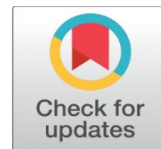


ALLELOPATHIC EFFECT OF THREE WEED SPECIES ON THE GERMINATION AND SEEDLING GROWTH OF TOMATO (*LYCOPERSICON ESCULENTUM*)



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ABSTRACT

Laboratory and green house experiments were conducted to ascertain the effect of exudates (from the vegetative parts of the weeds soaked in water) of different ages (36hrs, 72hrs and 120hrs) from three common weed species (namely, *Chromolaena odorata*, *Ageratum conyzoides* and *Cyperus esculentus*) on the seed germination and seedling growth of tomato (*Lycopersicon esculentum*). Tomato seeds were sown in petri-dishes on filter paper moistened with the treatments, and another set of tomato seeds were sown in soil, and treatments applied. The exudates of *C. odorata* had the greatest inhibitory effect on seed germination on filter paper, while those of *A. conyzoides* followed closely. *C. esculentus* had the least inhibitory effect. The weed exudates however did not have marked inhibition on seed germination and seedling growth in the soil medium; rather, they competed favorably with the Control. It was observed that the longer the soaking duration of the weeds in water, the less inhibitory their exudates were on seed germination, with water dilution. All the three weed species considered showed allelopathic effects, but especially *C. odorata* and *A. conyzoides* when in direct contact with tomato seeds.

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Keywords: Weeds, Exudate, *Chromolaena Odorata*, *Ageratum Conyzoides*, *Cyperus Esculentus*, Tomato

1. INTRODUCTION

Weed management has been a challenge, and its management with the use of herbicides is fast becoming least desired because of the pressure from society for healthier farm produce Kong (2010). There is therefore the need for other means of weed management such as cultural, physical, biological, mechanical, and maybe a combination of all these to avoid the use of herbicides Rizzardi (2011). Weeds are also known to have allelopathic effects as part of their competition with other plants. Allelopathy, according to Inderjit and Callaway (2003) has to do with effects a plant could have (directly or indirectly) on other plants around it, which could either be beneficial or harmful. A plant is capable of this by releasing chemicals it produces into the surrounding environment, by its root exudates, leaching, decomposition or volatilization. Put in other words, allelopathy could be said to be a natural biological defense mechanism of plants for their growth, reproduction, and survival, which they try to achieve by producing some biochemicals Roger et al. (2006). Furthermore, allelopathy, which is intrinsic in some plants, stimulates or stops the survival of neighboring plants by this ability to produce allelochemicals Javed (2020). This ability of these chemical compounds to hinder the growth of other plants depends on its



concentration in the allelopathic plants, and how susceptible those around it are [Koocheki et al. \(2001\)](#). This phenomenon of allelopathy has been growing in interest, especially now, in relation to solving the weed problem [Rice \(1984\)](#), [Marci et al. \(2004\)](#), [Vasilakoglou et al. \(2005\)](#), [Dhima et al. \(2006\)](#).

As a natural phenomenon, allelopathy is a welcome idea that could be used in weed and pest management in cultivated fields.

Among the water soluble allelochemicals are derivatives of phenols, flavonoids, coumarins, alkaloids, terpenoids, ethylene's and quite a number of other secondary metabolites which can stop or stimulate the germination and growth of plants and other organisms in the environment [Rashid et al. \(2010\)](#), [Fujji et al. \(2004\)](#). The deleterious action of these allelochemicals could be in different ways such as on the physiology, enzymatic activities, germination and even synthesis [Vasconcelos et al. \(2012\)](#). Hence the serious consideration of allelopathy as a tool in managing some weed species in farmlands. [Rezende et al. \(2003\)](#), [Kong \(2010\)](#).

Chromoleana odorata (Siam weed) and *Ageratum conyzoides* (Billy goat weed), both of the family Asteraceae; and *Cyperus esculentus* (Yellow nutsedge) of the family Cyperaceae, are common weeds of the tropics, growing aggressively in cultivated fields. *C. odorata* is a diffuse, rapidly growing, strongly scented perennial shrub, which reproduces from seeds and vegetative parts. Its invasiveness and aggressive growth can be tied not just to its heavy seed production, but also to the large amounts of allelochemicals such as flavonoids and phenols in its leaves. These are known to affect seedling germination [Zachariades et al. \(2009\)](#), [Eze and Gill \(1992\)](#).

