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Influence of an invasive weed *Chromolaena odorata* on agricultural crops

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Abstract
To understand the influence of *Chromolaena odorata* on various agricultural crops number of studies have been assessed in this paper. Most of the researchers have found inhibitory effect of extracts of *Chromolaena* root, stem, leaf and inflorences on seed germination and seedling growth, root-shoot length and yield of various crops like maize, mustard, soyabean, mungbean, chickpea, Rice due to presence of more allelochemicals like alkaloids. Phenols, amino acids. Some researchers have found increase in crop yield like ragi, broccoli and okra due to presence of less allelochemicals.

Keywords: agriculture, allelochemicals, invasive weed

1. Introduction

Plant species that move from one geographical region to the other (either accidently or intentionally), establish and proliferate there and threaten native ecosystems, habitats and such species are known as invasive alien plants [36].

The problem of invasive plants has become global and is largely human aided [39]. Such invasive alien plants threaten native biodiversity, disturb ecosystem functions and can cause large economic damage. Plant invasions have been predicted to increase further under ongoing global environmental change [19]. Many invasive plants are known in India. Recently [34] reported about, 117 genera from Indian region which are mostly from Tropical region. Many other researchers like [15, 16, 14, 28] have reported different invasive plants from north western Himalayas, Kashmir valley and Doon valley respectively mainly as ornamental plants.

Eupatorium odoratum / Chromolaena odorata L. (king) and (H.E. Robinson) is one such invasive ornamental plant introduced in India from Central America. It was first introduced in Calcutta in 1845 [23]. According to [10] it is included in the list of top 100 worst invasive weeds. The characters such as vigorous growth, high reproductive potential, with prolonged seed viability have made the plant a successful invader in many parts of India. It has encroached all types of land habitats [22, 29]. It is one of the most obnoxious weeds in the Western Ghats, North-western parts of the country. It affects a number of different lands such as coconut plantation, pastures, gardens, disturbed forests, roadsides, fringes, settlements and villages. Presently weeds infest agricultural lands very rapidly because of human activities like tourism, pollution, urbanization and rapid industrialisation.

This review presents conclusions on weed allelopathy in agriculture, with emphasis on allelochemicals and their effects on crops.

1.1 *Chromolaena* weed and Agriculture

A significant portion of the agricultural land in developing countries in the tropics is heavily infested with weeds [4]. Many weed species are reported to be phytotoxic and interfere with growth and production of crops [33]. They influence the growth of agricultural crops because of their allelopathic potential. Now their management is a difficult challenge to Asian farmers. In India biotic invasion at present is increasing especially in agricultural field because of diverse climatic and environmental conditions. Invasion of weed like *Chromolaena* in agroecosystem may lead to huge economic losses and serious challenges to the sustainability of the worldwide crop production.

India has gross irrigated crop area of 82.6 million hectares. Agriculture is the backbone of Indian economy. Introduction of such weed *Chromolaena odorata* mainly affects the crop production and economy. Many researchers carried out experiments with aqueous extracts and leachates of different parts of *Chromolaena* on various crops and observed reduction in germination percentage, root and shoot growth [21, 32]. There is much evidence that allelochemicals liberated from *Chromolaena* into soil reduce crop growth [30, 20, 12].

1.2 *Chromolaena* allelopathy and Allelochemicals

Molisch (1937) coined the term allelopathy which means affecting each other. Observation of allelopathic phenomenon dates since prehistoric times. The most primitive writings on the allelopathy are credited to Theophrastus (300 B.C) who detected the detrimental effects of cabbage over the growth of vine and proposed that such effects were occurred by odours from cabbage plant (Wilis, 1985). Allelopathic potential of numerous weeds on the crops has been reported by many workers [3, 9]. Many weeds like *Chromolaena* influence the crop plants by releasing allelochemicals through different modes like leaching from leaves or other parts, decomposing residues, exudation and volatilization [7]. Effects of leaf leachate of *Chromolaena* and other weeds on germination, radicle and plumule growth, root-shoot length of field crops reported by many workers [6, 18, 26].

