Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 06, pp.52401-52406, June, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

EVALUATION OF ALLELOPATHIC POTENTIAL OF *DELONIX REGIA* AGAINST GERMINATION PHYSIOLOGY OF MUNG BEAN SEEDLING

Rawal, A. V. and *Pawar, K. B.

Department of Botany, Shivaji University, Kolhapur- 416004 (MS), India

ARTICLE INFO

Article History:
Received 18th March, 2017
Received in revised form
03rd April, 2017
Accepted 24th May, 2017
Published online 30th June, 2017

Key words:

Delonix regia,
Leaf leachate,
Phytochemical analysis,
Seedling growth,
Vigna radiata.

ABSTRACT

In India, mungbean is the 3rd major pulse crop cultivated for best source of proteins, carbohydrates and minerals. Seed germination and germination physiology play an important role in crop production. Ornamental plant *Delonix regia* is planted as shade tree in farm competes with neighboring plant species. Phytotoxins released by dry, dropped leaves of *Delonix* may have adverse effects on neighboring crop plants. Hence a study was carried out to evaluate the effect of aqueous leachates of leaves of *D. regia* on germination and some metabolic facets of seedlings of mungbean. In petriplate bioassay root length (74.62%, 17.20%, and 47.31%) and shoot length (76.43%, 16.98% and 46.70%) were reduced due to 20%, 0.2%, and 0.1% respectively. In soil bioassay, decrease in root length (16.09%, 13.73%, 1.02%) was observed. In petriplate bioassay a decrease in starch content (14.55%, 10.97%, 36.42%), reducing sugar (60.94%, 67.45%, 17.45%), total sugar (43.50%, 57.62%, 18.25%) and increase in protein content (54.26%, 13.42%, 42.61%) was observed due to treatment of leaf leachates. In soil bioassay, there was increase in starch (42.24%, 1071.12%, 859.66 %) and total sugar content (20.06%, 63.78%, 23.81%) and decrease in reducing sugar content (32.93%, 3.44%, 15.17%) and soluble protein content (3.64%, 0.298%) in seedlings of mung bean. Leaf leachate showed considerable amount of polyphenols and number of phytochemicals. Inhibition of seed germination, seedling growth and alteration in metabolism of mungbean seedlings may be due to the synergistic effect of appreciable amount of polyphenols and phytochemicals present in the leaf leachates.

Citation: Rawal A. V. and Pawar K. B. 2017. "Evaluation of allelopathic potential of *Delonix regia* against germination physiology of Mung bean seedling", *International Journal of Current Research*, 9, (06), 52401-52406.

INTRODUCTION

Seed germination plays a significant role in the life cycle of crop plants, as well as for successful crop production. It sustains crop reproduction and restrains the dynamic of crop plants population (Dash, 2012). In germination of crop plants, seedling growth and physiological processes may be positively or negatively altered by the factors which are associated with climatic changes (Reddy *et al*., 2000). Mijani *et al*. (2013) reported that successful establishment of plant species is dependent on adaptive mechanisms of seed germination and seedling growth to hostile climatic conditions. Germination, growth and yield of crop plants may be distressed by the phytotoxins released by higher plants (Singh *et al*., 2006). Allelopathic agents affect the performance of plant by impeding seed germination, root length or plant growth (Djlirdjevic *et al*., 2007). In plants, allelochemicals affect the physiological processes like cell division, elongation, membrane permeability, plant nutrient uptake, photosynthesis, respiration, enzyme activities and protein synthesis (John and Sarada, 2012). In agroforestry programme, allelopathic interactions in tree-crop association crop production may be affected. A variety of secondary metabolites found in crop field, which are liberated by the tree species, may hamper germination and growth of crops (Singh *et al*., 2006). In India, mung bean is the third major pulse crop grown on 3.72 million ha area having about 1.56 million ton production (Abdel Haleem, 2007). Mung bean which is cultivated for its dry edible seeds and fresh sprouts is considered one of the best source of proteins, carbohydrates and minerals (Sehrawat *et al*., 2013). Though *Delonix regia* is planted as ornamental plant and shade tree in farms, it competes with neighboring plant species and turns land under its canopy barren (Orwa *et al*., 2009). Shedding of dried leaves of *Delonix* is observed frequently. These dried leaves may get accumulated in farms and may have antagonistic effect on crop plant species due to release of phytochemicals. In the light of the above the present study was carried out to evaluate allelopathic potential of *D. regia* against germination physiology of *Vigna radiata.*

