ALLELOPATHIC EFFECTS OF AQUEOUS EXTRACTS OF *Carthamus tinctorius* L. ON EMERGENCE AND SEEDLING GROWTH OF *Echinochloa crus-galli* L.

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ABSTRACT

Plant secretions have ability either to promote or inhibit seed germination and seedling growth of surrounding crops and weeds and this situation is termed as allelopathy. Laboratory experiment was performed to determine the suppressive or simulative influence of aqueous extracts of leaves, stem and fruit of Carthamus tinctorius L. *at different concentrations(0, 0.25, 0.50, 1, 2, 4, and 8%)on Echinochloa cruss-galli* L. *Results revealed that 8%concentration of aqueous extracts of all tested parts of C. tinctorius was most phytotoxic against germination as well growth of E. cruss-galli. Maximum mean emergence time (5.60 days), minimum emergence index (1.87), time to 50% emergence (6.17 days), minimum shoot (5.82 cm) and root length (1.91 cm) were recorded with the application of leaf extract at 8% concentration of C. tinctorius. The E. cruss-galli emergence percentage (53.33%) and seedling fresh biomass (15.35 g) was minimum when treated with 8% aqueous extract of C. tinctorius fruit extract. The lower concentration (0.25% to 2%) of all the studied extracts showed a hermetic response and stimulated the root, shoot and seedling fresh weight of E. cruss-galli. The aqueous extracts inhibitory effect was in order of leaf > fruit > stem. This study leads to conclusion that 8% or higher concentration of C. tinctorius leaf aqueous extract may be exploited to biologically suppress the E. cruss-galli.*

Keywords: Allelopathy, emergence, seedling growth, inhibitory, extracts-concentrations.

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INTRODUCTION

The plants ability to prevent the growth of unwanted plants is normally called as the allelopathy and it can be utilized in both organic and conventional agriculture (Machado, 2007). Allelopathy is a new technique that keeps weed under check, protect the atmosphere and help to get high quality crop produce (Younqing, 2005). Some plants have ability to release certain chemicals in the rhizosphere that have ability either to promote or suppress the nearby growing weeds or crops (Javaid *et al*.2005; Javaid and Khna, 2020; Javaid *et al.,* 2020). Sunflower is also famous for allelopathic effect (Ashrafi *et al.,* 2008). The leaves and roots are the plant parts that are key source of allelochemicals (Yang *et al.,* 2007). The chemicals like phenolics, flavonoids or terpenoids are generally recognized to own allelopathic characteristics (Macias *et al.,* 2002). Ahmad *et al*.(2000)described the inhibitory effect of allelochemicals exuded by sorghum on the growth of different weeds. Sorghum aqueous extract application @ 10Lha^{-1} in combination with pigmental herbicide results in 63 to 95%decrease in total weeds dry weight (Cheema *et al*., 2003). Sorghum, sunflower and oats have been examined for number of allelochemicals that behaved like hormones in low quantities and act as herbicides in high quantities (Weston and Mathesius,2013). Awan *et al*. (2012) reported that sunflower allelopathic chemicals efficiently control narrow and broad leaf weeds in the wheat indicating that some crop extracts can be used to manage weeds.

Echinochloa crus-galli commonly known as barnyard grass listed in the Global Compendium of Weeds are widespread in warmer temperate, sub-tropical regions and tropical of the world(Randall, 2012).It is known as one of the world's threatening weeds that has the ability to reduce crop yields and cause failure of forage crops by absorbing up to 80% of nitrogen available in the rhizosphere. So, it is imperative to explore possibilities of its suppression through natural environmentally safe means like bio herbicides. E. crus-galli has ability to produce large number of seeds and also have a level of seed dormancy, which ensures its propagation as well as seed bank build up in the soil profile (Clay et al., 2005). It may cause 21 to 79% yield loss in rice, depending upon the cropping system and management (Wilson et al., 2014). Research on E. crus-galli crop competition has shown that duration, time of its emergence, weed density, and crop sowing methods significantly affect the magnitude of competition and yield losses (Chauhan and Abugho, 2013). It is therefore, extremely encouraging to investigate the phytotoxic effects of this crop on *E. Cruss-galli*. The present research has therefore been designed to investigate the allelopathic potential of safflower against world's one of the worst crops and environmental weed.

