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Allelopathic Effect of Seed Extracts and Powder of Coffee (*Coffea arabica* L.) on Common Cocklebur (*Xanthium strumarium* L.)

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Abstract

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Pot trials were conducted to determine the allelopathic effect of water extracts and dry powder of ripe coffee beans on germination and growth dynamic of *Xanthium strumarium*. It was established that both the extract concentrations and the doses of the incorporated coffee powder decreased in the *X. strumarium* germination. The number of the seedlings was smaller but they were better developed. That resulted in a stimulating allelopathic effect on the weed growth dynamic, especially in relation to the fresh weight. There only was a slight depressive effect of the higher dose incorporated coffee powder.

Key words: allelopathy, coffee, germination, growth dynamic, *Xanthium strumarium* L., *Coffea arabica* L.

Introduction

Allelopathy is a phenomenon of direct or indirect, beneficial or adverse effects of a plant on its own or another plant through the release of chemicals into the environment. It affects plant distribution, community formation, intercrop evolution and biodiversity conservation and is now arousing further international interest (Zhang et al., 2004). Sometimes is difficult to put the precise borderline between allelopathy and competition (Nakova, Baeva, Nikolov, 2004). Caffeine (1, 3, 7 - trimethylxanthine) and theobromine (3, 7-dimethylxanthine) produced by *Coffea arabica* are purine alkaloids. They as well as their derivatives are powerfully allelopathic (Frischknecht et al., 1985; Mazzafera and Magalhaes, 1991; Vitoria and Mazzafera, 1998b; Saldaca et al., 1998; Hesse, 2002; Uefuji et al., 2003). Wild species of the coffee plant also contain cafestol, kahweol, and related diterpenoids (De Roos et al., 1997). Caffeine inhibits mitosis in the roots of many

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plants and thereby reduces access to nutrients and water (Friedman and Waller, 1983 a, b). Caffeine may causes autotoxicity in *Coffea arabica* (Waller et stems, roots, pulp of coffee, and undercanopy soil significantly inhibited the seed germination and radicle growth of barley, rye grass, lettuce, and fescue. The allelopathic compounds include caffeine, theobromine, theophylline, paraxanthine, scopoletin, and chlorogenic, ferulic, p-coumaric, p-hydroxybenzoic, caffeic, ursolic and vanillic acids (Chang and Waller, 1980; Ramos et al., 1983; Clifford et al., 1989; Waller et al., 1991; Fetene and Habtemariam, 1995). Coffee husk extract promoted initial growth stimulation of *Amaranthus viridis* L. (Santos et al., 2002). Positive responses were observed in elongation of soybean internodes. The hormone-like effect of caffeine might be related to the resemblance between caffeine and adenine derivatives (Vitoria and Mazzafera, 1998).

Material and Methods

In 2005 a pot trial with *Xanthium strumarium* was conducted. The trial included 5 treatments in 3 replicates and it was repeated twice. The treatments were as follows: 1 - Control with normal water, 2 - Hot water extract of ripe coffee beans dry powder at a ratio of 1:10 w/v for 24 h at a room temperature, 3 - Hot water extract of dry coffee powder at a ratio of 1:20 w/v for 72 h at a room temperature, 4 - Incorporated in the soil surface dry powder coffee in the same quantity as that in the 2nd treatment, 5 - Incorporated in the soil surface dry powder coffee in the same quantity as that in the 3rd treatment. Each pot contained 200 g absolutely dry ground soil. *X. strumarium* seeds (at 10 per pot) were sown after the coffee powder was incorporated. Normal water (in the treatments 1, 4 and 5), and the extracts (in the treatments 2 and 3) were applied at 50 cm 3 per pot to wet the soil to 50% humidity that was kept up every day during the trial. At the 7th, 14th, 21st, 42nd and 49th days after treatment (DAT), the percentage of *X. strumarium* germinated seeds was determined. At the 49th DAT, the weed seedlings height, root length, fresh and dry weights were recorded. The data were statistically analyzed by ANOVA followed by t-test.

