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(RESEARCH ARTICLE)

Allelopathic effect of some plants on morphological attributes of invasive alien weed: *Malachra capitata* (L.)L.

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Abstract

Vitex negundo L. [Verbenaceae] and *Ricinus communis* L. [Euphorbiaceae], are especially well known for their industrial, pharmacological, and toxicological properties, but to date very little is known about their allelopathic potential. Hence the present study was conducted to evaluate their allelopathic perspectives on morphological characters of invasive alien weed *Malachra capitata* [L.]L. Various concentrations [T1=5%, T2=10%, T3=15% and T=20%] of leaf leachates of selected plants were used as spray to test their effect on pot culture of test species. Results of present study indicated that the growth of plant was significantly inhibited in *Malachra* at all concentration of aqueous leaf leachates of selected plants when compared to control [T0]. Length of root and shoot, number of flowers, fruits and seeds of the weed was reduced with the increase in leaf leachates concentration. T1 of *R. communis* was least effective on root length. Branching was totally inhibited except for T1 of *V. negundo*. Dry weight and fresh weight of the weed were also negatively affected by aqueous leaf leachates of both the plants. Although results were significant at $P<0.05$ level, few parameters were not found significant.

Keywords: Allelopathic potential; Invasive alien weed; *Malachra capitata* [L.]L.; *Vitex negundo* L.; *Ricinus communis* L.

1. Introduction

Weeds are known to be the main constraint to agriculture production all over the world. Invasive nonnative plant species are causing enormous economic and ecological damage. Worldwide estimation of economic damage from invasive species totals more than $1.4 trillion, which is about 5% of the global economic loss [1]. Various common methods to control invasive weeds are mechanical, chemical and biological control. Mechanical method needs lot of man power and is laborious. Burning, as a control strategy too has proved to be inadequate because it requires large quantity of fuel and destroys all other economically important plants growing in its vicinity [2-3]. While the primary use of herbicides (Chemical control) is to control weeds in agricultural land, throughout the world herbicides are a common management tool used to control invasive species. Globally, most recent cases of herbicide resistant weeds are 476, with weeds resistance to 23 of the 26 known herbicide sites of action and to 161 different herbicides. Herbicide resistant weeds have been reported in 90 crops in 66 countries [4]. Moreover, using herbicides as a control method may have many disadvantages such as rise in environmental pollution, hazardous effects on agricultural products and costly affair. These chemicals can be replaced by low cost and environment friendly agents. Biological management through the use of suppressive plants or by authorized release of insects or pathogens as specific biological control agents is the new management option. To control weeds, biological control agents mainly from animal kingdom are regarded as relatively safe. At the same time impact of these agents can be low and unpredictable so it may be time consuming and cannot be overlooked. Although plants can be considered as biological control agents, data available only on animals as control agent, hence there remains a gap in utilizing control agents from plant kingdom to check the problem of invasion. Use

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of microbes or insects as control agents may lead to diseases or entry of new pathogens in plant kingdom while use of widely spread native or non-native plants as control agent for invaders can have additive benefits like maintenance of soil quality, balanced resource cycling and ecofriendly approach. In recent years, therefore, new approaches like plant allelopathic effects have been considered to suppress weeds in agricultural systems [5] as well as same can be employed for the control of invasive weeds.

For present study *Malachra capitata* (hereafter it will be referred as *M. capitata*) is a native of Tropical America [6], belonging to family Malvaceae was selected on the basis of field observations. Although review of literature did not show much of studies on its invasiveness and allelopathy but it was found growing luxuriantly in moist places, gardens, forest, wasteland and in agricultural field. *Malachra capitata* (L.)L. is listed as invasive alien plant species in the catalogue of invasive alien flora of India [7].

In recent times to control weeds either directly or as natural herbicides developed from allelochemicals isolated from allelopathic plants particularly those with medicinal properties have been gaining interest [8]. *Ricinus communis* L. [hereafter it will be referred as *R. communis*] is a plant belonging to Euphorbiaceae, commonly found in the tropical and temperate climates of the world [9-10], which is well known for many of its medicinal and industrial uses [11-12]. *Vitex negundo* L. [hereafter it will be referred as *V. negundo*] an aromatic shrub belonging to verbenaceae widely known for its use as green manure, medicine in ayurvedic, unani systems of medicine and as a mosquito repellent.

