Abrahamia
Vol. 5 (2)
44-53
2019
ISSN: 2395-4108

Germination studies and allelopathy of *Chromolaena odorata* L. (siam weed) and *Tridax procumbens* L. (coat buttons)

Rajalakshmi R.* and Soumya N. S.
Department of Botany, University of Kerala, Kariavattom, Thiruvananthapuram- 695581, Kerala , India.
*Corresponding author: rajalakshmi.murali@gmail.com

Abstract

Siam weed and coat buttons are most troublesome Asteraceae weed species. The influences of various environmental factors on seed germination and its allelopathic effect were determined. Greater germination was observed in six months stored seeds compared to that of fresh seeds. Light stimulated germination in both species; however, some seeds still germinated in the dark. Both species were moderately tolerant of salt and water stress, but Siam weed tolerated more stresses than coat buttons. At the soil surface, Siam weed and coat buttons emergence was 80 and 78%, respectively, but this declined rapidly with increasing soil depths. Laboratory and greenhouse experiments, to test the effect of aqueous extracts of *Chromolaena odorata* and *Tridax procumbens* on crops and weeds, showed that coat button extract was more allelopathic than siam weed on crop seed germination. This study has demonstrated that both Siam weed and coat buttons are adapted to a wide range of environmental conditions. As germination was strongly stimulated by light and seedling emergence was optimal at the soil surface, these species are likely to be favored in no-till systems. The inhibitory effect of siam weed extract on germination of its own seed suggests auto toxic effect of its allelochemical.

Keywords: *Chromolaena odorata*, *Tridax procumbens,* allelopathy and germination

Introduction

Chromolaena odorata (siam weed) and *Tridax procumbens* (coat buttons) (Asteraceae) are aggressive weeds originating in tropical America (Hilliard, 1977; Holm *et. al.*, 1997). They are now widely distributed in a number of tropical and sub-tropical countries, West tropical Africa, Philippines and India (Ambika, 1980). Siam weed and coat buttons are considered as noxious weeds because of prolific seed production and fast spreading ability, allelopathic effect on other plants strong competitiveness with crops (Orapa *et. al.*, 2002) and health hazard to humans as well as animals (Boppré, 1991).

Siam weed is found on cultivated lands, neglected fields, waste places, forest trails, roadsides, and riverbanks. It was first deliberately introduced to India as an ornamental into the Royal Botanic Gardens in Calcutta in 1845. In India it is variously known as Gandhi Gulabi, Communist pacha, Sam-Solokh, Tongal-lati, Sam-Rhabi while in other Asian countries it is called Siam weed. Siam weed can grow rapidly and form infestations that can affect agriculture, pastures and biodiversity, as it interferes with the functions of natural ecosystems. It can be very invasive, forming impenetrable thickets in open areas such as pastures and around villages and settlements, along roadsides, fallow areas, and disturbed forests. It can suppress crops and other plants by competing for nutrients and water, over-shading and allelopathy (releasing growth-inhibitors). *Chromolaena* leaves, especially the young ones, are toxic due to high levels of nitrate (Orapa *et. al.*, 2002). In seasonally dry areas, it can fuel hot bush fires after it dies back following flowering and seeding. This can lead to the death of other native flora and fauna. In its native range *Chromolaena odorata* is not a weed so no control is required (McFadyen, 1991). In contrast, it is a serious weed in many of the countries where it has been introduced. The leaves of *C. odorata* contain a large amount of allelochemicals, which may retard the growth of crop plants. It is a common weed in perennial crops such as coconut (*Cocos nucifera* L.), rubber [*Hevea brasiliensis* (Wild. ex A. Juss.) Muell. Arg.], and fruit trees, and in fallows and pastures (Galinato *et. al.*, 1999). Extracts of Siam weed were reported to reduce germination of spinach (*Spinacia oleracea* L.) Chinese cabbage (*Brassica chinensis* L.) oilseed rape [*B. juncea* (L.) Czern & Coss], and Chilli (Capsicum annuum var. annuum L.) (Sahid and Sugau, 1993). The presence of Siam weed may therefore influence the growth of certain crops by means other than competition.

Tridax procumbens L. (coat buttons) is a native to tropical America and is reported to be a noxious weed of 31 crops to 60 countries (Holm *et. al.*, 1997). Coat buttons is a semi prostrate annual or short-lived perennial, with stems up to 50 cm long. Coat button is a serious weed of rice (*Oryza sativa*), wheat (*Triticum aestivum* L.), corn (*Zea mays* L.), peanut (*Arachis hypogea* L.), soybean (*Glycine max*(L.) Merr.), sorghum (*Sorghum bicolor* (L.) Moench), sugarcane (*Saccharum officinarum* L.), cassava (*Manihot esculenta* Crantz), cotton (*Gossypium hirsuitum* L.), and vegetables. Its wide spread distribution and importance as a weed are due to its spreading stem and abundant seed production (Baker *et. al.*, 1965). Some allelopathic effect of Coat Buttons have been observed in Rice (Holm *et. al.*, 1977).