A. conyzoides is an erect, hairy aromatic annual herb that reproduces from seeds, while *C. esculentus*, is a tall, rhizomatous, tuber-bearing perennial sedge which reproduces mainly vegetatively from nutlets, and sometimes by seeds that germinate while on the spikes. Tomatoes, on the other hand, is considered one of the fast-germinating plants that is sensitive to secondary metabolites in the environment, so it can be used as a bioindicator of weed allelopathic activity [Ferreira and Áquila \(2000\)](#), [Cândido et al. \(2010\)](#).

The aim of this study is therefore to identify possible allelopathic effects of three different strengths of exudates from the weeds: *Cyperus esculentus* Lin. (Yellow nutsedge), *Chromolaena odorata* L. (Siam weed) and *Ageratum conyzoides* Linn (Billy goat weed), on seed germination and seedling growth of *Lycopersicon esculentum* L. (tomato).

2. MATERIALS AND METHODS

Laboratory and green house experiments were conducted at the Department of Plant Science and Biotechnology, Rivers State University, Port Harcourt, Nigeria. For the production of the exudates, the weeds: *Cyperus esculentus*, *Chromoleana odorata* and *Ageratum conyzoides* were collected by uprooting in the Teaching and Research Farm of the Rivers State University. Tomato fruits were purchased from the market, and their seeds separated, washed, and air-dried.

2.1. PREPARATION OF WEED EXUDATE

The collected weeds were washed free of soil and air-dried. One kilogram of each weed type was weighed out on a weighing scale, and the whole plant- leaves, stem, and roots, were sliced into small 2cm pieces with a kitchen knife, and then soaked in 1 litre of distilled water. This was done in three replicates for each weed

in plastic bowls: giving a total of nine bowls, well labelled. Each weed was soaked for varying periods of time viz: 36, 72 and 120 hours. These different durations of soaking the weed species constitute the treatments which were administered on the tomato seeds.

After 36 hours of soaking, the weed exudate was sieved using a cloth sieve and the extract stored in a refrigerator until used. The same thing was done with the second set of soaked weeds after 72 hours, and with the third set after 120 hours.

2.2. LABORATORY EXPERIMENT

Sets of 20 tomato seeds were each arranged on Whatman No. 1 filter paper placed in petri dishes. Nine petri dishes were arranged per treatment, and a set of control, making it 30 petri-dishes in all. The weed exudates were retrieved from the refrigerator and allowed to come to room temperature. They were then administered on the filter paper (with seeds on them); 4ml each of treatment exudate solution was applied. Only distilled water was used for the control. The petri dishes were placed near the window at room temperature ($28 \pm 2^\circ\text{C}$). Germination counts were made with emergence of 1mm of radicle. The filter papers were constantly moistened with the appropriate exudate until the eighth day after commencement of the experiment; subsequently, 2ml of distilled water was used to moisten the filter paper. Germination counts and measurement of the radicle of germinating seedlings continued until the fifteenth day.

2.3. GREENHOUSE EXPERIMENT

Polyethylene bags of 1kg capacity were half-filled with 500g of air-dried loamy soil. Three replicates for each of the three weed exudates for three treatments (36, 72 and 120 hours) were prepared, plus a set of three replicates for the control, making a total of 30 bags. The tomato seeds were sown in the bags, and 50ml of the different exudates were added, while distilled water was used for the control. Subsequently, the bags were watered every other day with 100ml of distilled water. Germination counts were made, and plant height measurement of the seedlings were taken.

2.4. DESIGN OF THE EXPERIMENT

The experiment was conducted in a randomized complete block design with three weed species (*C. odorata*, *A. conyzoides* and *C. esculentus*) and three treatments (weeds soaked for 36, 72 and 120 hours in distilled water), replicated three times each. Two experiments were conducted with three species and three treatments in a 3x 3 form and a control: one in the petri-dishes and the other in poly bags (a greenhouse experiment).