Most of the allelopathic studies were carried out in petriplates and in laboratory conditions, but it is equally important to test the extracts in soil or as foliar spray in pot culture. This study was conducted to investigate the allelopathic potential of different concentrations of aqueous leaf leachates of *V. negundo* and *R. communis* on the vegetative and reproductive attributes of alien invader *M. capitata* and an attempt has been made to find out alternate ecofriendly approach for weed management.

2. Material and methods

2.1. Seeds collection of test plant

Mature seeds of *M. capitata* were collected from the University campus; Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur, India.

2.2. Collection and extraction of plant materials

Leaves of *V. negundo* and *R. communis* were collected from the field during the full growing stage and washed with tap water followed by shade drying. Leaf leachates were prepared by using method given by Ghayal *et al*., [13] wherein the dried leaves were powdered and 100 g powder was soaked in 1000 ml distilled water for 24 hours at 25±2 °C and the leachates was filtered through Buchner funnel using filter paper. It was stored in amber colored bottles to avoid degradation. Various concentration [T1=5%, T2=10%, T3=15% and T4=20%] of leaf leachates were prepared. Leaf residue was prepared by grinding air dried leaves of selected plants to powder form with a grinder and kept in sealed polythene bags to prevent it from moisture and contamination [14].

2.3. Pot culture

Polythene bags [35cm X 25cm size] were filled with 5kg soil mixture [soil: sand in 3:1 ratio] and 100 g leaf residue was also mixed in top layer of soil. Bags were sown with 20 seeds of test species and were thinned to 3 healthy seedlings per bag after7-10 days of sowing. With the emergence of first leaf, seedlings were sprayed with various leaf leachates concentration [T1=5%, T2=10%, T3=15% and T4=20% of respective leaf leachates] with equal quantity per plant. Spraying of leaf leachates was carried out till the flowering at the interval of 10 days. The control polythene bags were sprayed with water [T0= control]. Various growth parameters were recorded at vegetative and reproductive stage by considering five plants per treatment. Fresh weight and dry weight of root and shoot were also recorded by uprooting the plants. Experiment was repeated consecutively for three years with three replications to measure various parameters as within one season all parameters were not possible to measure.

2.4. Statistical analysis

Data generated from present investigation was analyzed statistically by using SPSS version 17 [SPSS incorporation]. One way ANOVA was applied at the $P<0.05$ level. The resulted data was further analyzed by applying Post Hoc Test to find out significant difference between the means at the $P< 0.05$level. In one way ANOVA, some results were significant but Post Hoc test did not showed significant difference.

3. Results and discussion

Table 1 and 2 shows effect of leaf leachates of *R. communis* and *V. negundo* on vegetative and reproductive traits and biomass of *M. capitata* respectively. Highest plant height [PH] and girth in control gradually decreased as concentration increased. Length of primary root was found to be more in T1 of *R. communis* than control while T2 of *V. negundo* had more inhibitory effect on primary root. Inhibitory effect of *V. negundo* on secondary root was maximum in T4 which then followed by T1. All treatments had significant effect on RS [root lateral spread] and DDR [depth of deepest root]. Mean of DDR/RS, DDR/PH and root: shoot ratio was significantly different among the treatments. Nodes/plant were significantly reduced [P=0.000] in all treatments over control. Except for T1 of *V. negundo*, branches were not produced in other potted *M. capitata*. Highest number of leaves found in control while lowest in T1 and T3 of *R. communis* and *V. negundo* respectively. There was gradual and significant decrease in inflorescence/plant [F=5.33, P=0.004], flowers/plant [F=3.72, P=0.020], fruits/plant and seeds/plant at all concentrations of leaf leachates of *R. communis* while leaf leachates were found to be more inhibitory and significantly reduced all reproductive traits [P=0.000]. Biomass was significantly decreased in different treatments. T3 of *R. communis* had minimum inhibitory effect on fresh weight of root and shoot. Leaf leachates of *V. negundo* had shown significant reduction of biomass in all treatments over control. Except for few parameters [Table 1 and 2], all results were significant at P<0.05 level.