Siam weed and coat buttons are invasive weeds. Once established, it is very difficult to eradicate because of the large number of seeds and rootstocks that regrow. The seeds are borne in the composite flower heads. The individual seed favours a wet–dry seasonal climate, grows well in well-drained open areas and can tolerate all soil types and altitudes. *Chromolaena* flowers once a year, May to August - south of the Equator and October to April- north of the Equator. It produces massive amounts of seeds: 93,000 to 1,600,000 viable seeds per plant (Blackmore, 1998). The seeds germinate during the rainy season. The lightweight, parachutal structure of mature seeds can be windblown and spread over short distances. It can spread over long distances by attaching to clothing, vehicles, road works and farm machinery, seed contaminants, etc. Seed longevity can be up to 4 years. Under favorable conditions, single seeds can quickly give rise to infestations, which may spread further and become difficult to manage if unnoticed.

Several factors can affect weed seed germination (MacDonald *et. al.* 1992) and light has been shown to inhibit or promote seed germination in other species of Asteraceae (Chauhan and Johnson, 2008). Temperature may also be an important factor influencing weed seed germination. Some seeds possess temperature-regulated dormancy mechanisms, whereas other seeds germinate readily over a wide range of temperatures (MacDonald *et. al.*, 1992). Similarly, the ability to germinate under conditions of moisture stress or high salt content of soils may enable a weed to take advantage of conditions that limit the growth of other species. Seed burial depth also affects germination and emergence by influencing the availability of moisture, temperature, and light exposure. In addition, crop residue present on the soil surface may suppress weed emergence (Chauhan and Johnson, 2008), and therefore could be a component of an integrated weed management system.

Siam weed and coat buttons spread mainly by seeds, yet little is known about the environmental factors that affect germination and emergence of these species. Some information about the seed germination is available for Siam weed populations from North India (Chauhan and Johnson, 2008), but little is available for South Indian populations. Thus, the first part of the present study was undertaken in an attempt to record the results of a series of laboratory and greenhouse experiments conducted on the germination response of *Chromolaena odorata* and *Tridax procumbens* seeds to important physical and climatic factors influencing seed survival, germination and emergence in the field. Such data can help to develop predictive models of seedling.

The earlier studies reveal that in areas where Siam weeds and coat buttons grow, growth of other plants is always hampered (Akobundu, 1987). It is not yet clear whether allelopathy is responsible for such a growth behaviour. The study of compounds, which inhibit or stimulate the germination and the development of other species, is important for understanding the mechanisms of the ecological interaction. So the second part of the present work was to study the possible allelopathic effects of siam weed and coat buttons that, being rich in active principles, which are considered an important source of potential allelochemicals. A review of the literature indicates that work has not yet been done on the effect of aqueous extract of Siam weed and Coat buttons on the growth of chilly, rice and green pea. Thus, the present study was undertaken to determine the effect of siam weed and coat button extracts on the germination and seedling performance of these three crops along with siam weed and coat button seeds to test its autotoxic effects.

Materials and Methods

Germination study

Seeds of siam weed (*Chromolaena odorata*) and coat buttons *(Tridax procumbens*) were collected from different localities of Trivandrum district. Seeds collected from many randomly selected plants were bulked, cleaned, and stored at room temperature until used in the experiments. Germination of both species were determined by placing 10 seeds in a petridish, containing cotton moistened with distilled water or a treatment solution. Seeds of coat buttons were pre rinsed for 10 min in 1% sodium hypochlorite solution to avoid fungal growth. Germination was counted after 14 days, at which time a seed with a radicle was considered to have emerged.

Effect of seed storage on germination

The effect of different periods of storage on seed germination was determined by placing seeds in dishes treated with distilled water. Fresh seeds, two months, four months and six months stored seeds were used.

Effect of light and dark period on germination

Effect of light and dark period on germination was determined by placing seeds in petridish treated with distilled water. For germination in darkness, dishes were completely wrapped in a double layer of aluminium foil.

Effect of salt on germination

The effect of salts were determined by placing seeds on dishes containing 5 ml of solution of 0 mM, 25 mM, 50 mM, 100 mM, 150 mM, 200 mM and 250 mM Nacl.

Effect of osmotic stress on germination.