***Corresponding author: Pawar K. B.**
Department of Botany, Shivaji University, Kolhapur- 416004 (MS), India.

Table 1. Effect of leaf leachate of *D. regia* on seed germination of *Vigna radiata* (Petriplate bioassay)

Treatment	Germination percentage					
	24hrs		48hrs		72hrs	
		Percent increase (+)/decrease (-)		Percent increase (+)/decrease (-)		Percent increase (+)/decrease (-)
Control	75±15.16***	-	77±16.53***	-	80±15.49***	-
20% leaf leachate	20±12.65**	73.33 (-)	48±14.14***	37.66 (-)	48±11.69***	40 (-)
0.2% leaf leachate	42±23.16***	44 (-)	65±10.49***	15.58 (-)	67±12.11***	16.25(-)
0.1% leaf leachate	48±27.14***	36 (-)	57±23.38***	25.97 (-)	70±10.95***	12.5 (-)

Significantly different at * 1% level, ** 5% level, *** 1% and 5% level, NS- Non significant

Table 2. Effect of leaf leachate of *D. regia* on seedling growth of *Vigna radiata* (Petriplate bioassay)

Treatment	Seedling growth			
	Average root length (cm)		Average shoot length (cm)	
		Percent increase (+)/ decrease (-)		Percent increase (+)/ decrease (-)
Control	4.65± 0.65***	-	4.71± 0.64***	-
20% leaf leachate	1.18± 0.79**	74.62 (-)	1.11± 0.72**	76.43 (-)
0.2% leaf leachate	3.85± 0.70***	17.20 (-)	3.91± 0.69***	16.98 (-)
0.1% leaf leachate	2.45± 0.71***	47.31 (-)	2.51± 0.64***	46.70 (-)

Significantly different at * 1% level, ** 5% level, *** 1% and 5% level, NS- Non significant

Table 3. Effect of leaf leachate of *D. regia* on seedling growth of *Vigna radiata* (Soil bioassay)

Treatment	Seedling growth			
	Average root length (cm)		Average shoot length (cm)	
		Percent increase (+)/decrease (-)		Percent increase (+)/decrease (-)
Control	13.61±2.81***	-	13.39±1.59***	-
20% leaf leachate	11.42± 2.42***	16.09 (-)	12.09±2.49***	9.70 (-)
0.2% leaf leachate	11.74±2.11***	13.73 (-)	12.42±1.47***	7.24 (-)
0.1% leaf leachate	13.47±4.99**	1.02 (-)	14.04±2.40***	4.85 (+)

Significantly different at * 1% level, ** 5% level, *** 1% and 5% level, NS- Non significant

Table 4. Effect of leaf leachate of *D. regia* on starch content in seedling of *Vigna radiate*

Treatment	Starch content (mg g^{-1} d. wt.)			
	Petriplate bioassay		Soil bioassay	
		Percent increase (+)/decrease (-)		Percent increase (+)/decrease (-)
Control	12.85±1.76***	-	8.38± 1.59**	-
20% leaf leachate	10.98±1.21***	14.55 (-)	11.92±1.79***	42.24 (+)
0.2% leaf leachate	11.44±1.48***	10.97 (-)	98.14± 9.64***	1071.12 (+)
0.1% leaf leachate	8.17±0.90***	36.42 (-)	80.42±1.38***	859.66 (+)

Significantly different at * 1% level, ** 5% level, *** 1% and 5% level, NS- Non significant

Table 5. Effect of leaf leachate of *D. regia* on reducing sugar content in seedling of *Vigna radiata*

Treatment	Reducing sugar content (mg g^{-1} d. wt.)			
	Petriplate bioassay		Soil bioassay	
		Percent increase (+)/decrease (-)		Percent increase (+)/decrease (-)
Control	0.676±0.067***	-	1.16±0.068***	-
20% leaf leachate	0.264±0.044***	60.94 (-)	0.778±0.051***	32.93 (-)
0.2% leaf leachate	0.22±0.13NS	67.45 (-)	1.12±0.16***	3.44 (-)
0.1% leaf leachate	0.558±0.15**	17.45 (-)	0.984±0.067***	15.17 (-)

