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Evaluation of allelopathic effects of *Calotropis procera* against wheat (*Triticum aestivum*) using seedling vigor and germination indices

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Abstract

Many plants are known for their phytotoxic potential. Such plants tend to suppress the germination and normal growth processes in other plants under their effect. *Calotropis procera* is one of the most dominant weed plants in Pakistan and is largely known for its insecticidal, pharmacological and phytotoxic properties. It is found abundantly around and inside the agricultural field crops. This study was aimed at investigating the allelepathic effects of *C. procera* on *Triticum aestivm* (wheat) which is one of the most important agricultural crops in most of the Asian countries. The allelopathic effects were gauged using different indices for germination behavior and seedling growth. Results indicated that *C. procera* leaf extracts has such allelopathic compounds which can significantly reduce the germination of and seedling vigor of *Triticum aestivum*.

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Introduction

Apart from the fact that weeds compete with agricultural crops for light, nutrients, moisture and space, these unwanted plants also pose threat to the productivity and growth of the agricultural crops by release of certain allelochemicals in the environment (Kadioglue *et al.*, 2005). There are a number of water soluble compounds in leaves, roots, stems and fruit of weed plants which when released into the soil, inhibit the germination and subsequent growth of crops plants (Batish *et al.*, 2007). The phytotoxic nature of these allelochemicals is featured as selective (varies against different crops) and concentration dependant (more obvious at higher concentrations and vice versa) (Cheema *et al.*, 2004). Within the subject crops, these allelochemicals can disturb a number of metabolic processes like photosynthesis, respiration and water uptake (Einhelling, 2002).

Calotropis procera, locally known as "*Akk*" in Pakistan (Yasin *et al.*, 2012) is a member of family Asclepiadaceae (Parihar *et al.*, 2011). *C. procera* has been reported as one of the dominant weeds in agricultural crops of Pakistan (Qureshi *et al.*, 2009). Being abundant in tropical regions across the world, it is generally found along roads, sand dunes, fallow lands and on agricultural farmlands (Sastry and Kavathekar, 1990). *C. procera* has been studied by many a researchers for its anti-phytopathogenic and insecticidal properties (Begum *et al.,* 2010 and Kareem *et al.,* 2008). Studies conducted by different researchers (Yasin *et al.,* 2012; Al-Zohrani and Al-Robai, 2007; Samreen *et al.,* 2009) showed that leaf extract of *C. procera* has a number of water-soluble organic compounds which tend to inhibit the normal germination and growth performance of agricultural crop plants by suppressing the production of growth regulating hormones, checking the uptake of water and nutrients, decreasing the photosynthetic efficiency and affecting the seedling length of the subject plants.

Since wheat is one of the most important crops grown in most parts of the world including Pakistan, numerous studies have been carried out to assess the allelopathic potential of different weeds against wheat (Kadioglue *et al.,* 2005; Singh *et al.*, 2005; Mishra *et al.*, 2004). However, no significant study has yet been brought to light regarding the allelopathic effects of *C. procera* specifically on wheat crop.

Considering the fact that *C. procera* plants are found quite frequently in and around wheat field in Pakistan, it gives rise to serious question regarding the possible phytotoxic effects of this weed on wheat crop. Thus, keeping in view the susceptibility of wheat to different weeds, the current study was planned and carried out to evaluate the phytotoxic effects of *C. procera* on the germination behavior and seedling vigor of wheat plant (*Triticum aestivum*).

Material and methods

The experiment was conducted during December 2012 at room temperature (25°C±2) in the laboratory of Department of Forestry Wildlife and Range Management, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University Multan, Pakistan.

Calotropis procera leaves were collected from *C. procera* plants growing in the cropped area of Agriculture Research Farm of Bahauddin Zakariya University Multan. The leaves were chopped down and boiled in tap water for 60 minutes in following ratios to make respective treatments.

