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THE ALLELOPATHIC POTENTIAL OF THE WEED *AMARANTHUS VIRIDIS* L. ON GERMINATION AND PIGMENT PROFILE OF A PULSE CROP *VIGNA RADIATA* (L.) R. WILCZEK

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Abstract: Laborotory bioassay was conducted to establish the allelopathic activity of root, stem, leaf and flower extracts of the weed *Amaranthus viridis* L on seed germination, early seedling performance and pigment profile of *Vigna radiata* (L.)R. Wilczek. *A. viridis* grow luxuriently in open waste places and cultivated land was selected as donor plant and Mung bean or *Vigna radiata* (L.)R. Wilczek as recipient plant for allelopathic studies. The parameters like germination percentage (GP), Germination Index (GI), Germination speed (GS), Vigour Index (VI), Mean Germination Time (MGT), Radicle length (RL), Plumule length (PL), Number of lateral roots(LR) and Pigment profile were recorded and results were subjected to statistical analysis. The results showed that germination percentage and germination index was recorded more than 50% reduction with higher concentration of leaf and stem extract (20%). Leaf extract (10% and 20%) reduced the germination speed to almost 50%. Mean Germination Time registered an increase in almost all treatments as compared to control. Higher concentration of leaf extract reduced the radicle length to >75% whereas more than 50% reduction was noticed in the plumule length. The sequence of phytotoxicity exhibited an order of stem>leaf>root and flower. The photosynthetic pigments such as chlorophyll a, b and total chlorophyll exhibited significant reduction while carotenoid content was found to be increased in all treatments as compared to control. In general, the aqueous extracts of the bioparts of *A. viridis* was phytotoxic to the crop *V.radiata*.

Key words: Germination percentage, Germination index, Germination speed, Vigour index, Mean germination time, Radicle length, Plumule length, Lateral roots, Pigment profile.

INTRODUCTION

Plant interaction is inevitable for biodiversity and existence of communities where each plant might interact in a positive, negative or neutral manner. Plants often compete with each other for the availabe resources and physical habitat around them. The plant interactions may fall under various categories such as mutualism, commensalism, parasitism, competition and allelopathy (Raven *et al.*, 1999). Allelopathy played important role in plant biodiversity and sustainable agriculture through the production of specific biomolecules or allelochemicals that can induce suffering in, or give benefit to, another plant. This phenomenon is due to inhibitory substances that are released directly from living plant into the environment through root exudation, leaching, volatilization, and through the decomposition of plant residues (Rice, 1984). Majority of weeds act as a donor species and possess the capacity to enter in to allelopathic interaction with neighbouring species for their existence and luxuriant growth pattern. Some invasive plants can produce significant changes to vegetation, composition, structure, or ecosystem function. *Amaranthus viridis* commonly known as Slender Amaranth or Green Amaranth is a cosmopolitan fast growing annual belonging to the family Amaranthaceae and is widespread throughout different habitat types especially in open waste places and cultivated land. They are able to compete with crops for water, nutrients and light, causing severe reductions in yield, quality and cause significant reduction in yield harvest efficiency. Weeds are one of the biggest threats to the biodiversity that causes habitat destruction as well. There are many reports on the allelopathic activity of plants belonging to Amaranthaceae family like *Amaranthus viridis* (Roy *et al.*, 1982), *Amaranthus palmeri* and *Amaranthus artemissiifolia (*Menges, 1988*;* Connick *et al.*, 1987*), redroot pigweed* (Dielman *et al.*, 1995), *Amaranthus gracilis* (Obaid and Qasem, 2005), *Amaranthus retroflexus (*Namdari *et al.*, 2012; Rezaei *et al.*, 2008), *Amaranthus graecizans* (Sadaqa *et al.*, 2010).

The present study focuss on the evaluation of allelopathic potential of a weed *A.viridis* on germination and pigment profile of a pulse crop *Vigna radiata* (L.) R. Wilczek.

MATERIALS AND METHODS

The weed *A.viridis* was selected as the donor species and *Vigna radiata* is used as the recipient species. The weed sample was collected from its natural habitat, cleaned, bioparts were separated and aqueous extracts was prepared on weight/ volume basis and used for the allelopathic studies.The seeds of *Vigna radiata* were procured from Agricultural College, Vellayani. The seeds were soaked in water and were placed in Petri dishes lined with cotton for germination. Sets of 15 seeds each with two replicates per treatment with respective control were allowed to imbibe on cotton saturated with a known volume of respective extracts in different concentrations (1%, 5, 10 and 20%). The petridishes were constantly moistened with the appropriate extracts. Various parameters viz., Germination percentage, Germination index , Germination speed (Kendrick and Frankland, 1969) , Vigour index (Abdulbaki and Anderson, 1973), Mean germination time (Ellis and Roberts, 1981), Radicle length, Plumule length and Number of lateral roots were considered and the results were subjected to statistical analysis and mean value was computed. Estimation of chlorophyll a, b, Total chlorophyll and carotenoid present in the recipient plant was carried out by standard method (Arnon, 1949). The parameters were calculated as per formulae (Table 1)