Significantly different at * 1% level, ** 5% level, *** 1% and 5% level, NS- Non significant

Table 6: Effect of leaf leachate of *D. regia* on total sugar content in seedling of *Vigna radiata*

Treatment	Total sugar content (mg g^{-1} d. wt.)			
	Petriplate bioassay		Soil bioassay	
		Percent increase (+)/decrease (-)		Percent increase (+)/decrease (-)
Control	0.8±0.1***	-	1.331±0.085***	-
20% leaf leachate	0.452±0.037***	43.50 (-)	1.598±0.087***	20.06 (+)
0.2% leaf leachate	0.339±0.10**	57.62 (-)	2.18±0.12***	63.78 (+)
0.1% leaf leachate	0.654±0.18**	18.25 (-)	1.648±0.12***	23.81 (+)

Significantly different at * 1% level, ** 5% level, *** 1% and 5% level, NS- Non significant

Table 7. Effect of leaf leachate of *D. regia* on soluble protein content in seedling of *Vigna radiata*

Treatment	Soluble protein content (mg g^{-1} d. wt.)			
	Petriplate bioassay		Soil bioassay	
		Percent increase (+)/decrease (-)		Percent increase (+)/decrease (-)
Control	70.45±2.45***	-	87.22±2.79***	-
20% leaf leachate	108.68±3.30***	54.26 (+)	84.04±1.42***	3.64 (-)
0.2% leaf leachate	79.91±1.30***	13.42 (+)	86.96±0.84***	0.298 (-)
0.1% leaf leachate	100.47±1.42***	42.61 (+)	90.06±5.08***	3.25 (+)

Significantly different at * 1% level, ** 5% level, *** 1% and 5% level, NS- Non significant

Table 8. Chemical analysis of leaf leachate

Nitrate content (mg g^{-1} d. wt.)	Nitrite content (mg g^{-1} d. wt.)	Total polyphenol (mg g^{-1} d. wt.)	Phytochemicals detected
22.67±1.41***	0.048±0.003***	4.547±0.367***	Camphene; 2-Methyl-2-hepten-6-one; (1S)-2,6,6-Trimethylbicyclo(3.1.1) hept-2-ene; 1R-alphapinene; Ocimene; Dimethyloctatriene; Alpha-Fenchene; 4-Nonanone; 7- Methyl-4-octanone; 2-Methyl-3-octnone; 2, 6-Dimethyl-3-heptanone, Linalol, 2,4,6-Trimethyl-3-Cyclohexen-1-Carboxyaldehyde; Artemiseole; 2-Isopropenyl-5 methylhex-4-enal; (E)-3(10)-Caren-2-ol; Cis-Geraniol; Alpha-citral; Beta- citral; Neryl acetate; Caryophyllene; Germacrene; Copaene

Significantly different at * 1% level, ** 5% level, *** 1% and 5% level, NS- Non significant

MATERIALS AND METHODS

Procurement of plant material

In the month of November and December, 2013, dried and dropped leaves were hoarded from streets and farm sides in Kolhapur District (Maharashtra State, India). Certified seeds of mung bean (*V. radiata* (L.) R. Wilczek variety SML-668) (Ajinkya Seeds, Pune) were purchased from local market.

Formulation and chemical analysis of leaf leachate

Consistent with the method of Jadhav and Gaynar (1992), 10 grams of leaves sluiced 4-5 times with distilled water and soaked in 50ml distilled water for 24 hrs. Filtration of leaf leachate followed by dilution of 20% leachate to 0.1% and 0.2% concentrations. For assessment of nitrate content, 200µl 20% leachate was treated with salicylic acid-sulphuric acid and then with 2N NaOH to raise the pH above 12 and absorbance was recorded at 420nm (Cataldo *et al*. 1975). For nitrite determination leachate was treated with 1% Sulfanilamide and 0.02% NEEDA and absorbance was recorded at 540nm (Nair *et al*. 1988). As per the method of Folin and Denis (1915) total polyphenol content in leaf leachate was estimated by reaction between leachate and Folin Denis reagent and 20% Na_2CO_3 and recording absorbance at 660nm. Nitrate, nitrite and polyphenol content were expressed as mg per g dry weight with the help of standard curve. GC-MS technique utilized to detect phytochemicals in methanolic leachate of leaves.