MATERIALS AND METHODS

The study was conducted in 2017at weed science laboratory Department of Agronomy, University of Agriculture Faisalabad to investigate the potential allelopathic effects of aqueous extracts of different parts of safflower on barnyard grass. The study was laid out in completely randomized design with factorial arrangement having four number of replications.

Collection of *C. tinctorius* plant parts

To prepare aqueous extract of *C. tinctorius plants* were collected from Agronomic Farm, University of Agriculture Faisalabad, Pakistan. The plants of *C. tinctorius* were harvested above the ground surface at maturity and dried for two weeks at ambient temperature. After dried properly different parts of plants were separated and chopped into pieces of 2 cm to make aqueous extract.

Preparation of aqueous extracts of *C. tinctorius*

C. tinctorius aqueous extracts of various parts were made by adding 10 g of chopped dried plant material into 100ml of distilled water in bottles separately at ratio of 1:10 w/v. At room temperature plant material were soaked in the water for at least 24 hours. These aqueous

extracts were made from each desired part of *C. tinctorius* such as leaves, stem and fruit. Then the material was passed through a cheese cotton cloth to attain the 10% (w/v) water extracts of different parts of *C. tinctorius* which was used as stock solution. The stock solution diluted to prepare the required concentration of 0.25%, 0.5%, 1%, 2%, 4% and 8%.

Laboratory experiment

In laboratory experiment the aqueous extracts of *C. tinctorius* fruits, stem and leaves in different concentrations viz.0.25%, 0.5%, 1%, 2%, 4%, and 8% were used to explore their allelopathic effects on germination and growth of *E. cruss-galli*. For control, distilled water was used instead of plant extract. The study was performed in the 9 cm petri plates and filter paper of double layer was used as sowing medium.

Twenty-one treatment combinations of *C. tinctorius* leaves, stem and fruits in different concentrations viz. 0% (control), 0.25%, 0.5%, 1%, 2%, 4%, and 8% were tested against *E. cruss-galli* for their allelopathic effects. Five seeds of *E. cruss-galli* were placed in every petri plates. Then 7ml of all *C. tinctorius* extracts were added in all the petri plates having 4 replications. For control, distilled water was used. To reduce evaporation losses petri plates were covered and rapped with scotch tape. The petri plates were kept at 30°C temperature. The data regarding seeds germination were recorded every day for 14 days. After the 14 days, germinated seedlings of barnyard gras were harvested and used to record different *E.cruss-galli* seedling growth parameters like root and shoot length, dry and fresh weight. Fresh weight was noted instantly after harvesting whereas the dry weight of seedlings was observed after oven drying for two days at 60^0C.

Data collection

Mean emergence time of *E. cruss-galli* (days)

The mean emergence time (MET) was determined by the formula proposed by Ellis and Reborts (1981).

$$\text{MET} = \sum(Dn) / \sum n$$

Emergence index of *E. cruss-galli*

The emergence index was observed as per association of official seed analysis (1983) by using formula

$$GI = \frac{No.of\ emerged\ seeds}{Days\ of\ first\ count} + - + \frac{No.of\ emerged\ seeds}{Days\ of\ final\ count}$$

Emergence percentage of *E. cruss-galli* (%)

No of emerged seeds were counted daily by the method of association of Official Seed Analysis (1990) and converted into the emergence (%) by using the following formula.

$$Emergence\ percentage = \frac{Number\ of\ seeds\ emerged}{Total\ Number\ of\ seeds} \times 100$$

Time taken to complete 50% emergence of *E. cruss-galli*

The time taken to get 50% emergence (E_{50} or T_{50}) was calculated by the formula proposed by (Coolbear *et al.,* 1984).

$$T\mathbf{50} = ti + \left[\frac{\frac{N}{2} - ni}{nj - ni}\right](tj - ti)$$

Shoot length of *E. cruss-galli* (cm)

All seedlings from each petri plate were separated 14 days after emergence. Shoot length was calculated by using scale from base to plants top and their mean was taken.

Root length of *E. cruss-galli* (cm)

Root length was recorded by selecting plants from each petri plate 14 days after emergence with scale from start of root to root tip then average was calculated.

Fresh biomass of *E. cruss-galli* (g)

Fresh seedlings weight was measured by digital weight balance. Then average weight was worked out.

Dry biomass of *E. cruss-galli* (g)

The seedlings dry weight was noted by drying seedlings in oven for about 48 hours at 60°C. Then dry weight of seedling was calculated by using digital balance.

