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Seedling growth of selected field crop species as influenced by *Jatropha curcas* extract

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ABSTRACT

Purpose: The experiment was conducted to investigate into the allelopathic potential of the aqueous extracts of different parts of *Jatropha curcus* on seven selected field crop species. **Research method:** The leaf, stem, bark, twig, root, pericarp, seed and oilcake extracts of *J. curcus* at four different concentrations (1:5, 1:10, 1:15 and 1:20 (*w/v*)) were tested against jute, mungbean, mustard, radish, rice, wheat and tomato. Control *i.e.* distilled water without extracts was also maintained in each case. The experiments were conducted following completely randomized design with three replications. **Findings:** Except few, the aqueous extracts of *J. curcas* plant parts significantly inhibited the seedling growth of all the test species at concentration more than 1:15 (*w/v*) whereas, at or below this level stimulated the seedling growth. Percent shoot and root growth inhibition of the test crops varied among *J. curcus* parts extract from 10 to 100, at 1:5 *(w/v)* concentration. At the same concentration, *J. curcas* oilcake extract completely (100%) inhibited the shoot and root growth of all the test crop species except rice. Similarly, seed extract completely inhibited (100%) the shoot and root growth of jute and mustard, whereas around or more than 70% inhibition of the shoot and root growth of all the test species except rice. These results confirm that *J. curcus* has allelopathic properties and may possess allelochemicals. Since oilcake of *J. curcus* extract had greater inhibitory activity than other parts, this could be used for isolation and identification of allelochemical(s). The results of this experiment will be helpful for the researchers to know the plant-plant interaction of *J. curcus* with its neighboring plant species or the intercrops introduce in *Jatropha* field. **Limitations:** There was no significant limitation to the report. **Originality/Value:** This research compares the allelopathic properties of different parts of *Jatropha curcus* on seven selected field crop species.

INTRODUCTION

Allelopathy is the direct or indirect harmful or beneficial effect of one plant on another through the release of allelochemicals (Rice, 1984). When a receiver plants come in contact with this allelochemicals, their growth is either adversely or positively affected. Sometimes the growth of the progeny of allelopathic plants (donor) also been affected (Islam et al., 2018a). Hence, understanding the allelopathic behavior of a plant is crucial to know its plant-plant interaction with surrounding plant species under natural settings. Due to the growth suppressive ability, allelopathic plants are also been suggested as a tool for sustainable weed management either directly or through the development of natural product based herbicides from their allelochemicals (Islam et al., 2019; Kato-Noguchi, 2020).

Jatropha curcas (commonly known as Physic nut), a multipurpose shrub belonging to Euphorbiaceae family, is originated from Maxico, but now thrives in many parts of the tropical Asia and Africa (Islam et al., 2011; Yi et al., 2014; Islam et al., 2015a; 2015b). *Jatropha* plant is used to reclaim land, grown as a live fence, especially to contain or exclude farm animals. All parts of *J. curcus* have medicinal properties and traditionally used for the treatment of various ailments (Islam et al., 2011). The plant extracts and isolated substances have molluscicidal, insecticidal, fungicidal, antidiarrhoeal, wound healing and anti-inflammatory properties (Nwosu & Okafor, 1995; Liu et al., 2011; Solsoloy & Solsoloy, 1997; Nath & Dutta, 1991; Staubmann et al., 1997; Mujumdar et al., 2000).