Synthetic herbicides used to control many weeds; causing environmental pollution moreover they are non biodegeradable. With the increase in awareness about limitations of these synthetic chemicals, in recent times trend of using green control or biopesticides derived from plant kingdom is in practice. Invasive weeds are a topic of research because of their threat to biodiversity and environment. To control these invasives use of mechanical, chemical and biological control have been and are in use. Instead of using insects as biocontrol on weeds, use of other plant species to control non native invasives might be more ecofriendly. It may also possible that medicinal plants contain more bioactive compounds than other plants. To combat the hazardous effects of synthetic herbicides on environment, allelopathic properties of medicinal plants might be helpful to discover new natural herbicides for sustainable agriculture [15]. Many plant species including medicinal plants are able to produce and release secondary metabolites [bioactive compounds] into the environment and are capable of suppressing the growth of other plants [16].

Plant height of *M. capitata* has been reduced over control by all concentrations of leaf leachates of *R. communis* as well as *V. negundo*. Reduction in plant height might be due to effect of allelochemicals on gibberellins synthesis, the hormone responsible for cell elongation in turn plant height. Present findings are in line with findings of Gantayet *et al*., [17]. Root architecture of invasive was also affected by all treatment except in T1 of *R. communis* was not effective on length of primary root. Along with many effects it also includes decrease in plant growth by phenolic compounds [18]. The inhibitory effect of foliar spray was dosage dependent. Same trend was revealed by negative allelopathic effect caused by smooth Amaranth aqueous extracts on number of developed leaves, stem length, delayed flowering and total dry matter of red bean, white bean and pinto bean [19]. Number of nodes, branches and leaves per plant was highly reduced by all concentration of leaf leachates of all donors over control except in T3 of *R. communis* found least effective on branches while no branching was observed in *M. capitata* but seen in T1 of *V. negundo*. Inhibition of these growth parameters might be due to inhibitory influence of allelochemicals in synthesis of gibberellin, auxin and other growth hormones [20]. Yarnia *et al*., [21] reported reduction in plant height, leaf area, shoot and root dry weighs of *Amaranthus retroflexus* by 5 to 20% leaf extract of sorghum. The herbicidal potential of the foliar application of the isolated compounds from *Sterculia foetida* were inhibited seed germination, shoot and root length as well caused defoliation in *Calotropis gigantea*(R.Br.), *Parthenium hysterophorus* L., *Datura metel* L. and *Tridax procumbens* L. [22]. Defoliation has been also reported in *M. capitata* by foliar application of leaf leachates of *V. negundo* as well as *R. communis* in higher doses.

A significant reduction in reproductive traits including inflorescence, flowers, fruits and seeds per plant over control was observed by application of leaf leachates of different concentrations of *R. communis* and *V. negundo*. The inhibition was concentration dependent. Findings of Ramgunde and Chaturvedi [23], indicated that the vegetative and reproductive growth of*Cassia uniflora* was significantly inhibited at all concentration [T1=5%, T2=10%, T3=15% and T4=20%] of aqueous leaf leachates of *R. communis* and *V. negundo* when compared to control. These findings are in line with results of present study.

Table 1 Effect of leaf leachates of *Ricinus communis* on vegetative and reproductive characters and biomass of *Malachra capitata*

