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Allelopathic Potentials of *Tithonia diversifolia* (Hemsl) A. Gray: Effect on the Germination, Growth and Chlorophyll Accumulation of *Capsicum annum* L. and *Lycopersicon esculentum* Mill.

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Abstract: The study was carried out to evaluate the allelopathic effect of the fresh shoot aqueous extract (FSE) and water soluble root exudate (WRE) of *Tithonia diversifolia* (Hemsl) A. Gray on the germination, growth and chlorophyll content of pepper (*Capsicum annum* L.) and tomato (*Lycopersicon esculentum* Mill.). The aqueous extract of the fresh shoot (FSE) of *T. diversifolia* did not affect the germination of *L. esculentum* seeds but significantly retarded germination of *C. annum* seeds at $p<0.05$. The plumule length of both crops and radicle length of *C. annum* were not affected while the latter parameter was significantly reduced at $p<0.05$ for *L. esculentum.* The water soluble root exudate of *Tithonia diversifolia* plants did not have any significant effect on the growth parameters of both test crops. However, chlorophyll b of *C. annum* was significantly inhibited at $p<0.05$ especially in the older plants while chlorophyll b and total chlorophyll of *L. esculentum* were significantly enhanced at $p<0.05$. Evidently, the concentration of allelochemicals in the *T. diversifolia* exudate and extract that was inhibitory to germination and chlorophyll b accumulation in *C. annum* was ineffective on germination of *L. esculentum* and stimulatory to its chlorophyll accumulation. The allelochemicals in *T. diversifolia* are therefore capable of performing a dual role. Their mode of actions differing depending on the associated plant species.

Key words: Allelopathic, allelochemicals, aqueous extract, exudate, *Tithonia diversifolia*

INTRODUCTION

Allelopathic interaction involves the production and release of chemical substances (allelohemicals) by certain plants that inhibit the growth and development of the individuals of the neighboring species (Shaukat *et al*., 2003). The phenomenon of allelopathy in relation to weed-crop interaction has been reported by Ito *et al.* (1998) and Tajuddin *et al*. (2002). *Tithonia diversifolia* (Hemsl) A. Gray an aggressive weed in the family Asteraceae has high invasive capacity. Muoghalu and Chuba (2005) reported that this weed was introduced into Africa from North and Central America. Akinola *et al*. (2000) observed that *T. diversifolia* occurs on roadsides and fallow land and as invader of field crops in the forest-savanna transition zone. The plant associates and has the ability to compete successfully with agricultural crops like cassava, yam, rice, sorghum, soybean etc.

The detrimental effects of allelochemicals on plant germination and growth have been reported by Onwugbuta-Enyi (2001), Ismail and Tef-vum (2002), Bais *et al*. (2003), Iqbal *et al*. (2004), Bogatek *et al.* (2006) and Ilori *et al.* (2007). Leachates from plants have been shown to suppress seed germination and early seedling growth (Babu and Kandasanmy, 1997). Baziramakenga *et al.* (1994) found that allelochemicals reduced the number of lateral roots, root and shoot dry biomass of soybean.

Romero-Remoro *et al.* (2002) showed that aqueous extracts of four native shrubs of the Mexican desert (*Sicyos deppei* G. Don *Accacia sedillense*, *Sebastiania adenophora* Pax and K.Hoffm and *Lantana camara* L.) reduced root growth of *Zea mays* L., *Phaseolus vulgaris* L., *Cucurbita pepo* L. and *Lycopersicon esculentum.* Batish *et al.* (2006) reported that allelochemicals released from *Chenopodium album* into the soil had growth inhibitory effects on *Cassia occidentalis* L. and *Phaseolus aureus* Roxb.

Mersier and Singh (1993) reported that allelochemicals inhibited photosynthesis and protein synthesis of isolated leaf cells of velvet leaf (*Abutilon theophrasti* Medik). Since *T. diversifolia* is a weed often seen to form dense, almost pure stands, it is reasonable to suspect that allelopathy could be involved in the suppression of other associated plants. These experiments were designed to test the allelopathic potential of *T. diversifolia.*

The objectives of this study were to evaluate the effect of the fresh shoot aqueous extract of *T. diversifolia*

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(Hemls) A. Gray on germination and early seedling growth of *Capsicum annum* L. and *Lycopersicon esculentum* Mill and to determine the allelopathic effect of water soluble root exudate of *T. diversifolia* on some growth parameters and chlorophyll contents of *C. annum* and *L. esculentum*

MATERIALS AND METHODS

The experiment was carried out at the Botany Department of the Obafemi Awolowo University (OAU), Ile-Ife Nigeria during June-August, 2006. The seeds of *Tithonia diversifolia* were collected along Ede road near the Obafemi Awolowo University (OAU), Ile-Ife, while those of *Capsicum annum* L. and *Lycopersicon esculentum* Mill were collected from the National Horticultural Research Institute (NIHORT) Ibadan, Nigeria. To prepare the fresh shoot extract, 72 g of the tender shoot were cut into small chips and finely ground with a mortar and Pestle. The ground materials were soaked in 1 L of distilled water for 12 h. The soaked material was initially filtered through cheese cloth to remove the fiber debris and afterwards filtered through Whatman No. 1 filter paper. The filtrate obtained served as fresh shoot aqueous extract (FSE).