Seed germination and growth study

In petriplate bioassay, for surface sterilization healthy mungbean seeds treated with 0.1% $HgCl_2$ and rinsed with distilled water. Each sterile petriplate having 10 seeds supplied with 8ml of leachates (20%, 0.1% and 0.2%) and 8ml distilled water for treatment and control respectively. Seeds were allowed to germinate at room temperature (24-28^{0}C) under light and dark cycles. To note germination seeds at 24, 48 and 72hrs stage and for seedling growth 120hrs stage was considered. For soil bioassay, plastic trays (dimension 22cm x 17cm x 4.2cm) filled with 750 grams of dry soil. Thirty seeds were sown in moistened soil. Fifty ml of leachate and 50 ml of distilled water applied for 5 days (at alternate day). Root length and shoot length of 10 days old seedlings was noted.

Estimation of starch, sugars and protein

For determination of starch and sugar content ethanolic extract of dry seedlings and residue was used. For reducing sugar content filtrate was condensed and decolorized (Lead acetate + Potassium oxalate, 1:1 proportion) and filtered after addition of distilled water. For total sugar and starch, 20ml of filtrate and residue hydrolyzed by autoclaving with concentrated HCl. Contents were neutralized with Na_2CO_3 and filtered. For evaluation of starch and sugar contents filtrates were treated with Somogyi's alkaline copper tartarate reagent(4 g $CuSO_4$. $5H_2O$, 24 g anhydrous Na_2CO_3, 16 g Na-K-tartarate and 180 g anhydrous Na_2SO_4 dissolved in 1 liter distilled water) and Arsenomolybdate reagent (25 g Ammonium molybdate dissolved in 450 ml distilled water, 3 g sodium arsenate dissolved in 25 ml distilled water, 21 ml concentrated HCl. These ingredients were mixed well and digested for 48 hours at 37°C) and values were expressed as mg per g dry weight with standard curve of glucose (Nelson, 1944). For soluble protein content (Lowry *et al*., 1951) buffer extract of dry seedlings treated with reagent C(50 ml of A containing 2% sodium carbonate in 0.1 N aqueous NaOH was mixed with 1 ml of B containing 0.5% copper sulphate in 1%, Na-K tartarate) and Folin and Ciocalteau phenol reagent. Amount of soluble protein calculated by standard curve of Bovin Serum Albumin and values expressed as mg per g dry weight. The findings presented are mean of three independent determinations. These are analyzed statistically by standard deviation and checked whether values are significantly different (at $P< 0.01$) from population or not.

RESULTS AND DISCUSSION

Seed germination and seedling growth

The perusal of data reveals that seed germination in mung bean was inhibited due to treatment of leaf leachate of *D. regia*

(Table 1). Highest inhibition of seed germination was observed at 20% leaf leachate (73.33%), 0.2% (44%) and 0.1% (36%) after 24hrs stage compared to 48hrs (37.66%, 15.58%, 25.97%) and 72hrs (40%, 16.25%, 12.5%) of treatment. Seedling growth with respect to root length and shoot length was reduced due to treatment of leaf leachate at all concentrations in petriplate (Table 2). Reduction in root length was by 74.62%, 17.20% and 47.31% at 20%, 0.2% and 0.1% leaf leachate and 76.43%, 16.98% and 46.70% inhibition in shoot length was observed. In soil bioassay leaf leachate caused 16.09%, 13.73% and 1.02% decline in root length and 9.70% and 7.24% inhibition of shoot length (Table 3).