3. RESULT AND DISCUSSION

The effect of the weed exudates was much more pronounced in the petri dish germination experiment than in that of soil. Furthermore, the weed exudates, especially of *C. odorata* and *A. conyzoides*, soaked in distilled water for just 36hrs had more adverse effect on germination of the tomato seeds; and the adverse effect eased out, the older the exudate, as seen by the increase in germination counts [Table 1](#), [Figure 1](#) and [Figure 2](#). Even then, there was no germination until the seventh day, just before the treatment concentrations were diluted with the addition of 2ml of distilled water to moisten the filter paper, then germination commenced in earnest. However, the seeds in the 36 hours exudate of *A. conyzoides*, and 36 and 72 hours of

C. odorata still didn't grow at all, even when diluted (Figure 1 & Figure 2). Leachates from plants have been shown to suppress seed germination, vegetative propagules, and early seedling growth Babu and Kandasamy (1997), Dhwani and Gupta (1996), and decrease radicle growth Casado (1995).

Of the three weed species used, *C. esculentus* had the mildest adverse effect on germination; even with the 36 hours old exudate, it competed favourably with the control in germination count: it started on the fourth day, while the control started on the second day (Table 1, Figure 1). This general inhibition of seed germination by the treatments until water dilution, points to the fact that these weed exudates all have allelochemicals in them which inhibits tomato seed germination; *C. odorata* having the strongest inhibition. Eze and Gill (1992) reported that *C. odorata* contains a large amount of allelochemicals, especially in the leaves, which inhibits the growth of many plants in nurseries and plantations.

Table 1 Treatment means of the Germination Counts (in petri dishes) of the three weed exudates

DAP	Control	ExudateA (<i>Chromolaena odorata</i>)			ExudateB (<i>Ageratum conyzoides</i>)			ExudateC (<i>Cyperus esculentus</i>)		
		Trmt1 36hrs	Trmt2 72hrs	Trmt 3 120hrs	Trmt 36hrs	Trmt2 72hrs	Trmt 3 120hrs	Trmt 36hrs	Trmt2 72hrs	Trmt3 120hrs
1	-	-	-	-	-	-	-	-	-	-
2	7	-	-	-	-	-	-	-	-	-
3	16	-	-	-	-	-	-	-	-	-
4	17	-	-	-	-	-	-	3.3	-	-
5	17	-	-	-	-	-	-	5	-	-
6	17	-	-	-	-	-	-	5.7	-	-
7	17	-	-	-	-	-	-	6.7	2.3	0.3
8	18	-	-	1	-	-	-	8.7	4.7	1
9	18	-	-	2.7	-	-	1	9.7	9.3	2.7
10	19	-	-	4.3	-	2	3.3	12	12	5
11	19	-	-	6.3	-	5	4	13	17	5.3
12	19	-	-	7.3	-	5	4	14	17	6.7
13	19	-	-	11	-	6	9	12	17	8.7
14	19	-	-	11	-	6.3	10	12	17	10
15	19	-	-	13	-	6.3	12	11	17	12