The seeds of *L. esculentum* and *C. annum* were sterilized in 5% sodium hypochlorite and then rinsed in running water for 5 min. Twenty seeds of each test crop randomly selected were placed in each of the petri dishes which had been lined with whatman No. 1 filter paper. The filter paper in each petri dish allocated to the control was moistened with 10 mL of distilled water while the filter paper in each of the petri dishes in the aqueous extract treatment regime was moistened with 10 mL of FSE solution. The Petri dishes were incubated at room temperature for 2 weeks. Emergence of 1 mm of the radicle was used as criterion for germination. Once germination was initiated daily measurement of plumule and radicle lengths were taken.

For growth and chlorophyll determination, top soil was put in plastic pots (20 cm×9 cm) each having four perforated holes at the bottom for drainage. Ten seeds of *Tithonia diversifolia* were sown in each pot. The pots were supplied with 400 mL of water daily. Water drained from soil in the pots containing *Tithonia diversifolia* served as the root exudate treatment (WRE). Ten seeds of each of the test plants (*C. annum* and *L. esculentum*) were sown in similar plastic pots. The pots were arranged in a completely randomized design. Four hundred milliliter of water was supplied to each of the pots in the control regime while 400 mL of capillary water drained from the pot of *T. diversifolia* plants after watering was supplied to each of the pots in WRE regime daily. Thereafter, harvesting of the plants was on a weekly interval for a period of six weeks. The plants were weighed immediately after harvest to determine their fresh weights. They were then dried to constant weight at 80°C in a Gallenkamp (model 1H - 150) incubator to obtain their dry weights. Other parameters measured were root length, shoot height, leaf length and breadth. Leaf area was determined using the formula according to Pearcy *et al.* (1989) while the leaf area ratio was calculated using the formula of West *et al.* (1920). Chlorophyll contents were determined using the method of Comb *et al.* (1985). All experiments were conducted in five replicates and the data obtained were subjected to analysis of variance (ANOVA).

RESULTS AND DISCUSSION

The mean percentage germination of seeds of *C. annum* and *L. esculentum* in the control regime was higher than that of the seeds treated with FSE. This difference was found to be significant at $p<0.05$ in *capsicum annum*. The effect of the FSE on plumule and radicle length of germinating seedlings of *C. annum* and *L. esculentum* is shown in Table 1. The plumule and radicle lengths of the *C. annum* seedlings in the control regime was not significantly different from that of the seedlings in the FSE regime. There was no significant difference in plumule length of the control *L. esculentum* plants and that of the FSE plants but the radicle length of the *L. esculentum* plants in the control was significantly higher than that of the plants in the FSE regime at $p<0.05$.

Table 2 and 3 show the effect of the water soluble root exudate (WRE) on the shoot height, root length fresh weight dry weight, leaf area and leaf area ratio of

Table 1: Effect of fresh shoot aqueous extract(FSE) of *Tithonia diversifolia* (Hemsl) A. Gray on germination, radicle length and plumule length of *Capsicum annum* (L.) and *Lycopersicon esculentum* (Mill.)

Treatments	Germination (%)	F-value	Sig.	Radicle length (cm)	F-value	Sig.	Plumule length (cm)	F-value	Sig.
Capsicum annum									
Control	88.3	7.39	0.02*	3.7	1.05	0.33	3.4	1.82	0.210
FSE	22.5			4.3			4.1		
Lycopersicon esculentum									
Control	100.0	1.20	0.31	57.5	7.16	0.02*	36.6	2.28	0.169
FSE	90.0			27.0			36.1		

*Significant at $p<0.05$ probability level

Table 2: Effect of water soluble root exudate (WRE) of *Tithonia diversifolia* on the growth parameters of *Capsicum annum*