As a bio-diesel plant, *Jatropha curcus* is currently gaining world-wide popularity to avoid several environmental hazards created by fossil fuel combustion (Baruah et al., 2018). This plant is normally grown in widely spaced row (3 m apart) and after pruning newly emerged canopy does not cover the land adequately which encourage weed growth (Singh et al., 2007). Growing intercrops in between wide rows may utilize this land effectively. This cultivation practice not only increase the total return but also reduces weed infestation. Hence, before recommending intercrop species, it is important to know the allelopathic activity of *J. curcus* with them. Otherwise, the intercropping system will fail to produce the expected outcomes. Furthermore, the presence of higher nitrogen and phosphorus content in the seed oilcake and other industrial by-products of *J. curcas* make them to use as organic manure in the crop fields (Gubitz et al., 1999; Balasubramaniyan & Palaniappan, 2003; Mavankeni, 2007; Kumar & Sharma, 2008; Dhakane & Gourish, 2014). In other words, seed oilcake is a major byproduct of *Jatropha* oil extraction (around 70% of the total) and disposal of this cake has been a major challenge so far. Possibilities to use them as organic manure may increase the soil fertility and at the same time reduce environmental pollution (Inyew et al., 2019). However, seedling growth inhibition of tomato by *Jatropha* seed oilcake has been reported by Heller (1996). In this backdrop, the present study was conducted to explore the allelopathic potential of different parts of *J. curcas* on the seedling growth of seven selected field crop species.

MATERIALS AND METHODS

Site of the experiment

The experiment was conducted at the Agro Innovation Laboratory of the Department of Agronomy, Bangladesh Agricultural University, Bangladesh during March - August 2018.

Plant materials

Eight different plant parts *viz.* leaf, bark, stem, root, twig, pericarp, seed and oilcake of *Jatropha curcus* were used for this study. The fresh plant parts were collected during March -

April, 2018 from Bangladesh Agricultural University Research field whereas, the seed and oilcake were collected from the Department of Genetics and Plant Breeding, Bangabandhu Sheikh Mujibur Rahman Agricultural University. Jute (*Corchorus olitorius*), Mustard (*Brassica juncea*), Mungbean (*Vigna radiata*), Radish (*Raphanus sativus*), Rice (*Oryza sativa*), Tomato (*Solanum lycopersicum*) and wheat (*Triticum aestivum*) were used as test crop species.

Extraction and bioassay procedure

Bioassay of *J. curcus* was carried out following the procedure of Islam et al. (2018b). Except seed and oilcake, all other parts of *J. curcus* plant were washed with tap water, then with distilled water. One hundred gram of each part was then chopped and crashed into paste by a mechanical grinder. However, oilcake was directly used for the next steps. One hundred gram of each plant part was then soaked in 400 mL distilled water and homogenized in a warring blender for 5 minutes at room temperature (25 ºC). The extract was then filtered through one layer of filter paper (No. 2; Double Rings ® Hangzhou Xinhla Paper Industry Co. Ltd., China). The filtrate was then put into 500 mL volumetric flask and filled with distilled water up to the mark, and homogenized by manual shaking. The prepared concentration was considered full strength concentration *i.e.* 1:5 (*w/v*), and was stored at 4ºC (normal freezing condition) in a refrigerator until further used. The extraction was done separately for each plant parts of *J. curcas.*

The prepared full-strength concentration of leaf, bark, stem, root, twig, pericarp, seed or oilcake aqueous extracts were further diluted into three concentrations *viz.* 1:10, 1:15 and 1:20 (*w/v*), and a control (distilled water without extract) was also maintained. Twenty seeds of each crop such as jute, mustard, mungbean, radish, rice (sprouted), tomato or wheat were arranged on the filter paper in Petri dishes where 2.0 mL of each part extract as per treatment (except control) was previously added. After 48 h of incubation the shoot and root length of selected seven crop species were measured. All the laboratory experiments were conducted following completely randomized design (CRD) with three replications. The percentage of inhibition was calculated according to the equation (1) described by Islam et al. (2018b):

$$\text{Inhibition } (\%) = 1 - \frac{\text{Length in aqueous extract}}{\text{Length in control}} \times 100 \quad (1)$$

Statistical analysis

Data recorded on growth inhibition was compiled and tabulated for statistical analysis. The data were analyzed by using R Statistics Software (Version 3.5.0). Significant differences between treatments and control were examined using Tukey's HSD test at a 0.05 probability level.