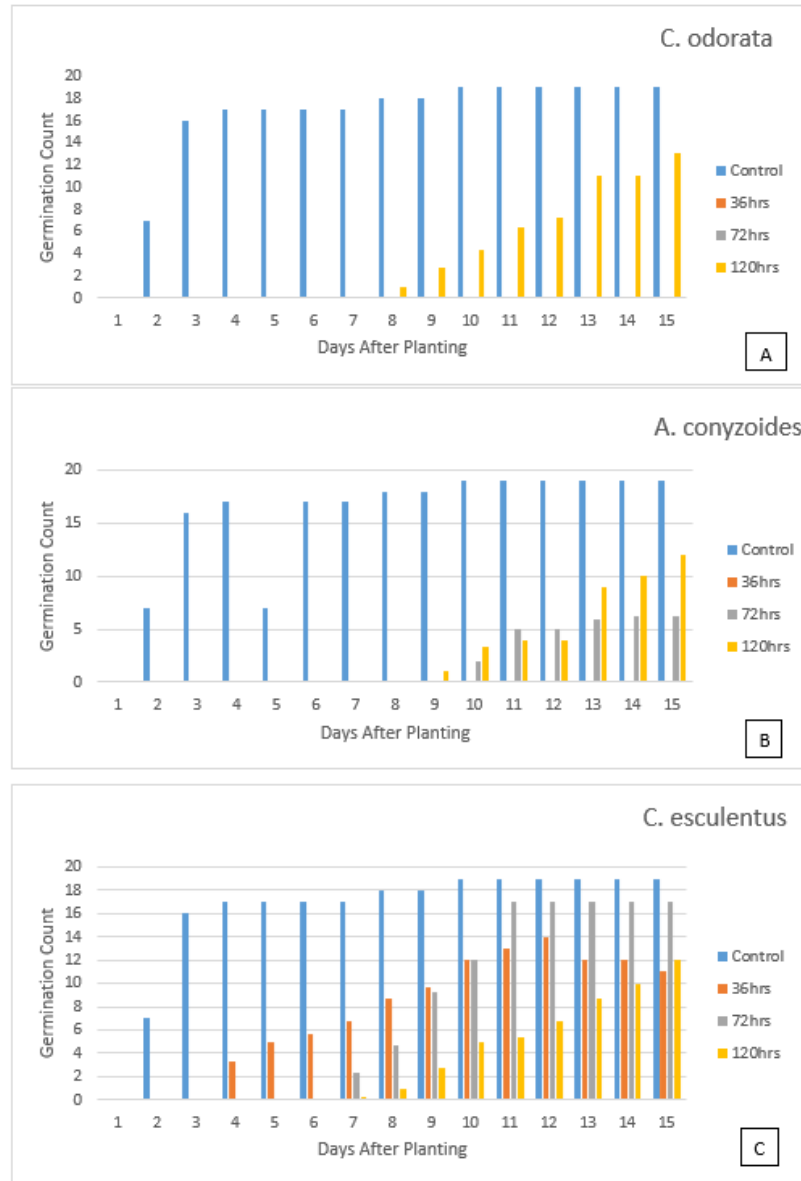


Figure 1 The effect, with age, of exudate from different weed species on germination of tomato seeds

A. conyzoides which was next to *C. odorata* in inhibition, allowed the germination of some tomato seeds with dilution of the 72- and 120-hour exudate, but not 36 hr. This similar effect it had as *C. odorata* is expected since they both belong to the same family, Asteraceae. Members of the Asteraceae family have aromatic polyacetylene compounds. Polyacetylene compounds of this family have cytotoxic, antimicrobial, anti-inflammatory, neurotoxic, phototoxic, and several other types of activity [Konovalov \(2015\)](#). Natural polyacetylenes are compounds whose structures contain two or more triple bonds [Christensen \(1998\)](#). In the wider sense, acetylene compounds include all substances with carbon-carbon triple bonds or alkynyl functional groups. Compounds containing triple bonds are relatively unstable compounds like other unsaturated organic substances; and they are chemically and biologically active. The high reactivity leads to rapid oxidation and degradation of these compounds, especially on exposure to UV light. [Konovalov](#)

(2015). This probably explains the observation in Table 1 that the longer the weeds were soaked (120 hrs), the lower the inhibitory effect of the exudate with dilution. Hence seeds of *C. odorata* germinated with dilution only at 120 hours and not before; and the same was observed with the radicle length in Table 2. With exposure therefore, the polyacetylene compounds were oxidized and degraded from the plant residue, thus reducing its inhibitory effect Gill et al. (1993).

C. esculentus on the other hand, is a member of family Cyperaceae commonly known as sedges. In the last few decades, constituents with great chemical diversity were isolated from sedges, and a wide range of biological activities were detected either for crude extracts or for pure compounds. Among the isolated compounds, phenolic derivatives are the most important, especially stilbenoids, and flavonoids. To date, more than 60 stilbenoids were isolated from 28 Cyperaceae species. Pharmacological investigation of Cyperaceae stilbenoids revealed that several compounds possess promising activities: mainly antiproliferative, antibacterial, antioxidant and anthelmintic effects. Moreover, stilbenes are important from chemotaxonomical point of view, and they play a key role in plant defence mechanisms as well Dávid et al. (2021).

