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Allelopathic potential of croton bonplandianus bail

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ABSTRACT

An extensive survey of floristic of native and invasive weed species was carried out during 2016 to 2019 in the semiarid agro ecosystem of Baramati Tahsil, Dist- Pune (M.S.). About 18 dominant invasive weeds such as Ageratum, Alternanthera, Croton., Xanthium, Parthenium and Tridax were encroaching the natives, becoming a serious threat to the major crops of this area such as wheat, sorghum, pearl millet, mung bean, pigeon pea, chillies and tomato. Amongst these Croton bonplandianus was highly dominant and wide spreading. Hence, its allelopathic potential was investigated. The allelopathic influence of leaf and root leachates as well as extracts of Croton bonplandianus Bail. was examined on seed germination of mung bean (Vigna radiata L.). The germination assay revealed that allelopathic potential and other factors are responsible for its dominance and successful invasion. The allelopathic influence of rhizosphere soil and its aqueous leachates indicated that both are responsible for inhibiting the seed germination and seedling growth of mungbean. Both the experiments have clearly confirmed the allelopathic potential of Croton bonplandianus. The HPTLC analyses confirmed the existence of a broad groups of allelochemicals like terpenoides, steroids, flavonoids, pungent and bitter essential oils and phenolics in its leaves and roots, which confirmed its allelopathic potential. Further characterization of above mentioned allelochemicals is in progress.

1. Introduction

Baramati region is considered as semiarid, because of rain shadow effect[1], in which different types of native and invasive weeds have been observed in different crop ecosystems causing about 16 to 58 % yield losses due to their allelopathic impact.[2–22] The phytosociological survey revealed that invasive weeds such as Tridax, Acanthospermum, Ageratum and Flaveria exhibiting xeric features while Cassia uniflora, Croton and Lantana showing adaptations to semiarid crop ecosystems have become dominant. Similarly, Alternanthera, Asclepias, Parthenium and Xanthium were dominant in irrigated crop ecosystems. Considering the dominance of these weeds among major crops like mung bean, pearlmillet and sunflower cultivated in semiarid agro-ecosystem, the allelopathic influence of highly dominant (as per our survey) Croton bonplandianus was undertaken, on sensitive crop like mung bean which is close associated to this weed. As recorded previousl[12] the allelochemicals released from the donor plants affect the growth and functioning of receptor species, therefore the present investigation was undertaken to know the allelopathic impact of Croton on mung bean.

Croton bonplandianus is an obnoxious weed belonging to family Euphorbiaceae. This plant is native from tropical South America. It has become dominant due to its wide adaptability, deep root system, most efficient and effective seed dispersal, biotic and abiotic stress tolerance and production of some novel allelochemicals.[7,23] The detailed allelopathic effects of Croton bonplandianus on the crops and native weeds have not been studied in India.[24] Hence, the aim of this work was to do a survey of dominant weeds in

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the region and then to determine, if the most dominant weed may have an allelopathic effect on the associated crop.

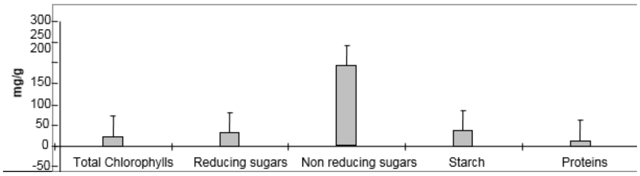

Fig. 1: Photosynthetic pigments and organic constituents in *Croton bonplandianus.*

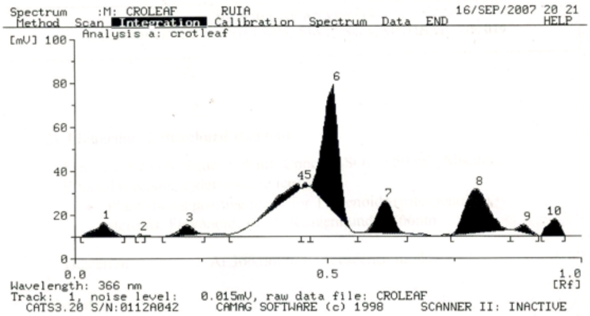

Fig. 2: Allelochemicals in *Crotonbon plandianus* leaf

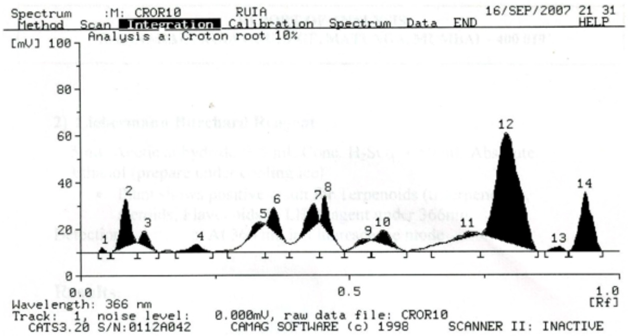

Fig. 3: Allelochemicals in *Croton bonplandianus* root.

