The Allelopathic Effect of Mango Leaves on the Growth and Propagative Capacity of Purple Nutsedge (*Cyperus rotundus* L.)

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Abstract: Two Pot experiments were conducted in the greenhouse of National Research Centre, Egypt during two successive summer seasons of 2008 and 2009 to study the effect of mango leaves on growth and propagative capacity of purple nutsedge. Two experiments were carried out include soil treatments with mango leaf extract (weekly for one month) at concentrations, 0, 5,10, 15 and 25%. The second experiment included soil treatments with mango leaf powder at the rate of, 0, 20, 40, 60, 80 and 100g/kg soil. Mango leaf extract as well as the powder exhibited different degree of inhibition in purple nutsedge growth after 30 and 75 days from sowing according to the concentration of the aqueous extract and the rate of mango leaf powder. The results indicated significant reduction in number of mother shoot, number of daughter shoots as well as dry weight of underground organs. Maximum inhibition was recorded by 25% leaf extract. Moreover, soil treatment with mango leaf powder showed significant reduction in dry weight of foliage and underground organs. The highest inhibitions were observed by using 80 and 100 g/kg soil of mango leaf powder. In general, non significant differences were found between inhibitions caused by 80 and 100g/kg soil. The total phenols in foliage and underground organs of purple nutsedge revealed that the inhibitory effects were concomitant with the accumulation of total phenols compared to controls. A high-performance liquid chromatography analysis showed that caffeic acid, ferulic acid, coumaric acid, benzoic acid, vanelic, chlorogenic, gallic; hydroxybenzoic and cinnamic acid were present in mango leaf extract. In general, mango leaves could be used as a safety tool to suppress purple nutsedge growth. [Journal of American Science 2010;6(9):151-159]. (ISSN: 1545-1003).

Keywords: *Cyperus rotundus*, Phenolic acids, Allelopathy, Mango leaves

1. Introduction

Purple nutsedge is the world's worst weed (Holm et al 1991 and Horowitz, 1992). It has the ability to survive adverse conditions and grow explosively (Williams, 1982; Kim et al 1994). The principal method of propagation of this weed is through the basal bulbs and tubers (Nishimoto, 2001). Great losses occurred when nutsedge compete with crops (El-Masry et al 1980; Messiha et al 1993; Bryson et al 2003; William and Hirase; 2004 and 2005).

During the 20th century, pronounced attention was paid to the use of herbicide to control the growth of weeds which compete with crops which absorb the soil's nutrients (Hussein, 2001). Different herbicides were used for purple nutsedge control (Altland et al 2003; Ferell et al., 2004; Durigan et al., 2006; El-Rokiek et al 2006a; 2007 and 2009). However, the use of herbicides during the last 50 years has raised pronounced doubts about the safety from their continuous use.

Allelopathy is a natural and environment-friendly technique which may prove to be a tool for weed management and thereby increase crop yields. So, the term allelopathy is commonly denotes the interaction in which one plant could cause suffering to another plant (Rice, 1984). Hence, the plant is a vast source of naturally occuring and selective herbicide. And as mentioned it may be environmental friendly since it could be extracted from flower, leaves, stem and roots. These allelopathic extracts could be used to control the growth of weeds (Chon and Kim, 2002 and 2004; Chon et al 2003; Singh et al 2003 and El-Rokiek et al 2006b).

The main principle in allelopathy arises from the fact that plants produce thousands of chemicals; and many of these chemicals are released by leaching, exudation, or decomposition processes.

Subsequently, some of these compounds which are known as allelochemicals alter the growth or physiological functions of receiving species. The most commonly found allelochemicals, cinnamic and benzoic acids, flavonoids, and various terpenes (Singh et al., 2003), these compounds are known to be phytotoxic (Einhellig, 2002).

It is worthy to mention that dried mango leaf powder completely inhibited sprouting of purple nutsedge tubers (James and Bala, 2003).

This work is an attempt to find out if the leaves of Mango have the capacity to control or suppress purple nutsedge growth.

