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LABORATORY STUDIES ON GERMINABILITY AND SEEDLING GROWTH OF COTTON CROP UNDER THE ALLELOPATHIC INFLUENCE OF PURPLE NUTSEDGE

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ABSTRACT

Weeds interfere with crop plants not only through competition but also with allelopathy. Purple nutsedge (Cyperus rotundus L.) is considered as a highly allelopathic weed causing considerable yield losses to crops. A pot study to evaluate the allelopathic effects of purple nutsedge on cotton crop was undertaken at Wire House, Sindh Agriculture University, Tandojam, Pakistan during Kharif (summer) 2013. The experiment was laid out under completely randomized design with three replications. The seeds of cotton variety Sadori were used in the experiment. The analysis of data indicated that application of C. rotundus in both forms (powder and water extract) caused significant (P≤0.05) adverse effects on germination and growth of cotton seedling when compared with control. The integrated application of C. rotundus powder and water extract at higher rates (30 g + 30 ml kg^{-1} soil..) exerted greater phytotoxic effects in comparison with combined application of powder or water at lower rates and sole application in both forms at higher rates. The results showed that integration of C. rotundus powder @ 30 g kg^{-1} soil + C. rotundus water extract @ 30 ml kg^{-1} soil resulted in lowest seed germination, root length, shoot length, fresh weight $seedling^{-1}$ and dry weight $seedling^{-1}$. The combination of C. rotundus powder @ 15 g kg^{-1} soil + C. rotundus water extract @ 15 ml kg^{-1} soil was found equal in allelopathic action with C. rotundus powder @ 15 g kg^{-1} soil + C. rotundus water extract @ 15 ml kg^{-1} soil due to having non-significant (P≥0.05) statistical differences with each other. Hence, it is concluded that C. rotundus possesses allelopathic compounds with inhibitory effects and the presence of this weed in the field may negatively affect growth and yield of cotton.

Key words: Allelopathic weed, *Cyperus rotundus*, cotton, germination, growth.

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INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is major cash crop of Pakistan known as white gold. It contributes about 8.6 percent of the value added in agriculture and 1.8 percent to the GDP (GoP, 2014). Cotton crop provides material for foreign exchange income as well as raw material for textile industry of Pakistan. Weeds are considered as serious menaces which block the way of crop yield improvement. Weed infestation is one of the main factors lowering yield through competition for resources and adverse allelopathic effects. Weeds in cotton are controlled manually, mechanically or chemically. Manual weed control is highly labor dependent. Mechanical control is economical but it controls only inter row weeds while chemical control is efficient method but in addition to resistance development it has many soil and environmental issues. Allelopathy is considered as natural and eco-friendly approach for weed management and unlike synthetic herbicides, such products are produced naturally in the crops and used directly as pesticides. They are effective, economically viable and environment friendly (Cheema *et al*., 2005; Afridi *et al.* 2014; Afridi and Khan, 2014). The weeds are a big source of allelochemicals (secondary metabolites) which have ability to modify the rhizospheric system of neighbouring plants (Cheema *et al*., 2003). It is also defined as the detrimental influence of chemical compounds released by plants of one species on germinability and growth of plants species in the same habitat (Belel and Belel, 2015). Several crops and their roots parts are reported having allelopathic adverse influence on plants of agricultural importance. The allelopathic plants are suspected to affect the growth of other plants by means of leachates from decomposing residues, root exudates and plant parts incorporated in growing media (Price *et al*., 2008).

Purple nutsedge is one of the worst weeds of the world which is widely distributed in 52 different crops and 92 countries of the world (Rao, 2000). In Pakistan, purple nutsedge is included in the most common weeds which are found in cotton, sugarcane and maize during summer. It is strong competitive and reduces seed cotton yield in the range of 62-85% over control treatments (Bryson *et al.,* 2003). Phytotoxins released by *C. rotundus* markedly affected the germination of cotton (Mahmood and Cheema, 2004). The fresh weight of cotton reduced 9 to 42% as compared to control when grown with purple and yellow nutsedge (Chris *et al*., 2003). The

