24	94.25	132	-	-
In plots	6.33	1.24	0.30	130.15	180	-	-
Post harvest							
Guard row	6.47	1.76	-	156.85	84	5098.4	335.1
In plots							
1. Control (water)	6.46	1.09	-	71.45	186	5098.4	304.3
2. Wood vinegar	6.42	1.55	-	37.4	138	5381	315.9
3. FLO (formula 1)	6.42	1.64	-	49.8	138	5143.9	233.2
4. FLO (formula 2)	6.5	1.69	-	81.78	144	5361	315.9
5. FLO (formula 3)	6.45	1.08	-	18.05	84	5221.2	342.1
6. FLO (formula 4)	6.61	2.24	-	92.48	300	5102	305.1

The soil was clay in the guard row and silty clay in the treated plots. The soils had an average pH of 6.4 which is moderately acidic. The highest organic matter (% OM), 2.24, was found

in the plots sprayed with Treatment 6 (citronella grass + tobacco + turmeric + molasses). Therefore, the highest level of major nutrients (P and K) occurred in Treatment 6 with 92.48 and 300, respectively. The lowest % OM occurred in the plot sprayed with citronella grass + neem seed + turmeric + molasses and control (water). There was no difference among treatments in the minor nutrients (Ca and Mg), but the lowest levels were found in Treatment 3: (derris + neem seed + turmeric + molasses).

Fermented liquid bio-fertilizer analysis

The nutrient values of wood vinegar and FLO= Fermented Liquid Organic Fertilizer treatments are shown in Table 5. The lowest of pH (2.74) and EC (Electrical Conductivity) (17.19) were found in Treatment 2 (wood vinegar). The major nutrients (NPK) and minor nutrients (Ca and Mg) in wood vinegar treatment were very low when compared with all of the other treatments.

Table 5. Nutrient content and chemical properties of wood vinegar and fermented liquid organic fertilizer.

Treatments	Nutrient content (%)						
	pH	EC (ms/cm)	N	P	K	Ca	Mg
1.Wood vinegar	2.74	17.19	0.03	0	0	0	0.003
2.FLO (formula 1)	4.28	26.70	0.14	0.010	0.97	0.25	0.13
3.FLO (formula 2)	4.99	28.30	0.16	0.014	0.75	0.30	0.05
4.FLO (formula 3)	4.20	23.30	0.14	0.089	0.79	0.11	0.09
5.FLO (formula 4)	4.24	25.30	0.16	0.027	0.85	0.14	0.10

Weather data

The weather data throughout the drought season showed that average rainfall between December 2008 and March 2009 was only 2.68 mm. Meantime, the averages of maximum and minimum temperature were in the range of 22.9°C in January to 29.0°C in March 2009. The average percent relative humidity was 72.14 % (Table 6).

Table 6. Weather data during the drought season (December 2008 - March 2009).

Weather data	Monthly data (2008-2009)				
	December	January	February	March	Average
Rain (ml.)	0.6	0.0	0.0	10.1	2.68
Temperature (°C)(max.)	29.4	29.7	33.8	36.5	32.35
(min.)	17.3	16.1	21.0	23.4	19.45
Average	23.35	22.9	27.4	29.0	25.66
Relative Humidity (%)	77.35	68.5	69.5	73.22	72.14

cited : Weather station, Phichit

DISCUSSION

Yield response of soybean to wood vinegar and fermented liquid organic fertilizers in different formulations were studied in the drought season at Phichit. Although Treatments 3 and 4

showed highest efficiency soybean yield, the highest efficiency in terms of number of seeds/plant, pods/plant and weight of 100 seeds (g) occurred in Treatment 6 when compared with the other treatments. The organic fertilizer formulation of citronella grass + tobacco + turmeric + molasses (5:3:1:5) showed the highest organic matter (%OM). The formulation seems to be appropriate in increasing soil fertility. Similarly, the result of the rainy season experiment at Phitsanulok indicated that the highest % OM occurred on soils which were treated with the same formation (Pangnakorn *et al.*, 2009). However, Treatment 2 (wood vinegar) tended to be the highly efficient as an insect repellent when compared with the other treatments which were fermented from various kinds of herbs. Although in 2004, Chotitayangkul *et al.* reported that application of wood vinegar on soybean (KKU 5E) did not increase significantly the height, dry weight and yield components, they observed high efficiency in germination of soybean seeds treated with wood vinegar in the ratio of 1:300. Similarly, in 2007, Chotitayangkul *et al.* (2007) indicated that application of wood vinegar at the ratio of 1:300 did not significantly increase yield and yield component of peanut but gave the highest pods/plant, yield and shelling percentage of peanut.

In additional, Pangnakorn *et al.*, (2007) reported that the application of wood vinegar in 0.1% and 0.2%, had high efficiency for controlling insect pests in Chinese kale. In addition, the application of only extracted substances had lower effect on yield components than mixing with bio-fertilizer and yeast (Mekki and Ahmed, 2005). Moreover, in testing some herb extracts for controlling Kiefer lime leaf miner it was demonstrated that derris gave higher efficiency in controlling leaf miner than the other treatments including ocimum (Uraisakul and Piadang, 2007). However, this study was conducted in experimental plots where soybean had never been planted.

The major insect pests of soybean found in the experimental plots were soybean pod bug (*Riptortus linearis* Fabricius), soybean looper (*Pseudoplusia includens*), and pod sucking bug (*Nezara viridula*). But the white fly (*Bemisia tabaci*) (Gennadius) which is the major problem of soybean variety Srisamrong 1 was not found in this study. It can be presumed that, wood vinegar has the potential to be used as a biopesticide for repelling soybean insect pests. Wood vinegar is a good resource for organic production in agriculture (Mu *et al.*,2003). Therefore, the application of wood vinegar with fermented liquid bio-fertilizer from herbs for soybean cultivation is one organic agriculture method, which can avoid chemical uses of pesticides and fertilizers, leading to safe food production .

CONCLUSION

In general, the addition of fermented liquid bio-fertilizer on crop plant is an effective method for increasing growth and yields of soybean. In particular, wood vinegar showed a potential for high efficiency in repelling insects and showed the highest significant efficacy of reducing pest infestation in soybean as well.

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