2. Material and Methods

Pot experiments were carried out under greenhouse conditions at the National Research Centre, during two successive summer seasons in August of 2008 and 2009. The stock of purple nutsedge (*Cyperus rotundus* L.) used as a source of tubers was collected from a dense stand at the National Research Centre garden.

a) The use of mango leaf extract

Mango leaves were dried in an electric oven at 40^0C. The dried leaves were ground to a fine powder. 5 g, 10 g, 15 g and 25g (pass through 1.5mm mesh) were transferred to labeled bottles, then 100 ml of sterile, deionized distilled water were added to each bottle. The mixture was shaken and the bottles were left for 48 h at room temperature, and then filtered to get extracts of 5%, 10%, 15% and 25%. These quantities were reduplicated.

Dormant tubers of purple nutsedge were planted in Plastic pots filled with 1kg of soil. After 7 days from planting, mango leaf extracts at 0, 5%, 10%, 15% and 25 % concentration were added to each pot at a rate of 500ml/ pot weekly for one month.

The experiment consisted of 5 treatments including untreated control. Each treatment was represented by six replicates; all pots were arranged at complete randomized design. Three plants were collected from each treatment and the following growth characters were taken after 30 and 75 days from sowing.

1- Number of mother shoots / tuber.
2- Number of leaves of mother shoots / tuber.
3- Length of mother leaves (cm).
4- Number of daughter shoots / tuber.
5- Number of leaves of daughter shoots / tuber.
6- Number of rhizomes / tuber.
7- Length of rhizomes / tuber.
8- Number of propagative organs / tuber (basal bulb and tubers) / plant.
9- Dry weight of foliage (g/plant).
10- Dry weight of underground organs (g/plant).
11- Total dry weight (g/plant).

b) The use of Mango leaf powder

Mango leaves were dried as mentioned previously and finely ground to powder. The dried mango powder was mixed with the soil at the rate of 20, 40, 60, 80 and 100g/kg soil. Dormant tubers of purple nutsedge were planted in these plastic pots that filled with 1kg of soil. The experiment consisted of 6 treatments including control, each was replicated 6 times, all pots were arranged at complete randomized design. Three plants were collected from each treatment 30 days and 75 days from sowing and the same previous growth characters were recorded.

Determination of total phenols

Total phenolic compounds in purple nutsedge were extracted from dry samples of the foliage and underground parts. Drying of tissues was carried out in an electric oven at 60^oC till constant weight. Total phenols were determined colorimetrically according to the method defined by Snell and Snell (1953) using Folin and Ciocalteu phenol reagent.

The Phenolic acids in the tested aqueous extracts of mango leaves were also extracted as follow: 5 g of finally ground dry leaves were immersed in 100 ml distilled water and allowed to soak for 48 hours, filtered, the filtrate was subjected to separation by HPLC with the following condition: mobile phase acetonitrile (86%), Buffer 14% (pot. dihydrogen phosphate: phosphoric acid, 2: 1v/v), flow rate 1ml/min, Agilent 1100 series (Waldborn, Germany), quaternary pump (G1311A), Degasser (G1322A), Thermo stated Autosamples (G1329A), variable wave length detector (G1314A), column: Zorbax 300SB C18 column (Agilent Technologies, USA). Injection was carried out at wave lengths 254, 280, and 320nm for separation of different phenolic acids.

All data were statistically analyzed according to Snedecor and Cochran (1980)

3. Results

The use of mango leaf extract

Growth characters of mother shoots

The results of the number of mother shoots / tuber, number of leaves of mother shoots and length of mother shoots (cm) of purple nutsedge after 30 and 75 days from sowing are shown in Table (1). These results reveal that the number of mother shoots / tuber was significantly decreased with all concentrations 30 and 75 days after sowing (DAS) compared with the respective control. The concentration of 25% was more phototoxic especially at the late stage (75 DAS).

The data illustrated in Table (1) also show that the number of leaves of mother shoots / tuber and the length of mother leaves (cm) decreased significantly with mango leaf extracts after 30 and 75 days from sowing as compared to the corresponding control. The rate of reduction increased with increasing concentrations. Maximum significant reduction in number of leaves of mother shoots resulted from treatment of 25% mango leaf extract, inhibition reached 39.3 and 65.5% 30 &75 DAS respectively.

Table 1. Effect of different concentrations of mango (*Mangifera indica)* leaf extract on the different growth parameters of foliage of purple nutsedge (*Cyperus rotundus* L.) (Average of the two seasons).