RESULTS AND DISCUSSION

The bioassay was conducted with aqueous extracts of *A. viridis* on the germination and seedling emergence of *Vigna radiata* (L.) R. Wilczek. The aqueous extracts altered the radicle length, plumule length, growth index and Vigour index of test species during germination at higher concentration of treatment. The results showed that the high concentrations of biopart extracts significantly inhibited the seed germination rate, growth of radicle, plumule, while the lower concentrations were found stimulatory to growth of the recipient species. These effects may probably be due to interaction of allelochemicals on the recipient plants.

Germination percentage

The extracts of various bioparts imparted a decrease in germination percentage (Fig. 1) as compared to control as treatment concentration increased from 1 to 20%. The germination percentage ranged from 49.99 to 63.33%, 23.33 to 56.66%, 33.33 to 69.99% and 43.33 to 76.66% on treatment with root, stem, leaf and flower extracts respectively. More than 50% reduction in the germination percentage was observed with higher concentration of stem and leaf extract.

Table 1. Formulae used for the calculation of various parameters

Germination Percentage (GP)	=	(Number of Germinated Seeds/ Number of planted seeds) x100
Germination Index (GI)	=	P/t (where p- final percentage of germination and t-time to reach 50% germination)
Germination Speed (GS)	=	Percentage of germination/Day of completion of germination
Vigour Index (VI)	=	(root length+ shoot length) × percentage of germination
Mean Germination Time (MGT)	=	? (Dn)/ ? n; where n-number of seeds germinated on the day D, D-number of days counted from the beginning of the germination test.
Chlorophyll a (mg /g)	=	$12.7 (A_{663}) - 2.69 (A_{645}) \times V/1000 \times W$
Chlorophyll b (mg/g)	=	$22.9(A_{645}) - 4.68 (A_{663}) \times V/1000 \times W$
Total chlorophyll (mg/g)	=	$(20.2 \times A_{645}) + (8.02 \times A_{663}) \times V/1000 \times W$
Carotenoids (mg/g)	=	$(A_{490} - 0.114) - (A_{663} - 0.638) - A_{645} \times V/1000 \times W$

Germination Index (GI)

The extracts of *A. viridis* affected the germination index (Fig. 2) in *Vigna radiata*. The germination index ranged from 49.99 to 63.33, 23.33 to 56.66, 31.66 to 53.33 and 43.33 to 56.66 in root, stem, leaf and flower extract respectively. Stem (20%) and leaf extracts (10 & 20%) imparted maximum decrease in germination index.

Germination speed (GS)

The extracts of *A. viridis* affected the germination speed (Fig. 3) in *Vigna radiata*. The germination speed ranged from 9.99 to 12.66, 4.67 to 11.33, 6.67 to 13.99 and 8.66 to 15.33 in root, stem, leaf and flower extract respectively. The germination speed decreased significantly in higher concentration of all extracts while lower concentrations imparted an enhancement. Leaf extract (10% and 20%) reduced the germination speed to almost 50%.

Vigour Index (VI)

The extracts of *A. viridis* affected the VI (Fig. 4) in *Vigna radiata*. The VI ranged from 848.26 to 2621.55, 208.66 to 1947.61, 330.31 to 2762.15 and 2398.63 to 3864.00 in root, stem, leaf and flower extract respectively. The sequence of phytotoxicity exhibited an order of stem>leaf>root and flower. VI was enhanced as compared to control at treatment concentration of 5 and 10% of flower extract.

Mean Germination Time (MGT)

MGT (Fig. 5) registered an increase in almost all treatments as compared to control. The MGT ranged from 50 to 57.64, 48 to 59.4, 330.31 to 57 to 61.53 and 51.11 to 61.46 in root, stem, leaf and flower extract respectively.

Radicle length

The extract of *A. viridis* reduced the radicle length (Fig.6) in *V. radiata* irrespective of the concentration and biopart. The radicle length varied from 1.02 to 1.17, 1.3 to 1.96, 0.76 to 1.32 and 1.02 to 1.82 in root, stem, leaf and flower extract respectively. Higher concentration of leaf extract reduced the radicle length to >75% and was found to be more allelopathic than the rest of the bioparts. The allelopathic impact of leachates and extracts are more harmful to radicle (Friedman, 1995).