2. Materials and Methods

An extensive ecological survey was carried out in and around Baramati Tahsil, during 2016-2019 and the dominant weed species growing in cultivated fields and fallow lands were identified with the help of The Flora of Presidency of Bombay, Flora of Kolhapur District,[25] Flora of Maharashtra, . For phytosociological studies, list count quadrat method was followed.[21]

Fig. 4: Allelochemicals detected in Croton leaf by HPTLC: 10 % Methanolic sulphuric acid

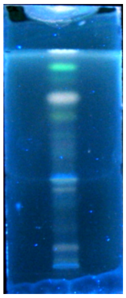

Fig. 5: Allelochemicals in Croton root detected by HPTLC: 10 % Methanolic sulphuric acid

2.1. *Preparation of extracts and leachates*

Croton bonplandianus was selected as a donor allelopathic invasive weed and mung bean (Vigna radiata L. var. Vaibhav) was selected as test crop. The aqueous extracts of Croton bonplandianus were prepared from 100 g fresh leaves and roots after crushing in 500 ml of distilled water and filtered through Buchner funnel using Whatman No.1 filter paper. These extracts were stored as stock solutions (20%) in amber coloured bottles, which were diluted with distilled water to make desired concentrations (5% to 20%). For preparation of leachates of leaves and roots, 100g shade dried material was soaked in 500 ml of distilled water for 48 hours at 27±2° C and the leachates were filtered through Buchner funnel using Whatman filter paper No.1. These leachates were stored as stock solutions (20%), and diluted with distilled water as mentioned above to make different concentrations (5% to 20%).

2.2. *Collection of rhizosphere soil and Preparation of its leachates*

About 500g of rhizosphere soil of Croton bonplandianus was collected randomly from the field to the depth of 15 — 20cm. The soil samples were cleaned, powdered and mixed to make a composite sample. 20g and 50g of this soil sample were suspended separately in 100ml distilled water.

Table 1: Dominant and Invasive weed species of baramati tahsil, dist- Pune.

Botanical name	Local name	Common english name	Family
*Acanthospermum hispidum DC.	Germankata	German prick	Asteraceae
Achyranthes aspera L.	Aghada	Pricklychafflow	Amaranthaceae
Ageratum conyzoides L.	Mahakaua	Goatweed	Asteraceae
*Ageratum conyzoides, L.	Osadi	Goat weed	Asteraceae
*Alternanthera tenella Veldk.	Reshimkata	Jacob's coat	Amaranthaceae
*Argemone mexicana L.	Piwala Dhodtra	Prickly poppy	Papaveraceae
*Asclepias curassavica L.	Haladkunku	Bastard ipecacuanha	Asclepiadaceae
Cassia tora L.	Takala	Sicklepod	Fabaceae
*Cassia uniflora, Mill.	Senna	Foetid senna	Fabaceae
*Celosia agrentia L.	Kurdu	Cock's comb	Amaranthaceae
Cleome viscose L.	Pivli-tilwan	Spiderflower	Cleomaceae
Commelina benghalensis L.	Kena	Dayflower	Commelinaceae
*Croton bonplandianus Baill.	-	Cascarilla	Euphorbiaceae
*Cryptostegia grandiflora R.Br.	Kawali	African rubber	Asclepiadaceae
Cynodon dactylon Pers.	Harali	Bermuda grass	Poaceae
Cyperus rothundus L.	Nagarmotha	Purple nutsedge	Cyperaceae
Digera arvensis Forsk.	Karigandhari	Kanjero	Amaranthaceae
*Euphorbia antiquorum L.	Ransher	Prickly spurge	Euphorbiaceae
Euphorbia geniculata Orteg.	Dudhani	Spurge	Euphorbiaceae
Euphorbia hirta L.	Bari-dudhi	Small spurge	Euphorbiaceae
*Flaveria trinervia C.Mohr.	German	–	Asteraceae
Indigofera linifolia Retz.	Pandharphalli	Indigo	Fabaceae
*Ipomoea carnea Jacq.	Besharam	Indian jalap	Convolvulaceae
Lagasca mollis Cav.	Jharvad	Softheaded flower	Asteraceae
*Lantana camara L.	Ghaneri	Yellow sage	Verbenaceae
*Martynia annua L.	Vinchu	Devil's claw	Pedaliaceae
Oxalis corniculata L.	Amboshi	Lady's sorrel	Oxalidaceae
*Parthenium hysterophorus L.	Gajargawat	Congress grass	Asteraceae
Peristrophe bicalyculata Ness.	Chikni	–	Acanthaceae
Portulaca oleracea L.	Gholu	Purslane	Portulaceae
*Prosopis julifera DC.	Kubabhul	Agaroba	Mimosaceae
Trianthema portulacastrum L.	Biskhapra	Purselane	Ficoidae
*Tridax procumbens L.	Ekadandi	Coat buttons	Asteraceae
Vernonia cinerea Less.	Sahadevi	Ironweed	Asteraceae
Withania somnifera Dunal.	Ashwagandha	Wintercherry	Solanaceae
*Xanthium indicum, L.	Landga	Dot cocklebur/burweed	Asteraceae

