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BIOORGANICS AND ALLELOPATHIC ACTIVITY OF AN INVASIVE WEED *MIKANIA SCANDENS* (L.) WILLD

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Mikania scandens a rapidly spreading weed of asteraceae was characterised through analysis of moisture content, bioorganics including photosynthetic pigments (chlorophylls and carotenoids), primary metabolites (total soluble sugar, total protein and lipid), total phenol and major elements (carbon, nitrogen, phosphorous, calcium, potassium and iron) in various bioparts. The distribution of primary metabolites followed almost similar pattern irrespective of the bioparts (lipid < protein < soluble sugar). Phenol remained high in the leaf. Major elements recorded a distribution pattern with C > N >Ca >K > Fe > Na > P in leaf, C > N> Ca >K > Fe >Na > P in stem and C > N >Fe > K > Ca > Na > P in root. Bioassay conducted with aqueous extract/ leachate/ dry powder extract on the germination of *Vigna radiata* exhibited significant decrease in the rate of germination, radicle and shoot length, MGT, GI and VI as compared to control irrespective of the treatments viz., concentration and biopart. Same biopart of the weed exhibited differential allelopathic effect on the radicle and shoot growth of the legume. The treatment of fresh stem extract of the weed even at lower concentration (1%) showed significant reduction in shoot length.

Keywords : Allelopathic activity; GI; Major elements; MGT; *Mikania scandens*; VI.

Introduction

Weeds comprise an indispensable group of plants which grow vigorously among the useful crop species in agricultural fields, abandoned lands and road sides. Taxonomic distribution of invasive angiosperms revealed that about 1348 species are serious agricultural weeds of which 1041 are wide spread and 381 are threatening natural invaders[1] and out compete native species for resources such as nutrients, light, physical space, water or food. Invasive weeds impair the structure, composition and function of natural and semi-natural ecosystems. The detailed understanding of the morphology, anatomy, phenology and reproductive behaviour of introduced weeds help device specific methods for their control. *Mikania scandens* is a rapidly spreading weed belonging to asteraceae which successfully establish in a vast area by competing with the native species and exhibit allelopathic potential. The term allelopathy denotes the production of specific biomolecules by one plant that can induce suffering in, or give benefit to, another plant[2]. Allelopathic activity may be detrimental/ stimulatory on germination and growth of recipient species. Systematic characterisation of this invasive weed remains few and fragmentary which prompted the present investigation. The present study envisages the analysis of moisture content and bioorganics which are biologically significant macromolecules including photosynthetic pigments viz., chlorophylls and carotenoids, primary metabolites viz., total soluble sugar, total protein and lipid, total phenol, elements viz., carbon, nitrogen, phosphorous, calcium, potassium and iron in various bioparts of *M. scandens* and the allelopathic activity of the weed on the germination of *Vigna radiata.*

Material and Methods

Mikania scandens (L.) Willd (Synonyms *Eupatorium scandens* L. ; basionym and *Willoughbya scandens* (L.) Kuntz) is a tropical creeper belonging to Asteraceae, luxuriantly distributed at field margins and stream banks. Whole plant with root system intact was collected from its natural habitat and leaves, stem, root and flowers were separated and used for analyses. The analyses were performed following standard methods viz., estimation of moisture [3], total soluble sugars [4], total protein[5], lipid[6], total phenol[7], photosynthetic pigments[8], carbon[9], total phosphorous [10] and major elements [11]. The concentration factor of the elements in various bioparts of the weed was computed against the elemental constitution of the soil.

The main bioassay generally followed to establish the effect of allelopathy is seed germination test[2]. The aqueous extract of the weed sample was prepared by

grinding the weighed plant part viz,, leaf and stem in cold distilled water at room temperature, filtered through muslin cloth and used as stock solution. Leachate and dry powder extract was prepared by soaking the weighed plant part in known quantity of distilled water, stirring continuously, kept for 24 hours, filtered and the resultant stock solution was stored under refrigeration. The extract/ leachate was serially diluted and used for the bioassay. Healthy seeds were placed in each Petri plate lined with filter paper, moistened with the known concentration (1, 5, 10 and 15%) of fresh extract, leachate and aqueous dry powder extract (as per w/v basis) as per treatment against distilled water as control and kept at room temperature. Rate of germination, root and shoot length was measured. The experiment was conducted in duplicate. The results were subjected to statistical analysis. Vigour Index (VI) was calculated by multiplying the germination percentage with dry matter production. Mean germination time (MGT)[12] and germination index (GI)[13] was calculated as per formulae :