phytotoxic efficacy of purple nutsedge was assessed in contrast to the growth of many crop plants. Its aqueous extracts caused substantial decrease in seed germination and subsequent growth of corn, rice, tomato, onion and cucumber. *Cyperus rotundus* tubers and leaves mixed with soil in a pot experiment suppressed growth of canary grass and barnyard grass (Ali, 2005). The tubers and foliage of *C. rotundus* incorporated with soil at different doses affected negatively the germination and growth of barnyard grass and jute (El-Rokiek *et al*., 2010). In another study, Cheema *et al*. (2003) reported that *Cyperus rotundus* L. water extracts at two concentrations (5 and 10 percent) had greater allelopathic inhibiting effects on the germination, length and seedling vigor index of soybean, wheat, groundnut and green gram. Similarly, Hamayun *et al.* (2005) revealed that water extract of purple nutsedge and *E. crus-galli* suppressed considerably maize seed germination, radicle and plumule growth. In Sindh, Pakistan research for management of weeds is carried out through manual, mechanical and chemical methods (Chachar *et al*., 2009). A little work has been done on exploitation of allelopathic properties of plants for weed control. Hence, this experiment was conducted to determine the allelopathic influence of *C. rotundus* on the germination and seedling growth of cotton under pot conditions.

MATERIALS AND METHODS

The pot experiments was conducted at Wire House, Sindh Agriculture University, Tandojam, Pakistan during Kharif (summer) 2013. The experiment was replicated thrice under completely randomized design. The pots having size of 30x15x15 cm were filled-up with 5 kg soil and moisten with water. The possible allelopathic effects of powder and water extract purple nutsedge were determined against cotton. The treatments included: control (untreated), *C. rotundus* powder @ 15 g kg^{-1} soil, *C. rotundus* powder @ 30 g kg^{-1} soil, *C. rotundus* water extract @ 15 ml kg^{-1} soil, *C. rotundus* water extract @ 30 ml kg^{-1} soil, *C. rotundus* powder @ 15 g kg^{-1} soil + *C. rotundus* water extract @ 15 ml kg^{-1} soil and *C. rotundus* powder @ 30 g kg^{-1} soil + *C. rotundus* water extract @ 30 ml kg^{-1} soil. The seed of cotton variety Sadori was used throughout the experiment. The soil for experimental purpose was obtained from Latif irrigation minor, Sindh Agriculture University, Tandojam.

Allelopathic material collection

The herbage of purple nutsedge was collected from field of Students' Experimental Farm, Department of Agronomy, Sindh Agriculture University, Tandojam. The herbage was dried under sun, chopped into small pieces and ground to powder by grinder.

Application water extract and powder

The allelopathic water extract was prepared by soaking powder in sterilized tap water for 24 hours. The ratio between herbage and water was 1:10 (w/v). The water extract was filtered through muslin cloth following method developed by Mahmood and Cheema (2004). The water extract was sprayed on soil immediately after sowing of cotton seed as per treatments. In case of soil incorporation, the ground powder of purple nutsedge was incorporated thoroughly with soil as per treatments before sowing of cotton seeds. Ten seeds of cotton were sown in each row by maintaining five rows in each box. The soil in each box was irrigated regularly through tape water as and when needed.

Data collection and Statistical analysis

The emerged seedlings were counted at 5 and 10 days after sowing (DAS) for recording germination (%) and average was worked out. For collecting data on other features, the cotton seedlings were uprooted at 30 DAS. The root/shoot length (mm) and fresh / dry weight seedling^{-1} (g) of cotton was recorded immediately after uprooting. The seedlings of cotton were kept in oven at 70 ^{0}C for 72 hours for drying then dry weight was noted. The collected data was subjected to statistical analysis using computer software Statistix version 8.1 (Statistix, 2006). The LSD test was applied to compare treatments superiority at alpha 0.05, where necessary.

RESULTS AND DISCUSSION

Seed germination (%)

The statistical analysis of data (Table-1) indicates that powder and water extract of purple nutsedge diminished significantly ($P \leq 0.05$) germination of cotton as compared to control (untreated). Nevertheless, purple nutsedge powders and water extracts showed considerable differences on germination of cotton in allelopathic potential from each other. Integrated application of *C. rotundus* powder @ 30 g kg^{-1} soil+*C. rotundus* water extract @ 30 ml kg^{-1} soil and Integration of *C. rotundus* powder @ 15 g kg^{-1} soil+*C. rotundus* water extract @ 15 ml kg^{-1} soil resulted in the lowest and equal ($P \geq 0.05$) values statistically for germination (53.3 and 60.7%) of cotton, respectively. The perusal of overall data confirmed the phytotoxic effect of *C. rotundus* on germination of cotton. The inhibition in seed germination resulted from allelochemicals from *C. rotundus* water extract and powder interference with many processes. The findings are agreement with those of Chris *et al.* (2003) who reported that *Cyperus rotundus* extracts had delayed the germination of cotton and soybean. The reduction in the cotton seed may be linked to water uptake imbalance in osmotic imbalance due to the allelopathic