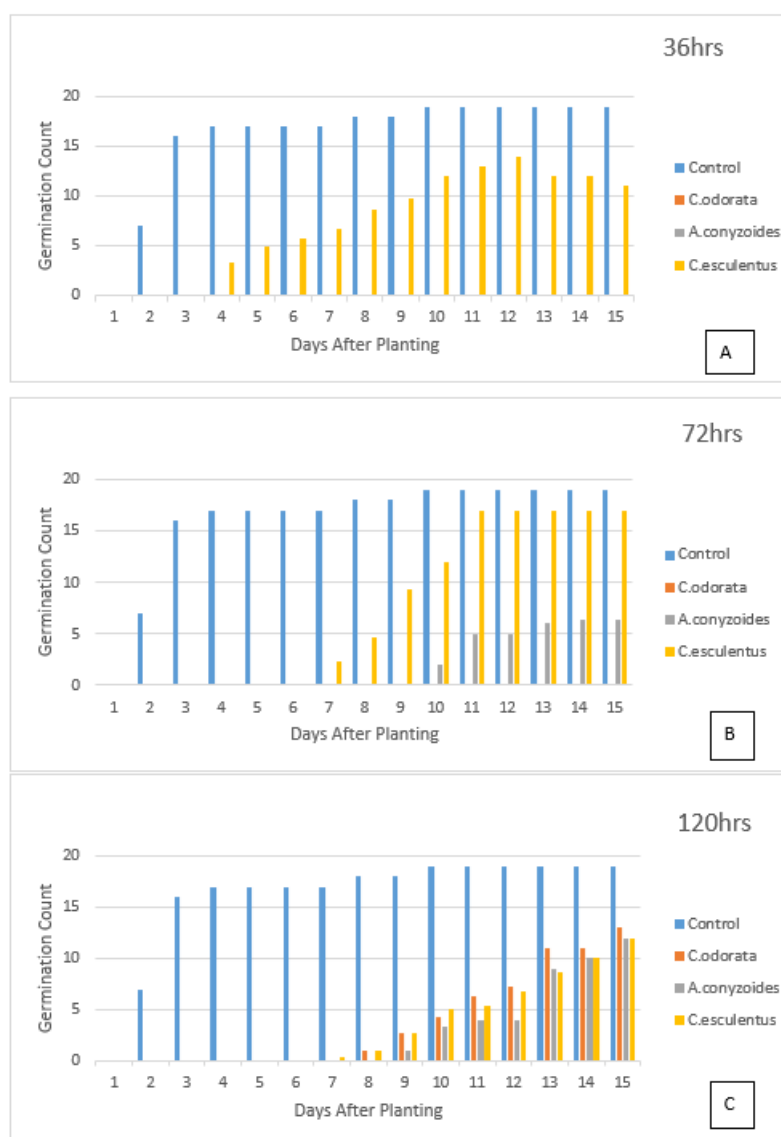


Figure 2 The effect of ageing weed exudates on the germination count of tomato seeds

Germination count was highest in the 72 hrs exudate of *C. esculentus* (Figure 1C), but highest in the 120hrs exudate for *C. odorata* and *A. conyzoides* (Figure 1 A and Figure 1B). The germination count for all three weed treatments were however almost the same at 14 and 15 days after planting (Figure 2 C) in 120 hrs exudate, but that of *C. odorata* was slightly higher.

Root length measurement of germinating seedlings in *C. esculentus* showed increase in length with increase in the duration of soaking the weed Table 3, but with dilution. Again, this could be as a result of the decomposition of the plant residue which provides more nutrients for seedling growth with dilution.

Table 1 Effect of weed exudate treatments on radicle length of tomato (mm)

TRMETS	DAP	Control	<i>C. odorata</i>	<i>A. conyzoides</i>	<i>C. esculentus</i>
36hrs	Day 3	10.4	-	-	-
	Day 7	15.2	-	-	4.17
	Day 11	18.2	-	-	8.48
	Day 15	31.4	-	-	9.2
72hrs	Day 3	12.4	-	-	-
	Day 7	26.6	-	-	-
	Day 11	41.1	-	-	17.7
	Day 15	49.3	-	-	20.5
120hrs	Day 3	17.5	-	-	-
	Day 7	27.2	10.2	17	24.4
	Day 11	42.2	18.5	24	27.6
	Day 15	46.3	22.6	23	28.8

Greenhouse

Experiment

The percentage germination of the tomato seeds in soil reveals that the treatment effect of the various exudates is not as pronounced as that in the petri dish. This could be as a result of the interactions of the various soil parameters, such as: soil temperature, soil moisture regime, alternate wetting and drying of soil, soil nitrate level, among others, that affect seed germination Akobundu (1987).