To determine the effects of osmotic stress on Germination, seeds were incubated in solution with osmotic potentials of 0 Mpa, -0.1 Mpa, -0.2 Mpa, -0.4MPa,-0.8MPa and -1.0MPa. These solutions were prepared by dissolving polyethylene glycol 8000 (PEG) in distilled water, according to Michel (1983).

Effect of seed burial depth on seedling emergence

The effect of seed burial depth of seedling emergence was conducted in a screen house. 10 seeds of each species were placed on the soil surface or covered to depths of 1 cm, 2 cm and 3 cm. pots were watered as needed to maintain adequate soil moisture. Seedlings were considered emerged when a cotyledon was visible at the soil surface.

Test of allelopathy

Chromolaena odorata and *Tridax procumbens* collected from Kerala University Campus were used for extracts. Seeds of three crops – green pea (*Vigna radiata)*, rice (*Oryza sativa*), and chilli (*Capscicum annuum*), and two weeds – Siam weed (*chromolaena odorata*) and coat buttons (*Tridax procumbens*) were used for experiments. *Chromolaena odorata* and *Tridax procumbens* were collected and immediately brought to the laboratory where the leaves were removed from their stems. The seeds used in the study were steeped in water to determine their viability; those that floated were not used. Laboratory and green house experiments were conducted to determine the effects of siam weed extract and coat buttons extract on seed germination and seedling growth of seeds.

Preparation of extract

Siam weed and coat buttons plants comprising of leaves and stems were cut, pounded with pestle and Mortar. Five Kg of the product was soaked in 20 liters of distilled water for a period of four days (96 hours). Water was used because most allelochemicals are water soluble. The composition was sieved and the extract was kept in a refrigerator at 5^0 C for subsequent experiments.

Laboratory experiment

The seeds used in the study were steeped in water to determine their viability; those that floated were not used. Extracts of *C. odorata* and *T. procumbens* were used for germination tests. Seeds were prerinsed with 1% sodium hypochlorite for 10 minutes to avoid fungal growth and rinsed thoroughly with distilled water before use. A sterilized petridish was lined with sterilized cotton for each treatment. Ten seeds of each of the three crop plants and weeds were placed in respective petridishes. Treated petri dishes were each supplied with 25 ml of extract, while the untreated control was treated with 25ml of distilled water. The germination was noted after radicle emergence. Response index (RI) was calculated according to Williamson and Richardson (1988).

Green house experiment

The green house experiment was to determine the effect of siam weed and coat buttons extract on germination and growth of crop and weed species in a soil medium. Seeds of three crops and two weeds, either treated with extracts or untreated comprised the treatments. Small polyethylene bags were filled with soil and seeds were planted. Extract was added to treated pots, while distilled water was used as control. Data on crop plant height, root length and number of leaves were taken at weekly intervals from 2 to 4 weeks after planting (WAP). Response index (RI) was calculated according Williamson and Richardson (1988), after radicle emergence.

Result

Germination study

Effect of seed storage on germination

Germination of both species increases with increased period of storage. Siam weed showed a maximum germination of 82% at 6 months storage, where as fresh seeds showed a maximum of 40% germination. Coat buttons showed a maximum germination of 86% at 6 months storage, where as fresh seeds showed a maximum of 13% germination.

Effect of dark and light period on germination

In both species light stimulated germination. Siam weed showed a maximum of 82% of germination on light, however 35% of seeds still germinated on dark. Coat buttons showed a maximum of 86%germination in light and only 6% germination in dark .

Effect of salt stress on germination

Germination of Coat buttons was more affected by increasing salt concentration than siam weed. Siam weed germination declined by 50% at NaCl concentration of 155 mM, Whereas only 60 mM NaCl was required to inhibit 50% of maximum germination of coat buttons. Some seeds of siam weeds germinated at NaCl concentration of 200mM, where as coat buttons did not germinate at NaCl concentration greater than100mM.

Effect of osmotic stress on germination

Germination of coat buttons was affected to a greater degree by increasing water stress than that of siam weed. Siam weed germination declined by 50% of the maximum at an osmotic potential of -0.5MPa, whereas only -0.3 MPa was required to inhibit 50% of the maximum germination of coat buttons.

Effect of seed burial depth on seedling emergence

Seed burial depth greatly influenzed seedling emergence of both species and the response was almost similar between the species. Seedling emergence of both species declined exponentially with increase in seed burial depth. The highest level of emergence was 78 to 80% for both species on the soil surface.

