Research article

Allelopathic activity of leaf extracts of benjamin fig on germination and early growth potentials of sunflower

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Abstract

In a laboratory assay, the allelopathic potential of water leaf extracts of benjamin fig (*Ficus benjamina*) at concentration 10, 20, 40 and 60% obtained after 24, 48, 72 and 96h of soaking, was evaluated on germination and early growth of sunflower hybrids viz Oliver, Parsun-3, SFH-80 and NKS- 278. Distilled water was used as control treatment. Significantly retarded effects of the aqueous extracts were observed on germination, radicle and plumule length. The bioassay indicated that inhibitory effect was proportional to the concentrations of the extracts and higher concentration had more drastic effects on the studied attributes than lower extracts concentrations. More negative effects were evident at 96h soaking duration. The test hybrids also revealed significant differences in different extract concentrations. In general, NK-S-278 responded more sensitively to the phytoinhibitory effects of extracts while hybrid SFH-80 was less severely affected.

Keywords: Allelopathy; Bioactive compounds; Chemical inhibition; Competition; Growth suppression

Introduction

Allelopathy is an important natural process of suppression or stimulation of plants and other organisms by the action of allelochemicals which are produced and released to the environment by different plants [1, 2]. The suppressive or promotion ability of allelochemicals generally depend on their type, concentration and plants/ organisms which respond to such chemicals [3, 4]. Understanding of the suppression or stimulation of germination, growth and other physiological activities of field crops in response to allelopathic substances released

by other plants is very important for researchers in general and farmers in particular for deploying appropriate measures in crop cultivation [2, 5].

Sunflower in family Asteraceae is an important oilseed crop cultivated throughout the world. The presence of allelopathic plants in fields where cultivation of sunflower is carried out can influence the germination, growth, and yield of this valuable crop; thus rigorous research work is needed to diagnose potential allelopathic plants which could interfere with sunflower. Benjamin fig (*Ficus benjamina*) is an ornamental plant widely

grown for various purposes. Although the allelopathic effects of different plants species such as *Chenopodium* on wheat [3], sunflower on wheat and maize [4], *Parthenium hysterophorus* L. on maize and sorghum [6], pepper on *Bidens alba* and *Rivina humilis* [7], *Acacia saligna* on wheat and canola [8], *Morus alba* L. on *Cucumis sativus* [9], Sugarcane on wheat [2], and some weeds on wheat growth [5] have been well established; however, reports on the allelopathic potential of *Ficus benjamina* on sunflower and other cultivated crops are lacking in the literature. Therefore, this study was carried out with the objectives of studying the allelopathic effects of aqueous leaf extracts of *Ficus* on germination and early growth parameters of sunflower under laboratory conditions.

Materials and methods

Fresh and mature leaves of *Ficus benjamina* were collected from the surroundings of the University of Peshawar. The leaves were air dried in shade at room temperature (25°C-30°C) and crushed into fine powder and separately stored in polythene bags. Four different hybrids of sunflower (Oliver, Parsun-3, SFH-80, and NKS- 278) were selected as test species. Seeds were collected from NARC (National Agricultural Research Centre) Islamabad.

Leaf powder of *Ficus* at different concentration was taken and soaked in distilled water separately for 24, 48, 72 and 96 hours at room temperature. In this way 10, 20, 40 and 60% w/v aqueous extracts were prepared after filtration of soaked materials and stored for further assay. For germination and growth bioassay, glass wears were thoroughly washed with tap water and were sterilized. Double fold of filter paper was placed in Petri dishes. Ten seeds of uniform sizes were placed in each petri dish. The filtrate was tested against 4 different sunflower hybrids (Oliver, Parsun-3, SFH-80, and NKS- 278). Ten seeds were placed in

each petri dish on two-fold of filter paper replicated 5 times. The Petri dishes were moistened with 8ml of aqueous extracts while distilled water was used as a control. Petri dishes were then placed in incubators which were set at 25 °C for 72 hours. Data for germination, plumule and radicle growth were taken after 72 hours. Data was analyzed statistically through M Stat-C software.