Statistical analysis

Data analyses were performed by using Statistics software (version, 8.1Statistix, Tallahassee, FL, USA). To compare the means least significant difference test was used at Probability level of 5% (Steel *et al*., 1997).

RESULTS AND DISCUSSION

1. Mean emergence time of *E. cruss-galli* (day)

Aqueous extracts of *C. tinctorius* leaves, stem and fruits depicted a significant influence on the mean emergence time of *E. cruss-galli* (Table 1). Extracts of all tested plant parts significantly delayed the mean emergence time of *E. cruss-galli* seedlings. Leaves extract of *C. tinctorius* showed maximum emergence time (4.68 days). While the flower extract gave the lower mean emergence time (4.49 days). The impact of extracts concentration on the *E. cruss-galli* mean emergence time was significant. Highest mean emergence time (4.86 days) was observed with 8% and lowest (4.39 days) at 1% concentration. Interactive effect of concentration and plant part aqueous extract was statically different on mean emergence time of *E. cruss-galli* seedlings. The highest mean time to emergence (5.60 days) was showed by leaves at 8% concentration while the lowest mean emergence time (4.28 days) was noticed in treatment where application of fruit extract 0.25% was applied. The inhibitory effect of extracts of *C. tinctorius* plant parts and their various concentrations on mean germination time observed in our study is supported by the findings of Rose and Anitha (2012) who noted that water extracts of *Euphorbiahirta* at different concentrations exhibited significant inhibitory impact on the groundnut mean emergence time and this inhibitory effect was directly proportional to extracts concentration. In another study Tanveer *et al.* (2010) found that the application of *Euphorbia helioscopia* extracts reduced the germination of *Cicer arietinum* L., *Lens culinaris* Medic and *Triticum aestivum* L. More delayed germination (higher MGT) of rice with higher (5%) than lower (2.5%) concentration of aqueous extract of *Vicia sativa* has also been described by previous scientists (Zohaib *et al*., 2014).

2. Emergence index of *E. cruss-galli*

Water extracts from all plant parts of *C. tinctorius* with all concentrations significantly affected the *E. cruss-galli* emergence index. Lowest emergence index (1.87) was noted at 8% while the highest (3.30) at 1% concentration. Leaf extract showed the maximum inhibitory effect. While the stem extract showed the promotive effect. Fruit also showed somewhat inhibitory effect. Interactive influence of all parts and their concentration was non-significant. Lower rate of germination due to the application of aqueous extracts and higher concentrations of extracts indicated by low values of emergence index found in this study was probably due the presence of phytotoxic metabolites in extracts which reduced germination index of *E. crus-galli* seeds. These findings are corroborated by the results of Khan *et al.* (2011) who studied the influence of *Silibummarianum* aqueous extracts and found that the germination percentage and germination index values of *Glycine max*, *Vigna radiata* L., *Cicer arientinum* L. and *Phaseolus vulgaris* L. seeds were significantly reduced. Our observations are also in conformity with report of D'armanti *et al*. (2015) who stated that the application of purple nutsedge tuber extract caused a significant reduce in GI of *Glycine max* L. at 5% and inhibitory effect was concentration dependent.

3. Emergence percentage of *E. cruss-galli* (%)

Influence of water extracts of fruit, leaves and stem of *C. tinctorius* on *E. cruss-galli* seedling emergence percentage was significantly different (Table 3). Fruit extract resulted in maximum reduction in the *E. cruss-galli* emergence than leaves

and stem extract. Maximum germination percentage was noted with stem extract.

The statically significant difference was found in emergence percentage of *E. cruss-galli* due to the application of aqueous extracts having different concentrations. The peak value of emergence percentage (100 %) was noted at 1%extract concentration. While the least value of emergence (77.78%) was observed with 8% extract concentration. The aqueous extract of fruits caused maximum inhibitory effect on emergence percentage (88.57%), while the stem extract showed the stimulatory effect (96.19%). Interactive impact of different *C. tinctorius* part extracts and their concentrations on emergence percentage of *E. cruss-galli* was also significant. Stem extracts gave maximum emergence percentage (100%) at 0.5% and 1% whereas minimum (53.33 %) emergence was noted with the application of fruit extract at 8% concentration. The significant reduction in *E. crusgalli* emergence percentage with aqueous extract application is attributed to the existence of water soluble phenolics in different tissues of tested plants (Heidarzade *et al*., 2012). These allelopathic compounds interfere with plant photosynthesis, cell division, respiration, hormonal activity and cell enlargement (Li *et al*., 2010). The abnormality in functioning of seed hydrolytic enzymes and respiration inhibit seed germination partially or fully. Zohaib *et al*. (2014) assessed the phytotoxic effects of 2.5% and 5% (w/v) extracts of five weed species and 2% (w/w) soil incorporated these weed residues found significant inhibitory effects on emergence percentage of rice. Takao *et al* (2011) explored the influence of leaf aqueous extract of *Ipomoea cairica* on Ipomoea *grandifolia, Euphorbia heterophylla, E. cruss-galli and Bidens Pilosa* and reported that the test species had a significant inhibitory impact on emergence (%) of these weeds at higher concentrations.