Table 2 Treatment Effect on the Germination percentage of Tomato seeds sown in soil

	DAP	Control	<i>C. odorata</i>	<i>A. conyzoides</i>	<i>C. esculentus</i>
36hrs	5	35	30	30	40
	10	40	35	35	40
	15	45	45	50	50
72hrs	5	35	40	30	30
	10	40	40	40	40
	15	45	45	45	45
120hrs	5	35	30	30	40
	10	40	40	40	40
	15	45	45	40	40

Table 3 Treatment effect on plant height (mm) of tomato seedlings sown in soil 15DAP

Trmets	Control	<i>C. odorata</i>	<i>A. conyzoides</i>	<i>C. esculentus</i>
36hrs	86.3	106	96.7	94
72hrs	86.3	103	87.8	88.7
120hrs	86.3	93.8	91.5	92.2

The plant height of the seedlings likewise reveal that all the treatments competed favourably with the control [Table 4](#). This means that the weed exudates had no inhibitory effect on seedling growth in the soil medium. This could be because the roots do not come in close contact with the exudate as much as they do on filter paper in the petri dish; as, according to [Patrick \(1971\)](#) the extent of damage to the crop is related to the degree of contact of roots to the exudates. In soil, the exudate, after application would naturally drain down through the soil particles, and more so with further wetting.

In conclusion, the exudates from *C. odorata* had the most adverse effect on tomato seed germination on filter paper in petri-dish, followed closely by *A. conyzoides* of the same family Asteraceae. *C. esculentus* had the least adverse effect on tomato seed germination of the three weed exudates used. The tomato seeds sown in soil didn't have any significant difference in germination percentage and growth from the control. Turnover of these weeds therefore into fields being prepared for crop cultivation should be avoided, except they are left for extended period of time for oxidation and degradation of polyacetylene and phenolic compounds, as close contact of the fresh exudates of these weeds with seeds could delay or completely prevent germination. On the other hand, the polyacetylene compounds in *C. odorata* and *A. conyzoides*, though relatively unstable, if extracted could serve as a natural herbicide.

REFERENCES

- Akobundu, J. O. (1987) Weed science in the topics : Principles and practices. John Wiley and sons : pp 522
- Babu, C. M., Kandasamy, O. S., (1997). Allelopathic effects of Eucalyptus globulus Labill. on *Cyperus rotundus* L. and *Cynodon dactylon* L. pers. Journal of Agronomy and crop science 179,2, 123 - 126. Retrieved from <https://doi.org/10.1111/j.1439-037X.1997.tb00507.x>
- Casado, C. M., (1995). Allelopathic effect of *Lantana camara* (Verbenaceae) on Morning glory (*Ipomoea tricolor*) *Rhodora*, 97 :891, 264 - 274. Retrieved from <https://www.jstor.org/stable/23313216>
- Christensen, L. P. (1998) *Rec. Res. Dev. Phytochemistry*, 2, 227 - 257.
- Cândido ACS et al. (2010). Potencial alelopático de lixiviados das folhas de plantas invasoras pelo método sanduiche. *Revista Brasileira de Biociências* 8 : 268-272. Retrieved from <https://www.seer.ufgrs.br/rbrasbioci/article/view/114940>
- Dhima KV, Vasilakoglou IB, Eleftherohorinos IG, Lithourgidis AS (2006). Allelopathic potential of winter cereals and their cover crop mulch effect on grass weed suppression and corn development. *Crop Science* 46 :345-352. Retrieved from <https://doi.org/10.2135/cropsci2005-0186>
- Dhwan, S. R. Gupta, S. K. (1996). Allelopathic potential of various leachate combinations towards SG and ESG of *Parthenium hysterophorus* Linn. *World - Weeds* 3 :1, 85 -88.
- Dávid, C. Z., Hohmann, J., & Vasas, A. (2021). Chemistry and Pharmacology of Cyperaceae Stilbenoids : A Review. *Molecules* (Basel, Switzerland), 26(9), 2794. Retrieved from <https://doi.org/10.3390/molecules26092794>
- Eze JMO, Gill LS (1992). *Chromolaena odorata* a problematic weed. *Compositae Newsletter* 20 :14-18.