Growth characters	DAS	Percentage of mango leaf extract					
		0 %	5 %	10 %	15 %	25% %	LSD
Number of mother shoots / tuber	30	4.00	2.66	2.33	2.00	2.00	0.61
	75	4.33	3.00	2.33	1.33	1.33	0.87
Number of leaves of mother shoots / tuber	30	28.00	24.00	20.33	17.33	17.00	2.23
	75	36.66	30.66	18.00	15.66	12.66	3.50
Length of mother leaves (cm)	30	45.33	41.00	37.33	32.33	27.00	3.13
	75	55.66	50.33	46.66	37.00	29.00	5.52
Number of daughter shoots / tuber	30	4.66	3.33	3.33	2.00	1.33	0.87
	75	6.00	5.00	3.66	2.33	0.33	0.75
Number of leaves of daughter shoots / tuber	30	23.00	15.00	12.00	10.00	4.66	2.77
	75	41.000	27.33	22.00	14.00	1.66	3.91

Growth characters of daughter shoots

The results demonstrated in Table (1) show the effects of mango leaf extract at different concentrations on the number of daughter shoots / tuber and the number of leaves of daughter shoots / tuber of purple nutsedge. The data in Table (1) show significant decrease in the number of daughter shoots as well as number of leaves of daughter shoots due to mango leaf extracts application. More significant reduction was observed with 25 % mango leaf extract in both characters. The reduction in number of daughter shoots and number of leaves of daughter shoots reached 71.5 and 79.7% 30 DAS. Additive significant reduction was detected 75 DAS, the reduction increased to 94.5 % in the number of daughter shoots and 96% in number of leaves of daughter shoots. This means that the rate of inhibition increased during the experimental period.

Growth characters of underground organs

The data in Table (2) show that phytotoxicity of mango leaf extract showed pronounced variation among different concentrations on the growth of underground organs of purple nutsedge. The effect was highly depending on concentration of the extract. Leaf extract at 25% caused strong, harmful effects which did not appear in low concentration. Consequently high significant inhibition in the underground organs (basal bulb and tubers) of purple nutsedge was detected which reached 71.4 and 87.9% 30 &75 DAS when compared with controls. This inhibition was accompanied by significant reduction in the number of rhizomes as well as their lengths. Remarkable reduction was obtained in the number of rhizomes with 25% leaf extract which reached to 66.7 and 85.4, 30 &75 DAS. The corresponding results in length of rhizomes recorded 65.6 and 88.6%.

Table 2. Effect of different concentrations of mango (*Mangifera indica*) leaf extract on the different growth parameters of underground organs of purple nutsedge (*Cyperus rotundus* L.) (Average of the two seasons).

Growth characters	DAS	Percentage of mango leaf extract					
		0 %	5 %	10 %	15 %	25%	LSD at 5%
Number of basal bulbs and tubers	30	11.66	8.00	5.66	4.00	3.33	1.51
	75	22.00	18.00	16.00	10.66	2.66	2.71
Number of rhizomes/ tuber	30	9.00	7.00	4.33	4.00	3.00	1.74
	75	16.00	12.00	10.33	7.33	2.33	2.40
Length of rhizomes (cm)	30	26.66	25.16	18.66	15.66	9.18	3.01
	75	44.00	37.33	29.00	25.33	5.00	4.20

Dry weight of foliage (g / plant)

The results in Table (3) show significant inhibition in dry matter accumulation in foliage of purple nutsedge in response to different concentrations of the extract. The degree of inhibition was concentration dependent. The allelopathic effect of the leaf extract was highly detectable at concentration of 25%. This treatment recorded 54% after 30 days

from sowing. The growth in the second stage (75 DAS) decreased markedly which increase the inhibition rate to 83%.

Dry weight of underground organs (g / plant)

The mango leaf extracts inhibited significantly the growth of underground organs of purple nutsedge and the harmful effect was more pronounced with the concentration of 25% than other concentrations. Moreover, the inhibition was more consistent during the experimental period leading nearly to complete death of the plant (95.9% inhibition) 75 DAS as compared with the untreated control.

Total dry weight

The pattern of change in the total dry weight (dry weight of foliage + dry weight of underground organs) was, to a great extent parallel to that recorded in the dry weight of foliage and underground organs (Table 3) 30 and 75 DAS as compared to the controls.