RESULTS

The aqueous extracts of different parts of *J. curcas* significantly inhibited the shoot and root growth of all the test species (Tables 1-7). Concentration dependent inhibitory activity was observed in all cases whereas, concentration at or lower than 1:15 (*w/v*) stimulated the shoot and/or root growth of most of the test species. Moreover, root growth of the test species inhibited more than their shoots irrespective of *J. curcas* parts extract (Tables 1-7).

Effect of aqueous extracts of *J. curcus* plant parts on jute seedling growth inhibition

At 1:5 *(w/v)* concentrations, *J. curcas* seed and oilcake extract completely (100%) inhibited the shoot and root growth of jute. Whereas, both leaf and stem extract showed more than 70% shoot and root growth inhibition of jute at the same concentration (Table 1). At 1:5 *(w/v)* concentration, the lowest inhibition was found in pericarp extract for shoot growth (22%) and *Jatropha* root extract for root growth (31%) of jute seedlings. The shoot and root growth of jute were stimulated by all the *Jatropha* parts extract except by leaf and oilcake on shoot, and leaf, oilcake and seed on root growth at 1:20 (*w/v*) concentration. At the same concentration around 50% shoot and root growth stimulation was found in jute by *J. curcus* stem extract (Table 1).

Table 1. Effect of different plant parts of *J. curcus* on the shoot and root growth inhibition/stimulation of jute

Plant parts	Shoot growth				Root growth			
	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)
Bark	-27.01bc	-2.53bc	22.98cd	56.09bc	-25.05bc	2.043bc	21.29cd	42.90de
Leaf	19.08ab	33.54ab	49.42bc	72.34b	24.02ab	24.50abc	50.80bc	82.09ab
Oilcake	66.98a	82.86a	98.11a	100.0a	69.65a	79.47a	94.51a	100.0a
Pericarp	-35.54bc	10.74bc	15.15cd	21.76e	-7.38bc	20.48bc	32.47bcd	62.18cd
Root	-24.21bc	0.79bc	4.40d	45.60cd	-25.29bc	-23.53c	7.06d	31.18e
Seed	-8.25bc	36.59ab	92.27ab	100.0a	20.16ab	36.08ab	66.46ab	100.0a
Stem	-49.42c	-30.89c	-3.17d	76.24b	-49.99c	21.98bc	19.82cd	78.45bc
Twig	-42.22bc	-28.36c	-4.69d	25.03de	-56.52c	-21.92c	27.72cd	43.48de
Level of sig.	*	*	***	***	***	*	**	***
C.V. (%)	-5.47	7.18	6.47	4.69	-3.68	7.35	5.84	4.85
LSD	63.18	56.35	44.24	22.11	51.78	55.87	38.52	19.45

In column, means followed by different letters are significantly different. *** Means significant at 0.1% level of probability. The positive value indicates inhibition whereas, the negative value indicates stimulation by the extract.

Table 2. Effect of different plant parts of *J. curcus* on the shoot and root growth inhibition/stimulation of mungbean

Plant parts	Shoot growth				Root growth			
	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)
Bark	-12.76bcd	23.75abc	38.29ab	74.82ab	-21.58ab	5.06abc	7.05bc	49.33bc
Leaf	13.24abc	26.48ab	19.51b	42.16c	-5.29ab	12.92abc	20.83b	26.13cd
Oilcake	36.23a	38.26a	37.68ab	95.65a	14.40a	25.92a	28.60b	94.23a
Pericarp	-14.01bcd	-6.80bc	39.86ab	35.91c	-22.02ab	-13.47cd	4.66bc	17.35d
Root	15.66ab	29.79ab	61.03a	73.86ab	-36.30ab	-2.39bc	55.47a	72.94ab
Seed	-29.70cd	-13.17cd	54.45a	70.19b	-58.71b	18.09ab	19.68b	76.74ab
Stem	-50.36d	-44.69d	-23.01c	29.94c	-26.33ab	-30.79d	-13.33c	10.21d
Twig	-0.50abc	3.12abc	17.91b	23.95c	-19.48ab	8.69abc	13.02b	30.43cd
Level of sig.	*	**	**	***	*	*	**	***
C.V. (%)	-3.42	6.47	7.36	5.47	4.21	6.57	4.36	5.63
LSD	43.62	38.15	32.71	25.03	56.76	27.56	24.66	31.83

Other details are same as Table 1.