$MGT = \Sigma(Dn)/ \Sigma n$ n= the number of seeds germinated on day D , D= number of days counted from the beginning of the germination test

$GI = P/ t$ P= final percentage of germination, t= time to reach 50% germination.

Results and Discussion

The analysis of moisture, biochemical and elemental constituents in the invasive weed *M. scandens* revealed significant variation among different bioparts such as root, stem, leaves and flower (Table 1-5). The plant exhibited comparatively high moisture content among the bioparts which varied from 36.5% to 87% in flower and stem, respectively. The physicochemical properties of plant fluids reflect in many instances the ecological environment of the plant and its ability to survive under specific environmental conditions[14].

The distribution of primary metabolites followed similar pattern of distribution in various bioparts. The concentration of total protein and lipid followed similar pattern of accumulation with leaf > stem > flower >root while soluble carbohydrates recorded a pattern with stem > leaf >flower> root. The soluble carbohydrate content remained high in stem (10.96%) while total protein (11.86%) and lipids (1.6%) in leaves and a progressive increase was noticed in the protein content from root to leaf (root <stem< leaf). Leaf proteins are normally abundant and have several roles to play as a catalyst and major sink of nitrogen. High sugar concentrations were recorded in leaves and stem of *Ranunculus aquatilis*[15] and the concentration of glucose increased with age and preferentially stored in the internodes of *Phargmites australis*[16], is in agreement with the present study.

The concentration of phenol was high in leaf (12.20 mg g^{-1}) as compared to root (5.09 mg g^{-1}) and stem (10.81 mg g^{-1}). Phenolics have known to possess antimutagenic, antiglycemic and antioxidant properties [17]. The total chlorophyll, chlorophyll a, b and carotenoids revealed high values in the leaf (0.97 mg g^{-1}, 0.25, 0.72 and 7.69 mg g^{-1}).

Major elements recorded a distribution pattern with C > N >Ca >K > Fe > Na > P in leaf, C > N> Ca >K > Fe >Na > P in stem and C > N >Fe > K > Ca > Na > P in root. Carbon was found to be the most abundant element in the plant and high concentration was noticed in leaf (814. 0 mg g^{-1}) as compared to the rest of the bioparts. Carbon in most plant materials accounts for 43 to 47% of dry weight and the nitrogen content in *Sparaganium, Typha* and *Scirpus* observed slight variation among the different parts of the same plant such as shoots and roots[18] remained in unison with the present study. Nitrogen content varied from 10.01 mg g^{-1} in flower to 18.97 mg g^{-1} in leaves while the concentration of phosphorus remained comparatively low in the bioparts with a distribution pattern of flower > leaf > stem >root. Normally plants take up phosphorous several times greater than the standing stock of inorganic phosphorous[19]. Calcium, potassium and sodium content recorded high value in the stem (15.93, 11.83 and 2.67 mg g^{-1} respectively) as compared to the rest of the bioparts. The concentration of potassium in the plant was above the normal limit of accumulation in plants (1 mg Kg^{-1}). *Mikania* sp. played important role in nutrient cycling and conserved lot of potassium in the biomass which remained in unison with the results of the Swamy and Ramakrishnan[20]. Iron content exhibited higher values in the roots (8.90 mg g^{-1}) rather than shoot remained in agreement with the findings of Ho[21]. Shaw and Panigrahy[22] opined that the concentration level of a metal generally decreases in the order of root > stem > leaves > fruit > seed, when the source of the metal is only soil. Even though iron is regarded as intermediate between major and trace elements, its accumulation in the plant body normally remain higher than most of the elements, which may be due to its high availability from the soil coupled with its weak association with humic matter in the soil rendering organically bound iron also available for bioaccumulation[23]. The concentration factor (Table 4) of nitrogen, potassium and calcium were above unity, irrespective of the bioparts, indicative of the efficiency of the weed in the incorporation of the element from the substratum.

