GERMINATION AND SEEDLING GROWTH OF COTTON UNDER THE INFLUENCE OF ALLELOPATHIC WEED BERMUDA GRASS (*CYNODON DACTYLON* L.)

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ABSTRACT: *Weeds interfere with crop plants through competition and allelopathy. Allelopathy has recently been recognized as direct or indirect effect of one plant species on another through releasing of certain chemical compounds. The laboratory study to assess the allelopathic impact of C. dactylon (L.) on germination and seedling growth of cotton was conducted at experimental laboratory, Department of Agronomy, Sindh Agriculture University, Tandojam, during summer 2011. The experimental design used was completely randomized design replicated thrice. The treatments consisted of: control (untreated), C. dactylon powder @ 10g kg^{-1} soil, C. dactylon powder @ 20g kg^{-1} soil, C. dactylon powder @ 30g kg^{-1} soil, C. dactylon water extract @ 10g kg^{-1} soil, C. dactylon water extract @ 20g kg^{-1} soil, C. dactylon water extract @ 30g kg^{-1} soil, C. dactylon powder @ 10g kg^{-1} soil+C. dactylon water extract @ 10g kg^{-1} soil, C. dactylon powder @ 20g kg^{-1} soil+C. dactylon water extract @ 20g kg^{-1} soil and C. dactylon powder @ 30g kg^{-1} soil+C. dactylon water extract @ 30g kg^{-1} soil. The statistical analysis of data illustrated that all the treatments of C. dactylon powder and water extract caused significant negative effcet on germination and seedling growth of cotton variety Hari dost. However, minimum seed germination (61.3 %), root length (64.0 mm), shoot length (61.7 mm), fresh weight (1023.0 mg seedling^{-1}) and dry weight (447.0 mg seedling^{-1}) of cotton was recorded under C. dactylon powder @ 30g kg^{-1} soil+C. dactylon water extract @ 30g kg^{-1} soil. sorghum shoot powder (10 g kg^{-1} soil), followed by C. dactylon powder @ 20g kg^{-1} soil+C. dactylon water extract @ 20g kg^{-1} soil in allelopathic efficacy. Combined application of C. dactylon powder+water extract was showed strong allelopathic effects than sole application of either powder or water extract. In case of sole applications, powder caused more allelopathic inhibitory effects compared with water extract. Hence, above results under laboratory conditions confirmed that C. dactylon possesses allelopathic compounds with phytotoxic efficacy. The presence of this weed in field may adversely affect cotton growth and yield. Furthermore, bioherbicidal properties of C. dactylon could be utilized to control weeds under field conditions.*