Effect of aqueous extracts of *J. curcus* plants parts on mungbean seedling growth inhibition

At concentration 1:5 (*w/v*), oilcake extract showed more than 90% shoot and root growth inhibition of mungbean (Table 2). The bark, root and seed extract of *Jatropha* showed more than 70% shoot growth inhibition, whereas root and seed extract showed more than 70% root growth inhibition of mungbean at the same concentration (Table 2). At 1:5 *(w/v)* concentration, the lowest inhibition was found in twig extract for shoot growth (24%) and stem extract for root growth (10%) of mungbean seedlings. The shoot and root growth of mungbean were stimulated by all *J. curcus* parts extract except by leaf, root and oilcake on shoot, and only oilcake on root growth at 1:20 (*w/v*) concentration. At the same concentration, more than 50% shoot and root growth stimulation was found in mungbean by *J. curcus* stem and seed extract, respectively (Table 2).

Effect of aqueous extracts of *J. curcus* plants parts on mustard seedling growth inhibition

At 1:5 *(w/v)* concentration, *J. curcas* seed and oilcake extract completely (100%) inhibited the shoot and root growth of mustard (Table 3). At the same concentration, root and twig extract showed more than 70% shoot growth inhibition. Whereas, bark, root, stem and twig extract of *Jatropha* showed more than 70% root growth inhibition of mustard (Table 3). At 1:5 *(w/v)* concentration, the lowest inhibition was found in bark extract for shoot growth (52%) and pericarp extract for root growth (52%) of mustard seedlings. The shoot and root growth of mustard were stimulated by all the *J. curcus* parts extract except by leaf and root on shoot, and bark and root on root growth at 1:20 (*w/v*) concentration. At the same concentration, more than 70% shoot and 100% root growth stimulation were found in mustard by *J. curcus* seed extract (Table 3).

Effect of aqueous extracts of *J. curcus* plants parts on radish seedling growth inhibition

At 1:5 *(w/v)* concentration, *J. curcas* oilcake extract completely (100%) inhibited the shoot and root growth of radish (Table 4). At the same concentration, root, seed and twig extract showed more than 70% shoot growth inhibition. Whereas, root, seed, stem and twig extract of *Jatropha* showed more than 70% root growth inhibition of radish (Table 4). At 1:5 *(w/v)* concentration, the lowest inhibition was found in bark extract for shoot growth (34%) and bark extract for root growth (55%) of radish seedlings. The results showed that only seed and stem extract of *J. curcus* stimulated the shoot growth of radish whereas, leaf, bark and stem extract stimulated the root growth at 1:20 (*w/v*) concentration. At the same concentration, only leaf extract showed strong stimulation (93%) on the root growth of radish (Table 4).

Effect of aqueous extracts of *J. curcus* plants parts on tomato seedling growth inhibition

At 1:5 *(w/v)* concentration, *J. curcas* oilcake extract completely (100%) inhibited the shoot and root growth of tomato (Table 5). At the same concentration, bark, root, seed and twig extract showed more than 70% shoot and root growth inhibition. In addition, leaf extract of *Jatropha* showed more than 70% inhibition on the root growth of tomato (Table 5). At 1:5 *(w/v)* concentration the lowest inhibition was found in stem extract for shoot growth (20%) and pericarp extract for root growth (26%) of tomato seedlings. The shoot growth of tomato was stimulated by pericarp, seed, stem and twig extract of *J. curcus* at concentration 1:20 (*w/v*). On the other hand, root growth of tomato was stimulated by leaf, oilcake, pericarp, seed, stem and twig of *J. curcus* at the same concentration. At 1:20 (*w/v*) concentration more than 40% and 70% tomato root growth stimulation was found by *J. curcus* pericarp and twig extract, respectively (Table 5).