Plumule length

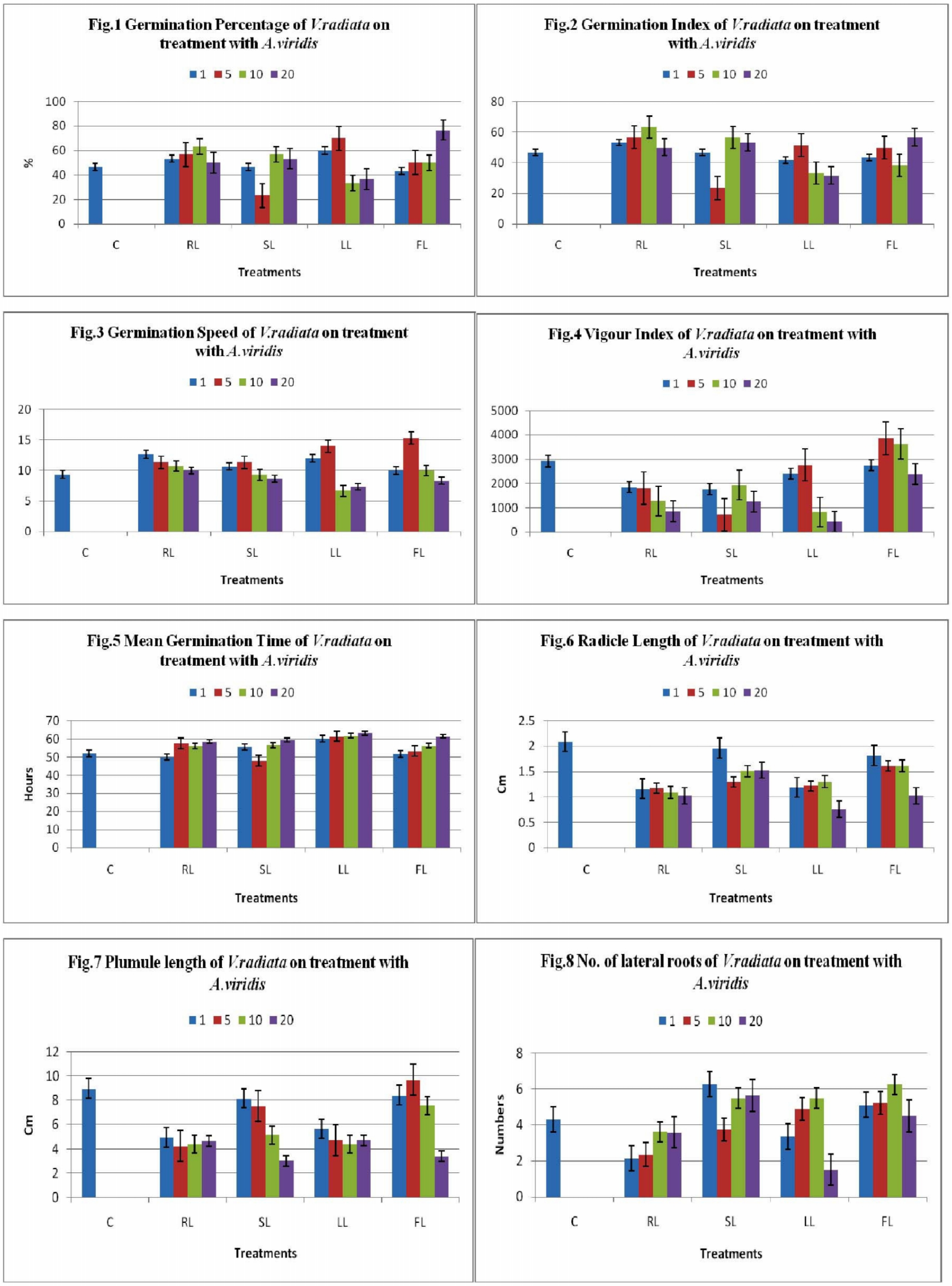
Plumule length (Fig.7) varied from 4.22 to 4.98, 3.05 to 8.15, 4.41 to 5.67 and 3.40 to 9.69 in root, stem, leaf and flower extract respectively. More than 50% reduction was noticed in the plumule length as compared to control. Root and leaf extracts were more allelopathic to plumule length.

Number of lateral roots

The number of lateral roots (Fig. 8) ranged from 2.14 to 3.62, 3.75 to 6.25, 1.5 to 5.5 and 4.5 to 6.25 in root, stem, leaf and flower extract respectively. Higher concentration of leaf extract was more allelopathic to lateral root production.