Table 3. Effect of different concentrations of mango (*Mangifera indica*) leaf extract on the dry weight of foliage, dry weight of underground and total dry weight (g / plant) of purple nutsedge (*Cyperus rotundus* L.) (Average of the two seasons).

Growth characters	DAS	Percentage of mango leaf extract					
		0 %	5 %	10 %	15 %	25%	LSD at 5%
Dry weight of foliage	30	1.586	1.250	1.160	0.970	0.730	0.305
	75	3.033	2.866	2.433	1.966	0.516	0.432
Dry weight of underground	30	1.723	1.520	1.406	1.113	0.486	0.155
	75	9.530	8.660	4.733	3.433	0.391	0.710
Total dry weight	30	3.309	2.770	2.566	2.090	1.216	0.365
	75	12.56	10.533	7.166	5.400	0.907	0.771

Changes in total phenol content

Total phenol contents of purple nutsedge at the two stages of growth are illustrated in Table (4). Total contents in both foliage and underground organs increased significantly when treated with all concentrations of allelopathic leaf extract of mango 30 and 75 DAS in comparison to the controls. Extracts at 25% caused accumulation of total phenol content which increased to a very high extent 30 and 75 DAS in both foliage and underground organs. The results also indicate that total phenol accumulations in underground parts exceeded those found in the foliage in comparison to the controls.

b) The use of mango leaf powder

Growth characters of mother shoots

The results illustrated in Table (5) show that mango leaf powder at different rates (from 20-100g/kg soil) delayed growth of mother shoots. In this respect, the number of mother shoots / tuber, number of leaves of mother shoots and length of mother shoots (cm) of purple nutsedge were significantly reduced. The reduction increased with increasing rate of mango leaf powder especially at the late stage (75 DAS) compared to controls. The addition of 80 and 100g mango leaf powder to the soil showed greatest effect. There is no significant difference between the reductions obtained by both 80 and 100g leaf powder.

Table 4. Effect of different concentrations of mango (*Mangifera indica*) leaf extract on total phenol contents in both foliage and underground parts of purple nutsedge (*Cyperus rotundus* L.) (Average of the two seasons).

Percentage of mango leaf extract	Total phenol contents (mg/g DW)			
	Foliage		Underground	
	30days	75days	30days	75days
0	49.70	76.54	80.70	99.41
5%	54.41	78.96	89.42	99.62
10%	62.03	99.23	111.26	153.309
15%	62.86	104.79	114.63	185.42
25%	66.93	109.02	131.23	187.41
LSD at 5%	3.34	5.19	10.11	10.49

Growth characters of daughter shoots

The data presented in Table (5) also indicate that mango leaf powder at different rates showed pronounced variation in the Phytotoxicity. The number of daughter shoots / tuber and the number of leaves of daughter shoots were highly affected especially at 80 and 100 g/kg soil after 30 and 75 days from sowing as compared to the corresponding controls. The rate of reduction increased after 75 days. Maximum and significant reduction resulted from treatment with 100g/kg, the number of daughter shoots decreased to 66.7%, moreover, the number of leaves of daughter shoots recorded 63% inhibition 75 DAS compared with controls.

Growth characters of underground organs

The underground organs of purple nutsedge responded differently to mango leaf powder. This application inhibited the growth of the underground organs of purple nutsedge significantly (Table 6) as compared to the controls. The degree of inhibition was highly dependent on the rate of application as well as growth stage. The lower rates were less phytotoxic, while using higher rates (80&100g/kg) caused great and significant inhibition in the growth of underground organs. In general, there was no significant difference between using 80 and 100g/kg. The reduction in number of bulbs and tubers, number of rhizomes and length of rhizomes corresponded to 85.3, 74 and 90.6% inhibition respectively by using 100g/kg (Table 6).

Table 5. Effect of different concentrations of mango (*Mangifera indica*) leaf powder on the different growth parameters of foliage of purple nutsedge (*Cyperus rotundus* L.) (Average of the two seasons).