toxicity of purple nutsedge extract and powder. The findings also support the results of Nouri *et al*. (2012) who found that when seeds during germination phase are brought in contact with compounds having allelopathic properties, the germinating capacity of those seeds reduces significantly. In this study, integrated use of powder and water extract of *C. rotundus* demonstrated highest allelopathic efficacy causing significantly highest decrease in germination in contrast to sole application of them in either form. The study indicated that the phytotoxic influence was comparative to the dose of the powder and extracts, and higher doses had the higher impact. The powder or water extract *C. rotundus* at higher dose showed stronger allelopathic inhibitory impact as compared to lower dose. The water extract of *C. rotundus* was higher phytotoxic efficacy against powder because allelopathic compounds in water extracts of purple nutsedge were dissolved more instantly and their absorption by the germinating seeds was fast. The water extract of purple nutsedge and *Echinochloa crus-galli* significantly reduced barley seed germination, plumule and radicle growth (Ashrafi *et al.*, 2009). These findings are also in conformity with those of Channappagoudar *et al*. (2005) who revealed that *C. rotundus* and *C. bengalensis* extracts demonstrated phytotoxic influence on germination of soybean, green gram and wheat.

Root and shoot length (mm)

The statistical analysis of data (Table-1) shows that powder and water extract of purple nutsedge caused substantial ($P \leq 0.05$) decline in root and shoot length of cotton over control . It is evident from the results values that application of *C. rotundus* powder @ 30 g kg^{-1} soil+*C. rotundus* water extract @ 30 ml kg^{-1} soil and *C. rotundus* powder @ 15 g kg^{-1} soil+*C. rotundus* water extract @ 15 ml kg^{-1} soil showed greatest allelopathic power and produced least and statistically non-significant ($P \geq 0.05$) with each other respective root length (37.0 and 45.7 mm) and shoot length (103.0 and 110.7 mm) of cotton. The decrease in root/shoot length of cotton through powder and water extract of purple nutsedge may be associated with the existence of phytotoxic compounds in them and this effect was dose and form specific. Water extract of purple nutsedge showed more allelopathic inhibitory activity as compared to its powder The highest allelopathic action of purple nutsedge water extract on root and shoot length of cotton was perhaps due to its solubilized form which caused adverse influences on cotton seedlings might be due to retarding nutrients and moisture uptake, formation of chlorophyll and ultimately effect the process of photosynthesis. Similarly, Chon *et al*. (2003) reported the strong phytotoxic herbicidal potential of water extracts of Compositae family weeds plants due to possession of allelopathic compounds e.g., benzoic acid, *p*-coumaric acid, *o*-coumaric acid, ferulic acid, coumarin,

and P-hydroxybenzoic acid. Similarly, El-Rokiek *et al*. (2010) indicated that inhibitory allelopathic efficacy of compounds released from nearby growing plants could be related directly to the decay or dead plant tissues. Moreover, the inhibition of root growth, twisting and distorting were also observed due to the incorporation of residues of allelopathic crops. These results confirm the influence of allelopathic compounds on morphology of roots (Hamayun *et al*., 2005). Samad *et al*. (2008) reported that seedlings of various crops could not develop normally due to less elongation of radical and necrosis of roots caused by allelopathic effects. Bouchagier and Efthimiadis (2010) revealed that under the influence of bermudagrass, cotton suffered significant reduction of stomatal aperture, leaf transpiration and significant increase in leaf temperature. Growth inhibition and deterioration of photosynthesis components indicate that cotton suffered serious allelopathetic stress due to the weed influence. In another study, water extracts of *E. crus-galli* and *C. rotundus* and inhibited markedly the growth of barley radicle and plumule (Ashrafi *et al.*, 2009). The growth inhibition resulted from allelochemicals from *C. rotundus* powder and water extract interfere with many processes. The decline in growth and biomass of cotton may be due to phytotoxic compounds of *C. rotundus* powder and extract. These findings support the results of Chris *et al.* (2003) who reported that *C. rotundus* extracts had reduced seedling growth of cotton and soybean. The growth suppressing activity accelerated with increasing the concentration of allelopathic material. This outcome suggested that the seedling growth was the best indicator of phytotoxic effects of purple nutsedge.