Many reports revealed that the different concentrations of *Chromolaena* extracts significantly affected seed germination of crops [25]. The biological activity of allelochemicals is concentration dependant. Threshold below which growth is stimulated in some instances. There are several reports on different allelochemicals released through leachates, residuals, or mulches from *Chromolaena odorata* [30, 20, 38]. Allelochemicals from *Chromolaena* extracts affected seed germination in various crops [12, 35, 8]. Different concentrations of aqueous leaf extract and leachate imparted strong inhibitory effect not only the germination of Mungbean but it also hampered the dehydrogenase and catalase activity along with decline in protein, DNA, and RNA contains [20, 12]. Similar observations were noted in Allium cepa [26] where leaf leachate impeded plant growth and decreased chlorophyll, protein and catalase contents. It showed cytotoxic effects with chromosomal anomalis. Aqueous extracts of different parts of *Chromolaena* affects seed germination in crops like, Mustard, Chickpea, Cowpea, Rice, Soyabean, Groundnut, Maize, and Cotton Melon, Okra [13, 18, 21, 38, 35, 25]. Same phenomenon observed when decomposed mulches were used [8]. Studied allelopathic effect of *Chromolaena* on seed germination and seedling growth of Cowpea and observed that presence of more allelochemicals in inflorescence than in leaf, stem, Root. Some researchers have also found the positive effect of *Chromolaena* on crops. Allelochemicals released from *Chromolaena odorata* increase growth and productivity in crop like Ragi [6, 27] Demonstrated that *Chromolaena odorata* has potential to produce large mineral nutrients which could be used as organic manure in okra cultivation. Use of *Chromolaena odorata* as green manure was beneficial to increase growth and yield of Broccoli [11, 31]. Reported the improvement in growth and yield of Soyabean with incorporation of fresh leaf biomass of *Chromolaena* into the soil as organic fertilizer.

1.3. Mode of release of allelochemicals from *Chromolaena*

Researchers have found that there are many allelochemicals present in different parts of *Chromolaena odorata*. They are released in soil by various modes like leaching, residual decomposing and mulching depending upon the environmental conditions. Phytotoxins or allelochemicals like ceryl alcohol, eupatol, (sesquiterpene alcohol), lupeol and B-amyrin (terpene alcohols), Salvigenin, isosakuranetin, flavan, 4',5-dihydroxy-3,7-dimethoxy flavone (flavonones) and odoratin (chalcone) and P- anisic acid are present in leaves and various parts of *Chromolaena* [5].

Chemical analysis of this plant reveals presence of Flavone and flavonoid, tannin, alkaloid, saponins and others phenolic compounds [12] Reported presence of alkaloids, tannins, flavonoids, steroids, terpenoids and carbohydrates in 80% methanolic extract of *Chromolaena* which inhibited germination in Mungbean. The methanol extract of inflorescence revealed presence of tannin, Triterpenoids, Flavonoids, Coumarins, Quinones, Cardiac glycosides, Steroids, Acids and Phenols. Qualitative analysis showed its richness in Quinones [24]. Allelochemicals present in *Chromolaena* revealed variable effects on different crops like Brassica, Rice [18].

The decomposed mulches of *Chromolaena* lowered the germination percentage in Maize, Melon, Okra, Cowpea, Soybean and Groundnut and inhibitory effect increased with increase in mulch level [38]. Addition of leaf residue to soil reduced water use, inhibited root and shoot growth and dry weight of Tomato [30].

Thus, liberation of various allelochemicals from *Chromolaena odorata* affected the germination, growth and yield of many crops (Table 1).

Table 1: Effects of various parts of *Chromolaena* on different crops

Sr.no.	Leaf extract/ leachate/ residue	Recipient crop	Nature of effect	Reference
1.	Leaf extract	1. Cowpea	1. Fungicide	Abiamere *et al*., 2014
			2. Increase in seed germination.	
2.	Leaf extract	2. Corn	3. Seed germination not hindered, plant height stimulated.	Adetayo *et al*., 2005
		3. Cowpea	4. Seed germination reduced, number of leaves stimulated	
		4. Soyabean	5. Dry weight inhibited but height and number of leaves were not affected.	
3.	Leaf extract	1. Chickpea	1. Reduction in germination percentage.	Hoque *et al*., 2003
		2. Mustard	2. Root, shoot length inhibited.	
		3. Cucumber	3. Lateral root development inhibited.	
		4. Blackgram.		
		5. Radish		
		6. Cowpea		
4.	Leaf extract (menthol)	1. Mung bean	1. Root, shoot growth affected.	Hamidi *et al*., 2014
			2. Lateral root development Reduced.	
			3. Germinability reduced hence slower rate of seed growth.	
			4. Colour and structure of root, shoot changed.	
5.	Leaf extract	1. Maize	1. Germination percentage affected.	Mausam *et al*., 2012
		2. Cotton	2. Radicle length reduced	
		3. Soyabean	3. Seed vigour index significantly reduced	
			4. Plumule and radicle growth reduced	
6.	Leaf extract	1. Maize(white)	1. Germination and seedling growth highly affected with aqueous extract of leaf in all crops.	Muzzo *et al*., 2018
		2. Jowar (Red)		
		3. Mungbean		
		4. Brownbean		
7.	Leaf extract	1. 1.Rice	1. Seed germination reduced.	