Results and discussion

Germination percentage

Analysis of variance (ANOVA) for percent germination revealed that significant differences were recorded among soaking duration, hybrids and concentration means. Moreover, Interaction means for hrs x hybrids, hrs x concentration, hybrids x concentrations and hrs x hybrids x concentration were also significant.

According to means value for germination the highest percent germination (62.20%) was noted in 48 hours soaking duration, followed by 24 hours (56.90%) and 72 hours (40.20%), however, lowest percent germination was recorded in 96 hours (38.90%) (Table 1). Among Hybrids mean maximum germination % was recorded in Oliver (71.10%), followed by SFH-80 (66.10%), NK-S-278 (38.80%) and Parsun-3 (25.20%). Moreover, hours × hybrids interaction revealed that germination % was maximum in SFH-80 (89.20%) at a 24hrs soaking duration which was statistically similar to 48 hrs (87.20%), while minimum percent germination (9.60%) was recorded in Parsun-3 at soaking duration 96 hrs. Concentration means revealed that highest percent germination (61.00%) was noticed under control condition, followed by 20g (51.62%) and 10g (47.75%). However, lowest percent germination was recorded in 40g (43.25%) statistically similar to 60g (44.13%). Moreover, hours x concentration means indicated that under control condition lowest inhibition (74.00%) was recorded in soaking duration 48hrs while the highest

inhibition (24.00%) at 40g was recorded at soaking duration 96hrs. However, hybrids x concentration means exhibited that less inhibitory effect (78.50%) was noticed at concentration 20g, followed by (74.50%) under control condition with soaking duration of 24hrs. However, more inhibitory effect (14.50%) was noticed in 48 hrs soaking duration at concentration 80g. Hours x hybrids x concentration give out the result that maximum percent germination (100%) was noticed in SFH-80 at concentration 40g in 72hrs, followed by SFH-80 (98.00%) at 40g in 24 hrs, while no germination was recorded by Parsun-3 at concentration 80g in 72hrs and 96 hrs soaking duration.

Results agree with previous studies on allelopathy of different plants on crops which demonstrated that aqueous extracts of sugarcane [2] and rice [10] at different concentration had drastic effects on wheat and *Zea mays* and *Vigna radiate*. Reduced germinability of test crops as a result of different extract concentration and soaking duration in the present study could be attributed to changes in enzymes and hormones activation pattern, water absorption potential, and embryonic abnormalities of the seedlings [2, 5]. Batish *et al.* [11] outlined that inhibition in seed germination due to allelopathic stress may indicate the presence of growth suppressing substances such as phenolics, terpenoids, monoterpenes which negatively affect the division of growing cells at germination stage.

Plumule growth

ANOVA for plumule growth manifested significant differences among concentration means. However, differences among mean values for hrs, hybrids, hrs x hybrids, hrs x concentration, hybrids x concentrations and hrs x hybrids x concentration show non-significant effect.