4. Time to 50% emergence of *E. cruss-galli* (days)

Allelopathic influence exerted by different plant parts of *C. tinctorius* and different concentrations on time taken to 50% emergence of *E. cruss-galli* was statistically significant (Table 4). Fruit extract resulted in least (3.58) days and stem extract caused maximum (4.24) days delay in 50% emergence of *E. cruss-galli* seeds. Highest time taken to complete50% emergence was recorded by 8% concentration of extract. The lowest values of time taken to the 50% emergence were observed with 1% concentration. The interactive influence of different plant part extracts and their concentration on the time to 50% emergence was significant. Fruit extract treated seeds of *E. cruss-galli* took least time to achieved50% emergence (3.33 days) at 2% concentration while leaves extract treatment resulted in maximum time (6.17 days) to complete 50% germination at 8% concentration. The longest time to reach 50% (T_{50}) of *E. crusgalli* seeds by the application of leave extract was probably due to the existence of more water soluble allelochemicals in this extract. Anjum and Bajwa (2005) reported *R. dentatus* aqueous extracts at higher concentration enhanced the time taken to the 50% germination of *T. aestivum and Helianthus annus* seedlings. The lower concentrations of aqueous extracts might have hermetic influence on growth of test species (Cheema *et al*., 2003). The negative impact leaf extracts of *Ageratum conyzoides* and *Eupatorium odoratum* on GP, GI, MGT of *Glycine max, Oryza sativa and Brassica campestris* has also been reported by Kumar *et al*. (2007).

5. Shoot length of *E. cruss-galli* (cm)

Different plant parts of *C. tinctorius* and their various concentrations had significant impact on the shoot length of *E. cruss-galli*. Maximum shoot length (9.80 cm) was recorded with aqueous extract of stem at 4% concentrations whereas minimum shoot length (4.51) was produced by leaves extract application at 8% concentration. Among different concentrations highest shoot length (7.63 cm) was noted at 2% while

smallest (6.17 cm) seedlings were produced at 8%concentration. The extracts of leaves, fruit and stem produced significant influence on shoot length of *E. cruss-galli*. Shortest shoot length (5.82 cm) was found with the aqueous extracts of leaves whereas, longest shoot lengths (9.06 cm) were noted by the application of stem extracts of *C. tinctorius*. The fruit and stem extracts caused stimulatory influence at lower extract concentrations. The application of stem extracts up to 4% concentration promoted shoot length while, the fruit extract stimulated shoot length up to 1%concentrationthan control. The allelochemicals present in extracts of different parts of safflower at lower concentration might have acted as growth regulators and stimulated the growth of barnyard grass. Increase in phytotoxicity of plant aqueous extract by increasing concentration has also been documented by Hossain and Alam (2010) who found that seedling length of *Albiziaprocera, Vigna sinensis*, *Paraserianth esfalcataria*, *Acacia auriculiformis, Amaranthus tricolor, Cucurbita pepo, Triticum aestivum, Oryzasativa* and *Abelmoschus esculentus*was reduced by *Lantana camara* water extract at higher concentrations while lower concentrations caused stimulatory effect. Khaliq *et al*. (2009) has also been observed inhibitory influence of safflower water extracts on *Cichorium intybus* seedling growth.