Starch, sugar and protein contents

In mung bean seedlings, starch content decreased by 14.55%, 10.97% and 36.42% in petriplate bioassay and increased by 42.24%, 1071.12% and 859.66% in soil bioassay. Relative to control, highest elevation in starch content was observed due to 0.2% (1071.12%) and 0.1% (859.66%) in soil bioassay (Table 4). Content of reducing sugar was reduced by 60.94%, 67.45%, 17.45% and 32.93%, 3.44%, 15.17% in petriplate and soil bioassay respectively (Table 5). In mung bean seedlings total sugar content was decreased (43.50%, 57.62% and 18.25%) in petriplate bioassay while it was increased (20.06%, 63.78% and 23.81%) in soil bioassay (Table 6) However reverse trend was observed in soluble protein content, which increased (54.26%, 13.42%, 42.61%) in petriplate and decreased (3.64%, 0.298%) in soil bioassay (Table 7).

Chemical analysis of leaf leachate

Appreciable amount of nitrate and polyphenols were detected in leaf leachates. Camphene, 2-Methyl-2-hepten-6-one, (1S)-2,6,6-Trimethylbicyclo(3.1.1) hept-2-ene, 1R-alpha-pinene, Ocimene, Dimethyloctatriene, Alpha-Fenchene, 4- Nonanone, 7- Methyl-4-octanone, 2-Methyl-3-octanone, 2, 6-Dimethyl-3-heptanone, Linalol, 2,4,6-Trimethyl-3-Cyclohexen-1-Carboxyaldehyde, Artemiseole, 2-Isopropenyl-5-methylhex-4-enal, (E)-3(10)-Caren-2-ol, Cis-Geraniol, Alpha-citral, Beta-citral, Neryl acetate, Caryophyllene, Germacrene, Copaene phytochemicals were detected in leaf leachate (Table 8). Seed is an important organ and germination of seed compiles acute step in propagation and cultivation of most crop species. Seed germination and seedling growth are the imperative morphological parameters studied when plants are exposed to allelochemicals (Kruse *et al*. 2000). In present study, seed germination is hindered and seedling growth is declined due to leaf leachates (20%, 0.2% and 0.1%) of *D. regia*. Inhibition was more prominent in 20% leaf leachate treatment. The present findings are in accordance with earlier reports in which evaluation of allelopathic potential of aqueous extracts or aqueous leachates of plant species was carried out by using mung bean as accessible bioassay material. Patil *et al*. (2013) have examined effect of leaf extract (5%, 10%, 15% and 20%) of *Alternanthera tenella, Croton bonplandianum* and *Xanthium indicum* on germination and seedling growth of mung bean by using petriplate bioassay and found reduction in germination percentage due to leaf extract of all the weed species except 10% leaf extract of *A.tenella*. Complete inhibition of seed germination was reported due to leaf extract of *C. bonplandianum* (15%, 20%) and *X. indicum* (20%). Root length and shoot length of mungbean seedlings completely restrained due to high concentration of leaf extract of *Croton* and *Xanthium* (20%). As per the observations of Shruthi *et al*. (2014) seed germination, radicle and plumule length were reduced due to aqueous extract of powder of dried leaves of *Azadirachta indica* having 10%, 15% and 20% concentrations in soil bioassays. In existent observation also 20% leaf leachate was initiated as more effective as compare to 0.2% and 0.1%. Maiti *et al*. (2010, 2013 and 2015) have assessed allelopathic potential of aqueous leaf leachates (1:1, 1:2 and 1:3 proportions) of *Lantana camara, Eupatorium odoratum* and *Hyptis suaveolens* on germination of mung bean in petriplate and soil bioassays and reported impediment of seed germination due to treatment of leachates with maximum inhibition at high concentration (1:1). Ojha *et al*. (2013) noticed inhibition of seed germination of mung bean due to leachates of dry leaves of *Melaleuca leucadendron* (1:1, 1:2w/v). In mung bean germination percentage was inhibited due to aqueous extract of dried, ground leaves of *Moringa oleifera* of 2.5%, 5.0%, 7.5%, 10%, 12.5% and 15% concentrations on 3rd, 5th and 7th day of germination in petriplate bioassay (Hossain *et al*., 2012). Joshi *et al*. (2015) found decreased radicle length of *Vigna radiata* in petriplate bioassay by applying 5ml of extract of grinded dry leaves of *Ipomoea carnea* (2%, 3%, 5%) and *Ricinus communis, Hyptis suaveolens, Malachra capitata, Cymbopogon citrulus*, *Alternanthera sissilis* at concentrations 1%, 2%, 3% and 5% and same pattern of inhibition of plumule length due to all the weed species.