According to the mean value for soaking duration maximum plumule growth

(0.454cm) was noticed in 24 hrs, followed by 48hrs (0.422cm), 96 hrs (0.399cm) and 72 hrs (0.366cm). Hybrid mean reported highest plumule growth in SFH-80 (0.548cm), followed by Oliver (0.421cm), NK-S-278 (0.399cm) and Parsun-3 (0.271cm). According to interaction means for hours x hybrids plumule growth was highest in NK-S-278 (0.752cm) at 24 hrs soaking duration, followed by SFH-80 and Parsun-3 (0.650cm, 0.138 cm respectively) at 72 hrs. Whereas concentration means display significant differences with highest plumule growth (0.952cm) under control condition, followed by 0.397cm at 10g statistically similar to (0.299cm) at concentration 20g, and (0.226cm) at concentration 40g and (0.174cm) at concentration 80g. Hours x concentration interaction for plumule growth showed highest plumule growth at control (1.323cm) in 24 hrs soaking duration. While lowest value for plumule growth (0.143cm) was notated at concentration 40g in 72 hrs soaking duration. The gradual decrease was seen in plumule as concentration and soaking duration increases. Among the interaction between hybrids x concentrations less inhibition was recorded (1.251cm) at control level in 96 hrs soaking duration. While more inhibitory effect (0.074cm) was noticed at concentration 80g in soaking duration 48hrs. According to hours x hybrids, x concentration means maximum inhibition was recorded at control (1.251cm) under soaking duration 96hrs. While no plumule growth was observed in Parsun-3 at control level in 72hrs and 96 hrs soaking durations (Table 2).

Dastagir *et al.* [12] worked on the effect of aqueous extract of *Quercus baloot* plant on plumule growth of *Setaria italic*, *Pennisetum americanum* and *Lactuca sativa*. Results were observed after 24, 48, 72 and 96 hours. After 24 hrs (578.0cm) growth was observed in plumule of *Setaria italic*, (37.9cm, 100cm, 84.8cm) plumule growth was recorded after

48, 72 and 96 hours at concentration 5g which agree with our results in which maximum growth (0.454cm) was observed at soaking duration 24 hrs and (0.422cm) at 48 hrs. Similar findings were reported by [13] on the allelopathy of *Broussonetia papyrifera*. Our results are in contrast to [14] who studied the effect of *Cannabis sativa* on *Lantana camara* and *Parthenium hysterophorus* plumule growth where stimulatory effects were observed. The existence of the significant amount of phenolics in the aqueous extracts of *B. papyrifera* suggested that the practical inhibition could be due to the presence of phenolic content [15].

Radicle growth

ANOVA for plumule growth depicted significant variation among means of hybrids, concentration, and interaction between hybrids x concentrations. However, mean values for different soaking duration and interaction between means of hrs x hybrids, hrs x concentrations and hrs x hybrids x concentrations show the non-significant difference.

Moreover, according to soaking duration maximum radicle growth (0.387cm) was observed in 72 hrs soaking duration. While minimum radicle growth (0.290cm) was recorded at 24 hrs soaking duration. Hybrids means show less inhibition SFH-80 (0.659cm) & Oliver (0.464cm). While more inhibition was recorded in Parsun-3 (0.129cm) statistically similar to NK-S-278 (0.148cm). Interaction means of hrs x hybrids for radicle growth exhibited highest (0.863cm) in SFH-80 with soaking duration 96hrs. However, minimum radicle growth was recorded in Parsun-3 (0.013cm) in 96 hrs soaking duration. Means value for different concentration divulged that highest radicle growth (1.033cm) was noticed under control condition, followed by (0.320cm) 10g and (0.189cm) 20g. While minimum growth (0.100cm) was recorded at concentration 40g which was statistically similar to 80g

(0.109cm). According to interaction means for radicle growth between hrs x concentration highest value (1.280cm) was noticed under control condition in 72hrs soaking duration. While minimum radicle growth (0.025cm) was noticed at concentration 40g under 96hrs soaking duration. Among means values for interaction between hybrids x concentrations less inhibitory effect was recorded at control level (2.205cm) in 72hrs soaking duration. While more inhibition (0.015cm) was recorded in 48 hrs soaking duration concentration 80g statistically similar to 10g & 20g (0.051cm 0.057cm). Hours x hybrids x concentrations interaction noticed highest radicle length (2.943cm) in 72hrs soaking duration under control condition, followed by (2.222cm) under soaking duration 96hrs. While no radicle growth was observed in NK-S-27 8 and Parsun -3 at concentration 10g, 20g, 40g, 80g under soaking duration 72 hrs and 96 hrs (Table 3).