Table 3. Effect of different plant parts of *J. curcus* on the shoot and root growth inhibition/stimulation of mustard

Plant parts	Shoot growth				Root growth			
	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)
Bark	-19.68b	-15.28b	-7.77d	51.81c	0.49b	6.14cd	9.99c	73.46bc
Leaf	3.35ab	33.09a	51.08ab	63.30bc	-36.00cd	-10.77d	37.18bc	68.46c
Oilcake	-20.32b	38.21a	81.30a	100.0a	-28.76bcd	37.47ab	82.35a	100.0a
Pericarp	-10.61b	4.24b	8.49cd	58.09c	-8.82bc	-1.38d	0.53c	51.86d
Root	37.07a	47.41a	63.79a	79.31b	38.80a	51.74a	63.68ab	78.11bc
Seed	-74.62c	-69.89c	40.32abc	100.0a	-111.33e	-40.33e	32.66bc	100.0a
Stem	-25.20b	-0.46b	11.15bcd	64.46bc	-52.08d	-10.22d	13.94c	71.59bc
Twig	-20.42b	-14.04b	10.14bcd	75.77b	-4.55bc	24.98bc	27.12bc	84.09b
Level of sig.	**	***	**	***	***	***	*	***
C.V. (%)	4.35	6.28	7.65	6.84	5.31	7.68	8.29	4.51
LSD	38.48	25.93	42.41	16.83	35.03	22.58	42.78	14.22

Other details are same as Table 1.

Table 4. Effect of different plant parts of *J. curcus* on the shoot and root growth inhibition/stimulation of radish

Plant parts	Shoot growth				Root growth			
	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)
Bark	3.87b	18.45b	23.81bc	33.93d	-27.40c	-10.73d	-6.05d	44.97c
Leaf	6.52b	13.97b	18.27c	53.62c	-92.89d	-86.44e	-55.32e	46.12c
Oilcake	1.46b	24.54b	81.68a	100.0a	13.11b	49.70b	92.40a	100.0a
Pericarp	9.11b	13.07b	17.22c	67.12bc	1.60bc	14.48c	18.00c	67.52b
Root	50.26a	62.10a	72.63a	82.63ab	66.74a	70.86a	81.97a	88.64a
Seed	-14.67b	-6.84c	29.03bc	97.41a	5.50b	32.58bc	40.17b	98.26a
Stem	-15.46b	8.61bc	28.22bc	69.32bc	-28.15c	13.95c	48.75b	81.72ab
Twig	4.12b	16.16b	41.17b	72.47b	3.99b	16.71c	49.71b	86.20a
Level of sig.	*	***	***	***	***	***	***	***
C.V. (%)	8.01	7.63	5.12	7.20	4.14	6.04	5.47	7.41
LSD	32.37	19.61	17.94	18.46	30.66	21.09	17.99	18.39

Other details are same as Table 1.

Effect of aqueous extracts of *J. curcus* plants parts on rice seedling growth inhibition

Rice seedling showed less sensitivity to any parts extract of *J. curcus* compare to other test species. At 1:5 *(w/v)* concentration, only oilcake extract showed more than 50% shoot growth inhibition (Table 6). Whereas, at the same concentration more than 60% root growth inhibition was observed when rice seed was treated with leaf, oilcake and seed extract of *Jatropha* (Table 6). At 1:5 *(w/v)* concentration the lowest inhibition was found in root extract for shoot (11%) and root (27%) growth of rice seedlings. The rice shoot growth was stimulated by all the *J. curcus* parts extract except leaf and pericarp at concentration 1:20 (*w/v*). At the same concentration, only bark, root and seed extract of *J. curcus* stimulated the rice root growth. However, no strong stimulation was found in rice seedling growth by any *J. curcus* parts extract (Table 6).