Test of Allelopathy

Laboratory experiment

Crop seed germination was less affected by siam weed extract compared to the weed seed germination. In the laboratory, green pea germination was not hindered by siam weed extract. On rice and chillli, siam weed extract showed 15% and 19% reduction respectively, to that of control. The extract showed a high reduction in the germination of siam weed itself. The germination percentage of siam weed treated with its own extract was only 6% and that for coat buttons was 45%. Coat buttons extract affects much more than siam weed extract on crop germination. On green pea, 12% reduction in germination was observed. Germination of rice and chilli was reduced by 38% and 28% respectively, when compared to that of control. The siam weed showed 40% germination with coat buttons extract and coat buttons itself showed 50 % germination. The RI values was found to be negative (inhibitory, RI<0) for all the weeds. The negative RI values were comparatively lesser for crops. Positive (RI>0)/no effect was observed only in *Vigna radiata*. Response Index (RI) values for seed germination in food crops and weeds are given in table 2.

Green house experiment

The germination response of crop seeds maintained in green house was as much as similar to the laboratory experiment. But the weed seeds in green house germinated much better than in the laboratory. Siam weed showed 15% germination when treated with its own extract and coat buttons showed 55% germination. Siam weed showed 51% germination when treated with coat buttons extract. Coat buttons showed 63% germination when treated with its own extract.

The response index (RI) values were noted and was found to be negative (inhibitory, RI<0) for both the weeds and crops.

Coat buttons extract affects the crop plant growth much greater than Siam weed extract. In the case of shoot length, green pea shows a maximum of 32.2 cm and 29.5cm with Siam weed and coat buttons extract respectively after 5WAP, where as control have a length of 26.5cm. The rice showed a maximum of 25cm and 24.2cm length, when treated with Siam weed and coat buttons extracts respectively. However control showed a maximum of 26.5cm. Chilli showed a maximum of 24.9cm and 23.6cm length when treated with Siam weed and coat buttons extract respectively after 5WAP. However, control showed a maximum of 26.2cm.

In the case of root length green pea showed a maximum of 7.2cm and 6.1cm, when treated with Siam weed and coat buttons extract respectively after 5WAP, whereas control showed a maximum of 8.9cm. Rice seedlings have a maximum of 12.4cm and 11.2cm when treatred with Siam weed and coat buttons extract respectively, whereas control seedlings showed maximum of 16.8cm. Chilli showed a maximum of 12cm and 11.3cm when treated with Siam weed and coat buttons extract respectively, whereas control seedlings showed a maximum of 13.1cm after 5WAP.

In the case of number of leaves, green pea seedlings showed maximum number of 17 and 14 leaflets when treated with Siam weed and coat buttons extract respectively, whereas control seedling showed 20 leaflets after 5WAP. Rice seedling showed a maximum of 8 and 6, when treated with Siam weed and coat buttons extract respectively, whereas control showed 9 after 5WAP. After 5WAP, chilli showed a maximum of 14 and 13 when treated with Siam weed and coat buttons extract respectively, however control seedling showed 15.

Discussion

Germination study

Germination study of *Chromolaena odorata* and *Tridax procumbens* conducted in various environment conditions showed that seeds of *Chromolaena odorata* and *Tridax procumbens* stored after harvest for up to 6 months in the laboratory showed significantly greater germination. Germination of siam weed exceeds to 82% at 6 months storage, where as fresh seeds showed only 40% germination. Coat buttons germination was also increased with extent of storage and showed 80% germination at 4 months of storage. Thus siam weed and coat buttons share the requirements of after ripening period to improve germination. This has been reported for many species and is common with in Asteraceae (Karlsson and Milberg, 2007 a). Such an after ripening requirement may be of benefit to the species by ensuring temporal distribution in germination, which is likely to increase the chance of establishment when growing conditions are highly variable. Further, where seed harvest is followed by a dry season, it may be an advantage for a species if germination is initially suppressed, so that seed can instead germinate at the beginning of the succeeding wet season when establishment may have a greater chance of success.

Seed germination response to light is species specific. Germination of threehorn bedstraw (*Galium tricornutum* Dandy) seeds, for example, is inhibited by light (Chauhan *et. al.*, 2006b). In contrast, a number of species of Asteraceae require light to stimulate germination (Chauhan *et. al.*, 2006a; Chauhan and Johnson, 2008; MacDonald *et. al.*, 1992). Siam weed and coat buttons in these studies were shown to be positively photoblastic, as light stimulated germination. The response to light is thought to be controlled by phytochrome, a light-absorbing pigment within most plants. In photoblastic seeds, light exposure may convert inactive-phytochrome "red" to the active-phytochrome "far-red."(Rollin, 1972). Coat buttons was highly sensitive to light, whereas Siam weed was less sensitive, with 40% of its seeds germinated in the absence of light. This differential weed germination response to light is a previously reported phenomenon that may occur even with closely related species (MacDonald *et. al.*, 1992).