*Invasive alien species

Table 2: Phytosociological studies of *Croton bonplandianus* Baill.

Name of the weed	Density/m2	% frequency	Abundance
Croton bonplandianus Baill..	10.1	70	14.4
Achyranthes aspera, L.	1.7	40	2.2
Bidens pilosa, L.	2.3	30	1.3
Oxalis corniculata, L.	3.8	50	3.2
Tephrosia purpurea, Pers.	3.4	50	4.3
Vernonia sineria,Less.	1.3	10	5.1
Boerhaavia diffusa,L.	4.2	20	3.4
Digera arvensis, Forsk.	2.3	40	3.6
Tridax procumbens, L.	6.8	60	5.2
Portulaca oleracea, L.	3.2	30	4.3
Cyperus rotundus, L.	3.4	20	4.2
Cynadon dactylon, Pers.	4.3	50	5.1

Average of 25 quadrats (1 x 1m)

Table 3: Effects of croton bonplandianus leaf and rootextracts on seed germination and seedling growth in mung bean (Vigna radiata L. Var. Vaibhav).

Plant part	Conc. of extracts (%)	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index	Dry wt. of 10 seedlings (g)
	Control	100	6.0	5.9	1190.0	0.346
Leaf	5	40.00	2.0	5.8	312.0	0.332
	10	30.00	3.4	3.6	210.0	0.307
	15	0.00	00	0.00	0.00	0.00
	20	0.00	0.00	0.00	0.00	0.00
Root	5	90.00	4.06	9.2	1193.4	0.319
	10	85.00	3.7	12.9	1411.0	0.313
	15	80.00	3.3	12.2	1240.0	0.301
	20	70.00	2.4	10.2	882.0	0.296
CD at 5%		7.44	0.66	1.21	150.71	0.29
SEM		3.21	0.31	0.75	71.13	0.014
CV		7.21	13.46	10.42	10.91	6.74

Table 4: Effects of croton bonplandianus leaf and root leachates on seed germination and seedling growth in mung bean (Vigna radiata L. Var. Vaibhav).

Plant part	Conc. of leachates (%)	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index	Dry wt. of 10 seedlings (g)
	Control	100	6.0	5.9	1190.0	0.346
Leaf	5	90	3.8	4.1	711.0	0.420
	10	40	1.5	3.2	188.0	0.403
	15	00	00	00	0.00	00
	20	00	00	00	0.00	00
Root	5	90	5.7	7.5	1188.0	0.346
	10	90	4.8	6.3	999.0	0.314
	15	80	3.8	6.2	800.0	0.140
	20	70	3.3	5.5	616.00	0.101
CD at 5%		8.14	0.59	0.45	106.02	0.034
SEM		3.83	0.28	0.22	50.01	0.016
CV		7.38	10.67	5.85	9.26	7.51

Table 5: Effect of crotonbonplandianus rhizosphere soil and its leachates on seed germination and seedling growth in mung bean (Vignaradiata L. Var. Vaibhav).

Treatments	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index
Control	90.20±3.83 a	4.52±0.32 b	9.06±0.37 c	1227.03±114.59 b
Soil leachates 20%	80.00±4.12 b	3.80±0.12 c	8.70±0.44 c	1001.86±96.59 c
Soil leachates 50%	70.00±5.10 c	3.44±0.18 d	6.94±0.49 d	729.31±99.54 d
Control soil	95.00±3.16 a	5.52±0.17 a	10.20±0.32 a	1494.66±96.94 a
Rhizosphere soil	80.00±5.10 b	4.23±0.26 b	9.63±0.49 b	1111.85±130.55 bc
p-value$	<0.001	<0.001	<0.001	<0.001

*Data are the mean (n=5) ± standarddeviation. $Treatment means compared with one-way ANOVA analysis. Thedifferent letters followed by values represent significant difference byDuncan's multiple range test at p=0.05.

The solutions were stirred properly and kept for 48 hrs. These were filtered through Buchner funnel using Whatman filter paper No.1. The filtrates (20% and 50%) were used for seed germination bioassay along with control. Similar studies were carried out with rhizosphere soil directly and control soil (not having any vegetation).

