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ARTICLE

Allelopathic Potential of Three Oil Enriched Plants against Seedling Growth of Common Field Crops

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ABSTRACT

Current study aims to investigate the allelopathic potential of the different parts (leaf, bark, stem, twig and root) of three oil-enrich plant species of Bangladesh *viz*., *Jatropha curcus*, *Ricinus communis* and *Aphanamixis polystachya*. The aqueous extract of those plant parts were diluted into four different concentrations *viz*., 1:5, 1:10, 1:15, 1:20 (*w/v*) and tested against the seedling growth of jute, rice, wheat, radish, tomato, mungbean and mustard under control laboratory condition. A control (distilled water without extract) was also maintained in every cases and the bioassay experiment was replicated thrice. The results of this research showed that the shoot and root growth inhibition of rice, wheat, jute, tomato, radish, mungbean and mustard by leaf, bark, stem, twig and root extracts of *J. curcus*, *R. communis* and *A. polystachya* varied significantly. Compare to the shoot growth, the root growth of the test species inhibited more except *J. curcus*. The leaf and root have higher allelopathic potential than any other parts of the studied plants. Finally, it can be concluded here that *J. curcus* plant extracts has higher allelopathic potential than other two plants *R. communis* and *A. polystachya*. Therefore, *J. curcus* can be used as a candidate plant for isolation and identification of allelopathic substances for the development of new natural herbicides.

1. Introduction

Allelopathy, a process involving secondary metabolites produced by plants, microorganisms, viruses and fungi that influence the growth and development of neighboring plants. The allelopathic substances (compound released by allelopathic plants) upon release, may suppress the germination, growth and establishment of neighboring plants, even the secreting plant itself either directly by affecting their physiological properties [1], or indirectly by modifying the rhizosphere soil properties [2]. Several areas of allelopathy have already been studied by the researchers around the world and some studies are in progress, although some areas are needed to be studied extensively to implicate the mechanism of allelopathy successfully. It has been reported that more than 5000 plant species are available in Bangladesh. Among them only very few species have been studied so far for their

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allelopathic potentiality.

Ricinus communis L. is a non-edible crop belonging to the family Euphorbiaceae grown under tropical, sub-tropical and temperate regions [3]. The plant generally grows wild in waste lands of Bangladesh. *Ricinus communis* is well known for many of its medicinal and industrial uses [4,5,6,7]. All parts of *R. communis* (bark, leaves, flowers, seed, oil etc.) are used for the treatment of different ailments. The leaf, root and seed oil of this plant have been used for the treatment of the inflammation and liver disorders, hypoglycemic and laxative. Oil of *R. communis* is widely used in ayurveda, unani, homeopathic and allopathic system of medicines as cathartic. The plant also have antioxidant, anti-inflammatory, antidiabetic, antitumour, larvicidal and antinociceptive properties [8,9].

Aphanamixis polystachya (Wall.) R.N. Parker, belonging to Meliaceae family, a large evergreen tree found in India and Bangladesh. The plant is commonly known as Roina or Pittraj in Bangladesh, and are very well known for its medicinal [10, 11], insecticidal [12] and biodiesel properties [13]. Different parts of this plant has been reported to possess analgesic [14], antimicrobial [15,16,17], antioxidant [18,19], antitumor [10], CNS depressant [14], cytotoxic [19], hepatoprotective [20], insecticidal [12], laxative [15], membrane stabilizing [19], anticancer [21] and thrombolytic [17] properties. The plant has also antibacterial, mild antifungal [11], antifeedant, repellant properties, and contact toxicity to beetles [12].

Jatropha curcas, a multipurpose shrub belonging Euphorbiaceae family. The plant is originated from Maxico, but now thrives in many parts of the tropical Asia and Africa [22,23,24,25]. *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 [22]. The plant extracts and isolated substances have molluscicidal, insecticidal, fungicidal, antidiarrhoeal, wound healing and anti-inflammatory properties [26,27,28,29].

Besides, oil-enrich plants *J. curcas*, *A. polystachya*, *R. communis* are well known for the production of bio-diesel [31,32]. Although a number of evidences are found in the literature about the industrial, pharmacological, and/or toxicological properties of these plants, research articles about their allelopathic potentiality have rarely been reported [33,34,35,36]. Even though few reports have been documented, those are very preliminary work rather than details phytotoxic studies of their specific organs [33,37,38,39]. Hence, details allelopathic study of *J. curcas*, *R. communis* and *A. polystachya* in laboratory conditions to investigate their actual allelopathic potentiality is necessary. Keeping all these in views, the present research was conducted to assess the allelopathic potential of three oil-enriched plants parts' (leaf/twig/bark/stem/root) extracts on the seedling growth of some field crops under laboratory condition.