Greater germination of Siam weed and coat buttons seeds in light (optimum conditions) suggests that their germination and subsequent emergence in the field will be favoured by the presence of seeds at or near the soil surface which occurs under no-till systems. We can assume that most seeds of these species occurring in soil seed banks remain ungerminated because of a lack of light. It is soil disturbance or cultivation that will therefore allow the portion of the seeds exposed to light during or after cultivation to germinate (Milberg *et. al.*, 1996), as long as temperature and soil moisture are adequate. In theory, it should then be relatively easy to manage these two species by repeated soil cultivation and allowing germination in between (Karlsson and Milberg, 2007). In practice, however, control on arable

Table 1
Germination response of *Chromolaena odorata* and *Tridax procumbens* seeds in different germination conditions

	Germination percentage of *Chromolaena odorata* and *Tridax procumbens* in different conditions																			
	Periods of storage of seeds				**Effect of light**		**Concentrations of NaCl (mM)**						**Concentrations of PEG (MPa)**						**Seed burial depth (cm)**			
	0 months	2months	4months	6months	light	dark	0 (mM)	50 (mM)	100 (mM)	150 (mM)	200 (mM)	250 (mM)	-0 (MPa)	-0.2 (MPa)	-0.4(MPa)	-0.6 (MPa)	-0.8(MPa)	-1.0 (MPa)	0 cm	1 cm	2 cm	3 cm
C. odorata	40	60	73	82	82	35	82	77	73	53	13	0	82	73	60	41	13	0	80	13	6	0
T. procumbens	13	66	80	86	86	6	86	53	7	0	0	0	82	67	27	7	0	0	78	13	6	0

Table 2
Germination percentage and response index of crop and weed seeds in the treatment of *Chromolaena odorata* and *Tridax procumbens* extracts

Seeds used	Laboratory experiment						Green house experiment					
	Siam weed extract			**Coat buttons extract**			**Siam weed extract**			**Coat buttons extract**		
	Germination percentage		**Response index RI**	**Germination percentage**		**Response index RI**	**Germination percentage**		**Response index RI**	**Germination percentage**		**Response index RI**
	Control	**Treated**		**Control**	**Treated**		**Control**	**Treated**		**Control**	**Treated**	
Green pea	100	100	0.00	100	88	-0.12	100	92	-0.08	100	80	-0.2
Rice	100	85	-0.15	100	62	-0.38	100	80	-0.2	100	60	-0.4
Chilli	100	81	-0.19	100	72	-0.28	100	80	-0.2	100	72	-0.28
Siam weed	82	6	-0.9	82	40	-0.51	84	15	-0.82	84	51	-0.39
Coat buttons	85	45	-0.4	85	50	-0.41	88	55	-0.38	88	63	-0.28

Table 3
Seedling growth of *Vigna radiata, Oriza sativa* and *Capsicum annuum* in different extracts

Treatment	Weeks After germination/ planting	Seedling growth of ***Vigna radiata*** in different extracts			Seedling growth of ***Oriza sativa*** in different extracts			Seedling growth of ***Capsicum annuum*** in different extracts		
		Shoot Length (in cm)	**Root length (in cm)**	**No; of leaflets**	**Shoot Length (in cm)**	**Root length (in cm)**	**No; of leaves**	**Shoot Length (in cm)**	**Root length (in cm)**	**No; of leaves**
Control	2	13.5±.0.01	1.9±0.03	8±0.00	22.5±0.03	6.2±0.04	2±0.00	10.6±0.05	2.3±0.08	5±0.00
	3	18.2±0.06	2.8±0.05	11±0.01	28.5±0.07	9.8±0.02	4±0.00	15.3±0.04	4.8±0.06	8±0.01
	4	22.0±0.05	5.5±0.05	14±0.00	32.4±0.06	13.9±0.05	7±0.01	20.1±0.01	8.2±0.06	11±0.00
	5	26.5±0.01	8.9±0.04	20±0.00	36.1±0.03	16.8±0.03	9±0.00	26.2±0.03	13.1±0.09	15±0.01
Siam weed extract	2	12.8±0.02	1.3±0.07	5±0.02	20.1±0.02	3.1±0.05	2±0.00	9.4±0.01	1.9±0.05	4±0.02
	3	17.9±0.09	2.2±0.08	8±0.00	25.8±0.04	6.2±0.04	3±0.00	14.6±0.01	3.8±0.09	7±0.00
	4	22.2±0.07	3.6±0.06	11±0.01	29.6±0.05	9.7±0.06	6±0.01	19.2±0.07	7.5±0.03	10.0.00
	5	25.0±0.08	7.2±0.07	17±0.00	32.2±0.08	12.4±0.05	8±0.01	24.9±0.03	12.0±0.08	14±0.01
Coat button extract	2	12.1±0.05	0.8±0.02	5±0.00	16.8±0.06	2.7±0.01	2±0.01	8.9±0.01	1.7±0.09	4±0.00
	3	10.0±0.04	1.8±0.08	5±0.00	21.1±0.02	5.8±0.03	2±0.00	13.6±0.02	3.7±0.05	6±0.01
	4	21.5±0.04	3.3±0.06	8±0.01	25.0±0.05	8.1±0.06	4±0.00	18.1±0.02	7.1±0.04	8±0.00
	5	24.2±0.05	6.1±0.03	14±0.00	29.5±0.05	11.2±0.07	6±0.01	23.6±0.05	11.3±0.08	13±0.00