Table 5. Effect of different plant parts of *J. curcus* on the shoot and root growth inhibition/stimulation of tomato

Plant parts	Shoot growth				Root growth			
	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)
Bark	20.44a	34.80a	56.35b	80.11ab	12.04a	29.01a	36.11bc	75.30a
Leaf	7.83ab	15.06abc	29.51c	65.66b	-6.27abc	6.27ab	13.28c	70.42a
Oilcake	4.67abc	33.64a	85.98a	100.0a	-5.12abc	33.52a	86.93a	100.0a
Pericarp	-3.84abc	14.42abc	17.95c	35.57c	-46.94cd	-5.56b	16.67c	26.11b
Root	12.50ab	27.27ab	27.27c	87.50ab	12.29a	22.38ab	30.71bc	86.03a
Seed	-25.97bc	-29.18d	57.14b	85.71ab	-38.04bcd	-9.79b	53.15b	82.51a
Stem	-13.43abc	5.973bc	16.22cd	19.90c	-2.36ab	6.30ab	7.87cd	31.61b
Twig	-35.78c	-7.74cd	-5.28d	72.95b	-74.92d	-52.57c	-19.95d	72.20a
Level of sig.	*	**	***	***	**	**	***	**
C.V. (%)	-5.43	7.45	5.74	7.23	-5.45	7.35	5.25	7.35
LSD	41.21	25.39	22.74	22.41	44.27	33.05	29.50	32.67

Other details are same as Table 1.

Table 6. Effect of different plant parts of *J. curcus* on the shoot and root growth inhibition/stimulation of rice

Plant parts	Shoot growth				Root growth			
	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)
Bark	-1.53abc	4.43bc	20.27ab	27.25bc	-0.29c	3.236 c	17.45b	38.72bc
Leaf	10.88 a	19.0a	26.77a	43.00ab	19.29a	29.65a	45.16a	62.51ab
Oilcake	-11.69cd	-5.39cd	2.10c	58.47a	5.506bc	6.10c	28.62ab	72.57a
Pericarp	4.69ab	5.22bc	13.08abc	25.35bc	12.06abc	16.94abc	24.78ab	41.85abc
Root	-20.68d	6.46abc	6.84bc	11.31c	-28.92d	-19.55d	-9.06c	26.47c
Seed	-10.65cd	-8.52d	7.25bc	14.34c	-21.36d	-16.77d	-16.04c	67.10ab
Stem	-4.99bc	7.73b	15.56abc	17.40c	14.62ab	25.12ab	26.08ab	57.14abc
Twig	-5.79bc	0.0bcd	10.82abc	14.06c	4.90bc	9.52bc	13.29b	28.50c
Level of sig.	**	*	**	*	***	***	***	*
C.V. (%)	3.02	7.18	6.47	5.69	4.37	7.45	6.24	7.41
LSD	12.60	12.61	16.58	25.30	13.07	17.48	21.30	31.41

Other details are same as Table 1.

Effect of aqueous extracts of *J. curcus* plants parts on wheat seedling growth inhibition

At 1:5 *(w/v)* concentration, *J. curcas* oilcake extract completely (100%) inhibited the shoot and root growth of wheat (Table 7). At the same concentration, seed and stem extract showed more than 70% shoot growth inhibition. Whereas, root and stem and extract of *Jatropha* showed more than 70% root growth inhibition of wheat (Table 7). At 1:5 *(w/v)* concentration the lowest inhibition was found in twig extract for shoot (23%) and pericarp extract for root (40%) growth of wheat seedlings. The shoot growth of wheat was stimulated by leaf, oilcake, seed and twig extract and the root growth was by leaf, seed and twig extract of *J. curcus* at 1:20 (*w/v*) concentration. At the same concentration only seed extract showed more than 50% shoot growth stimulation of wheat (Table 7).