Starch forms the major reserve food in many seeds. During germination it is converted to soluble from and transported to the obligatory sites for further metabolism and plant growth. It is involved in regulation of osmotic potential of cells. Sugars are casting building blocks for amino acids and fatty acids. Leguminous seeds are the rich source of proteins, the main source of amino acids for growing embryo. The released amino acids are utilized to construct necessary enzymes and components for seedling growth. In present study starch and sugar contents are decreased in petriplate bioassay and increased in soil bioassay except reducing sugar which is declined due to leaf leachate treatment. On the contrary protein content of mung bean seedlings is increased in petriplate bioassay while decreased in soil bioassay. The present observations corroborate with the earlier findings. Singh and Singh (2003) have observed increase in sugar content of *Vigna radiata* due to aqueous leaf leachates of *Eucalyptus citriodora*. Shruthi *et al*. (2014) found reduction in total carbohydrate content and protein content in shoot and root of mung bean and increase in the same in cotyledons due to 10%, 15% and 20% aqueous extracts of dried leaves of *Azadirachta indica* in soil bioassay. Maiti *et al*. (2010) noted increase in soluble carbohydrate content and decrease in protein content in mung bean seeds due to aqueous leaf leachates of *Lantana camara* (1:1,1:2 proportions) maximum at 1:1 proportion. In extant observations seed germination and seedling growth of mung bean declined and contents starch, sugars and protein are altered due to leaf leachate treatment higher at 20% by following similar petriplate and soil bioassays and applying leaf leachates for treatment and distilled water for control. In present investigation phytochemicals detected in leaf leachates of *D. regia* might be involved in inhibition of seed germination, seedling growth and altered biomolecules are in compliance with earlier reports on camphene, alpha-pinene, ocimene, nonanone, copaene and caryophyllene. Nishida *et* al. (2005) noted inhibition of cell proliferation, DNA synthesis in root apical meristem and root growth of *Brassica campestris* seedlings due to camphene and alpha-pinene isolated from

Salvia leucophylla. Alpha- pinene and Copaene isolated and identified from *Eucalyptus urophylla* by Qui *et al*. (2010). Xue *et al*. (2011) observed inhibition of germination and seedling growth of *Leymus chinensis, Stipa krylovii* and *Cleistogenes squarrosa* due to camphene and alpha-pinene isolated from *Artemissia frigida*. Kanchiswamy *et al* (2015) reported production of camphene, alpha-pinene, ocimene, nonanone, copaene and caryophyllene by a wide array of microorganisms from bacteria to fungi. Phytochemicals active as an allelochemicals may manipulate growth and development by inhibiting root elongation, cell division, changing cell ultrastructure, reducing chlorophyll content and photosynthetic rate, declining enzyme activities and protein synthesis (Zhao-Hui *et al*., 2010). Accumulation of nitrate in soil, due to reduction in root surface and number of root nodules, causes hostile effects on nitrogen fixation in legume plants (Hannaway and Shuler, 1993). Serious health disorders have been observed in animals due to consumption of plants with high nitrate content (Shiel *et al.* 1999). Inhibition of seed germination and reduced seedling growth due to leaf leachate at high and low concentration may further affect the growth and development of *V. radiata.* In soil bioassay seedling growth was not adversely affected as in petriplate bioassay, which might be due to degradation of allelochemicals by soil microbes or by binding of allelochemicals to soil particles. Disturbed metabolism of *Vigna* due to alterations in the contents of starch, sugars and proteins, may obstruct growth of seedlings which may affect further growth, development and yield of crop plant . Reduction in seed germination and seedling growth of mung bean may be synergistic effect of the appreciable amount of polyphenols and phytochemicals detected in leaf leachate. Growth performance of mungbean under allelopathic potential of Gulmohar may help to select plant species in agroforestry programme. Chemical analysis of leachate may be utilized for selection of phytochemicals for eradication of weeds.

Acknowledgment

Authors are grateful to the Head, Department of Botany, Shivaji University, Kolhapur, India for providing facilities for the research work.