Treatments	**T0**	**TI**	**T2**	**T3**	**T4**	**F -Value**	**P-Value**
Plant height [PH][cm]	39.6±4.118^{abcd}	25.8±2.267^{a}	21.4±0.748^{b}	19.4±0.872^{c}	17±1.378^{d}	15.87	0.000
Girth [cm]	1.3±0.093^{abcd}	0.8±0.122^{a}	0.8±0.122^{b}	0.5±0.000^{c}	0.5±0.000^{d}	13.80	0.000
I ry root [cm]	14.08±1.410^{a}	14.16±1.238^{b}	9.32±1.156	9.2±0.489	7.84±0.552^{ab}	8.20	0.000
II ry root [cm]	9±0.805^{ab}	6.72±1.417^{c}	5.56±0.397	4.08±0.602^{a}	2.76±0.211^{bc}	8.99	0.000
III ry root [cm]	1.18±0.326	0.72±0.086	0.66±0.136	0.5±0.000	0.5±0.000	2.94	0.046
Root lateral spread [RS][cm]	3.23±0.245^{abcd}	1.3±0.187^{a}	1.27±0.121^{b}	1.17±0.145^{c}	0.97±0.195^{d}	25.20	0.000
Depth of deepest root [DDR][cm]	15±1.643^{ab}	14.6±1.363^{c}	9.4±1.166^{a}	9.9±0.781	8.58±0.516^{bc}	6.87	0.001
Ratio: DDR/RS	4.694±0.538^{a}	12.780±2.729^{a}	7.636±1.145	8.927±1.149	9.969±1.630	3.39	0.028
Ratio: DDR/PH	0.378±0.010	0.569±0.039	0.439±0.052	0.509±0.026	0.520±0.063	3.05	0.041
Root: Shoot ratio	0.358±0.015^{a}	0.552±0.034^{a}	0.435±0.052	0.501±0.0145	0.473±0.055	3.56	0.024
Nodes/plant	15.6±0.872^{abcd}	11.4±1.030^{a}	9.8±0.374^{b}	9.0±0.316^{c}	8.4±0.510^{d}	17.99	0.000
No. of Branches/plant	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	0.00±0.000	--	--
No. of leaves/plant	24.2±5.544	16.6±1.631	18.6±1.208	17.8±3.231	18.2±3.023	0.80	0.537
Inflorescence/plant	12.40±1.691^{ab}	8.00±0.316	8.40±1.166	7.40±0.510^{a}	6.40±0.600^{b}	5.33	0.004
Flowers/plant	43.20±6.422^{a}	37.00±1.703	37.20±2.577	31.80±2.764	25.00±2.025^{a}	3.72	0.020
Fruits/plant	32.60±5.758	32.00±1.643	29.80±2.672	27.20±2.311	20.40±1.691	2.39	0.085
seeds/plant	152.20±33.110	145.60±9.437	134.00±11.261	118.60±8.812	92.60±8.047	2.15	0.112
Fresh wt. of root [g]	1.464±0.08^{a}	1.192±0.044	1.117±0.017	1.283±0.136	1.011±0.016^{a}	4.25	0.012
Dry wt. of root [g]	1.051±0.049^{ab}	0.899±0.038	0.838±0.016	0.784±0.0158^{a}	0.721±0.007^{b}	8.46	0.000
Fresh wt. of shoot [g]	6. 909±0.498^{abc}	5.473±0.123^{a}	5.754±0.042^{b}	6.211±0.289	4.840±0.145^{c}	7.12	0.001
Dry wt. of shoot [g]	2.273±0.267^{ab}	1.729±0.098	1.540±0.022^{a}	1.634±0.157	1.109±0.083^{b}	4.42	0.010

T0=control, T1=5% leaf leachates, T2=10% leaf leachates, T3=15% leaf leachates and T4= 20% leaf leachates. Data are the pooled means of five replicates ±SE. Values with same letters are significantly different from each other according to Post Hoc test at the $p<0.05$ level.

Table 2 Effect of leaf leachates of *Vitex negundo* on vegetative and reproductive characters and biomass of *Malachra capitata*