- Ferreira AG, Áquila MEA. (2000). Alelopatia : uma área emergente da ecofisiologia. *Revista Brasileira de Fisiologia Vegetal* 12 : 175-204.
- Fujji Y et al. (2004). Assessment method for allelopathic effect from leaf litter leachates. *Weed Biology and Management* 4 : 19-23. Retrieved from <https://doi.org/10.1111/j.1445-6664.2003.00113.x>
- Gill LS, Anoliefo GO, Iduoze UV (1993). Allelopathic effect of aqueous extracts of siam weed on growth of cowpea. *Chromoleena Newsletters* 8.1.
- Inderjit, Callaway RM. (2003). Expérimental design for the study of allelopathy. *Plant and Soil* 256 : 1-11. Retrieved from <https://doi.org/10.1023/A:1026242418333>
- Javed K (2020). Allelopathy : A brief review. *Journal of Novel Applied Sciences* 9(1) : 1-12. Retrieved from https://www.researchgate.net/publication/338854230_ALLELOPATHY_A_BRIEF_REVIEW
- Kong CH. (2010). Ecological pest management and control by using allelopathic weeds (*Ageratum conyzoides*, *Ambrosia trifida*, and *Lantana camara*) and their allelochemicals in China. *Weed Biology and Management*,10 : 73-80. Retrieved from <https://doi.org/10.1111/j.1445-6664.2010.00373.x>
- Konovalov, D. A. (2015) Polyacetylene Compounds of Plants of the Asteraceae Family (Review). *Pharmaceutical Chemistry Journal* 48(9) : 36-53 Retrieved from <https://doi.org/10.1007/s11094-014-1159-7>
- Koocheki A, Zarif Ketabi H, Nakhforoush A (2001). Ecological approaches to weeds management. (Trans.), Ferdowsi University of Mashad Press, Iran.
- Marci'as FA Galindo JLG, Molindo JMG, Cutler HG (ed.) (2004). Allelopathy: Chemistry and mode of action of allelochemicals. CRC Press, New York.
- Patrick, Z. A., (1971). Phytotoxic substances associated with the decomposition in soil of plant residues. *Soil Sc. III* : 13 - 18. Retrieved from <https://doi.org/10.1097/00010694-197101000-00002>
- Rashid MH et al. (2010). The allelopathic potential of kudzu (*Pueraria montana*). *Weed Science*,58 : 47-55. Retrieved from <https://doi.org/10.1614/WS-09-106.1>
- Rezende CP et al. (2003). Alelopatia e suas interações na formação e manejo de pastagens. *Boletim Agropecuário. Lavras : UFLA.* p. 1-55.
- Rice EL (1984). Allelopathy. *Academy Press: New York, NY.* 1-6. Retrieved from <https://doi.org/10.1016/B978-0-08-092539-4.50007-1>
- Rizzardi MA. (2011). Associação de herbicidas no manejo de plantas daninhas resistentes. *Revista Plantio Direto* 122 : 117-127.
- Roger, M. R., Reigosa, J., Pedrol, N. and Gonzalez L. (2006) Allelopathy: A Physiological Process with Ecological Implications. Springer, pp 1, ISBN 1402042795 Retrieved from <https://doi.org/10.1007/1-4020-4280-9>
- Vasconcelos MCC et al. (2012). Interferência de plantas daninhas sobre plantas cultivadas. *Revista Agropecuária Científica no Semiárido* 8 : 1-06.
- Vasilakoglou I Dhima K, Eleftherohorinos I (2005). Allelopathic potential of Bermuda grass and johnson grass and their interference with cotton and corn. *Agronomy Journal* 97 :303 313 Retrieved from <https://access.onlinelibrary.wiley.com/doi/abs/10.2134/agronj2005.0303a>
- Zachariades C, Day M, Muniappan R, Reddy GVP (2009). *Chromolaena odorata* (L.) King and Robinson (Asteraceae). In *Biological Control of Tropical Weeds*

Using Arthropods (eds. Muniappan R, Reddy GVP, Raman A), pp. 130-162, Cambridge University Press, Cambridge, UK Retrieved from <https://doi.org/10.1017/CBO9780511576348.008>