Results

The data are based on the mean values from both the replicates of the trial as the results were similar and unidirectional. Both the ripe coffee bean water extracts and dry powder decreased in *X. strumarium* germination (Table 1; Figure 1). The standard error (SE) was mainly from 6.67 to 17.64 and 24.04 only in the 3rd treatment at 7 DAT. The differences were better expressed 21, 42 and 49 DAT. All the differences between the control and the other treatments as well as these between 2nd and 3rd , and 3rd and 5th treatments were proved at a level of significance $P<0.05$. It was established that although the seed germination decreased, the seedlings developed better in the treatments with both the concentrations of the coffee extract as well as in the treatment with the lower dose incorporated coffee powder (Table 2; Figures 2 and 3). That resulted in a stimulating allelopathic effect on *X. strumarium* growth dynamic especially in relation to the seedlings height and fresh weight. The standard error (SE) was from 0.06 to 0.29 for the root length, from 0.54 to 3.31 for the seedlings height, from

Table 1

Germination percentage of *Xanthium strumarium* L. seeds at 7, 14, 21, 42 and 49 DAT as affected by water extracts and dry powder of seeds of coffee (*Coffea arabica* L.)

Treatments	Days after treatment (DAT)				
	7	14	21	42	49
Control	53.33	93.33	140	140	140
SE	6.67	6.67	11.55	11.55	11.55
%	100	100	100	100	100
2	26.67	73.33	86.67*	86.67*	86.67*
SE	17.64	26.67	24.04	24.04	24.04
% to Control	50.01	78.57	61.91	61.91	61.91
P (between 1 and 2)			0.047	0.047	0.047
3	33.33	86.67	106.67*	113.33*	113.33*
SE	24.04	13.33	6.67	6.67	6.67
% to Control	62.5	92.86	76.19	80.95	80.95
P (between 1 and 3)			0.042		
P (between 2 and 3)				0.038	0.038
4	46.67	86.67	93.33*	93.33*	100
SE	17.64	6.67	6.67	6.67	11.55
% to Control	87.51	92.86	66.66	66.67	71.43
P (between 1 and 4)			0.025	0.025	
5	66.67	73.33	73.33*	86.67*	86.67*
SE	13.33	17.64	17.64	13.33	13.33
% to Control	125.01	78.57	52.38	61.91	61.91
P (between 1 and 5)			0.034	0.039	0.039
P (between 3 and 5)			0.04	0.045	0.045

*P<0.05 P = p-observed

ANOVA: df = 1, 4; F-theoretical = 7.71 *t*-test: df = 4; N = 3

68.07 to 233.33 for their fresh weight and from 8.11 to 15.57 for the dry weight. The higher dose coffee powder had a slight depressive effect on the growth dynamic

Table 2

Growth characteristics of *Xanthium strumarium* L. seedlings at 49 DAT as affected by water extracts and dry powder of seeds of coffee (*Coffea arabica* L.)

Treatments	Root length, cm	Height, cm	Fresh weight, mg	Dry weight, mg
Control	2.84	17.29	756.67	82
SE	0.06	3.31	233.33	15.57
%	100	100	100	100
2	2.44	22.61	1133.33*	88.67
SE	0.24	1.06	120.05	14.84
% to Control	85.92	130.77	149.78	108.13
P (between 1 and 2)			0.045	
3	3.96*	19.24	1043.33	85.89
SE	0.07	2.27	180.49	14.26
% to Control	139.44	111.28	137.88	104.74
P (between 1 and 3)	0			
P (between 2 and 3)	0.004			
4	3.21	16.69*	686.67*	63.61
SE	0.29	1.4	94.93	12.82
% to Control	113.03	96.53	90.75	77.57
P (between 2 and 4)		0.028	0.043	
5	4.42*	21.74*	1100*	83.33
SE	0.26	0.54	68.07	8.11
% to Control	155.63	125.74	145.37	101.62
P (between 1 and 5)	0.004			
P (between 2 and 5)	0.005			
P (between 4 and 5)	0.035	0.028	0.024	