REFERENCES

Abdel Haleem M.A.M. 2007. Physiological aspects of mungbean plant (Vigna radiata L.Wilczek) in response to salt stress and gibberellic acid treatment. *Res. J. Agric. Bio. Sci.*3: 200-213

Cataldo, D.A., Hanoon M., Schrader I.E. and Youngs V.I. 1975. Rapid calorimetric determination of nitrate in plant tissue by nitration of salicylic acid. *Comm. Soil Sci. Plant Anal*. 6: 71-80

Dash, A. K. 2012. Impact of domestic waste water on seed germination and physiological parameters of rice and wheat. Int. J. Res. Rev. Appl. Sci., 12: 280-286

Dhawan S.R., Dhawan P. and Gupta S.K. 2001. Allelopathic potential of leguminous plant species towards Parthenium hysterophorus L. (1)-Effect of aqueous foliar leachates. *Legume Res.-An Int. J.* 24

Djlirdjevic, L., Mitrovi, M. and Pavlovi, P. 2007. Methodology of Allelopathy Research: 2. Forest Ecosystems. *Allelopathy J.* 20: 79-102

Folin, O. and Denis, W. 1915. A colorimetric estimation of phenols and phenol derivatives in urine. *J. Biol. Chem.* 22: 305-308

Hannaway, B.D. and Shuler, E.P. 1993. Nitrogen fertilization in lucerne production. *J. Prod. Agric*. 6: 80-85

Hossain, M. M., Miah, G., Tofayel, A. and Noor, S.S. 2012. Allelopathic effect of Moringa oleifera on the germination of Vigna radiate. *Int. J. Agric. Crop Sci.,* 4: 114-121

Jadhav, B.B. 2003. Allelopathic effect of leaf leachate of different tree species. *Abstract, 2nd International Congress of Plant Physiology. Jan. 8-12, 2003. New Delhi, India,* 292

Jadhav, B.B. and Gaynar, D.G. 1992. Allelopathic effects of *Acacia auriculiformis* A. Cunn on germination of rice and cowpea. *Indian J. Plant Physiol.*, 35: 86-89

John, J. and Sarada, S. 2012. Role of phenolics in allelopathic interactions. *Allelopathy J.* 29: 215-229

Joshi, N., Nangia, N. and Joshi, A. 2015. Seed germination studies on allelopathic effects of weeds on *Vigna radiata* L. *Int. J. Bioassays*, 4: 3664-3666

Kanchiswamy, C.N., Malnoy, M. and Maffei, M.E. 2015. Chemical diversity of microbial volatiles and their potential for plant growth and productivity. *Frontiers in Plant Sci.,* 6 1-23

Kruse, M., Strandberg, M. and Strandberg, B. 2000. Ecological Effects of Allelopathic Plants – a Review. *National Environmental Research Institute, Silkeborg, Denmark NERI Technical Report No.* 315 : 66

Lowry, O.H., Rosenbrough, N.J., Furr, A.L. and Randall, R.J. 1951. Protein measurement with folin phenol reagent. *J. Biol. Chem.* 193: 262-263

Mahadik, S.G. and Jadhav B.B. 2003. Influence of kokam(Garcinia indica Choisy) and Gulmohar (Delonix regia Raffin) leaf leachates on germination of rice and cowpea. *Abstracts, 2nd International Congress of Plant Physiology*, *Jan.,8 – 12,2003, New Delhi,* 292.

Maiti, P., Bhakat, R. K., Jha, Y. and Bhattacharjee, A. 2015. Allelopathic potential of *Hyptis suaveolens* on physio-biochemical changes of mung bean seeds. *Commun. Plant Sci*. 5:67-75

Maiti, P., Bhakat, R.K. and Bhattacharjee, A. 2013. Allelopathic potential of a noxious weed on mung bean. *Commun. Plant Sci*. 3: 31-35

Maiti, P.P., Bhakat, R.K. and Bhattacharjee, A. 2010. Evalution of allelopathic potential of an obnoxious weed using Mung Bean as a bioassay material. *Int. J. Sci. Res.*,1, 236-241