6. Root length of *E. cruss-galli* (cm)

Aqueous extracts of various parts of *C. tinctorius* had significant influence on the root length of barnyard grass (Table 6). The weed seedlings with smallest root length (1.92 cm) were produced by safflower leaves aqueous extract whereas, seedlings with lengthiest roots (4.02 cm) were noted by application of stem aqueous extracts of *C. tinctorius*. The interactive effect of different *C. tinctorius* part aqueous extracts and their concentrations on *E. cruss-galli* seedling root length was significant. Maximum root length (4.80 cm) was noted with 2% aqueous extract concentration of stem whereas, minimum (1.78 cm) shoot length was recorded by leaves extract at 1%concentration. Among various aqueous extract concentrations, minimum root length (2.38 cm) was found at 8% while maximum root length (3.54 cm) was notedby0.25%concentrated extracts. The allelochemicals in different parts of safflower at lower concentration may have behaved as hormones and promoted the root length of *E. cruss-galli*. Reduction in root length by aqueous extracts application of safflower leaves may be due to suppressive effects of allelopathic mixtures found in the extracts. Results are parallel with the observations of Randhawa *et al*. (2002) who noted reduction in *Tianthema portulacastrum* root length by sorghum aqueous extract application. The increase in root length of barnyard seedling with the treatment of safflower stem extract is in harmony with the findings of Mubeen *et al*. (2012) who recorded an increase in root length of rice seedlings over control with sole or combined application of sunflower and sorghum water extracts which indicate the presence of stimulatory allelochemicals in these extracts.

7. Fresh biomass weight of *E. cruss-galli* (g)

The extracts of different *C. tinctorius* parts had a significant influence on the fresh weight of *E. cruss-galli* seedling (Table 7). The lowest values of fresh weight (11.18 g) was recorded in those seedlings which were treated with the aqueous extract of fruits of safflower because it restricted the growth of seedlings whereas, higher values of fresh weight (15.52 g) was found by stem aqueous extracts of *C. tinctorius*.

The interaction among different concentrations and plant parts produced a significant impact on barnyard seedling fresh weight. It has been noted that control treatment (0.0% concentration) resulted in higher values of seedling fresh weight due to no interference of allelochemicals in distilled water (control)which was statically similar with

the fruit extract application at the concentration of 0.25%. The stem extract of safflower gave higher values of fresh weight of *E. crus-galli* seedlings at lower concentrations up to 2.00% concentration. Fruit extract application at 0.25% concentration demonstrated a stimulatory response however its higher concentrations reduced the fresh weight of *E. cruss-galli* seedling. Among different concentration maximum seedling fresh weight (19.16 g) was obtained at 0.25% and minimum (11.55 g) at 8%concentration. The delayed germination and slow growth of seedlings can be attributed to the reduction in the fresh weight. The significant modifications in barnyard seedling fresh weight detected with the application of water extracts of safflower leaves, stem and fruits were probably due to hermetic effect which enhanced seedling length and thickness and ultimately fresh weight at lower concentrations. The lower concentration of metabolites in aqueous extracts of various parts of safflower might have acted as growth regulators and improved barnyard grass seedling growth and ultimately seedling fresh weight was enhanced. The increase in rice seedling weight due to the treatment of sunflower and sorghum water extract has also been reported and attributed to improved seedling length and thickness caused by stimulatory allelochemicals (Mubeen *et al*., 2012). Lowest barnyard seedling fresh weight with the application of safflower fruit aqueous extract at higher concentration is attributed to presence of phenolics such as gallocatechin and epigallocatechin with a 4-hydroxy benzhydrazide derivative (Yu *et al*., 2013) which repressed the growth of seedling. Past studies (Calabrese and Baldwin, 2003) have frequently related stimulatory effects of aqueous extracts at low concentrations and inhibitory at higher concentration (hormesis). The development of *E. crus-galli* shoot was improved by the 2.5% extract concentration and inhibited at higher concentrations of extracts (Takao *et al*., 2011).

8. Dry weight of *E. cruss-galli* (g)

The extracts of *C. tinctorius* leaves, stem and fruits had significant influence on dry weight of *E. cruss-galli* seedlings. The extracts of *C. tinctorius* parts and their different concentrations had non-significant influence on *E. cruss-galli* dry weight (Table 8). Among aqueous extracts of different *C. tinctorius* parts the lowest seedlings dry weight (0.65 g) was recorded with leaves extract at 0.25% because its application reduced growth of barnyard grass seedlings whereas, highest value of dry weight (5.83 g) was noted by fruit aqueous extracts of *C. tinctorius*. Minimum barnyard seedling dry weight with the leaf aqueous extract application was due to fact that phytotoxic compounds were released in higher concentration from leaves which imparted growth inhibitory rather than promontory action. Hamidi *et al*. (2008) reported the repressive effects of *Hordeum spontaneum* decomposing residues on seedling dry weight of *T. aestivum*. Ismail and Siddique (2011) also documented decrease in seedling weight of *O*. *sativa* by residues of *Cyperus iria*.