		2. Groundnut 3. Mustard 4. Chickpea	2. Root, shoot length, dry weight and average inhibition percentage reduced. 3. Highest loss in seed germination. 4. Root, shoot length reduced 5. Dry weight reduced 6. Less seed germination 7. Root, shoot length reduced 8. Dry weight reduction is less as compare to other crops. 9. Seed germination reduced 10. Root, shoot length reduced 11. Dry weight reduced.	Rezaulkarim *et al.*, 2017
8.	Leaf extract and leaf leachate	1. Mungbean	1. Seed germination percentage decreased. 2. TTC stainability decreased. 3. T50 increased. 4. Protein, DNA, RNA activity decreased. 5. Dehydrogenase and catalase activity decreased.	Maiti *et al.*, 2013
9.	Leaf extract and leaf leachate	1. Sesame 2. Mustard 3. Radish 4. Lai-patta	1. Germination percentage decreased in all crops. 2. Root, shoot length affected.	Pertin *et al.*, 2018
10.	Leaf leachate	1. Clusterbean 2. Soyabean 3. Radish 4. Spinach 5. Ragi	1. Plant height, root depth increased. 2. Fresh, dry weight and yield increased. 3. Root, shoot length increased. 4. Fresh, dry weight and pod yield increased. 5. Root length decreased 6. Fresh, dry weight and length of leaf increased. 7. Root length decreased 8. Number of leaves increased. 9. Fresh and dry weight increased. 10. Number of leaves increased 11. Fresh and dry weight in root and shoot increased 12. Yield increased.	Ambika and Poornima., 2004
11.	Leaf leachate	1. Rice 2. Mustard 3. Soyabean	1. No effect on seed germination. 2. Radicle elongation inhibited. 3. Germination completely inhibited. 4. Radicle elongation completely inhibited 5. Germination inhibited. 6. Radicle elongation inhibited.	Kumar *et al.*, 2007
12.	Leaf leachate	1. Onion	1. Affects cell division 2. Chromosome anomalis, erosion of chromatin observed 3. stickness and clumping of chromosomes observed 4. Chlorophyll, Protein and catalase enzyme decreased.	Nandi *et al.*, 2009
13.	Leaf extract and leaf residue	1. Tomato	1. Plant Growth inhibited 2. Decrease in water potential and use of water 3. Leaves folded, wiltered with necrotic and scorched leaf tips. 4. Addition of residue reduced dry weight of tomato.	Onwugbuta 2001.
14.	Leaf, Root, Stem, Inflorescence extract	1. Cowpea	1. All extracts inhibited germination and seedling growth of cowpea. 2. Inflorescence extract have more inhibitory effect than other parts.	Binumol *et al.*, 2019
15.	Leaf, Root, Stem extract	1. Paddy, Barnyard grass	1. Inhibitory effect on germination and seedling growth of grass	Suwal *et al.*, 2010
16.	Leaf, Root, Shoot extract and decomposing mulch	1. Maize 2. Melon 3. Cowpea 4. Okra 5. Soyabean 6. Groundnut	1. Inhibitory effect on seed germination. 2. Poor seedling growth in all crops.	Usuah, *et al.*, 2013
17.	Green manure	Broccoli	1. Increase in growth and yield of broccoli.	Hafifah, *et al.*, 2016
18.	Biomass (compost)	1. Okra (Bhendi)	1. High crop yield. 2. High Benefit cost ratio.	Nawaz *et al.*, 2004
19.	Biomass(fresh)	1. Soyabean	1. Improvement in growth and yield of soyabean.	Oluwafemi., 2012

2. Materials and Methods

Many researchers have carried out various experiments in different ways *to* study impact of *Chromolaena odorata* on agricultural crops. Most of the bioassays were carried out in laboratories by Petri plates using various extracts, leachates, residues and mulches of different parts of *Chromolaena* [13, 18, 20, 25] While some other researchers [30, 26] used pot method and [38] applied polybag method to check or to observe allelotoxicity of *Chromolaena*. Majority of the researchers have used 10 to 100% concentration of aqueous leaf extract and leaf leachate of *Chromolaena* to observe inhibition or stimulation effect on crops.