Fresh and dry weight of seedlings (g)

The data in Table-1 suggests that all the treatments of purple nutsedge weed water extracts and powders reduced significantly ($P \leq 0.05$) the fresh and dry weight seedling^{-1} (mg) of cotton as compared to control (untreated) treatment. The lowest values for fresh weight and dry weight seedling^{-1} (7.0 and 2.8 g) were observed in *C. rotundus* powder @ 30 g kg^{-1} soil+*C. rotundus* water extract @ 30 ml kg^{-1} soil. Whereas, *C. rotundus* powder @ 15 g kg^{-1} soil+*C. rotundus* water extract @ 15 ml kg^{-1} soil followed showing statistically similar ($P \geq 0.05$) fresh weight and dry weight seedling^{-1} (8.3 and 3.7 g). The findings of this study revealed that integration of *C. rotundus* water + powder with each other proved highly phytotoxic over individual application in any form. It is observed that phytotoxic efficacy was enhanced with the increase in dose. The water extract of *C. rotundus* caused higher allelopathic inhibition than its powder perhaps due to solubilized form which was readily available. The suppression in weight of cotton seedling may be associated to reduced root and shoot length caused by phytotoxic compounds found in plant parts of *C. rotundus*.

The phytotoxins of plant might be decreased water and minerals uptake and eventually negative effect occur on photosynthesis, respiration, protein synthesis, cell division and thickness of roots (Tesio and Ferrero, 2010). The decrease in biomass of cotton may be attributed to inhibitory effects of purple nutsedge water extract and powder. The findings are in agreement with those Chris *et al.* (2003) who suggested that *Cyperus rotundus* extracts caused substantial reduction in growth of cotton seedling and eventually biomass. Chon *et al*. (2003) reported the strong phytotoxic power in extracts of Compositae family weeds due to the availability of allelochemicals like benzoic acid, coumarin, *p*-coumaric acid, *o*-coumaric acid, ferulic acid and P-hydroxybenzoic acid. Similarly, the extracts of *Commelina bengalensis* and *Cyperus rotundus* exhibited strong allelopathic effects on seedlings weight of soybean, wheat and green gram (Channappagoudar *et al*., 2005). The adverse inhibitory effects of purple nutsedge water extracts on growth of *Chorchorus olitorius* and *Echinochloa crus-galli* could be due to toxic compounds present in it (El-Rokiek *et al*., 2010).

Table-1. Allelopathic impact of purple nutsedge on germination and growth traits of cotton

Treatments	Seed germination (%)	Root length (mm)	Shoot length (mm)	Fresh weigh seedling $^{-1}$ (g)	Dry weight seedling $^{-1}$ (g)
Control (untreated)	96.7 a	110.0 a	170.0 a	16.0 a	7.2 a
C. rotundus powder @ 15 g kg^{-1} soil	73.3 cd	85.3 bc	145.3 bc	12.3 b	5.5 b
C. rotundus powder @ 30 g kg^{-1} soil	66.7 d	62.0 d	122.3 d	11.0 bc	4.9 bc
C. rotundus water extract @ 15 ml kg^{-1} soil	86.0 ab	92.7 b	152.7 b	13.7 c	6.0 c
C. rotundus water extract @ 30 ml kg^{-1} soil	83.3 bc	81.0 c	141.0 c	11.7 c	5.0 c
C. rotundus powder @ 15 g kg^{-1} soil+ water extract @ 15 ml kg^{-1} soil	60.7 e	45.7 e	110.7 e	8.3 d	3.7 d
C. rotundus powder @ 30 g kg^{-1} soil + water extract @ 30 ml kg^{-1} soil	53.3 e	37.0 e	103.0 e	7.0 d	2.8 d
S.E ±	5.039	3.892	3.651	0.848	0.427
LSD $_{0.05}$	10.980	8.480	8.342	1.837	0.931

Means sharing the same letter in a column do not differ significantly at LSD$_{0.05}$

CONCLUSION

The results concluded that water extract and powder of *C. rotundus* significantly (P≤0.05) inhibited the germination and growth of cotton seedlings as compared to control (untreated). The higher dose caused more phytotoxic effect than lower one. Water extract was found highly allelopathic in contrast to powder. Combined application of water and powder with each other was found highly allelopathic than their individual application. The integration of *C. rotundus* powder @ 15 g + water extract @ 15 ml kg^{-1} soil showed equal and statistical similar (P≥0.05) values with *C. rotundus* powder @ 30 g +water extract @ 30 ml kg^{-1} soil for germination and seedling growth of cotton.

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