land may be complicated by the high fecundity of plants and seeds that are well suited to wind dispersal (Baker, 1965; Kushwaha *et. al.*, 1981). Further, a proportion of Siam weed (35%) and coat buttons (6%) seeds germinated readily in the darkness, suggesting that some seeds would probably germinate even when buried provided moisture and temperature are favorable.

Salinity can be a major constraint for crop production. Germination response to salt stress suggests that *Tridax procumbens* may not be a problematic weed at very high soil salinity, while siam weed may germinate at high soil salinity. Differential germination response to salt has also been reported in other species of Asteraceae family. The concentration required to inhibit 50 % of maximum germination of *Eclipta prostrata* L. was 194 mM (Chauhan and Johnson, 2008), where as this concentration for annual *Sonchus oleraceus* L. was 89.6 mM NaCl (Chauhan et al., 2006a). As these weed species can adapt to saline conditions, crop cultivation may be limited not only by salinity, but also by weed competition. Salinity can negatively affect important physiological processes and is a major abiotic constraint to plant growth (Greenway and Munns, 1980; DiTommaso, 2004). In addition to physiological processes in plants, sodium present in salt can alter soil structure and fertility by replacing Calcium and Magnesium in the anion exchange process and this may lead to nutrient and water stress in plants (DiTommaso, 2004).

Coat buttons was more sensitive to water stress than siam weed, suggesting that siam weed may be found in areas of drier and well drained soils and part of its adaptations could be the ability to germinate in habitats with limited soil water. Coat buttons did not germinate at osmotic potentials lower than -0.6 MPa, suggesting that its germination is encouraged by moist conditions. Tamado *et. al.* (2002) also reported a remarkable delay in germination at high PEG concentrations in the study of germination of both *Parthenium hysterophorus* and *Sorghum*.

Seed burial depth greatly influenced seedling emergence of both the species. Seedling emergence of both species declined exponentially with increases in seed burial depth. Seedling emergence of both species was greatest from the seeds present on soil surface, which is consistent with germination being stimulated by light. No emergence was observed at burial depths below 3cm in both species.

Decreased seedling emergence due to increased burial depth has been reported in several weed species (Boyd and Van Acker, 2003). There are several possible explanations for the lack of emergence from seeds buried at deeper depths. Light penetration is generally limited to the first few millimeters of the soil (Woolley and Stoller, 1978) and seeds deeper in the soil would not receive light. Because of the requirement for light by these species, limited light penetration is probably the main reason for low emergence of buried seeds. In addition to a lack of light, hypoxia and low rates of gaseous diffusion in deeper depths could be other reasons for the lack of emergence (Benvenuti, 2003). Larger seeds with greater carbohydrate reserves can emerge from greater depths of burial (Baskin and Baskin, 1998). On the other hand, small-seeded species such as Siam weed and coat buttons may not have sufficient food reserves to support seedling emergence. Greater emergence from seeds placed on the soil surface suggest that no till forming practices would favour emergence of both Siam weed and coat buttons.

This study has demonstrated that both Siam weed and coat buttons are adapted to a wide range of environmental conditions. As germination was strongly stimulated by light and seedling emergence was optimal at the soil surface, these species are likely to be favored in no-till systems. Although coat buttons may not be considered as much of a problem as Siam weed, present data suggest that this species could become a serious problem in field crops if farmers shift to no-till systems. These species can be managed by burying their seeds below the maximum depth of emergence by a tillage operation and subsequently using shallow tillage operations to avoid bringing back the seeds onto the soil surface. The information gained in this study will be used to facilitate development of effective weed control programs.