T_1 = Tap water,

T_2 = 50 g *C. procera* leaves boiled in 1 L tap water for one hour,

T_3 = 100 g *C .procera* leaves boiled in 1 L tap water for one hour,

T_4 = 150 g *C. procera* leaves boiled in 1 L tap water for one hour,

T_5= 200 g *C. procera* leaves boiled in 1 L tap water for one hour.

After filtering through filtering through muslin cloth, the leaf extracts were collected in bottles and were tagged.

The experiment was carried out in Completely Randomized Design with five replications. Each replication had two soil filled plastic pots. The pots were placed on the laboratory table according to the procedure laid down by Steel and Torrie (1997). Ten seeds of wheat were sown in each pot. Different concentrations of *C. procera* leaf extracts were applied to respective pots to keep the soil moistened. The study was carried out for 21 days.

Germination Parameters

Following the standard procedure (AOSA, 1990), germinated seeds were counted and recorded after every 24 hours interval. A seed was considered as germinated when its radical become at least 2 mm in size. Ten days after sowing, the final germination percentage was calculated.

Following indices were used to evaluate the allelopathic effects of *C. procera* on germination behavior of wheat: Germination Energy (GE), Mean Germination Time (MGT), Final Germination Percentage (FGP), Relative Germination Rate (RGR) and Germination Index (GI) were determined using the formula as mentioned by Li (2008). Moreover, Days Required For 50% Germination of Total Seeds (T_{50}'), Days Required For 50% of Total Germinated Seeds (T_{50}), Speed of Germination (S), Speed of Accumulated Germination (AS), Coefficient of The Rate of Germination (CRG) were calculated using formulas as mentioned by Anjum and Rukhsana (2005). Germination Value (GV), Peak Value (PV), Percent Inhibition (PI) and Delay Index (DI) were determined using formulas as used by Malaviya and Anuradha (2011). Corrected Germination Rate Index was calculated using formula as used by Dewir *et al.,* (2011) and Germination Distribution (GD) was determined following the mentioned by Schrader and Williams (2000). Besides seedling vigor index was determined using the formula mentioned by Li *et al.,* (2008).

Statistical Analysis

The data was subjected to ANOVA technique and Least Significance difference test was applied to separate the treatment means as explained by Steel and Torrie (1997).

Results and discussion

Table 1 shows the allopathic effects of different concentrations of *C. procera* leaf extracts on *Triticum aestivum* (wheat) in terms of various germination and seedling vigor indices. Taking into consideration all the mentioned indices (in Table 1) depicting germination behavior it becomes clear that higher concentrations (T5) of *C. procera* leaf extract have significantly negative effect on the germination behavior of wheat crop indifferent of the index used. Interpreting the germination data through all of the germination indices, no concentration of treatment seemed to have enhanced the germination of wheat seeds while 100% concentration of leaf extracts appears most suppressing concentration in all cases. In fact, there are a number of compounds in *C. procera* leaf extracts which can significantly inhibit the germination of many agricultural crops. Moradshahi *et al.,* (2003) concluded that higher concentration of allelochemicals in *C. procera* tend to inhibit the seed germination by checking the production of indole acetic acid and gibberellins in seeds. Al-Zahrani and Al-Robai (2007) also reported similar results in their stdudy carried out on *C. procera leaves* which suggested that *C. procera* had inhibitory effects on seed germination of agricultural crops. (Samreen *et al.,* 2009, Hussain & Ilahi, 2009) have also reported similar results for allelopathic effects of various plants.

Seedling length and seedling vigor also decreased with increasing concentrations of leaf extract. Highest suppression of seedling length was recorded in treatment T_5 which was followed by T_4 and T_3 while there was no significant different between control and T_2. In case of seedling vigor, value of index stood inversely proportional to the increase in leaf extract concentration. Root length seemed to have been more adversely affected by the allelopathic compounds present in *C. procera* leaf extract. This is possibly due to the fact that roots are first to encounter the allelochemicals in the soil. *C. procera* leaf extract has been widely reported to be a suppressing agent for seedling vigor of many crops (Oudhia and Tripathi, 1999). Allelopathic compounds like those of p-Menthane-3 and 8-trans-diol are present in *C. procera* leaves and these compounds can inhibit the cell division and cell elongation process in the root and shoot apical, leading to a decrease in seedling length (Moradshahi *et al.*, 2003). Many other scientists (Samreen *et al.,* 2009, Hussain & Ilahi, 2009) have also reported similar results for studies carried out on allelopathic effects of *C. procera*.