Our results are in close accordance with [12] who observed inhibition of radicle length of *Lactuca sativa* and *Setaria italic* when an aqueous extract of *Quercus baloot* at different concentration and soaking period were applied to test plants. Similarly, findings of [13] also confirm our results which stated that aqueous extract of Neem reduced the radicle length of *Vigna mungo*, *Vigna unguiculata*, *Vigna aconitifolia*, *Cicer arietinum* and *Vigna aconitifolia* at different concentration obtained after the different soaking duration. In a recent study, Majeed et al. [2] found retarded radicle growth of wheat in response to aqueous extracts of sugarcane at the different soaking period and attributed that suppression to negative interactions of allelochemicals with corresponding enzymes required for normal growth. It may be argued that leaf of *Ficus* may possess different allelochemicals which could have imparted negative effects on the studied parameters

with linear correlation with concentration and soaking duration.

Table 1. Effect of different concentration of *Ficus benjamina* leaf extract on germination of sunflower in freshwater bioassay

Hrs.	Concentrations	Hybrids				Means hrs × conc.	Means hyb × conc.
		Oliver	Parsun-3	SFH-80	NK-S-278		
24 hrs.	Con	90.00 ^{A-F}	58.00 ^{M-T}	96.00 ^{DCH}	44.00 ^{S-Z}	72.00 ^{D*H}	74.50 ^{D*H}
	10g	58.00 ^{M-T}	38.00 ^{U-Z}	84.00 ^{A-I}	36.00 ^{V-Z}	54.00 ^{CD}	69.50 ^{D*H*C}
	20g	64.00 ^{J-R}	30.00 ^{YZ}	84.00 ^{A-I}	26.00 ^Z	51.00 ^D	78.50 ^A
	40g	62.00 ^{K-S}	28.00 ^Z	98.00 ^{D-H}	26.00 ^Z	53.50 ^{CD}	63.50 ^{CD}
	80g	82.00 ^{A-J}	18.00 ^{D-H}	84.00 ^{A-I}	32.00 ^{XYZ}	54.00 ^{CD}	69.50 ^{D*H*C}
Means hrs.		71.20 ^B	34.40 ^{EF}	89.20 ^A	32.80 ^F	56.90 ^B	
48 hrs.	Con	82.00 ^{A-J}	66.00 ^{I-R}	92.00 ^{A-E}	56.00 ^{N-U}	74.00 ^A	43.50 ^{FG}
	10g	88.00 ^{A-G}	42.00 ^{T-Z}	78.00 ^{C-L}	48.00 ^{R-Y}	64.00 ^B	25.50 ^H
	20g	84.00 ^{A-I}	32.00 ^{XYZ}	86.00 ^{A-H}	50.00 ^{Q-X}	63.00 ^{H*C}	20.50 ^{HI}
	40g	86.00 ^{A-H}	44.00 ^{S-Z}	100.00 ^A	28.00 ^Z	64.00 ^{D*H}	22.50 ^{HI}
	80g	52.00 ^{P-W}	38.00 ^{U-Z}	80.00 ^{B-K}	12.00 ^{DH}	45.50 ^{DEF}	14.50 ^I
Means hrs.		78.40 ^B	44.40 ^D	87.20 ^A	38.80 ^{DEF}	62.20 ^A	
72 hrs.	Con	68.00 ^{H-I}	30.00 ^{YZ}	58.00 ^{M-T}	48.00 ^{R-Y}	51.00 ^D	74.00 ^{D*H}
	10g	78.00 ^{C-L}	14.00 ^{D-H}	24.00 ^A	36.00 ^{V-Z}	38.00 ^{E-H}	55.00 ^{DE}
	20g	72.00 ^{F-O}	12.00 ^{D-H}	38.00 ^{U-Z}	42.00 ^{T-Z}	41.00 ^{EFG}	67.50 ^{H*C}
	40g	76.00 ^{D-M}	6.00 ^{D-H}	30.00 ^{YZ}	12.00 ^{D-H}	31.00 ^{HI}	65.00 ^{H*C}
	80g	74.00 ^{E-N}	0.00 ^B	64.00 ^{J-R}	22.00 ^A	40.00 ^{E-H}	69.00 ^{D*H*C}
Means hrs.		73.60 ^B	12.40 ^G	42.80 ^{DE}	32.00 ^F	40.20 ^C	
96 hrs.	Con	58.00 ^{M-T}	20.00 ^A	50.00 ^{Q-X}	60.00 ^{L-T}	47.00 ^{DE}	52.00 ^{EF}
	10g	54.00 ^{O-V}	8.00 ^{D-H}	34.00 ^{W-Z}	44.00 ^{S-Z}	35.00 ^{GH}	41.00 ^G
	20g	94.00 ^{A-D}	8.00 ^{D-H}	62.00 ^{K-S}	42.00 ^{T-Z}	51.50 ^D	40.00 ^G
	40g	30.00 ^{YZ}	12.00 ^{D-H}	32.00 ^{XYZ}	22.00 ^A	24.00 ^I	22.00 ^{HI}
	80g	70.00 ^{G-P}	0.00 ^B	48.00 ^{R-Y}	30.00 ^{YZ}	37.00 ^{FGH}	24.00 ^H
Mean hrs.		61.20 ^C	9.60 ^G	45.20 ^D	39.60 ^{DEF}	38.90 ^C	
Means Hybrids		71.10 ^A	25.20 ^D	66.10 ^B	35.80 ^C		
Means Concentrations		61.00 ^A	47.75 ^{H*C}	51.62 ^B	43.25 ^C	44.13 ^C	