Treatments	T0	TI	T2	T3	T4	F -Value	P-Value
Plant height [PH][cm]	39.6±4.118^{abcd}	28.4±2.502^{ae}	21.8±0.800^{b}	20.2±1.158^{c}	15.2±0.860^{de}	17.06	0.000
Girth [cm]	1.3±0.093	1±0.158	0.9±0.100	0.88±0.073	0.82±0.091	3.14	0.037
I ry root [cm]	14.08±1.410^{abc}	11.2±0.374	8±0.547^{a}	9±0.894^{b}	8.6±0.927^{c}	7.60	0.001
II ry root [cm]	9±0.805^{abcd}	5.6±0.565^{a}	5.72±0.542^{b}	5.88±0.749^{c}	3.54±0.406^{d}	9.60	0.000
III ry root [cm]	1.18±0.326	0.74±0.128	0.74±0.103	0.56±0.060	0.5±0.000	2.58	0.068
Root lateral spread [RS][cm]	3.23±0.245^{ab}	2.5±0.518	1.92±0.222	1.25±0.104^{a}	0.92±0.122^{b}	10.75	0.000
Depth of deepest root [DDR][cm]	15±1.643^{abc}	12.1±0.737	9.86±0.345^{a}	9.66±0.647^{b}	9.26±1.147^{c}	5.68	0.003
Ratio: DDR/RS	4.694±0.538^{a}	5.467±0.854^{b}	5.599±1.070^{c}	7.950±0.776	10.637±1.637^{abc}	5.42	0.004
Ratio: DDR/PH	0.378±0.010^{a}	0.434±0.035	0.456±0.029	0.478±0.016	0.621±0.089^{a}	3.86	0.017
Root: Shoot ratio	0.358±0.015^{a}	0.404±0.030	0.371±0.0375^{b}	0.441±0.026	0.576±0.074^{ab}	4.35	0.011
Nodes/plant	15.6±0.872^{abc}	13±0.775^{d}	11.6±0.245^{af}	9.8±0.374^{bd}	8±0.837^{cef}	18.89	0.000
No. of Branches/plant	0.00±0.000	0.4±0.400	0.00±0.000	0.00±0.000	0.00±0.000	1.00	0.431
No. of leaves/plant	24.2±5.544	15.6±2.159	14.6±1.806	12.4±1.536	16.2±3.426	1.90	0.148
Inflorescence/plant	12.40±1.691^{a}	9.20±0.663	8.80±0.490	8.00±0.548	5.80±.970^{a}	11.36	0.000
Flowers/plant	43.20±6.422	41.80±3.441	38.40±2.731	33.60±2.205	24.00±5.339	8.68	0.000
Fruits/plant	32.60±5.758	33.80±4.716	31.60±3.982	26.20±2.653	18.40±4.202	9.86	0.000
seeds/plant	152.20±33.110	148.01±22.132	138.40±15.214	112.60±9.983	77.20±18.797	8.31	0.000
Fresh wt. of root [g]	1.464±0.081^{abc}	1.198±0.076	1.121±0.015^{a}	1.109±0.02^{b}	1.101±0.009^{c}	7.01	0.001
Dry wt. of root [g]	1.051±0.049^{a}	0.968±0.045	0.891±0.012	0.686±0.015	0.661±0.005^{a}	6.09	0.002
Fresh wt. of shoot [g]	6.909±0.498^{ab}	5.386±0.488	5.309±0.122	4.782±0.106^{a}	4.661±0.159^{b}	4.76	0.007
Dry wt. of shoot [g]	2.273±0.267^{ab}	2.165±0.240	2.110±0.050	1.536±0.058^{a}	1.363±0.070^{b}	4.60	0.008

T0=control, T1=5% leaf leachates, T2=10% leaf leachates, T3=15% leaf leachates and T4= 20% leaf leachates. Data are the pooled means of five replicates ±SE. Values with same letters are significantly different from each other according to Post Hoc test at the $p<0.05$ level.

The allelochemicals might be involved in reducing reproductive traits of treated invasives by leaching of allelochemicals into the soil and affecting physiological processes involving in flower, fruit and seed formation. Components of yield [production of number of heads per plant, production of seeds per head, weight of seeds, seed yield per plant] of niger [*Guizotia abyssinica*] were decreased by leaf litter dust of *Lantana camara* [17]. In green house experiment, the powder and extract of *R. communis* significantly inhibited height, leaf area, dry weight and amount of chlorophyll of pigweed and the inhibitory effect was dosage dependent, higher the concentration, strongest the inhibitory effect [24].

4. Conclusion

In conclusion higher concentration of leaf leachates inhibit various growth parameters hence, further investigations needed to isolate and identify such growth inhibitors from leaves of *R. communis* and *V. negundo* and formulate natural or green control for invasive weed management strategy over synthetic or chemical control.

Compliance with ethical standards

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Disclosure of conflict of interest

We declare that there is no conflict of interest between us and we are solely responsible for the contents and writing of this research paper.

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