Table 1. Allelopathic Effects of *Calotropis procera* on seed germination behavior and seedling vigor of *Triitcum aestivum.*

	MGT	T50	GI	T50'	FGP	CGRI
T1	7.42±.04(a)	4.79±.19(a)	12.6±.25(a)	5.15±.18(a)	91±1.87(a)	13.97±.39(a)
T2	7.7±.048(b)	5.48±.17(b)	10.9±.483(b)	5.78±.16(ab)	87±21(a)	12.66±.64(a)
T3	7.93±.031(b)	5.82±.05(b)	9.8±.234(c)	7.83±1.71(abc)	77±1.52(b)	12.83±.32(ab)
T4	8.07±.08(c)	5.591±.41(b	8.1±.25(d)	6.89±.7(bc)	73±1.5(b)	10.98±.35(ab)
T5	8.64±.12(d)	6.408±.12(c)	6.07±.13(e)	9.04±.15(c)	50±41(c)	12.387±11(b)
	RGR	DI	CRG	S	AS	GV
T1	-	-	13.50±.11(a)	9.12±.16(a)	14.0±.44(a)	4.1
T2	0.95±.021(a)	0.39±.07(a)	12.75±.07(ab)	7.51±.25(b)	10.4±.37(b)	2.66
T3	0.846±.02(b)	0.34±.08(b)	13.14±.13(bc)	7.74±.32(bc)	11.1±.61(bc)	2.63
T4	0.802±.05(b)	0.53±.09(b)	13.02±.19(cd)	6.57±.61(c)	9.2±11(c)	2.12
T5	0.549±.04(c)	0.86±.21(b)	12.61±.21(d)	4.69±.35(d)	6.3±.534(d)	1.54
	PV	GE	RL	SL	SdL	SV
T1	2.2	65	9.99±.10(a)	18.37±.32(a)	28.3±.42(a)	2578.8±31.1(a)
T2	2.79	65	9.66±.11(a)	17.91±.38(a)	27.5±.41(a)	2395.6±27.1(b)
T3	1.75	55	8.30±.2(b)	15.22±.3(b)	23.5±.35(b)	1811.5±16(c)
T4	1.51	55	6.61±.3(c)	10.71±.5(c)	17.3±.7(c)	1265.5±60(d)
T5	1.31	45	3.68±.1(d)	7.584±.4(d)	10.2±.4(d)	500±58(e)

*T_1 = Control (Tap Water), *T_2= 25% *C. procera* leaf extract, *T_3= 50% *C. procera* leaf extract, *T_4= 75% *C. procera* leaf extract, *T_5= 100% *C. procera* leaf extract.

*T50'= Days Required for 50% Germination of total germinated seeds ,*T50= Days Required for 50% Germination of total seeds ,*DI= Delay Index ,*GI= Germination Index,*FGP= Final Germination Percentage ,*MGT= Mean Germination Time,*PV=Peak Value ,*S= Speed of Germination,*AS= Accumulated Speed of Germination ,*GE= Germination Energy ,*GV= Germination Value ,*CGRI= Corrected Germination Rate Index ,*RGR= Relative Germination Rate, CRG=Coefficient of Rate of Germination. *RL=Root Length, *SL= Shoot Length, *SdL= Seedling Length, *SV= Seedling Vigor.

Conclusion

Keeping in view the fact that *C. procera* can significantly suppress the germination activity in wheat seeds, it would be recommended to make sure that wheat fields should be kept free of *C. procera* plants. Presence of this weed plant in or around wheat fields can result in release of allelocheicals in the microenvironment of wheat field, especially with the rain water, which in turn can reduce the crop yield to a great extent.

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