Mijani, S., Eskandari nasrabadi, S., Zarghani, H. and Ghias abadi, M. 2013. Seed Germination and Early Growth Responses of Hyssop, Sweet Basil and Oregano to Temperature Levels. *Not. Sci. Biol.* 5: 462-467

Nair, T.V.R., Kalm, M.S., Pande, H.C. and Mytill, J.B. 1988. Cluster bean (*Cymopsis tetragonoloba* L.) accumulate nitrite in roots. *Proceedlings of the International Congress of Plant Physiology, New Delhi, India, February 15-20, 1988*: 1065-1070

Nelson, N. 1944. A photometric adaptation of somogy method for the determination of glucose. *J. Biol. Chem.* 15: 375-380

Nishida, N., Tamotsu, S., Nagata, N., Saito, C. and Sakai, A. 2005. Allelopathic effects of volatile monoterpenoids produced by Salvia leucophylla: Inhibition of cell proliferation and DNA synthesis in the root apical meristem of Brassica campestris seedlings. *J. Chem. Ecol*. 31: 1187-1203

Ojha, S., Pati, C. K. and Bhattacharjee, A. 2013.Evaluation of allelopathic potential of an aromatic exotic tree, *Melaleuca leucadendron* L. *Afr, J. Plant Sci.*7: 558-560

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Anthony, S. 2009. Agroforestry Database: a tree reference and selection guide version 4.0 (http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp)

Oudhia, P. 2011. Research Documents with New comments 8:Unique traditional allelopathic knowledge about herbs in Chhatisgarth, India : effect of extract.http:/ pankajoudhia.com.

Patil, H. S, Shitole, S. M. and Dhumal, K. N. 2013. Effect of Leaf and Root Extracts of Selected Weed Species on Seed Germination and Seedling Growth in Mung Bean. *Int. J. Curr. Res.,* 5, 094-098

Qiu, X., Yu, S., Wang, Y., Fang, B., Cai, C. and Liu, S. 2010. Identification and allelopathic effects of 1,8-cineole from *Eucalyptus urophylla* on lettuce. *Allelopathy J.* 26: 255-264

Ramamoorthy, K., Radhamani, S., Amanillah, M.M. and Subbian, P. 2009. Biology and integrated management of congress grass (Parthenium hysterophorus L.) *A Rev. Green Farming* 2 :702-706

Reddy, K.R., Hodges, H.F. and Kimbell, B.A. 2000. Crop Ecosystem responses to climate change: Cotton. Climate Change and Global Crop productivity : *CAB Int*. 8: 161-187

Sehrawat, N., Jaiwal, P. K., Yadav, M., Bhat, K. V. and Sairam, R. K. 2013. Salinity stress restraining mungbean (Vigna radiata (L.) Wilczek) production: Gateway for genetic improvement. *Int. J. Agric. Crop Sci.*, 6: 505-509

Shiel, R.S., Tilib, A.B.A. and Younger, A. 1999. The influence of fertilizer nitrogen, white clover content and environmental factors on the nitrate content of perennial ryegrass and ryegrass/white clover swards. *Grass and Forage Sci.* 54: 275-285

Shruthi, H. R., Hemanth Kumar, N. K. and Jagannath, S. 2014. Allelopathic potentialities of *Azadirachta Indica A. Juss.* Aqueous leaf extract on early seed growth and Biochemical parameters of *Vigna Radiata* (L.) Wilczek. *Int. J. Latest Res. Sci. Technol.* 3: 109-115

Singh, B., Uniyal, A.K., Bhatt, B P. and Prasad, S. 2006. Effects of agroforestry tree spp. on crops. *Allelopathy J.* 18: 355-362

Singh, N.B. and Singh, R. 2003. Effect of leaf leachate of Eucalyptus on germination, growth and metabolism of greengram, blackgram and peanut. *Allelopathy J.* 11: 43-51

Xue, F. L., Wang, J., Huang, D., Wang, L. X. and Wang, K. 2011. Allelopathic potential of Artemisia frigida and successional changes of plant communities in the Northern China Steppe. *Plant & Soil*, 341: 383

Zhao-Hui, L., Qiang, W., Xiao, R., Cun-De, P. and De-An, J. 2010. Phenolics and Plant Allelopathy. *Molecules* 15: 8933-8952.

****