3. Results and Discussions

Different concentrations of aqueous extracts of root, stem, leaf and inflorescence of *Chromolaena odorata* significantly affected the seed germination, root-shoot length, and yield of crops due to various allelochemicals. Leaf extract of *Chromolaena* increased seed germination and inhibited seed borne fungi in Cowpea [1]. It also demonstrated strong inhibitory effect on seed germination and seedling growth in various crops due to presence of major allelochemicals like alkaloids, phenols and amino acids [5, 26]. Such inhibitory impact observed not only in crops but also in Paddy and barnyard grasses [37]. Leaf leachate and residue of *Chromolaena* proved toxic to crop like Tomato [30]. *Chromolaena* inflorescence and leaf extract has strong inhibitory effect on seed germination and seedling growth due to presence of more allelochemicals in them. In some crops higher concentration of allelochemicals brought inhibitory effect in turn lower concentration proved beneficial in crops like Ragi [6]. Composting of biomass of *Chromolaena* showed degradation potent of allelochemicals hence yield increased in Okra [27] while fresh biomass also raised yield in Broccoli and Soyabean [11, 31].

Table 2: Parameters undertaken for common crops

Common crops used by many researchers	Parameters studied	Reference
1. Cowpea	1. % incidence seed borne fungi.	Abiamere *et al., 2014*
	2. Seed germination.	
	3. Seed germination (laboratory and green house).	
	4. Height of crop plants.	Adetayo *et al.*, 2005
	5. Number of leaves.	
	6. Dry matter accumulation.	
	7. Germination percentage.	Hoque *et al.*, 2003
	8. Shoot and root elongation.	
	9. Number of lateral roots.	
	10. Seed germination.	Binumol *et al.*, 2019
	11. Seedling growth.	
	12. Seed germination.	Usuah *et al.*, 2013
	13. 13. Effect of decomposing mulches on germination percentage and emergence of seedling.	
2. Soyabean	14. Seed germination.	Adetayo *et al.*, 2005
	15. Height of crop plants.	
	16. Number of leaves.	
	17. Dry matter accumulation.	
	18. Seed germination.	Mausam *et al.*, 2012
	19. Plumule length and radicle length.	
	20. Seed vigour index.	
	21. Root and shoot length.	Ambika and Poornima, 2004
	22. Fresh and dry weight.	
	23. Pod yield.	
	24. Germination percentage.	Kumar *et al.*, 2007
	25. Radicle length.	
	26. Seed germination percentage.	
	27. Effect of decomposing mulches on germination percentage and emergence of seedling.	Usuah *et al.*, 2013
	28. Crop growth and yield	Oluwafemi, 2012

4. Conclusion

The Indian region because of its diverse climatic and environmental conditions is very vulnerable to biotic invasion. Disturbed and fragmented areas, provide habitat for invasion. Such conditions help to increase bio invasion equally in agricultural lands. Agriculture is the pillar of Maharashtra state in India. *Chromolaena odorata* was introduced as an ornamental plant which started encroaching agricultural areas later on. Allelochemicals released by different plant parts of *Chromolaena odorata* inhibited root, shoot length, plant growth, and crop yield like maize, tomato, groundnut, mungbean, rice. etc. The allelopathic impact of *Chromolaena odorata* on agricultural crops has been considered pivotal as it resulted yield drop. On the other hand, these allelochemicals help to increase production in crop like Ragi. It has potential to produce considerable quantity of biomass used as compost manure in Okra and broccoli production. It is reported that elevated temperature and CO_2 enrichment have increased the survival rate and allelobiogenetic performance of invasive alien plants. Hence research efforts should be focused on evaluation of potential of *Chromolaena odorata* in changing local climatic conditions to achieve sustainability in crop yields and economic stability.

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