Growth characters	DAS	Mango leaf powder (g)						
		0	20	40	60	80	100	LSD at 5%
Number of mother shoots / tuber	30	2.00	2.00	2.00	2.00	1.00	1.00	0.66
	75	3.33	2.00	2.00	1.33	1.00	1.00	0.53
Number of leaves of mother shoots / tuber	30	25.00	24.00	20.00	18.00	16.33	15.00	2.32
	75	38.00	30.66	24.00	15.33	13.00	12.33	2.64
Length of mother leaves (cm)	30	41.00	38.33	37.00	35.00	31.00	30.00	2.22
	75	52.33	50.66	43.33	36.33	23.00	21.66	2.70
Number of daughter shoots / tuber	30	9.00	8.50	8.00	5.30	5.00	4.33	0.94
	75	12.00	9.33	8.66	5.66	5.33	4.00	1.39
Number of leaves of daughter shoots / tuber	30	32.33	26.00	24.33	22.00	19.00	17.33	2.09
	75	45.000	37.66	31.33	29.00	20.66	16.66	2.58

Table 6. Effect of different concentrations of mango (*Mangifera indica*) leaf powder on the different growth parameters of underground organs of purple nutsedge (*Cyperus rotundus* L.) (Average of the two seasons).

Growth characters	DAS	Mango leaf powder (g)						
		0	20	40	60	80	100	LSD at 5%
Number of basal bulbs and tubers	30	13.00	9.33	8.00	7.33	6.66	4.33	1.21
	75	22.66	19.00	13.66	12.00	7.66	3.33	1.37
Number of rhizomes/ tuber	30	13.66	11.33	9.00	7.33	6.66	4.66	1.57
	75	16.66	14.00	10.00	8.66	7.33	4.33	1.02
Length of rhizomes (cm)	30	35.33	34.33	23.33	20.33	20.00	18.60	2.61
	75	64.00	56.33	36.00	29.00	6.66	6.00	2.85

Dry weight of foliage (g/plant)

Evidences for growth inhibition were observed in Table (7), the inhibition in dry weight of foliage varied significantly with different rates of mango leaf powder. The allelopathic effect of leaf powder was most phytotoxic at rate of 100g/kg as compared to the controls. The results indicate that the rate of reduction increased along experimental period. Maximum inhibition in dry matter accumulation of foliage reached 42% 30 DAS while, the rate of

inhibition increased 75 DAS to reach 64.9%, i.e. there is no sign for recovery.

Dry weight of underground organs (g/plant)

Application of mango leaf powder (20-100g/kg soil) caused injury to purple nutsedge growth leading to high significant reduction in dry matter accumulation of underground organs at the highest rate. The initial damage was detected 30 DAS as it reached 50.4%. Moreover, the plant at the late stage cannot overcome this initial damage recording great injury which reached 86.1%.

Total dry weight

Total dry weight (dry weight of foliage + dry weight of underground organs) showed parallel effect to that recorded in the dry weight of foliage and underground organs (Table 7).

Table 7. Effect of different concentrations of mango (*Mangifera indica*) leaf powder on the dry weight of foliage, dry weight of underground and total dry weight (g / plant) of purple nutsedge (*Cyperus rotundus* L.) (Average of the two seasons).

Growth characters	DAS	Mango leaf powder (g)						
		0	20	40	60	80	100	LSD at 5%
Dry weight of foliage	30	2.366	2.153	1.966	1.750	1.463	1.373	0.151
	75	3.566	3.200	2.500	1.833	1.400	1.250	0.341
Dry weight of underground	30	3.033	2.950	2.516	2.103	1.616	1.503	0.146
	75	10.433	9.600	6.483	4.273	1.600	1.452	0.764
Total dry weight	30	5.400	5.103	4.483	3.853	3.079	2.876	0.217
	75	14.00	12.800	8.983	6.106	3.000	2.703	0.991

Changes in total phenol content

Endogenous phenol contents in purple nutsedge tissues (foliage or underground organs) at the two stages of growth exhibited significant responses to soil applied mango leaf powder (Table 8). The results reveal gradual significant increase in the total contents in both foliage and underground organs due to different applied powder rates in comparison to the untreated controls. The increase in total phenol contents reached high level in both foliage and underground with the addition of 100g powder to the soil. Moreover, the level of phenols in underground parts exceeded to a high extent the corresponding level in foliage parts in comparison with the controls.