Test of allelopathy

Crop seed germination was generally less affected by siam weed extract than was weed seed germination. In the laboratory green pea germination was not hindered by siam weed extract. On rice and chilli 15 and 19 percent reduction in seed germination, respectively was recorded when compared with the control. Coat button extract showed more allelopathic effect than siam weed on crop seed germination. Studies by Datta and Bandopadhyay, 1981; Augiras *et. al.*, 1988 showed that *Chromolaena odorata* has allelopathic effects in wheat, mustard, chick pea and white clover. But Coat buttons extract showed low germination percentage in green pea, rice and chilli (88%, 62%, 72%) respectively in the laboratory condition. Chauhan and Johnson (2008) reported that Coat buttons is a serious weed of rice (*Oryza sativa*), wheat (*Triticum aestivum* L..), corn (*Zea mays* L.), peanut (*Arachis hypogaea* L.), soybean (*Glycine max* (L.) Merr.), sorghum (*Sorghum bicolor* (L.) Moench), sugarcane (*Saccharum officinarum* L.), cassava (*Manihot esculenta* Crantz), cotton (*Gossypium hirsuitum* L.), and vegetables.

The same trend of germination was maintained in the green house except that the weed seed germinated better than in the laboratory. This way suggests that the weed seeds in the laboratory were exhibitiing dormancy which may have been broken by seeds interaction with soil components. Various biological chemical and physical components may be responsible. Akobundu (1987) listed factors such as soil temperature, soil moisture regime, alternate wetting and drying of soil, soil nitrate level among others as those affect seed germination. Although the effect was slight on crop seeds and more on weed seeds, this finding is corroborated by the findings of Oke (1988) that siam weed extract inhibited the germination of seeds of cowpea, soybean and coat buttons.

The inhibitory effect of siam weed extract on germination of its own seed is in agreement with the findings of Bhowmic and Doll (1982) who observed that many weed species exhibit allelopathic (autotoxic) effects on the germination of their own seeds. Weed growth in terms of height and number of leaves could not be assessed because the weeds generally had slow growth and were too tiny to be handled up till 6 weeds of growth assessment. This could not be attributed to the detrimental effect of siam weed extract and coat buttons extract, as the untreated plant were equally affected due to the growth characteristic of the weeds. Alabi (1999) had indicated that the stem girth and number of branches in thorny mimosa (*Mimosa invisa* Mart) could not be assessed until 6 weeks after establishment due to small plant size.

In rice and chilli, root length and number of leaves were reduced by both extracts. The results demonstrate that Siam weed and coat button extracts have inhibitory effects on the growth of roots, stems, and the leaves of crop plants. The growth inhibition caused by allelochemicals released from these plants may be due to its interference with the plant growth processes. The allelochemicals may be reducing cell division or auxin induced growth of roots. Thus it is recommended that the Siam weed and coat button should be physically removed from green pea, rice and chilli fields before the allelochemicals wash down with the rains.

References

Akobundu, I.O. (1987): Weed science in the tropics: Principles and practices. John wiley and Sons.

Alabi, B. S. (1999): Effect of Growth Characteristics of Thorny Mimosa on the performanceof Cassava. - Ph.D. Thesis, University of Ibadan.

Ambika, S. R. (1980): Suppression of plantation crops by Eupatorium weed.- Curr. Sci. (Bangalore) 49: 874–875.

Angiras, N N, Singh, S. D and Singh, C. M. (1988): - Indian J. weed sci. 20: 85-87.

Baker, H. (1965): Characteristics and modes of origin of weeds. In: H. Baker and G stebbins, (eds). The Genetics of colonizing species. New York : Academic press.

Baskin, C. C. and J. M. Baskin. (1998): Seeds: Ecology, Biogeography, and Evaluation of Dormancy and Germination. San Diego, CA: Academic.

Benvenuti, S. (2003): Soil texture involvement in germination and emergence of buried weed seeds. - Agronomy Journal 95: 191 – 198.

Bhowmic, P. C and Doll, J. D. (1982): Corn and soybean response to allelopathic effects of weed and residues.- Agronomy Journal 74: 601-606.

Blackmore, A. C. (1998): Seed dispersal of *Chromolaena odorata* reconsider In Ferrar, P., Muniappan, R.and Jayanth, K.P. (eds). Proc. 3rd International Workshop on the Biological Control and Management of *Chromolaena odorata.* Bangalore (India) Oct. 1996.

Boyol, N. S and Van Acker, R.C. (2003): The effects of depth and fluctuating soil moisture on the emergence of eight annual and six perennial plant species. - Weed sci. 51:854-860.