The allelochemicals, particularly phenolics and other secondary metabolites like alkaloids and terpenoids present in the plant parts may inhibit seed germination and these biomolecules are released in to the environment through volatilisation, leaching, root exudation and decomposition of plant residues (Geissman *et al.*, 1969). The activity of allelochemicals depends on the environmental conditions and its interaction with other compounds in soils. Ciarka *et al.* (2009) pointed out that extraction from homogenised tissue is more effective in releasing the compounds remained in agreement with the present study. Abbas (2010) reported that the stem extract of *Emex australis* was most inhibitory and concluded that the aqueous extracts adversely affected the seed germination. The collective effect of these interactions influences the environment of soil and plant growth (Zhu *et al.*, 2005). Similar harmful effects were reported with different weed residues on the crop plants. Ismail and Chong (2002) reported that short exposure time with high concentration may promote or inhibit seed germination and seedling growth and the stimulatory and inhibitory effects are functions of extract concentration and exposure time. The results obtained in the present study remained in agreement the above observation.

The leaf extracts of some weed species *Ageratum conyzoides*, *Anagallis arvensis*, *Chenopodium album*, *Parthenium hysterophorus* and *Rumex dentatus* reduced all growth parameters viz., root-shoot length, leaf area, root biomass, shoot biomass, total biomass, pod number and seed



C- control; RL- root extract; SL- stem extract; LL- leaf extract; FL- flower extract

Fig. 1. Germination details

weight of green gram (Dongre *et al*., 2010). In pot culture the weed residues of *Amaranthus graecizans* inhibited the germination and growth of onion (Sadaqa *et al*., 2010). In the present investigation, the allelopathic effects not only decreased the germination but also delayed the germination. The strong allelopathic potential of *A.viridis* was displayed by the decrease in the seed vigour, seed germination and seedling growth of target species even with a short exposure time.

The photosynthetic pigments (Table 1) in *V. radiata* exhibited significant reduction as compared to control due to the allelopathic interference of *A. viridis*. Chlorophyll estimation is an indicator of biomass and the reduction in the pigment level in the recipient species indirectly indicate retardation in photosynthetic activity which will be reflected in the seedling growth. The photosynthetic pigments in *V. radiata* exhibited significant reduction as compared to control. In the present investigation both Chlorophyll a and total chlorophyll was mostly affected by the stem extract (20%) while chlorophyll b by leaf extract (20%). The carotenoid content was found to be increased from lower to higher concentration in all treatments as compared to control.

There were reports that the allelochemicals have immense role on the reduction of photosynthetic pigments (Singh *et al*., 2009; Moradshahi *et al*., 2003; Ervin and Wetzel, 2000). This may be due to lowering of biosynthesis of chlorophyll molecules or may be due to the stimulation of chlorophyll degradation (Yang *et al*., 2004). Carotenoid content was found to be increased with higher concentrations of extracts of the weed and many researchers reported that the allelochemicals enhanced the carotenoid content which act as an antioxidant under stress conditions (El-Rokiek and Eid, 2009; Grassmann, 2005). Omidpanah *et al*. (2011) reported that an increase in carotenoid content under the allelopathic treatments can be attributed to its antioxidant property and protective role for photosynthetic membrane under the stress conditions.

CONCLUSIONS

Allelopathic interaction was evident between the leguminous plant *Vigna radiata* and the weed *Amaranthus viridis* in the present study. The weed species was found potentially harmful to crop species through the release of toxic chemicals from their aqueous extracts. Allelopathy has a crucial role in future weed and

Table 1. Pigment Profile of *V.radiata* (L.) R. Wilczek on Treatment with Biopart extracts of *A.viridis* L.

Bioparts	Concentration	Chlorophyll a	Chlorophyll b	Total Chlorophyll	Carotenoids
Root	1%	0.026	0.0023	0.0282	0.020
	5%	0.010	0.0041	0.0142	0.0261
	10%	0.0098	0.0011	0.00996	0.02156
	20%	0.081	0.00426	0.0123	0.02389
Stem	1%	0.0146	0.0011	0.01467	0.0251
	5%	0.0124	0.0023	0.0134	0.0175
	10%	0.0156	0.0016	0.02112	0.005
	20%	0.0003	0.0469	0.00021	0.0049
Leaf	1%	0.018	0.011	0.028	0.0294
	5%	0.0072	0.0030	0.015	0.0213
	10%	0.0115	0.0022	0.0223	0.0301
	20%	0.0156	0.0010	0.0181	0.0923
Flower	1%	0.0049	0.0083	0.0157	0.0152
	5%	0.0143	0.0123	0.00238	0.012
	10%	0.061	0.0081	0.0612	0.011
	20%	0.0098	0.019	0.0631	0.021
Control		0.0209	0.006	0.0270	0.0112

pest management strategies. The stimulatory activity of the weed extract in most of the parameters at lower concentration warrants further study on its utlisation as a biofertlizer and the inhibitory activity of plant extracts at higher concentration could be candidates for commercialization as herbicides.

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