Keywords: Allelopathic, weed, *C. dactylon*, cotton, germination, growth.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important cash and fibre crop being grown in Pakistan and many other countries of the world [1]. Weeds reduce cotton yield by 16-53% [2]. Existing weed control methods are either expensive or hazardous. Allelopathy is a natural phenomenon in which allelopathic plants release certain chemical compounds into the environment through root exudation, leaching by dew and rain, and volatilization or decaying plant tissues [3]. It plays an important role in agro-ecosystems leading to a wide range of influences and interactions in biotic communities. Such influences and interactions are mainly a result of allelochemical released from the donor plants that generally have harmful effects on the receiver plants [4]. A number of weed and crop species have been reported to possess allelopathic activity on the growth of other plant species [5]. Bermuda grass (*Cynodon dactylon* L.) is widely dispersed most dangerous weed throughout the world and is considered having fourth most allelopathic compounds. It is an effective colonizer due to its ability to compete for water, nutrients and space etc. [6]. *C. dactylon* (L.) contains ferulic, p-coumaric, vanillic, p-hydroxybenzoic, caffeic and syringic acids [7]. Similarly, [8] found caffeicchlorogenic, isochlorogenic, ferulic, o-coumaric, p-coumaric acids and scopoletin as the component of *Cynodon dactylon* (L.). All of these phenolics have also been shown to possess allelopathic effect. This supports the assumption that extract phototoxicity of *C. dactylon* might be due to the presence of phenolic compounds. Barley and mustard seedlings showed inhibition of radicle elongation when extracts of decaying *C. dactylon* were mixed in the seedlings' soils [9]. [10] reported that reduction in radicle length of weeds by allelochemicals is due to the effects of these substances on reduction of cell division, reduction in auxine which induces root development and disturbance of respiration. Bermuda grass extract also stopped seed germination, of foxtail, cotton, and barnyard grass. Under field conditions, growth of cotton is decreased 50% by Bermuda grass residues. The growth of barley, mustard, and wheat radicles was decreased by the residues of bermuda grass [11]. Bermuda grass extract had strong allelopathic and inhibitory effects on different traits of basil and common purslane. [12] reported that allelopathic effects of the bermuda grass extract on radicle and coleoptile length and weight of basil and common purslane were significant. *C. dactylon* extract and residues decreased wheat yield by 71% and 81%, respectively [13]. The germination, growth parameters and fresh and dry matter production of *Triticum aestivum* were retarded by all the four different aqueous extracts of allelopathic material applied. *Cynodon dactylon* had a such phytotoxic potency that could suppress the growth and nutrient accumulation of associated crop plants [14]. Cotton growth suppression was more pronounced in plots where *Cynodon dactylon* (L.) rhizomes were planted adjacently to cotton at the same time as sowing cotton. [15]. Similarly, a bioassay experiments showed that cotton germination, total fresh weight, and root length were inhibited by *Cynodon dactylon* (L.) extracts [16]. [17] revealed that seed germination of all Labiatae species was

completely inhibited at treatments more than 2% rhizome extract of *Cynodon dactylon*. The extract had strong inhibitory effect on root elongation of seedling in legums and Labiatae to shoot elongation in Poacae. Rhizomes of *Cynodon dactylon* may be a source of natural herbicide against *Sorghum halepense* which will help to control invasive plants. Considering the economic importance of cotton in the economy of Pakistan, the yield losses caused by weeds and costs of weed control, the present study was carried out to examine the germinability and seedling growth of cotton under the influence of allelopathic weed *Cynodon dactylon* (L.).

MATERIALS AND METHODS

The laboratory study to evaluate the germinability and seedling growth of cotton under the influence of allelopathic weed (*Cynodon dactylon* L.) was conducted at experimental laboratory, Department of Agronomy, Sindh Agriculture University, Tandojam, Pakistan during summer 2011. The experimental design completely randomized design replicated thrice was used. The seed of cotton variety Hari Dost was used throughout the experiment. To prepare powder, uprooted and well dried whole plant herbage of *Cynodon dactylon* (L.) was ground in a grinding machine whereas, to prepare water extract the herbage was soaked in water for 24 hours in the ratio of 1:8 and then filtered in cloth. The extract was boiled at 100^{o}C on a gas burner to concentrate 20 times for easy handling. The powder and water extract of *Cynodon dactylon* (L.) was applied as per treatments. The powder was mixed thoroughly in the canal sand before sowing seeds of cotton whereas the water extract was applied at 5, 10 and 15 days after sowing. The treatments included: control (untreated), *C. dactylon* powder @ 10g kg^{-1} soil, *C. dactylon* powder @ 20g kg^{-1} soil, *C. dactylon* powder @ 30g kg^{-1} soil, *C. dactylon* water extract @ 10g kg^{-1} soil, *C. dactylon* water extract @ 20g kg^{-1} soil, *C. dactylon* water extract @ 30g kg^{-1} soil, *C. dactylon* powder @ 10g kg^{-1} soil+*C. dactylon* water extract @ 10g kg^{-1} soil, *C. dactylon* powder @ 20g kg^{-1} soil+*C. dactylon* water extract @ 20g kg^{-1} soil and *C. dactylon* powder @ 30g kg^{-1} soil+*C. dactylon* water extract @ 30g kg^{-1} soil. The iron boxes having size 10x5x4 cm were filled with 5 kg box^{-1} of sandy loam soil and then watered with canal water. The observations were recorded on seedling emergence (%), root length (mm), shoot length (mm), fresh weight seedling^{-1} (mg) and dry weight seedling^{-1} (mg). The number of germinated seedlings was counted in each treatment and percentage was worked out. Root and shoot length was measured in millimeters in each treatment and averaged. Fresh weight of total seedlings emerged in each treatment was recorded in milligrams and divided with the total number of seedlings to get the fresh weight seedling^{-1}. The seedlings weighed in fresh state in each treatment were dried and weighed again to get the dry weight seedling^{-1} on average. The data were subjected statistical analysis using Statistix 8.1 computer software [18]. The LSD test was applied to compare treatments superiority, where necessary.

