Using wood vinegar in enhancing peanut yield and in controlling the contamination of aflatoxin producing fungus

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Abstract

Wood vinegar or pyroligneous acid is a brown transparent liquid that produced by the condensation of the smoke from the process of producing charcoal. Wood vinegar consists mainly of water soluble compounds, over 200 kinds. The main components are organic acids, phenolic, alkone, alcohol and ester compounds with acetic acid being a main component. Wood vinegar has been used in agriculture as fertilizer, insect repellent or organic fungicide. The effect of wood vinegar on peanut yield and on the contamination of aflatoxin producing fungus was investigated in five growing seasons. Wood vinegar at 20 times dilution was used as soil application at 10 days before planting. The foliar application of wood vineagr at the dilution of 200, 300 or 500 times was applied at two-week interval to peanut, 25 days after planting until 15 days before harvest. Two types of peanut, large-seeded type and small-seeded type peanut were used. The results indicated that wood vinegar increased dry weight accumulation of peanut. The responses were different among the two types of peanut. Wood vinegar did not significantly increase yield but shelling percentage was slightly increased. Wood vinegar when used as soil application once before planting did not effectively control the incidence of soil fungus, *Aspergillus flavus*, *A. parasiticus* and aflatoxin contamination in peanut seed.

Media Summary

Investigating the possible use of wood vinegar, by-product from charcoal burning as fertilizer or organic fungicide.

Key words

Smoke, wood pyrolysis, mycotoxin, groundnut, *Aspergillus flavus*, *Aspergillus parasiticus*

Introduction

Wood vinegar or pyroligneous acid is a condensed smoke produced from wood pyrolysis or charcoal burning. Wood vinegar consists mainly of water soluble-compounds, over 200 kinds. The main components are organic acids, phenolics, alkone, alcohol and ester compounds with acetic acid being a main component. Wood vinegar has many uses. Wood vinegar when used as foliar fertilizer enhances yields in cucumber, lettuce and cole (Jun et al. 2006) and in jasmine rice (Jothityangkoon et al. 2007). Mixing charcoal and wood vinegar in planting materials improves growth, branching and survival rate of zinnia (Kadota and Niimi 2004) and increases yield of Hiratake mushroom (*Pleurotus ostreatus*) (Yoshimura et al. 1995). Wood vinegar contains phenolic compound that is toxic to microbial activity if used in high concentration. Zagori (1981) reported that smoke was effective in reducing the incidence of alfalfa anthracnose, barley powdry mildew, and cotton damping off as well as in reducing the number of propagules of *Pythium ultimum* in field soil. However, if wood vinegar is used at the appropriate concentration, it can be used as soil fertilizer. It has been reported that charcoal and smoke stimulate the soil microbial community (Steiner et al. 2007). Aflatoxin is a toxic substance produced by soil fungus, *Aspergillus flavus* and *A. parasiticus*. Aflatoxin contamination has been found in many agricultural products especially in peanut and causes a serious adverse effect on human health and economics loss worldwide. Using wood vinegar in controlling aflatoxin producing fungus in soil and aflatoxin contamination in peanut seed was investigated.

Methods

Five experiments were conducted during 2004 to 2006. Four experiments were conducted at experimental station in Khon Kean University, Thailand and one experiment at farmer's field in Khon Kaen province. Wood vinegar at 20 times dilution was used as soil application at 10 days before planting. The foliar application of wood vinegar at the dilution of 200, 300 or 500 times was applied at two-week interval to peanut, 25 days after planting until 15 days before harvest. Two types of peanut, large-seeded type and small-seeded type peanut were used. Contaminations of *A. flavus* and *A. parasiticus* in seed were determined using blotter method. Aflatoxin in seed was analyzed using modified direct competitive ELISA method.