Table 1. Biochemical analysis of *Mikania scandens.*

Parameter (%)	Root	Stem	Leaf	Flower
Soluble carbohydrates	1.04±0.57	10.96 ±0.80	6.58± 1.02	8.83± 0.03
Total protein	8.20±1.01	10.13±1.13	11.86±1.12	6.21±0.07
Lipid	0.40±0.004	1.30±0.001	1.60±0.04	0.70±0.01
Phenol	5.09±0.09	10.81±0.10	12.20±0.80	6.05±1.25

Table 2. Pigment analysis of *Mikania scandens.*

Parameter mg g^{-1}	Stem	Leaf
Total chlorophyll	0.85±0.01	0.97±0.03
Chlorophyll a	0.20±0.042	0.25±0.001
Chlorophyll b	0.70±0.05	0.72±0.06
Carotenoids	5.85±0.002	7.69±0.004

Table 3. Elemental analysis of *Mikania scandens.*

Parameter mg g^{-1}	Root	Stem	Leaf	Flower
Carbon	510.00±4.13	762.00±6.25	814.00±1.18	431.00±3.03
Nitrogen	13.12±0.50	16.20±0.14	18.97±0.97	10.01±0.03
Phosphorous	0.11±0.001	0.13±0.03	0.14±0.003	0.24±0.01
Sodium	2.37±0.31	2.67±0.01	1.50±0.004	1.63±0.10
Potassium	6.16±0.02	11.83±1.20	6.30±1.11	5.23±0.90
Calcium	3.03±0.32	15.93±1.01	9.70±0.81	12.06±1.16
Iron	8.90±0.03	4.07±0.002	3.98±0.48	4.09±0.003

Table 4. Concentration factor in bioparts of *Mikania scandens.*

Parameter	Root	Stem	Leaf	Flower
Nitrogen	11.6	20.20	23.70	12.5
Phosphorous	0.05	1.0	1.07	1.05
Sodium	0.50	0.77	0.55	0.60
Potassium	1.73	3.13	1.74	1.42
Calcium	2.42	11.70	7.13	8.86
Iron	0.45	0.21	0.20	0.21

Table 5. Effect of aqueous extract of *Mikania scandens* on germination of *Vigna radiata.*

Treatment	Concentration	% Germination	Root length	Shoot length	VI	MGT	GI
Control		100	1.5± 0.69	2.6± 0.69	260.0	410	100.0
Leaf	1%	86.60	1.40± 0.70	1.01± 0.40	129.9	208.7	86.60
	5%	73.30	0.4± 0.22	0.8± 0.50	102.0	87.9	73.30
	10%	54.80	0.4± 0.25	0.7± 0.26	42.0	60.2	26.60
	15%	40.62	0.3± 0.72	0.8± 0.27	28.0	44.6	20.03
Stem	1%	46.60	2.3± 0.50	0.9± 0.63	47.7	149	23.30
	5%	53.00	1.9± 0.50	0.6± 0.40	27.6	132	26.50
	10%	40.00	1.8± 0.40	0.5±± 0.35	20.0	92	20.05
	15%	33.00	1.0± 0.80	0.43± 0.32	13.2	47	16.50

Table 6. Effect of leachates of *Mikania scandens* on the germination of *Vigna radiata.*

Treatment	Concentration	% Germination	Root length	Shoot length	VI	MGT	GI
Control		100	1.5± 0.69	2.6± 0.60	260	1.0	100.0
Leaf	1%	60.03	0.46± 0.3	1.01± 0.4	198	7.4	60.03
	5%	53.36	0.43± 0.2	0.8 ±0.4	128	6.5	26.68
	10%	53.36	0.38± 0.4	0.7± 0.26	80	6.5	26.68
	15%	53.36	1.48± 0.9	0.8± 0.27	91	7.3	26.68
Stem	1%	66.70	2.3± 0.5	0.9± 0.62	150	8.4	66.70
	5%	46.69	1.9± 0.5	0.6 ±0.47	98	6.3	23.34
	10%	40.08	1.3± 0.4	0.55± 0.35	58	7.0	20.01
	15%	33.35	1.2 ±0.3	0.43 ±0.32	16	4.4	16.67