2. Materials and Methods

2.1 Experimental Site

The experiment was conducted at the Agro Innovation Laboratory, Department of Agronomy, Bangladesh Agricultural University (BAU), Bangladesh.

2.2 Collection of Plant Materials

Different parts (leaf, bark, stem, twig and root) of three oil-enriched plants *e.g.*, *Jatropha curcus*, *Ricinus communis* and *Aphanamixis polystachya* were collected between July and October 2017 from different locations of Mymensingh district, Bangladesh.

2.3 Test Plants

Seeds of seven field crops *viz.*, jute (*Corchorus capsularis*), rice (*Oryza sativa*), wheat (*Triticum aestivum*), tomato (*Solanum lycopersicum*), radish (*Raphanus sativus*), mungbean (*Vigna radiata*) and mustard (*Brassica* spp.) were used as a test plants. Radish was used in this experiment because it is highly sensitive to allelochemicals even at very low concentrations [40].

2.4 Extraction and Bioassay Procedure

One hundred gram of each collected plant parts was crashed into paste by a grinder and soaked with 400 mL distilled water and homogenized in a warring blender for 5 minutes at 25°C. 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 filed with distilled water up to the mark, and homogenized by manual shaking. The prepared concentration was considered as full strength concentration *i.e.* 1:5 (*w/v*), and was then stored at 4°C as a stock solution until used. The extraction of each plant parts of three plant species was done separately.

The prepared aqueous extracts (stock solution) was then diluted into three concentration *viz.* 1:10, 1:15 and 1:20 (*w/v*), respectively, and control (distilled water without extract) was also maintained. A small amount (2.0 mL) of plant extract concentration was added to a sheet of filter paper (No.2) in a 28 mm Petri dish. Twenty seeds of rice, wheat, jute, tomato, mungbean, mustard or radish were then arranged on the filter paper in each Petri dish. The experiment was conducted following a completely randomized block design with three replications. The bioassay experiment for each plant parts was done separately. After 48h of incubation the shoot and root growth of rice, wheat, jute, tomato, mungbean, mustard or radish were measured. The percentage of inhibition was then calculated according to the equation described by Islam et al. [41] as stated below –

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

2.5 Statistical Analysis

Data recorded on growth inhibition was compiled and tabulated for statistical analysis. The data were analyzed statistically by using R Statistics Software (Version 3.0). The mean differences among the treatments were adjudged following Duncan's Multiple Range Test.

3. Results

The results of the experiment showed that the inhibitory activity of *Jatropha*, *Ricinus*, *Aphanamixis* plant parts extract to the test species were concentration dependent. In addition, the variation of their inhibition to the test species is prominent only in 1:10 (*w/v*) concentration and therefore, in this paper only the results of that concentration have been presented and discussed.

3.1 Effect of *Jatropha* Extracts on the Seedling Growth of Field Crops

The aqueous extract of the different parts of *Jatropha* plant inhibited the shoot and root length of all field crops at different inhibition values (Figure 1 and 2). The results showed that wheat, radish, mungbean, mustard were highly sensitive to *Jatropha* root extracts and the inhibition value was 50, 73, 61 and 64%, respectively at 1:10 (*w/v*) concentrations (Figure 1). On the other hand, shoot growth of jute and mustard was sensitive to *Jatropha* leaf and their inhibition value was 50 and 51%, respectively at the same concentration. The bark extracts inhibited mostly the shoot growth of tomato by 56%. The shoot growth of rice is comparatively less sensitive to all the extracts.

Similar to shoot growth, the root growth of wheat, radish, mungbean, mustard were highly sensitive to *Jatropha* root extracts and the growth was inhibited by 52, 82, 56 and 64%, respectively at 1:10 (*w/v*) concentrations. Root growth of jute and rice was sensitive to *Jatropha* leaf extracts and were inhibited by 51 and 45%, respectively, whereas the root growth of radish was stimulated by 55% at the same concentration. Stem extracts of *Jatropha* inhibited the root growth of radish by 49%. Twig extracts inhibited the root growth of wheat and radish by 48 and 50%, respectively at 1:10 (*w/v*) concentrations (Figure 2).