LSD value for hrs= 4.356, for hybrids = 4.356, for hrs x hybrids = 8.712, for concentration= 4.870, hrs x concentration = 9.741, hybrids x concentration = 9.741, hrs x hybrids x concentration = 19.48 at α value 5%

Table 2. Effect of different concentration of *Ficus benjamina* leaf extract on plumule growth of sunflower in freshwater bioassay

Hrs.	Concentrations	Hybrids				Means hrs × conc.	Means hyb × conc.
		Oliver	Parsun-3	SFH-80	NK-S-278		
24 hrs.	Concentration	0.846	0.414	0.840	3.192	1.323	0.805
	10g	0.348	0.187	0.479	0.135	0.287	0.460
	20g	0.330	0.118	0.366	0.223	0.259	0.379
	40g	0.259	0.130	0.258	0.106	0.188	0.222
	80g	0.289	0.160	0.285	0.106	0.210	0.237
Means hrs.		0.414	0.202	0.445	0.752	0.454	
48 hrs.	Concentration	0.704	0.723	1.037	0.673	0.784	0.615
	10g	0.517	0.449	0.602	0.196	0.441	0.259
	20g	0.443	0.305	0.615	0.203	0.391	0.229
	40g	0.248	0.120	0.274	0.555	0.299	0.177
	80g	0.219	0.137	0.307	0.110	0.193	0.074
Means hrs.		0.426	0.347	0.567	0.347	0.422	
72 hrs.	Concentration	0.589	0.180	1.228	0.606	0.651	1.139
	10g	0.750	0.240	1.144	0.198	0.583	0.698
	20g	0.272	0.172	0.352	0.176	0.243	0.393
	40g	0.214	0.100	0.354	0.170	0.210	0.257
	80g	0.269	0.000	0.174	0.130	0.143	0.256
Means hrs.		0.419	0.138	0.650	0.256	0.366	
96 hrs.	Concentration	1.079	1.142	1.452	0.532	1.051	1.251
	10g	0.227	0.160	0.567	0.152	0.276	0.170
	20g	0.472	0.320	0.238	0.185	0.304	0.197
	40g	0.166	0.360	0.140	0.160	0.207	0.248
	80g	0.170	0.000	0.257	0.168	0.149	0.129
Mean hrs.		0.423	0.396	0.531	0.239	0.399	
Means hybrids		0.421	0.271	0.548	0.399		
Means Concentrations		0.952 ^A	0.397 ^B	0.299 ^B	0.226 ^B	0.174 ^B	