Table 7. Effect of different plant parts of *J. curcus* on the shoot and root growth inhibition/stimulation of wheat

Plant parts	Shoot growth				Root growth			
	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)	1:20 (w/v)	1:15 (w/v)	1:10 (w/v)	1:5 (w/v)
Bark	10.77a	25.77abc	27.31bc	31.15c	13.18a	17.62abc	27.50cd	41.54d
Leaf	-31.57ab	-24.81c	1.506c	26.31c	-25.16a	-21.32c	-2.77d	49.68cd
Oilcake	-6.09ab	70.73a	78.04a	100.0a	5.27a	66.45a	79.53a	100.0a
Pericarp	3.29ab	16.33bc	25.75bc	27.42c	4.65a	29.43ab	29.73bcd	39.64d
Root	1.16ab	17.54bc	49.71ab	64.91b	14.23a	23.40abc	52.06abc	71.53bc
Seed	-50.69b	36.80ab	71.69a	73.61b	-21.26a	25.59abc	63.64ab	68.35bc
Stem	18.55a	23.38abc	33.06bc	87.09ab	21.92a	25.42abc	32.48bc	88.25ab
Twig	-15.05ab	7.53bc	21.50bc	22.58c	-13.84a	13.02bc	48.19abc	68.42bc
Level of sig.	*	*	**	***	NS	**	**	***
C.V. (%)	-3.60	5.68	7.41	5.74	7.11	6.45	8.14	6.47
LSD	54.40	52.55	36.82	23.56	48.57	49.87	34.30	23.10

Other details are same as Table 1.

DISCUSSION

Jatropha curcas has now gained popularity as biodiesel plant in different countries to combat the hazardous effect of fossil fuel. This plant is cultivated in wider spacing and therefore, several crops are suggested to cultivate as intercrops in between the rows of *Jatropha* for maximizing the total returns and better utilization of land resources. However, before introducing any intercrops, it is necessary to evaluate phytotoxic effect of *J. curcas* on target crops. The present study investigates the allelopathy potentiality of the different parts of *J. curcus* on seven selected field crop species under laboratory condition. It was observed that different *J. curcus* parts aqueous extract significantly inhibited the shoot and root growth of all the crop species (except few) at or more than 1:15 (*w/v*) concentration. However, concentration lower than 1:15 (*w/v*) mainly stimulated the test species. These type of concentration dependent inhibitory activity of *J. curcus* plant extract were also reported by Abugre and Sam (2010), Ma et al. (2011), Reichel et al. (2013), Khattak et al. (2015), Irshad et al. (2016) and Baruah et al. (2018).

A number of articles are available in literature about the allelopathy of *J. curcus* leaf and root extracts on different crop species. For example, germination and initial growth of maize and tobacco were inhibited by the aqueous extracts of *J. curcus* (Ma et al., 2011). Abugre and Sam (2010) reported that the aqueous leaf extract had greater inhibitory effect than root extract on germination, plumule and radicle length of common bean, maize, tomato and ladies finger. From a bioassay experiment, Rejilia and Vijaykumar (2011) reported the germination and growth suppressing behavior of *J. curcus* leaf extract on green chilli and sesame. Similar types of inhibitory effects were also reported by Tomar and Agarwal (2013) on wheat by *J. curcus* leaf leachate. However, the current research evaluated all the parts of *J. curcus* including leaf and roots. The inhibitory activities of different *J. curcus* parts on test crop specific were observed, and it varied from 10 to 100%. Inhibitory activity increased with the increasing concentration of the extract irrespective of *J. curcus* parts and test species. At 1:5 *(w/v)* concentration *J. curcas* oilcake extract completely (100%) inhibited the shoot and root growth of all the test crop species except rice. At the same concentration *J. curcus* seed extract completely inhibited (100%) the shoot and root growth of jute and mustard, whereas around or more than 70% inhibition of the shoot and root growth of all other test species was

observed. At this concentration the average sensitivity of the test species to *J. curcus* extracts appeared in the order of mustard>radish>tomato>jute>mungbean>wheat>rice for shoot growth, and mustard>radish>tomato>jute>wheat>rice>mungbean for root growth. Abugre and Sam (2010) reported higher inhibitory activity of *J. curcus* leaves and roots extract on ladies finger than common bean, maize and tomato. Whereas, Sanderson et al. (2013) reported no adverse effect of *J. curcus* leaf extract on the germination of lettuce but after germination, increase in concentration inhibited its seedling growth appreciably.