Results

Wood vinegar used as foliar application promoted vegetative growth of large seeded type peanut and significantly increased dry weight of KK60-3 when used at 200 times dilution. Small seeded type peanut variety Tainan9 responded differently as peanut applied with wood vinegar had lesser dry weight accumulation (Exp.4). Wood vinegar did not significantly increase yield and yield components. However, seed yield and shelling percentage were slightly increased. Suitable concentration was varied between cropping seasons. At 200 times dilution, wood vinegar significantly promoted vegetative growth but higher seed yield and shelling percentage were obtained at lower concentrations (300 or 500 times dilution) (Table 1). Wood vinegar when used as soil application once before planting and at two-week interval as foliar application did not effectively control the incidence of *A. flavus*, *A. parasiticus* in soil (Figure 1a, d, g). Contamination of *A. flavus* and *A. parasiticus* in soil from control plot was slightly lower than those of other treatments throughout the 2005/2006 dry cropping season. However, the contamination in soil from all treatments was markedly increased at harvest (Figure 1a). Wood vinegar did not significantly reduce the contamination of *A. flavus* and *A. parasiticus* in soil (Figure 1b, e, h) and aflatoxin in seed during 8 weeks storage under ambient condition (Figure 1c, f, i). Five experiments provided similar responses (Data of Exp.1, 3 not shown).

Conclusion

Foliar application of wood vinegar significantly increased vegetative growth of large-seeded type peanut and slightly enhanced seed yield and shelling percentage but wood vinegar when used as soil application before sowing did not effectively control the population of aflatoxin producing fungus. Foliar application of wood vinegar increased vegetative growth and this may has resulted in preventing the sunlight reaching the soil surface under the plant canopy and consequently higher in soil moisture content and in contamination of aflatoxin producing fungus in soil and in seed. This was evident in 2005/2006 dry cropping season where control plot had a lesser contamination. The environment influenced the population of *A. flavus* and *A. parasiticus* in soil as the population was markedly increased at harvest in 2005/2006 dry cropping season as it entered the rainy season. Soil application of wood vinegar before sowing and during the cropping season, to control the population of aflatoxin producing fungus needs a further investigation.

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Table 1 Effect of wood vinegar on growth, yield and yield components of peanut.