LSD value at 5% for concentration= 0.2432 at α value 5%

Table 3. Effect of different concentration of *Ficus benjamina* leaf extract on radicle growth of sunflower in freshwater bioassay

Hrs.	Concentrations	Hybrids				Means hrs × conc.	Means hyb × conc.
		Oliver	Parsun-3	SFH-80	NK-S-278		
24 hrs.	Concentration	0.946	0.404	1.720	0.120	0.798	1.008 ^B
	10g	0.317	0.066	0.302	0.020	0.176	0.663 ^C
	20g	0.178	0.060	0.142	0.120	0.125	0.342 ^{DEF}
	40g	0.296	0.050	0.193	0.000	0.135	0.163 ^{EFG}
	80g	0.287	0.040	0.541	0.000	0.217	0.146 ^{FG}
Means hrs.		0.405	0.124	0.579	0.052	0.290	
48 hrs.	Concentration	0.835	0.633	1.934	0.648	1.012	0.501 ^{CD}
	10g	0.603	0.160	0.365	0.425	0.388	0.057 ^G
	20g	0.585	0.145	0.342	0.105	0.294	0.051 ^G
	40g	0.173	0.040	0.175	0.060	0.112	0.023 ^G
	80g	0.127	0.020	0.144	0.080	0.093	0.015 ^G
Means hrs.		0.464	0.200	0.592	0.264	0.380	
72 hrs.	Concentration	0.912	0.902	2.943	0.363	1.280	2.205 ^A
	10g	0.597	0.000	0.778	0.065	0.360	0.422 ^{CDE}
	20g	0.200	0.000	0.215	0.071	0.122	0.250 ^{DEFG}
	40g	0.142	0.000	0.294	0.080	0.129	0.180 ^{EFG}
	80g	0.100	0.000	0.085	0.000	0.046	0.237 ^{DEFG}
Means hrs.		0.390	0.180	0.863	0.116	0.387	
96 hrs.	Concentration	1.338	0.067	2.222	0.541	1.042	0.418 ^{CDE}
	10g	1.136	0.000	0.244	0.050	0.358	0.140 ^{FG}
	20g	0.404	0.000	0.300	0.150	0.214	0.112 ^{FG}
	40g	0.040	0.000	0.060	0.000	0.025	0.035 ^G
	80g	0.071	0.000	0.177	0.000	0.079	0.038 ^G
Means hrs.		0.598	0.013	0.601	0.162	0.343	
Means hybrids		0.464 ^B	0.129 ^C	0.659 ^A	0.148 ^C		
Means Concentrations		1.033 ^A	0.320 ^B	0.189 ^{H*C}	0.100 ^C	0.109 ^C	

LSD value for hybrids= 0.1197, for Concentration= 0.1338, hybrids x Concentration = 0.2676 at α value 5% LSD value for Hybrids = 4.569 at α value 5%

Conclusions

It is concluded from the results of this study that different concentrations of aqueous leaf extracts of *F. benjamina* obtained after soaking for different duration revealed significantly inhibitory effects on the

germination and early seedling growth of four hybrids of sunflower. Higher extracts (60%) showed maximum inhibitory effects than lower concentrations. In general, NK-S-278 responded more sensitively to the

phytoinhibitory effects of the extracts while hybrid SFH-80 was less severely affected.

Authors' contributions

Conceived and designed the experiments: Z Muhammad, Performed the experiments: Sobia, Analyzed the data: R Ullah & A Majeed, Wrote the paper: Z Muhammad.

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