3.2 Effect of *Ricinus* Extracts on the Seedling Growth of Field Crops

The aqueous extract of the different parts of *Ricinus* plant parts either inhibited or stimulated the shoot and root growth of all field crops at different inhibition values (Figure 3 and 4). The results showed that only the shoot growth of jute and radish was inhibited by *Ricinus* leaf by *Ricinus* twig by 40 and 74, respectively at 1:10 (*w/v*) concentrations (Figure 3). The shoot growth of jute, tomato, radish and mustard was inhibited by 40, 40, 40 and 55% by the twig of *Ricinus*, whereas, this extract stimulated the shoot growth of rice by 50% (Figure 3). The root extracts of *Ricinus* inhibited the shoot growth of jute by 58% and stimulated the growth of radish by 42% (Figure 3). The shoot growth of other crop species was not strongly inhibited by *Ricinus* parts extract rather stimulated by the extract at the same concentration (Figure 3).

The root growth of jute was strongly inhibited by leaf, twig and root extracts of *Ricinus* and the inhibition value was 63, 57 and 68%, respectively. The root growth of tomato, radish and mustard was inhibited by the twig extracts of *Ricinus* at 1:10 (*w/v*) concentrations and the inhibition value was 40, 59 and 82%, respectively (Figure 4). The root growth of tomato and mustard was inhibited by the stem extracts of *Ricinus* at values 40% or more. The root growth of radish was strongly inhibited by *Ricinus* leaf extracts and the value was 74%. The root extracts of *Ricinus* stimulated the root growth of radish by 99% at 1:10 (*w/v*) concentrations. The root growth of rice and wheat was not strongly inhibited by the extracts of different parts of *Ricinus* (Figure 4).

3.3 Effect of *Aphanamixis* Extracts on the Seedling Growth of Field Crops

The aqueous extract of different *Aphanamixis* plant parts either inhibited or stimulated the shoot and root growth of all field crops at different values (Figure 5 and 6). The results showed that only the shoot growth of radish was 74% inhibited by *Aphanamixis* leaf at 1:10 (*w/v*) concentrations (Figure 5). The shoot growth of jute and mustard was 47 and 46% inhibited by the root and twig extracts of *Aphanamixis*, respectively. The shoot growth of other crop species was not strongly inhibited by *Aphanamixis*

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parts extract rather stimulated by the extract at the same concentration (Figure 5). Root extracts of *Aphanamixis* stimulated the shoot growth of wheat by 45% (Figure 5).

The root growth of jute was strongly inhibited by leaf, twig and root extracts of *Aphanamixis* and their inhibition values were 60, 55 and 59%, respectively at 1:10 (*w/v*) concentrations. At the same concentrations the root growth of radish and mustard was inhibited by the twig extracts and their inhibition values were 50 and 77%, respectively (Figure 6). In addition 43% root growth inhibition of mustard occurred by the stem extracts of *Aphanamixis*. The root growth of rice, wheat, tomato and mungbean was not strongly inhibited by the extracts of different parts of *Aphanamixis* at 1:10 (*w/v*) concentrations (Figure 6). Moreover, at this concentration the root growth tomato was 75 and 71% stimulated by the bark and root extracts of *Aphanamixis*, respectively.

3.4 Average Inhibition of Seedling Growth of Field Crops by Different Plant Parts of Three Oil-enrirched Plants

Figure 7 showed the average inhibition values of different plant parts extract of *Jatropha*, *Ricinus* and *Aphanamixis* on different field crops at 1:10 (*w/v*) concentrations. The results showed that except the stem and root extracts of *Ricinus*, and root extract of *Aphanamixis* all other parts extracts showed inhibition to the test species. However, on an average the root extracts of *Jatropha* showed 41% inhibition on the shoot growth of test species (Figure 7).

Similar to shoot growth, except *Ricinus* and *Aphanamixis* root extracts all the parts showed inhibition on the root growth of the test species. The root extracts of *Jatropha* and twig extracts of both *Ricinus* and *Aphanamixis* showed 40, 43 and 40% root growth inhibition of the field crop species, respectively (Figure 7).

Compare to overall inhibition, *Jatropha* plant extracts equally inhibited the shoot and root growth of field crops (Figure 8). However, *Ricinus* and *Aphanamixis* extract inhibited the seedling growth of field crops but the root growth of the test species was more sensitive to their extract than the shoots (Figure 8).