Treatment	LAI	DW (g/plant)	Pod yield (kg/ha)	Seed yield (kg/ha)	100 seed weight (g)	Shelling (%)	HI
Experiment 1	**2004/2005 dry cropping season (variety KK60-3 large-seeded type peanut)**						
Inoculation							
With inoculation	na	54.96	786.50	353.44	47.82	62.47 a	na
Without inoculation	na	51.45	861.38	388.44	49.93	61.93 b	na
F-test	-	ns	ns	ns	ns	*	-
WV (Dilution, times)							
No wood vinegar	na	49.69 b	733.75	303.50	49.02	59.93	na
500	na	53.22 ab	881.88	393.69	48.84	62.10	na
300	na	53.00 ab	899.38	437.75	49.78	66.67	na
200	na	56.90 a	780.63	348.81	47.87	60.10	na
F-test		*	ns	ns	ns	ns	
C.V. (%)		8.70	19.15	31.55	7.65	17.92	
Experiment 2	**2005/2006 dry cropping season (variety KK6, large-seeded type peanut)**						
Inoculation							
With inoculation	3.16	62.04	3432.69	1947.25	62.91	71.27	0.35
Without inoculation	3.26	60.52	3257.75	1867.44	64.66	70.52	0.33
F-test	ns	ns	ns	ns	ns	ns	ns
C.V. (%)	17.19	15.83	13.86	23.82	9.21	0.80	9.33
WV (Dilution, times)							
No wood vinegar	3.23	61.34	3338.94	1832.69	62.15	69.61	0.35
500	3.17	59.29	3392.81	1929.06	66.09	70.93	0.34
300	3.09	63.49	3264.25	1815.56	63.81	71.24	0.33
200	3.36	64.05	3385.00	1966.25	63.09	71.81	0.35
F-test	ns	ns	ns	ns	ns	ns	ns
C.V. (%)	12.87	8.59	5.39	6.56	8.05	2.67	0.79
Experiment 3			**2005 rainy cropping season**				
Variety							
KK60-3 (large-seeded type)	1.43	19.98	208.50 b	103.81	51.35	70.68 a	0.06 b
KKU60 (large-seeded type)	1.53	15.87	449.63 a	237.06	56.83	58.32 b	0.22 a
F-test	ns	ns	*	ns	ns	*	**
WV (Dilution, times)							
No wood vinegar	1.55	16.01	340.60	157.13	53.50	61.70	0.14 ab
500	1.49	17.09	339.63	163.69	54.85	67.17	0.13 b
300	1.39	18.96	393.13	199.5	53.78	67.81	0.17 a
200	1.48	19.64	343.38	161.50	54.22	61.38	0.13 b
F-test	ns	ns	ns	ns	ns	ns	*
C.V. (%)	18.32	21.56	17.51	20.74	6.30	7.19	20.24
Experiment 4			**2006 early rainy cropping season**				
Variety (V)							
KK6 (large-seeded type, V1)	3.14 a	18.92	1229.56 a	760.06 a	64.03 a	67.11	0.30
Tainan9 (small-seeded type, V2)	2.41 b	17.38	784.63 b	514.50 b	35.50 b	68.47	0.28
WV (Dilution, times)							
No wood vinegar (D1)	2.55	19.02	1119.44	703.25	49.80	68.04	0.29
500 (D2)	2.90	18.79	963.81	601.31	49.47	66.49	0.31
300 (D3)	3.05	16.40	988.75	642.19	50.63	69.51	0.29
200 (D4)	2.61	18.38	956.31	602.31	49.17	67.12	0.28
V x D							
V1 X D1	2.91	18.30 ab	1398.38 a	846.25 a	64.33	65.94	0.29
V1 X D2	3.67	19.12 ab	1101.25 b	687.31 ab	63.30	67.28	0.30
V1 X D3	3.30	15.83 b	1376.50 a	888.25 a	65.43	70.52	0.31
V1 X D4	2.69	22.42 a	1042.06 bc	617.00 bc	63.09	64.73	0.28
V1 X D1	2.20	19.75 ab	840.56 cd	558.75 bc	35.27	70.16	0.29
V1 X D2	2.12	18.46 ab	826.38 cd	515.31 bc	35.64	65.71	0.31
V1 X D3	2.80	16.95 b	600.94 d	396.31 c	35.83	68.50	0.26
V1 X D4	2.54	14.34 b	870.30 bc	587.56 bc	35.25	69.52	0.27
C.V. (variety, %)	12.73	23.73	18.89	18.30	17.78	10.43	28.95
C.V. (dilution, %)	23.79	17.82	15.31	22.03	13.57	7.98	14.96
Variety	**	ns	**	**	**	ns	ns
Dilution	ns	ns	ns	ns	ns	ns	ns
V X D	ns	*	**	*	ns	ns	ns

Table 1 Effect of wood vinegar on growth, yield and yield components of peanut (cont.).

Treatment	LAI	DW (g/plant)	Pod yield (kg/ha)	Seed yield (kg/ha)	100 seed weight (g)	Shelling (%)	HI
Experiment 5			**2006 late rainy cropping season**				
Variety (V)							
KK6 (large-seeded type, V1)	3.75	16.52	1431.31 a	888.19 a	67.56 a	66.85	0.35
Tainan9 (small-seeded type, V2)	3.08	16.04	586.06 b	378.81 b	35.66 b	68.00	0.29
WV (Dilution, times)							
No wood vinegar (D1)	3.32	14.69	897.50	568.81	52.64	66.42	0.32
500 (D2)	3.41	17.23	1105.94	762.19	49.44	72.35	0.31
300 (D3)	3.19	17.31	903.13	550.19	52.95	66.58	0.31
200 (D4)	3.74	15.89	1128.19	652.69	51.41	64.35	0.32
C.V. (variety, %)	50.77	7.21	17.57	29.57	19.17	10.95	20.01
C.V. (dilution, %)	34.69	21.31	43.66	41.50	15.26	13.27	19.41
Variety	ns	ns	*	**	**	ns	ns
Dilution	ns	ns	ns	ns	ns	ns	ns
V X D	ns	ns	ns	ns	ns	ns	ns