RESULTS AND DISCUSSION

Seed germination (%)

The statistical analysis of data showed that the allelopathic effect of different levels of *C. dactylon* powder and water extracts on seed germination of cotton was significant (P<0.05). The results presented in Table-1 demonstrated that minimum germination of 61.3% was registered in *C. dactylon* powder @ 30 g kg^{-1} soil+*C. dactylon* water extract @ 30 ml kg^{-1} soil, followed by 69.7 and 75.3% in *C. dactylon* powder @ 20 g kg^{-1} soil+*C. dactylon* water extract @ 20 ml kg^{-1} soil and *C. dactylon* powder @ 10 g kg^{-1} soil+*C. dactylon* water extract @ 10 ml kg^{-1} soil, respectively. The germination of 87.0, 91.0 and 92.3% was recorded in *C. dactylon* powder @ 30 g kg^{-1} soil, *C. dactylon* powder @ 20 g kg^{-1} soil and *C. dactylon* powder @ 10 g kg^{-1} soil, respectively. The germination of 90.0, 92.0 and 94.7% was noted in *C. dactylon* water extract @ 10 ml kg^{-1} soil, *C. dactylon* water extract @ 20 ml kg^{-1} soil and *C. dactylon* water extract @ 30 ml kg^{-1} soil. However, maximum germination of 96.7% was observed in control (untreated). The lower germination in treated pots than control was mainly due to allelopathic effect of *C. dactylon*. The above results exhibited that powder and water extract of *C. dactylon* (L.) contained germination inhibiting chemicals and cotton seed was sensitive to its allelopathy which resulted in reduced germination. It is also reported that material of allelopathic plants can affect the antioxidant arrangement in targeted plants, causing cellular damage, cell-membrane permeability and reducing the ability of target plants to germinate. The results are in accordance with the findings of [14] who concluded that extracts from the fresh and dry shoot and root tissues of *Cynodon dactylon* had inhibitory effects on the germination of *Triticum aestivum* seeds. Similarly [11] reported that allelopathic compounds from water extracts of *Cynodon dactylon* inhibited the germination of cotton and corn. *Cynodon dactylon* has allelopathic potential to reduce germination and emergence of plants of another species [19].

Root and shoot length (mm)

The analysis of data pertaining to root and shoot length of cotton as influenced by *C. dactylon* powder and water extract illustrated that allelopathic effect of *Cynodon dactylon* on the root length of cotton was significant (P<0.05). The results (Table-2) indicated that the root and shoot length of cotton was minimum (64.0 and 61.7 mm) in *C. dactylon* powder @ 30 g kg^{-1} soil+*C. dactylon* water extract @ 30 ml kg^{-1} soil, followed by 71.0/78.3, 77.3/84.3 and 81.0/88.0 mm root/shoot length in *C. dactylon* powder @ 20 g kg^{-1} soil+*C. dactylon* water extract @ 20 ml kg^{-1} soil, *C. dactylon* powder @ 10 g kg^{-1} soil+*C. dactylon* water extract @ 10 ml kg^{-1} soil and *C. dactylon* powder @ 30 g kg^{-1} soil, respectively. The root/shoot length of 90.0/91.3, 96.7/90.0 and 97.7/96.0 mm was recorded in *C. dactylon* powder @ 20 g kg^{-1} soil, *C. dactylon* water extract @ 30 ml kg^{-1} soil and *C. dactylon* powder @ 10 g kg^{-1} soil, respectively. The respective root/