CONCLUSION

It is concluded from this research that water extracts of safflower leaf, stem and fruit possess phytotoxic potential against *E. crus-galli* germination and seedling establishment. Higher concentration (8%) of all plant part extracts was found highly toxic as compare to control (0%). The overall inhibition in the germination and seedling growth of barnyard grass was highest by leaf water extract application. The inhibitory ingredients in safflower aqueous extract could be exploited as a potent bio herbicide for the eco-friendly management of *E. crus-galli*.

Table 1: Mean emergence time of *E. cruss-galli*as influenced by different aqueous extract concentrations of leaf, stem and fruits of *C. tinctorius*.

Plant Parts	Mean emergence time							
	Concentration							Mean
	0%	0.25%	0.5%	1%	2%	4%	8%	
Leaf	4.60b-g	4.43d-g	4.74b-f	4.36fg	4.43d-g	4.59b-g	5.60a	**4.68a**
Stem	4.40efg	4.85bcd	4.81b-e	4.29g	4.76b-f	4.92b	4.40efg	**4.63ab**
Fruit	4.34fg	4.28g	4.31g	4.52b-g	4.48c-g	4.88bc	4.59b-g	**4.49b**
Mean	**4.44c**	**4.52c**	**4.63abc**	**4.39c**	**4.56bc**	**4.80ab**	**4.86a**	

Means not sharing identical alphabets are different significantly at 5% probability level.
HSD at 5%: Concentration=0.263, Plant parts= 0.166, Concentration × plant parts =0.161

Table 2: Emergence index of *E. cruss-galli* as influenced by different aqueous extract concentrations of leaf, stem and fruits of *C. tinctorius*.

Plant Parts	Emergence index							
	Concentration							Mean
	0%	0.25%	0.5%	1%	2%	4%	8%	
Leaf	2.11^{NS}	2.92	1.72	3.08	2.69	2.03	1.86	**2.35b**
Stem	2.92	2.94	3.31	3.36	3.08	3.58	2.42	**3.09a**
Fruit	2.78	3.47	2.89	3.44	3.17	3.08	1.33	**2.88a**
Mean	**2.60c**	**3.11ab**	**2.64bc**	**3.30a**	**2.98abc**	**2.89abc**	**1.87d**	

Means not sharing identical alphabets are different significantly at probability level of 5%.
HSD at 5%: Concentration=0.437, Plant parts= 0.394, Concentration × plant parts =^{NS}

^{NS}= Non-significant.

Table 3: Emergence percentage (%) of *E. cruss-galli*as influenced by different aqueous extract concentrations of leaf, stem and fruits of *C. tinctorius*.

Plant Parts	Emergence percentage (%)							
	Concentration							Mean
	0%	0.25%	0.5%	1%	2%	4%	8%	
Leaf	93.33^{NS}	100.00	93.33	100.00	100.00	86.67	93.33	**95.24 NS**
Stem	100.00	93.33	100.00	100.00	93.33	100.00	86.67	**96.19**
Fruit	86.67	100.00	93.33	100.00	86.67	100.00	53.33	**88.57**
Mean	**93.33a**	**97.78a**	**95.55a**	**100.00a**	**93.33a**	**95.56a**	**77.78b**	

Means not sharing identical alphabets are different significantly at probability level of 5%.

HSD at 5%: Concentration= 6,983, Plant parts=^{NS}, Concentration × plant parts =^{NS}

^{NS}= Non-significant.

Table 4: Time taken to 50% emergence of *E. cruss-galli* as affected by different aqueous extract concentrations of leaf, stem and fruits of *C. tinctorius*.