*P<0.05 P = p-observed

ANOVA: df = 1, 4; F-theoretical = *t*-test: df = 4; N = 3

of *X. strumarium*. The differences in relation to the root length were statistically proved and significant at P<0.05 between the 3rd treatment and the control and the treatment 2 as well as between the 5th treatment and the control and the treat-

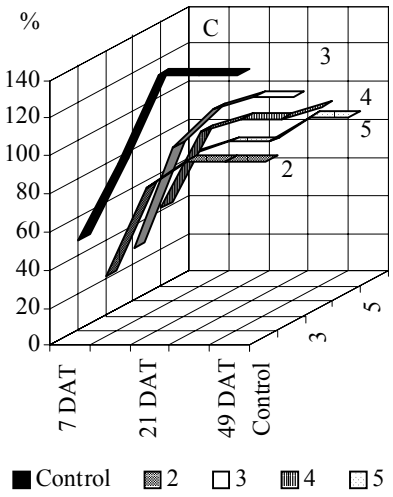

Fig. 1. Germination percentage of *Xanthium strumarium* L. seeds at 7, 14, 21, 42 and 49 DAT as affected by water extracts and dry powder of seeds of coffee (*Coffea arabica* L.)

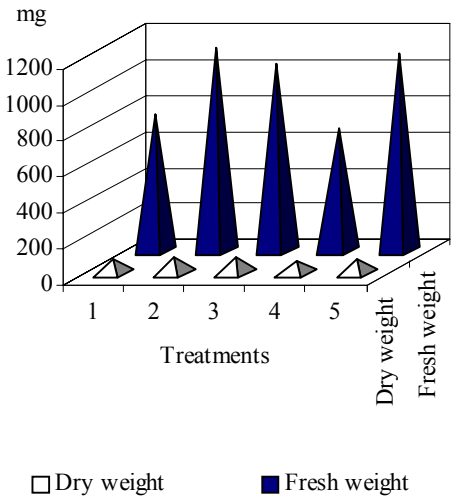

Fig. 3. *Xanthium strumarium* L. seedlings fresh and dry weights at 49 DAT as affected by water extracts and dry powder of seeds of coffee (*Coffea arabica* L.)

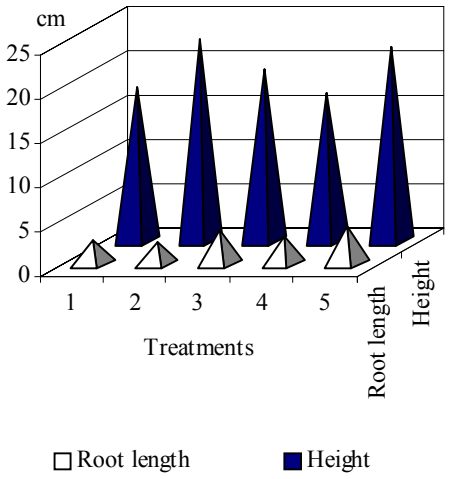

Fig. 2. Root length and height of *Xanthium strumarium* L. seedlings at 49 DAT as affected by water extracts and dry powder of seeds of coffee (*Coffea arabica* L.)

ments 2 and 4. The differences in relation to the seedlings height were statistically proved and significant at $P<0.05$ between the 2nd and the 4th treatments as well as between both the treatments with coffee powder (treatments 4 and 5). The differences in relation to the seedlings fresh weight were statistically proved and significant at $P<0.05$ between the same treatments as well as between the control and the treatment 2. The differences in relation to their dry weight were less and were in significant at $P<0.05$.

Conclusions

- Coffee bean water extracts and dry powder decrease in the *X. strumarium* germination.
- The number of *X. strumarium* seedlings is smaller but they are better developed that these in the control.

• Coffee water extracts and the lower dose dry powder have a stimulating allelopathic effect on *X. strumarium* growth dynamic.

• The higher dose incorporated coffee powder has a depressive allelopathic effect on *X. strumarium* growth dynamic.

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