Table 1. Germinability and related growth traits of cotton variety Hari dost in response to *Cynodon dactylon* (L.) powder and water extract allelopathy

Treatments	Seed germination (%)	Root length (mm)	Shoot length (mm)	Fresh weigh seedling^{-1} (mg)	Dry weight seedling^{-1} (mg)
Control (Untreated)	96.7 a	123.3 a	120.0 a	1540.7 a	524.3 a
C. dactylon powder: 10 g kg^{-1} soil	92.3 bc	97.7 b	96.0 b	1304.7 b	493.33 b
C. dactylon powder: 20 g kg^{-1} soil	91.0 c	90.0 c	91.3 b	1223.7 d	477.3 c
C. dactylon powder: 30 g kg^{-1} soil	87.0 d	81.0 d	88.0 c	1189.7 d	470.0 c
C. dactylon wat. ext: 10 ml kg^{-1} soil	94.7 ab	116.7 a	104.7 b	1506.7 a	514.3 a
C. dactylon wat. ext: 20 ml kg^{-1} soil	92.0 bc	102.7 b	98.0 b	1401.0 b	503.7 b
C. dactylon wat. ext: 30 ml kg^{-1} soil	90.0 c	96.7 b	90.0 b	1300.0 c	496.0 b
C. dactylon powder: 10 g kg^{-1} soil + *C. dactylon* wat. ext: 10 ml kg^{-1} soil	75.3 e	77.3 d	84.3 c	1163.3 d	474.3 c
C. dactylon powder: 20 g kg^{-1} soil + *C. dactylon* wat. ext: 20 ml kg^{-1} soil	69.7 f	71.0 e	78.3 c	1102.7 e	458.3 d
C. dactylon powder: 30 g kg^{-1} soil + *C. dactylon* wat. ext: 30 ml kg^{-1} soil	61.3 g	64.0 f	61.7 d	1023.0 e	447.0 d
S.E ±	1.3	3.8	7.1	47.1	7.7
LSD $_{0.05}$	2.9	8.0	14.9	98.9	16.3

Means not showing same letter are significantly different at p=0.05.

shoot length upto 102.7/98.0 and 116.7/104.7 mm was observed in *C. dactylon* water extract @ 20 ml kg^{-1} soil and *C. dactylon* water extract @ 10 ml kg^{-1} soil

However, maximum root/shoot length of 123.3/120.0 mm was recorded in control (untreated). The results suggested that *C. dactylon* powder and water extract markedly decreased the root and shoot length of cotton seedlings. It was further observed that *C. dactylon* powder or water extract at higher rates resulted in a more decrease in the root and shoot length as compared to lower concentrations. This clearly indicates their marked allelopathic effect to suppress the root growth of the cotton seedlings. The decrease in cotton root and shoot length indicated that allelochemicals present in bermuda grass perhaps affected directly to the roots as a result reduced water absorption, transpiration, regulation of stoma, content of chlorophyll, photosynthesis and respiration of seedlings. The results of our experiment also showed that root length was more adversely affected than shoot. The strong allelopathic suppressing effects that *Cynodon dactylon* caused on root elongation were perhaps due to direct contact of root with the soil. Radicle growth of *Triticum aestivum* seedlings treated with the aqueous extract prepared from flesh and dried shoot of *Cynodon dactylon* was observed to be inhibited [14]. [20] also revealed that radicle growth is more effectively inhibited than hypocotile growth through allelopathic plants because of radicle is the first part of plant which absorbs the allelochemicals. The results of this study support the view of [21] who reported that *Cynodon dactylon* produces allelopathic chemical materials and thus decreased growth of wheat considerably. *Cynodon dactylon* plant releases many water soluble allelopathic compounds such as caffeic acids, phenolic acid, vanillic, ferulic and pcumaric. The phenolics found in bermuda grass rhizomes have shown inhibitory effects on growth of cotton, corn and barnyardgrass [11].