Table 8. Effect of different concentrations of mango (*Mangifera indica*) leaf powder on total phenol content in both foliage and underground parts of purple nutsedge (*Cyperus rotundus* L.) (Average of the two seasons).

Mango leaf powder (g)	Total phenol contents (mg/g dry weight)			
	Foliage		Underground	
	30days	75days	30days	75days
0	59.71	65.85	61.38	82.11
20	64.84	66.73	61.54	89.75
40	68.85	81.81	101.98	128.24
60	73.87	96.21	107.78	135.07
80	95.40	98.51	112.45	141.63
100	117.293	113.1	133.45	169.62
LSD at 5%	2.71	10.24	6.55	10.84

Table 9. Percentage of phenolic acids in mango leaf extract

Phenolic acids	Percentage %
Ferulic	5.98
coumaric	15.49
benzoic	10.32
vanelic	11.82
chlorogenic	7.85
caffiec	36.74
Gallic	3.78
hydroxybenzoic	2.87
cinnamic	5.15
Total	100.00

4. Discussion

Indiscriminate amount of synthetic herbicides are being used over the world to control purple nutsedge (Bryson et al 2003; William and Hirase, 2004 and 2005; El-Rokiek et al., 2007). Owing to their toxicological effects on crops, efforts are being made to find out new environmental-friendly means for weed management.

Allelopathy can be defined as the effects of one plant on another plant through the release of chemical compounds in the environment (Rice, 1984). Allelochemicals produced by plants may be released into the surrounding environment in sufficient amounts with enough persistence to affect neighboring and succession species (Akram et al 1990). These compounds are inhibitory to growth of weed plants (Chon and Kim, 2004).

Mango (*Mangifera indica*) which is one of the abundant trees in our country has different part which can be use. One of this is the leaves. The leaves can be another source of herbicide. The extract of Mango leaves has the capacity of killing or supressing weed growth (Padmanaban and Daniel, 2003; Rudramuni et al., 2006).

The results illustrated in this investigation revealed that mango leaves either in aqueous extract (Tables 1-3) or soil applied powder (Tables 5-7) induced significant reduction in the growth of mother shoots / tuber (Tables 1&5). The results also recorded significant reduction in the growth of daughter shoots. The allelopathic extracts of mango leaf powder as well as soil applied powders at different rates caused great inhibition in the growth of underground organs which correspond to complete death by using the aqueous extracts or powder at the highest level (Tables 2&6). Tables 3&7 consequently revealed significant reduction in dry matter accumulation of both foliage and underground organs. These results coincided with that obtained by James and Bala (2003) who reported that dried mango leaf powder completely inhibited sprouting of purple nutsedge tubers. In general, mango leaves have allelopathic effects on controlling or suppressing weed growth (Padmanaban and Daniel, 2003; Rudramuni et al., 2006).

The results in Tables 4&8 indicated that the contents of phenolic compounds in both foliage and underground organs of purple nutsedge increased with increasing the concentration of aqueous extracts of mango leaves or soil applied powders. Phenolic contents reached the double quantity or higher of that recorded in the tissues of untreated control. It is obavious from the results that growth inhibition in the growth of purple nutsedge recorded by different mango aqueous extracts or powder concomitant with accumulation of phenolic compounds that might indicated a sort of allelopathic stress (Ahmed and Rashad, 1996; El-Rokiek, 2002 and 2007).

Analyses of the aqueous extracts of mango leaves by HPLC (Table 9) indicated the presence of ferulic, coumaric, benzoic, vanelic, chlorogenic, caffiec, gallic, hydroxybenzoic and cinnamic acids. Caffiec acid is presented in the highest amount followed by coumaric acid, vanelic acid and benzoic acid.

In this connection, Chon et al (2003); Chung et al (2003); Singh et al 2003; Chon and Kim, 2004 attributed the highly allelopathic herbicidal potential of some plant extracts to the presence of allelopathic substances e.g. coumarin, o-coumaric acid, p-coumaric acid, benzoic acid, P-hydroxybenzoic acid, ferulic acid and cinnamic acid.

According to the data above, mango leaves could be used as a safety tool to suppress purple nutsedge growth although the commercial herbicide could kill the weeds faster than the mango leaves.

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