	Plant height (cm)				Root length (cm)				Leaf area (cm^2)			
Weeks	Control	WRE	F-value	Sig.	Control	WRE	F-value	Sig.	Control	WRE	F-value	Sig.
0	5.02	4.36	2.88	0.12	3.94	4.96	0.95	0.35	4.16	3.90	0.18	0.68
1	6.10	5.78	0.64	0.44	5.44	5.84	0.12	0.73	6.91	7.74	3.73	0.08
2	6.72	6.84	0.16	0.69	6.08	6.32	0.08	0.77	10.54	9.41	2.04	0.19
3	9.18	8.98	2.85	0.13	6.96	6.44	1.43	0.26	18.19	15.35	1.70	0.22
4	11.32	10.14	0.04	0.83	9.32	7.72	1.66	0.23	21.69	16.73	5.03	0.05*
5	11.78	11.72	0.31	0.59	10.22	9.06	1.23	0.29	24.24	26.81	1.35	0.27
	Leaf area ratio (cm^2 g^{-1})				Fresh weight (g)				Dry weight (g)			
Weeks	Control	WRE	F-value	Sig.	Control	WRE	F-value	Sig.	Control	WRE	F-value	Sig.
0	314.04	263.82	2.06	0.18	0.17	0.16	0.48	0.50	0.01	0.02	2.00	0.19
1	247.05	235.82	0.15	0.70	0.36	0.41	1.66	0.23	0.03	0.03	2.69	0.13
2	188.76	192.13	0.12	0.72	0.69	0.58	4.54	0.06	0.06	0.05	2.27	0.17
3	210.29	173.20	4.08	0.07	0.94	0.97	3.53	0.09	0.09	0.09	0.04	0.84
4	164.75	115.23	1.06	0.33	1.62	1.29	0.17	0.68	0.13	0.12	0.37	0.55
5	111.62	113.48	0.18	0.67	2.16	2.27	4.57	0.06	0.22	0.23	0.35	0.50

Table 3: Effect of water soluble root exudate (WRE) of *Tithonia diversifolia* (Hemsl) A. Gray on the growth parameters of *Lycopersicon esculentum* (Mill)

	Plant height (cm)				Root length (cm)				Leaf area (cm^2)			
Weeks	Control	WRE	F-value	Sig.	Control	WRE	F-value	Sig.	Control	WRE	F-value	Sig.
0	6.28	5.64	4.50	0.06	2.88	3.10	0.22	0.64	2.62	2.76	0.08	0.77
1	8.36	9.40	6.19	0.03*	4.26	3.68	2.32	0.16	4.37	4.19	0.09	0.76
2	11.18	10.88	0.08	0.78	7.20	5.20	2.97	0.12	5.63	4.03	1.72	0.22
3	16.46	19.38	5.20	0.05	9.66	7.38	0.01	0.91	6.44	7.94	1.68	0.23
4	19.24	21.52	2.35	1.63	9.66	10.28	0.47	0.51	6.42	9.08	8.09	0.02*
5	23.24	26.72	2.85	0.12	9.88	8.78	0.81	0.39	6.75	8.38	0.01	0.90
	Leaf area ratio (cm^2 g^{-1})				Fresh weight (g)				Dry weight (g)			
Weeks	Control	WRE	F-value	Sig.	Control	WRE	F-value	Sig.	Control	WRE	F-value	Sig.
0	211.81	293.68	8.145	0.020*	0.100	0.16	0.79	0.39	0.012	0.00	3.30	0.10
1	108.73	710.40	0.68	0.800	0.510	0.57	0.62	0.45	0.040	0.03	0.13	0.71
2	72.00	71.73	0.95	0.350	1.169	0.84	3.26	0.10	0.070	0.05	3.54	0.04*
3	45.30	45.02	3.42	0.100	1.770	2.18	1.57	0.24	0.140	0.17	1.49	0.25
4	38.81	34.60	0.59	0.460	2.164	2.23	6.17	0.03	0.160	0.26	5.38	0.04*
5	20.40	27.09	3.52	0.097	3.450	3.54	0.01	0.90	0.330	0.31	0.09	0.76

Table 4: Effect of water soluble root exudate (WRE) of *Tithonia diversifolia* on the chlorophyll content of *Capsicum annum* and *Lycopersicon esculentum*

	Chlorophyll a				Chlorophyll b				Total chlorophyll			
Weeks	Control	WRE	F-value	Sig.	Control	WRE	F-value	Sig.	Control	WRE	F-value	Sig.
Capsicum annum												
0	16.61	18.49	1.17	0.31	22.69	17.37	3.904	0.084	39.30	35.86	6.17	0.038*
1	21.69	21.68	0.00	0.97	20.47	19.75	0.500	0.500	42.16	41.43	0.66	0.439
2	21.62	21.68	0.01	0.90	21.78	13.86	22.740	0.001*	43.40	35.54	23.58	0.000*
3	20.87	21.05	0.03	0.86	24.32	18.09	9.930	0.010*	41.16	39.54	0.98	0.350
4	21.76	21.63	1.07	0.33	20.66	21.58	0.394	0.010*	43.75	43.21	0.05	0.820
5	21.62	17.70	23.08	0.00*	23.00	7.64	25.490	0.000*	44.62	25.69	21.11	0.000*
Lycopersicon esculentum												
0	16.08	17.88	0.00	0.94	21.08	11.49	6.620	0.030*	37.16	32.44	6.54	0.030*
1	20.84	22.14	5.53	0.04*	15.23	21.03	38.510	0.000*	36.09	43.29	36.24	0.000*
2	21.46	22.46	0.95	0.35	12.49	17.68	8.800	0.010*	33.97	40.14	7.62	0.020*
3	15.88	19.38	4.66	0.06	7.92	14.52	8.650	0.190	24.74	32.97	10.01	0.010*
4	19.38	21.68	8.99	0.01*	11.86	14.52	5.570	0.040*	31.23	36.20	4.35	0.070
5	20.36	22.96	0.57	0.47	12.36	14.23	9.600	0.010*	32.72	35.19	12.19	0.000*