Fresh and dry weight (seedling^{-1} mg)

The results of the analysis of variance indicated significant (P<0.05) allelopathic effect of *C. dactylon* on the fresh and dry weight seedling^{-1} of cotton. It is apparent from the data (Table-3) that fresh and dry weight seedling^{-1} of cotton was adversely affected by application of *C. dactylon* powder or water extract. The fresh and dry weight seedling^{-1} reduced to minimum (1023 and 447 mg) in *C. dactylon* powder @ 30 g kg^{-1} soil+*C. dactylon* water extract @ 30 ml kg^{-1} soil, followed by 1102.7/ 458.3, 1163.3/ 474.3 and 1189/ 470.0 mg fresh/dry weight seedling^{-1} in *C. dactylon* powder @ 20 g kg^{-1} soil+*C. dactylon* water extract @ 20 ml kg^{-1} soil, *C. dactylon* powder @ 10 g kg^{-1} soil+*C. dactylon* water extract @ 10 ml kg^{-1} soil and *C. dactylon* powder @ 30 g kg^{-1} soil, respectively. The fresh/dry weight seeding^{-1} of 1223.7/ 477.3, 1304.7/ 493.3 and 1300.0/ 496.0 mg was noted in *C. dactylon* powder @ 20 g kg^{-1} soil, *C. dactylon* powder @ 10 g kg^{-1} soil and *C. dactylon* water extract @ 30 ml kg^{-1} soil, respectively. The fresh/ dry weight seedling^{-1} increased to 1401.0/ 503.7 and 1506.0/ 514.3 mg in *C. dactylon* water extract @ 20 ml kg^{-1} soil and *C. dactylon* water extract @ 10 ml kg^{-1} soil, respectively. However, highest (1540.7/ 524.3 mg) fresh/dry weight seedling^{-1} was recorded in control (untreated). It was noted that *C. dactylon* powder and water extract showed linear allelopathic effect and decreased the fresh/dry weight seedling^{-1}. The *C. dactylon* powder or water extract at higher levels decreased fresh/dry weight seedling^{-1} more than the lower levels. The reduction in fresh and dry weight of cotton seedlings may be attributed to reduced root and shoot length which was caused by allelochemicals of *Cynodon dactylon*.

Allelopathic compounds found in bermuda grass probably lowered water and minerals uptake through roots which ultimately caused adverse effects on respiration, photosynthesis, cell division, protein synthesis and roots thickness. At par results have been revealed by earlier workers that *Cynodon dactylon* (L.) showed more pronounced suppression in growth and weight of cotton [15] and wheat [21]. Similarly, [14] reported that growth parameters and fresh and dry matter production of *Triticum aestivum* were retarded by different aqueous extracts of *Cynodon dactylon*. Bermuda grass extract had strong allelopathic and inhibitory effects on radicle and coleoptile length hence reduced weight of Basil and Common purslane seedlings was observed [12].

CONCLUSIONS AND RECOMMENDATIONS

The results of this study under laboratory conditions confirmed that Cynodon dactylon (L.) possesses allelopathic compounds with strong inhibitory potential. Seed germination, root length, shoot length, fresh weight and dry weight of cotton variety Hari dost was affected adversely by the application of powder and water extract of *C. dactylon*. The higher rate combination of *C. dactylon* powder @ 30 g kg^{-1} soil+*C. dactylon* water extract @ 30 ml kg^{-1} soil caused maximum inhibition as compared to their combination at lower rate. Combined application of powder or water extract demonstrated strong allelopathic effects in contrast to sole application. Soil incorporation of powder was found more inhibitory than spray of water extract. Hence, it can be conferred that this weed might have been interfering with crop plants not only through competition but also allelopathy.

ACKNOWLEDGEMENT

This research paper is prepared from M.Sc Thesis research submitted to SAU, Tandojam, Pakistan.

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