4. Discussion

The aqueous extracts of different parts of *Jatropha*, *Ricinus* and *Aphanamixis* were evaluated against the seedling growth seven selected field crops. The extracts inhibited the seedling growth at different inhibition values. The inhibitory activity was test species, plant parts extract dependent. In few cases growth stimulatory activity was also observed. This type of growth inhibition by the aqueous extract of allelopathic plants was also reported by many researchers around the world [41,42,43,44,45,46,47,48].

The results of the study showed that average inhibition percent of test crops by the extracts of different parts of *Jatropha*, *Ricinus* and *Aphanamixis* differ among the extracts. In both cases of shoot and root growth inhibition *Jatropha* root extracts have the highest inhibitory activity on the test crop species as compared to other parts of the plant. Working with aqueous methanol extract of the leaves of *Ricinus* and *Jatropha* Islam and Kato-Noguchi [33] also reported test specific inhibitory activity by this two plant species. However, they observed higher germination and growth inhibitory activity of *Ricinus* than *Jatropha*. It might be due to the use of different test species and solvent of extraction. As it is well known that water cannot dissolve most of the non-polar bioactive sub-stances under room temperature.

The results showed that twig extracts of *Ricinus* and *Aphanamixis* were most phytotoxic to the test species than that of their other part. On the other hand, root extracts of *Jatropha* had greater inhibitory activity against the test species than that of its other part. Whereas, Tanveer et al. [49] concluded that leaf extract had a greater inhibitory effect than the other extracts while investigating the allelopathic effect of root, stem, leaf, and fruit water extracts on the seed germination and seedling growth of wheat, chickpea, and lentil.

5. Conclusion

The results of this research showed that the shoot and root growth inhibition of rice, wheat, jute, tomato, radish, mungbean and mustard by leaf, bark, stem, twig and root extracts of *Jatropha*, *Ricinus*, *Aphanamixis* varies significantly. Compare to the shoot growth, the root growth of the test species inhibited more except *Jatropha*. The leaf and root have higher allelopathic potential than any other parts of the studied plants. Finally, it can be concluded that *Jatropha curcus* plant extracts have higher allelopathic potential than other two plants *Ricinus communis* and *Aphanamixis polystachya*. Therefore, *Jatropha curcus* can be used as a potential candidate plant for isolation and identification of allelopathic substances. The findings of this experiment would be helpful for the researchers to know the plant-plant interaction of these plant species with their neighbors under natural settings.

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Disclosure Statement

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

Appendixes

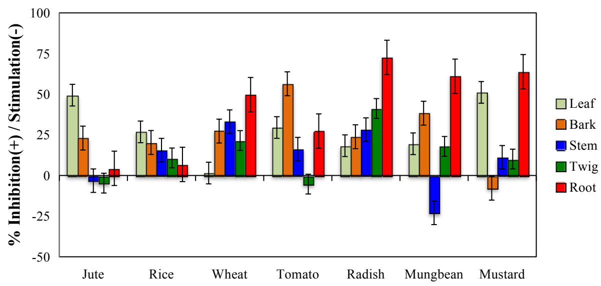

Figure 1. Effect of different parts extract of *Jatropha* plant on the shoot growth of field crop species

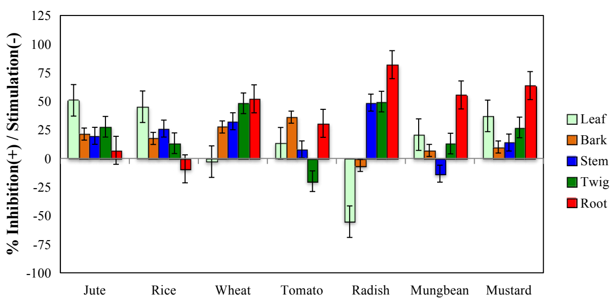

Figure 2. Effect of different parts extract of *Jatropha* plant on the root growth of field crop species

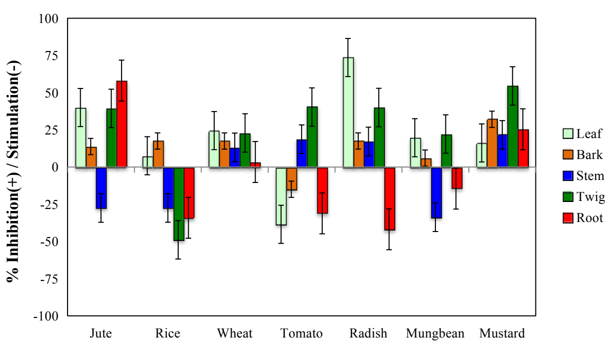

Figure 3. Effect of different parts extract of *Ricinus / plant* on the shoot growth of field crop species