*Significant at $p<0.05$ probability level

C. annum and *L. esculentum*. The growth parameters of plants in the control regime were not significantly different from those of the plants in the WRE regime. Chlorophyll a accumulation in the *C. annum* and *L. esculentum* plants treated with WRE was not significantly different from that of the control (Table 4). The chlorophyll b contents of *C. annum* plants in control was higher than that of the WRE plants throughout the experiment and this was significantly different at $p<0.05$ in the latter weeks of the experiment. However, in the case of *L. esculentum* plants chlorophyll b accumulation in the WRE plants was higher in most part of the experiment than that of the plants in the control and this was significantly different at $p<0.05$. The total chlorophyll accumulation in *C. annum* plants in the control regime was not significantly different from that of the plants in the WRE regime whereas the total chlorophyll accumulation in the *L. esculentum* plants treated with WRE was higher and significantly different from that of the plants in the control regime at $p<0.05$.

The mean percentage germination of the *L. esculentum* plants was unaffected while that of *C. annum* was significantly inhibited by the application of FSE at $p<0.05$. The result obtained for *L. esculentum* was contrary to that of Qasem (2001), who reported that volatiles from Syrian sage (*Salvia syriaca*) reduced germination and inhibited seedling growth of tomato (*L. esculentum*). However, the observed significant retardation of the germination of the *C. annum* plants was consistent with the findings of several other workers. Narwal *et al*. (2002) observed that allelochemicals from aqueous extract of sunflower (*Helianthus annus* L.) inhibited germination in species like linseed (*Linum usitatissum* L.) and Mustard (*Brassica Juncea* L.). Indergit and Darkshimi (1994) found that water extracts from several species of the family Asteraceae and the soil on which they were grown inhibited germination and growth of the plants species.

Chlorophyll b accumulation in *C. annum* plants was significantly inhibited by WRE at $p<0.05$ especially during the latter weeks of the experiment. This result agreed with that of Ahmed *et al*. (2004) who reported that the root and shoot aqueous extract of *Chenopodium murales* L. reduced chlorophyll content and protein content of *Mililotus indicus* L., *Trifolium alexandrium* L., *Triticum pyramidal* L., *Lycopersicon esculentum* Mill and *Cucumis sativa* L. They further stated that the inhibition was a function of extract concentration and plant tissue type. Patterson (1981) found that allelochemicals suppressed photosynthesis in soybean (*Glycine max*). Also, Yang *et al.* (2002) stated that the supply-orientation of chlorophyll in rice (*Oryza sativa* L.) was significantly inhibited by exogenous application of phenolics. In this study however, the chlorophyll b and total chlorophyll accumulation in *L. esculentum* plants treated with WRE was enhanced significantly at $p<0.05$ almost throughout the duration of the experiment. This was consistent with the finding of Dieguez-Rojo and Gonzalez (2003), who found that allelochemical enhanced chlorophyll b content in *Tetraselmis suecica* (Kylin) Butch. The two test crops in this study differ in their respond to the allelochemicals in the exudate of *T. diversifolia.* This varying effect of the water soluble root exudate on chlorophyll b and total chlorophyll accumulation in the two test crops suggested that the allelochemicals in the exudate were capable of performing a dual role. That is, one of inhibition of chlorophyll b synthesis in *C. annum* and the other of stimulation of chlorophyll b and total chlorophyll synthesis in *L. esculentum.* The differential effects of the soluble allelochemicals observed in this study showed that the allelopathic potential of *T. diversifolia* is species dependent. The concentration of allelochemical that is inhibitory to chlorophyll synthesis in a particular plant species could be stimulatory to the same process in another plant species.

CONCLUSION

In conclusion, *T. diversifolia* is considerably allelopathic and can inhibit or stimulate germination and chlorophyll accumulation of associated crops. Consequently, this weed should be carefully monitored and managed particularly in susceptible crops like *C. annum.*

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