Jatropha curcus oilcake has been suggested by many researchers to use as organic manure due to its higher nitrogen (3.2%) and phosphorus (1.4%) content (Gubitz et al., 1999; Openshaw, 2000; Keremane et al., 2003). But in the present research it was observed that *J. curcus* seed oilcake completely inhibited (100%) the shoot and root growth of all the test plant species except rice at the highest concentration. In addition, the seed oilcake was more phytotoxic than leaf or root or any other parts of *J. curcus*. At 1:5 (*w/v*) concentration the average inhibitory potential of the different parts extract of *J. curcus* followed the order oilcake>seed>root>leaf>stem>bark>twig>pericarp for shoot growth and oilcake>seed>root>stem>twig>leaf>bark>pericarp for root growth of the test species. The inhibitory activity of *J. curcus* seed oilcake is also supported by the findings of Heller (1996), who reported that *J. curcus* seed cake used as bio-fertilizer inhibited the seedling growth of tomato. Contrary to these studies, Mavankeni (2007), Olowoake (2014) and Inyew et al. (2019), who reported an improvement of growth and yield of maize, *Amaranthus caudatus* and potatoes when *J. curcus* seed cake at the rate of 0.78 to 2.5 t ha^{-1} was supplemented with inorganic fertilizer compare to the sole application of NPK fertilizer. The current research also observed a growth promotion by *J. curcus* parts extract at lower concentration. Percent shoot and root growth stimulation of the test crops varied among *J. curcus* parts extract from 0.3 to 111%, at 1:20 *(w/v)* concentration. The stimulatory activity of *J. curcus* under field condition could be due to the following three reasons: (i) the strong phytotoxic activity of seed oilcake in laboratory may degrade in field condition by environmental factors (Qasem, 2010; Islam et al., 2019), or (ii) the compound(s) present in seed oilcake may stimulate the growth at lower concentration and inhibit at higher concentration due to hormesis effect (Stebbing, 1982; Calabrese & Baldwin, 1997; Liu et al., 2011; Islam et al., 2014), or (ii) the phytotoxic compound(s) present in seed oilcake is crop specific (Abugre & Sam, 2010). Therefore, before supplementing *J. curcus* plant residues with inorganic fertilizer the amount of allelochemicals released from the residue or the nature of intercrops should be taking under consideration.

CONCLUSION

The shoot and root growth inhibition of rice, wheat, jute, tomato, radish, mungbean and mustard by leaf, bark, stem, twig, root, pericarp, seed and seed oilcake extracts of *J. curcus* varied significantly. Compared to the shoot growth, root growth of the test species were inhibited more. Among the plant parts seed oilcake completely (100%) inhibited the shoot and root growth of all the test species except rice seedlings. The average inhibitory potential of the different parts extract of *J. curcus* followed the order, oilcake>seed>root>leaf>stem>bark>twig>pericarp for shoot growth and oilcake>seed>root>stem>twig>leaf>bark>pericarp for root growth of the test species at 1:5 (*w/v*) concentration. Since oilcake of *J. curcus* extract had greater inhibitory activity than other parts, this plant part could be used for isolation and identification of allelochemicals. On the other hand, *J. curcus* parts extract have growth promotive activity at concentration 1:20 (*w/v*). Hence, the findings of this experiment would be helpful for the researchers to know the

prospects of *J. curcus* seed oilcake or its other parts as organic manure. However, more research under laboratory and field condition should be conducted to know the allelopathic properties of *J. curcus* and the allelochemicals responsible for its phytotoxic activity.

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Disclosure statement

All the authors declare that there is no conflict of interest in publishing this manuscript.

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