Plant Parts	Time to 50% emergence							
	Concentration							Mean
	0%	0.25%	0.5%	1%	2%	4%	8%	
Leaf	3.94b-f	3.64d-g	4.22bcd	3.64d-g	3.94b-f	4.14bcd	6.17a	**4.24a**
Stem	3.67c-g	4.08b-e	3.92b-g	3.42fg	4.25bc	4.33b	4.06b-e	**3.96 b**
Fruit	3.42fg	3.33g	3.67c-g	3.50efg	3.33g	4.06b-e	3.75b-g	**3.58c**
Mean	**3.68cd**	**3.69cd**	**3.94bc**	**3.52d**	**3.84bcd**	**4.18b**	**4.66a**	

Means not sharing identical alphabets are different significantly at 5% probability level.
HSD at 5%: Concentration=0.334, Plant parts= 0.217, Concentration × plant parts = 0.411

Table 5: Shoot length of *E. cruss-galli*as influenced by different aqueous extract concentrations of leaf, stem and fruits of *C. tinctorius*.

Plant Parts	Shoot length (cm)							
	Concentration							Mean
	0%	0.25%	0.5%	1%	2%	4%	8%	
Leaf	5.98de	5.91de	6.52cd	7.10bcd	6.18cde	5.34de	4.51e	**5.82c**
Stem	8.45ab	6.17cde	4.59e	9.55a	8.80ab	9.80a	8.72ab	**9.06a**
Fruit	7.43bc	7.07bcd	7.4bc	7.90abc	7.91abc	7.23bcd	5.57de	**7.21b**
Mean	**7.28ab**	**6.38b**	**6.27b**	**8.27a**	**7.63ab**	**7.37ab**	**6.17b**	

Means not sharing identical alphabets are different significantly at 5% probability level.
HSD at 5%: Concentration= 0.994, Plant parts= 0.864, Concentration × plant parts = 1.904

Table 6: Root length of *E. cruss-galli*as influenced by different aqueous extract concentrations of leaf, stem and fruits of *C. tinctorius*.

Plant Parts	Root length (cm)							
	Concentration							Mean
	0%	0.25%	0.5%	1%	2%	4%	8%	
Leaf	2.58cd	2.46cd	2.32cd	1.78d	2.01cd	1.68d	1.53d	**1.92c**
Stem	4.03ab	5.13a	3.27bc	3.55abc	4.80a	4.21ab	3.49abc	**4.02a**
Fruit	3.19bc	3.03bcd	3.61abc	2.89bcd	3.40abc	2.90bcd	2.13cd	**2.90b**

Mean	**3.27a**	**3.54a**	**3.4a**	**2.74ab**	**3.40a**	**2.93ab**	**2.38b**	

Means not sharing identical alphabets are different significantly at 5% probability level.
HSD at 5%: Concentration= 0.797, Plant parts= 0.415, Concentration × plant parts =1.412

Table 7: Fresh weight of *E. cruss-galli* seedling as influenced by different aqueous extract concentration of leaf, stem and fruits of *C. tinctorius*

Plant Parts	**Fresh biomass (g)**							
	Concentration							**Mean**
	0%	**0.25%**	**0.5%**	**1%**	**2%**	**4%**	**8%**	
Leaf	18.00ab	15.33ab	14.33bc	12.66bcd	14.00bc	18.00ab	15.16b	**15.35a**
Stem	14.00bc	17.50ab	14.66b	14.66b	17.33ab	16.00ab	14.50b	**15.52a**
Fruit	16.00ab	24.66a	12.88bcd	12.00bcd	3.77d	4.00d	5.00cd	**11.18b**
Mean	**16.00ab**	**19.16a**	**13.94ab**	**13.11b**	**11.70b**	**12.66b**	**11.55b**	

Means not sharing identical alphabets are different significantly at probability level of 5%.
HSD at 5%: Concentration= 5.222, Plant parts= 0.189, Concentration × plant parts =9.127

Table 8: Dry weight of *E. cruss-galli* seedling as influenced by different aqueous extract concentrations of leaf, stem and fruits of *C. tinctorius*.

Plant Parts	**Dry weight (g)**							
	Concentration							**Mean**
	0%	**0.25%**	**0.5%**	**1%**	**2%**	**4%**	**8%**	
Leaf	0.98^{NS}	0.80	0.65	0.80	1.00	0.57	0.45	**0.75b**
Stem	3.00	3.25	2.73	2.33	1.08	1.06	0.93	**2.05ab**
Fruit	1.10	4.53	5.83	4.73	2.20	2.60	0.83	**3.12a**
Mean	**1.69^{NS}**	**2.86**	**3.07**	**2.62**	**1.42**	**1.41**	**0.73**	

Means not sharing identical alphabets are different significantly at 5% probability level.
HSD at 5%: Concentration=^{NS}, Plant parts=1.083, Concentration × plant parts =^{NS}

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