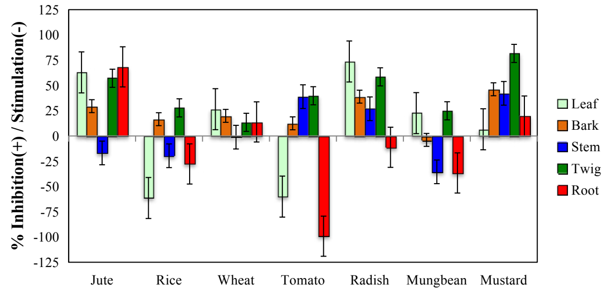

Figure 4. Effect of different parts extract of *Ricinus / plant* on the root growth of field crop species

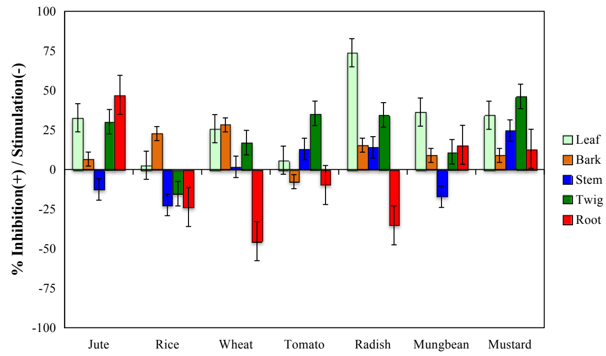

Figure 5. Effect of different parts extract of *Aphanamixis / plant* on the shoot growth of field crop

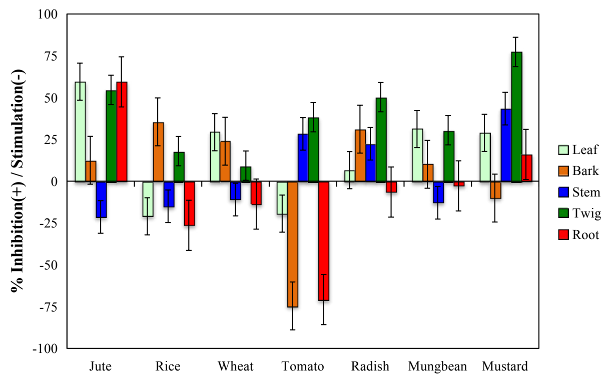

Figure 6. Effect of different parts extract of *Aphanamixis / plant* on the root

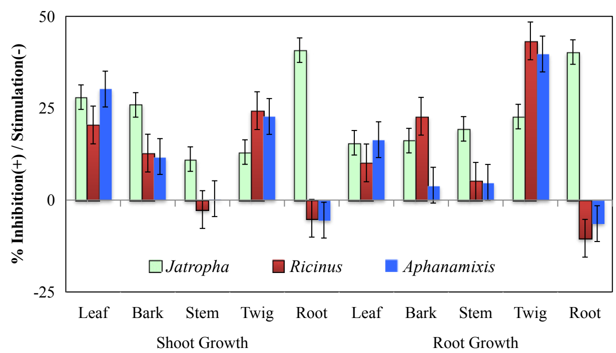

Figure 7. Average inhibitions of shoot and root growth of field crops by different plant parts of *Jatropha*, *Ricinus* and *Aphanamixis*

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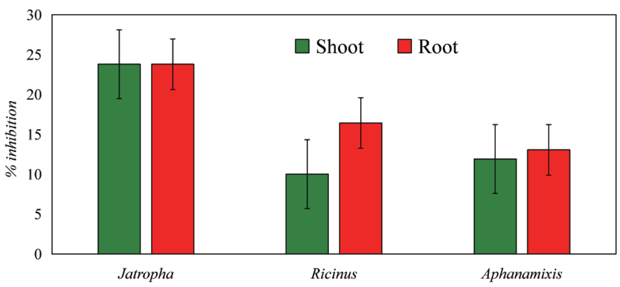

Figure 8. Overall inhibitions of shoot and root growth of seven field crops by *Jatropha*, *Ricinus* and *Aphanamixis*

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