2.3. *Seed germination bioassay*

The seeds of mung bean (Vigna radiata L. var. Vaibhav) were procured from College of Agriculture, Pune (M.S. India). The healthy seeds were used for bioassay studies using sterilized Petri-plates (9cm diameter) lined with special type of seed germination paper. The seeds were surface sterilized with 0.02% aqueous $HgCl_2$ for two minutes and thoroughly washed with distilled water. The

Table 6: Allelochemicals detected in Croton leaf by HPTLC: 10 % Methanolic sulphuric acid.

No. of Peaks	Rf	AUC	% Area
1	0.06	164.1	5.11
2	0.13	3.8	0.12
3	0.22	106.4	3.31
4	0.40	176.6	5.50
5	0.46	13.6	0.42
6	0.51	1380.5	42.96
7	0.61	381.1	11.86
8	0.79	762.5	23.73
9	0.89	69.6	2.17
10	0.95	155.3	4.83

germination papers in Petri plates were moistened with 10 ml of respective concentrations of leaf and root extracts and leachates of Croton bonplandianus. The seeds placed in Petri plates moistened with distilled water were considered as control. Each Petri plate containing 10 seeds were kept in triplicate at room temperature (27+2^{o}C) wrapped in black paper to avoid direct sunlight. Seed germination percentage, root and shoot length, vigour index, root: shoot ratio, fresh and dry weight of seedlings were recorded on 7^{th} DAS.[8]

3. Statistical Analysis

The data were analyzed statistically using ANOVA test. All the calculations were made by using (Sigma stat 3.5) and Microsoft Excel (office 2003).

4. Results and Discussion

4.1. *Phytosociological studies on weeds of baramati tahsil, dist. Pune.*

Results recorded in Table 1 revealed that about 36 weed species were dominant in irrigated, semi-arid crop ecosystems and fallow lands. Amongst these about 50% of the dominant weeds were of exotic nature. These results have clearly indicated very high rate of invasion of non-native weeds in this region. Similar results were reported by some other workers.[5–24,26–30] The phytosociological survey of dominant weeds had given an alarming indication about the invasion rate of non-natives in this region. If their invasion is not controlled effectively, they may substitute and reduce the diversity of natives. These invasive alien species (IAS) may be responsible to degrade the crop ecosystems in this region, causing significant yield reduction.[17–22,24,27,28]

Croton bonplandianus was the weed with highest density (10.1 /m^2), frequency (70%) and abundance(14.4) in the field, followed by Tridax procumbens and Cynodon dactyl on Table 2.

5. Seed Germination Bioassays

5.1. *Effects of rhizosphere soil and its leachates*

The results presented in Table 5 clearly indicated the inhibition of seed germination percentage with 20% and 50% soil leachates over control in mungbean. The seed germination bioassay conducted in rhizosphere soil had also shown considerable reduction in seed germination percentage, root and shoot length and thereby vigour index as compared to control. This has confirmed that the rhizosphere soil leachates and the soil itself had negative influence on seed germination and seedling growth. The different allelochemicals existing in the weed might be leaching into the soil from the whole plant and exuding from the roots. These may accumulate in the soil and affect seed germination and seedling growth of recipient plant species.[9] A similar trend was reported by other workers.[31]

5.2. *Effects of leaf and root extracts*

Inhibitory effects of leaf and root extracts of Croton on seed germination and seedling growth were recorded in mung bean at higher concentrations (15, 20%). The root and shoot length of seedlings was also reduced significantly along with vigour index and dry wt. of seedlings with increasing concentrations of leaf and root extractsTable 3.

5.3. *Effects of leaf and root leachates*

The leachates of Croton leaves significantly affected seed germination percentage and seedling growth in mung bean. The leaf leachates have caused full suppression of vigour index at higher concentrations (15, 20%), whilst at lower concentration (5%) stimulatory effects were recorded. Similarly, root leachates also showed positive effects on seed germination and seedling growth at lower concentration treatments while at higher concentration there was inhibitionTable 4.

Similar inhibitory allelopathic effects of Parthenium leaves on germination and seedling vigour of sunflower were reported.[24] The allelopathic impact of extracts or leachates is more harmful to radicle.[3,4]The level of phytotoxicity was directly proportional to concentration of leachates.[6–10] The results of present investigation are in agreement with the above workers. The vigour index indicates the allelopathic effects on seedling establishment same was the trend in present study.

The successful invasion and dominance of Croton over native weed species might be due to different allelochemicals existing in it. Present studies may help for understanding crop weed interaction in semiarid agro ecosystem of Baramati Tahsil.

6. Source of Funding

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7. Conflict of Interest

None.

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