Chauhan, B. and Johnson, D.E. (2008); Influence of environmental factors on seed germination and seedling emergence of eclipta (*Eclipta prostrata*) in a tropical environment- Weed sci. 56: 383-388.

Chauhan, B.S. Gill. G and Preston, C. (2006 b): Factors affecting seed germination of Threehorn bedstraw (*Galium tricornutum*) in Australia. - Weed sci. 54: 471-477.

Chauhan, B. S. Gill,G and Preston,C. (2006a): Factors affecting seed germination of annual Sowthistle (*Sonchus oleraceus*) in Southern Australia.- Weed sci .54:854-860.

Datta, S. C and Bandyopadhyay, A. K. (1981): Proc. 8th Asian Pacefic weed Sci. Soc. Cont. Vol.1, p p. 391-399. - Asian Pacific weed Science Society, Bangalore, India.

Di Tommaso, A. (2004): Germination behaviour of common ragweed (*Ambrosia artemisiifolia*) populations across a range of salinities. -Weed sci 52:1002-1009.

Galianto, M. I., Moody K and Piggin., C.M. (1999): Upland rice weeds of South and Southeast Asia. Makati city, Philippines: International Rice Research Institute.

Greenway, H and Munns, R. (1980): Mechansims of salt tolerance in nonhalophytes. - Annual Review of plant physiology 31:149-190.

Hillard, O. M. H (1977): Compositae in Natal. Pietermaritzburg, South Africa : University of Natal press.

Holm, L., Doll, J., Holm, E., Pancho, J and Herberger, J. (1997): World weeds: Natural Histories and Distrtibution. New York: John Wiley and sons.

Karlsson, L. M and Milberg, P. (2007): Comparing after ripening response and germination requirements of *Conyza canadensis* and *Conyza bonariensis* (Asteraccae) through logistic functions. - Weed Res. 47:433-441.

Kushwaha, S. P. S. Ramakrishnan, P. S and Tripathi, R.S. (1981): Population dynamics of *Eupatorium odoratum* in sucessional environments following slash and burn agriculture. -J.Appl. Ecol. 18 : 529 – 535.

Mac Donald, G. E., Brecke, B. J and Shilling, D.G. (1992): Factors affecting germination of dogfennel (*Eupatorium capillifolium*) and yankeeweed (*Eupatorium compositifolium*). - Weed sci. 40: 424-428.

McFadyen, R. E. C. (1991); The ecology of *Chromolaena odorata* in the Neotropics. Ecology and Management of *Chromolaena odorata*. BIOTROP Special Publication: 1-9.

Michel, B. E. (1983): Evaluation of the water potentials of solutions of Polyethylene glycol 8000 both in the absence and presence of other solutes. - Plant physiol. 72: 66-70.

Milberg, P., Andersson, L and Noronha, A.(1996): Seed germination after short duration light exposure: implications for the photo-control of weeds. - Journal of Applied Ecology 33: 1469-1478.

Oke, A. E. (1988): The allelopathic potential of *Chromolaena odorata* on seed germinatin and seedling growth of *vigna unguiculata* var. K 59 and *Zea mays* var DMR – SRW and germination of *Chromolaena odorata* and *Tridax procumbens* weed seeds. *B*. Agric. Tech. (crop Production) Project Report; The Federal University of Tech., Akure, Nigeria.

Orapa, W. I. Bofeng and G. Donnelly. (2002): Management of *Chromolaena odorata* in Papua New Guinea: status of a biological control programme. In Zachariades, C., R. Muniappan, and L. W. Strathie (eds). Proceedings of the 5th International Workshop on Biological Control and Management of *Chromolaena odorata*. 23-25 October 2000, Durban (S. Africa). pp40-44

Rollin, P. (1972): Phytochrome control of seed germination. *In Phytochrome*. pp.229-257. Eds Mitrakos K., Shropshire Jr. W. NewYork: Academic press.

Sahid, I. B. and Sugau, J. B.(1993); Allelopathic effect of Lantana (*Lantana camara*) and Siam weed (*Chromolaena odorata*) on selected crops.- Weed sci. 41:303-308

Tamado, T., Dhlander, L and Milberg, P. (2002): Interference by the weed *Parthenium hysterophorus* L. with grain sorghum: influence of weed density and duration of competition.- International Journal of Pest Management 48: 24-29.

Williamson, B and Richardson, D. (1988): Biomass for allelopathy measuring treatment responses with independent controls. - J. Chem. Ecol. 4:81-187.

Woolley, J. T and Stoller, E. (1978): Light penetration and light induced seed germination in soil. -Plant physiology, 61: 597-600.

Received: 10 September 2019
Revised and Accepted: 21 September 2019