Note : **Experimental location**: All experiments were in Univ. Research Station except Exp. 4 was in the farmer's field**.**
Inoculation: *Aspergillus flavus* was inoculated in soil as treatments in Exp.1-2, and in all plots in Exp. 3-5
Experimental design: Exp.1 and 3 were factorial in RCB, Exp.2, 4 and 5 were split plot in RCB.
LAI and DW: leaf area index and total dry weight were at harvest in Exp.1-2 and at 60 days after sowing in Exp.3-5.
na: not applicable; ns, * and ** = not significant, significant at p<0.05 and 0.01, respectively. Means in the same column with different letters are significantly deferent at <0.05 or p<0.01, respective to significant level by Duncan's Multiple Ranges Test, DMRT

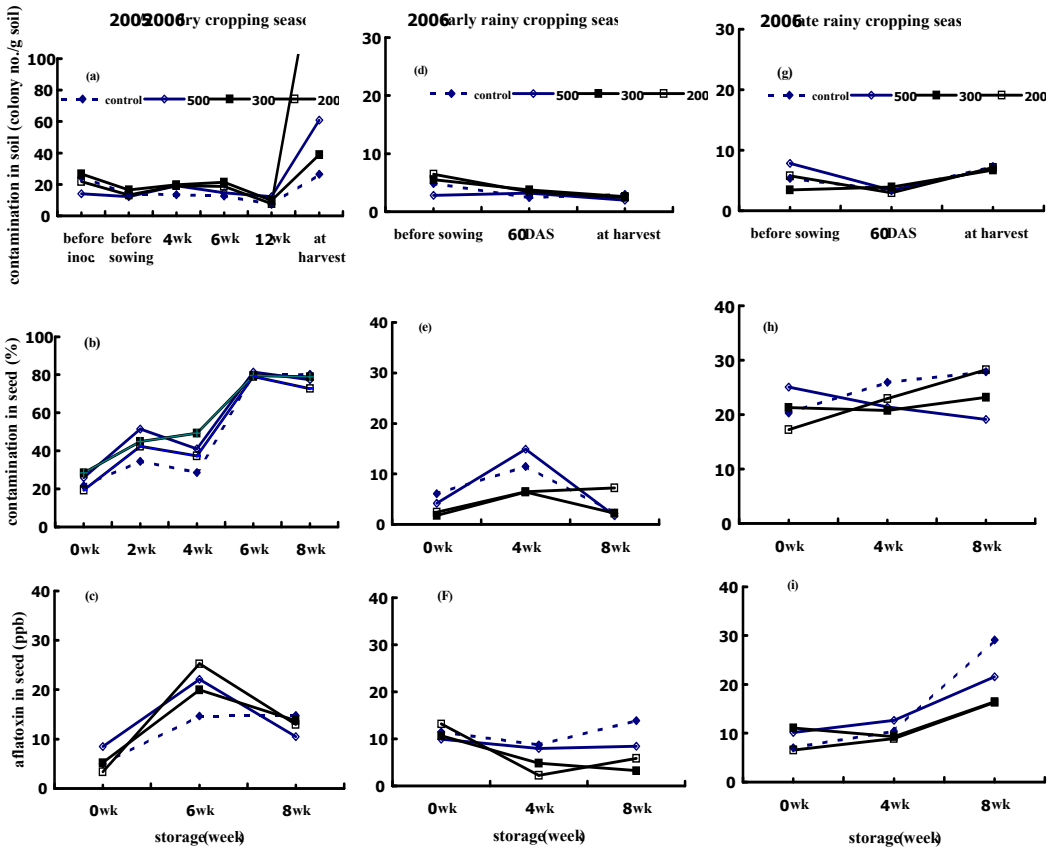

Figure 2 Effect of wood vinegar on contamination of *Aspergillus flavus* and *A. parasiticus* in soil and in seed and effect on aflatoxin contamination in seed during eight-week storage under ambient condition.