Table 7. Effect of dry powder extract of *Mikania scandens* on germination of *Vigna radiata.*

Treatment	Concentration	% Germination	Root length	Shoot Length	VI	MGT	GI
Control		100	1.5 ±0.69	2.6± 0.6	260	1.0	100.0
Leaf	1%	60.03	2.3± 0.59	2.3± 1.6	207	9.0	60.03
	5%	60.03	2.0± 0.61	1.3± 1.5	104	10.0	60.03
	10%	53.36	1.5 ±0.26	1.25± 1.4	100	9.0	30.01
	15%	33.35	1.3± 0.46	1.0± 0.91	50	3.5	30.01
Stem	1%	60.03	1.8± 0.25	1.5± 0.25	135	10.0	30.01
	5%	53.36	1.4 ±0.22	1.01± 0.22	87	7.8	26.68
	10%	46.40	1.0 ±0.35	0.7 ±0.36	80	7.7	23.20
	15%	40.0	0.5 ±0.72	0.7 ±0.36	35	6.3	20.00

Allelopathic activity- The bioassay conducted with aqueous extract, leachate and dry powder extract of *M. scandens* on the germination of *Vigna radiata* exhibited variation in rate of germination, radicle and shoot length, vigour index, mean germination time and germination index (Table 6,7 and 8). Significant decrease was recorded in the germination percentage, root length, shoot length and vigour index as well as length of root and shoot in *V. radiata* with increase in concentration of aqueous extract. Lower concentration (1%) of the aqueous extract, leachate and dry powder extract also reduced germination indicating the allelopathic potential of the weed even at low concentrations. Germination time was delayed especially in treatment with leaf extract as compared to leaf leachate and leaf dry powder extract. The higher concentration of stem extract/ leachate (5, 10 & 15%) induced significant reduction in germination percentage (< 50%) as compared to dry powder extract.

Leaf aqueous extract induced significant reduction in radicle length (<1cm) against control while that of stem remained less toxic (>1 cm). The treatment of stem extract even at lower concentration (1%) showed significant reduction in shoot length. Stem leachate showed lesser as well as gradual reduction in root length as compared to shoot length. Leaf leachate exhibited reduction in root length as concentration increased while shoot length was not affected much. Dry powder extract of stem inhibited growth of radicle more than leaf extract. Shoot length failed to establish significant variation in treatment of stem and leaf dry powder extract especially at 5 and 10% concentration. VI recorded successive decrease as the concentration of the extract/ leachate increased. GI decreased significantly as compared to the control in all treatments irrespective of the concentration of treatments as well as the biopart. The water soluble allelochemicals in the weed extract may change the environment for the effective germination of the test species there by causing variation in the pattern of germination as suggested by Ni *et al.* [24]. The dried samples of root, stem and leaf extracts of *M. scandens* at lower concentrations (1& 5%) was found to be enhancing the growth of radicle and shoot length. Rice [25] opined that allelochemicals which inhibit the growth of some species at certain concentrations may even stimulate the growth of the same or different species at lower concentrations is in agreement with the above observation. The allelopathic potential of a weed varied not only to the environment factors but also among plant tissues[26], is in unison with the present investigation.

Plant produces different phytotoxic chemicals which suppress the regenerative capacity of other plants[27]. The growth inhibition caused by allelochemicals released may be due to its interference with the plant growth processes or it reduces cell division or auxin induced growth of roots. In general, all the treatments of the weed (extract/ leachate) inhibited and delayed germination of the legume and decreased germination index which indicated that not only total percentage of germination had declined but the entire process of germination was retarded. The present study warrants further detailed investigation on to the nature of the allelochemical, characterisation of allelopathic mechanism at both micro and macro levels, process of release of the allelochemicals, and its impact on the growth, flowering and yield of native crop species to become a successful invader. More over, the control of invader species involves its eradication/ containment in a specific area especially through sustainable utilization needs special emphasis.

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