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Effects of Allelochemical of *Jatropha curcas* L. Leachate on Germination and Shooting of Four (4) Pepper (*Capsicum*) Species in Keffi Nasarawa State, Nigeria

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Abstract

A laboratory study was carried out to evaluate the effect of leaf aqueous extract of *Jatropha curcas* L. on germination and early shoot growth of four pepper (Capsicum) species at the Department of Plant Science and Biotechnology Laboratory, Nasarawa State University, Keffi, Nigeria. Data collected were percentage inhibition and shoot length. Results from the experiment indicated that there was significant difference between the treatments (4%, 8%, 12%, 16% and 20%) and the control (0%) and within the treatments at $P \leq 0.05$. All the test crops were affected by different concentrations of the aqueous extracts and the most pronounced effect was at 12%, 16% and 20% concentrations of the extracts in all cases respectively. Germination, shooting were inhibited completely at higher concentrations in the cases when compared with the control. The inhibitory effect was found to be concentration dependent and may be due to the presence of water soluble allelochemicals like phenols, tannins and azeliac acid.

Subject Areas

Plant Science

Keywords

Jatropha curcas, Capsicum, Aqueous, Allelochemicals, Phenols, Azeliac

1. Introduction

Allelopathy refers to the beneficial or harmful effects of one plant on another plant, both crop and weed species, by the release of chemicals from plant parts by leaching, root exudation, volatilization, residue decomposition and other processes in both natural and agricultural systems [1]. The failure of most crops in agro forestry systems has been attributed to allelopathic effects of tree species. A number of allelochemicals are present in cells and tissues of plants [2] [3] and this phenomenon is as a result of phytochemicals exuded by trees. These chemicals are largely classified as secondary metabolites (such as alkaloids, isoprenoids, phenolics, flavonoids, terpenoids and gluconolactes, etc.) [4].

According to [5], this process can be defined as the studies involving any process with secondary metabolites which are produced by plants, algae, bacteria and fungi, which may affect the growth and development of agricultural production and biological systems. When released, the allelochemicals may influence the growth and development of surrounding biological systems [6] and can even be used to control undesirable plants [7] in agriculture , in rotating systems such as *Helianthus annuus* that when grown before soybean (*Glycine max* (L.) Merr.) reduces the amount of weed species [8], terpenes, and phenols [9] that can combat herbivorous insects and fungi, besides influencing the growth of other plants [10].

First widely studied in forestry systems, allelopathy has been found to have effect on many aspects of plant ecology including occurrence, growth, plant succession, and the structure of plant communities, dominance, diversity, and plant yield. Initially, many of the forestry species evaluated had negative allelopathic effects on food and fodder crops, but in the 1980s research was begun to identify species that had beneficial, neutral, or selective effects on companion crop plants. *Jatropha curcas* L. is a perennial poisonous shrub belonging to the family of Euphorbeaceae. The plant originates from Central America to tropical and subtropical countries and mainly grows in Asia and Africa. Common names include Barbados nut, purge nut, physics nut, black vomit nut, or curcas bean. The Hausa people of Northern Nigeria called it "Bini-da-zugu". *J. curcas* has gained popularity as biodiesel plant both in developed and developing countries of the world. Its seed contains predominantly crude fat (oil), protein and fibres [11]. *Jatropha* oil is non-edible and is mainly used as biodiesel energy [12] [13]. The potentials of *J. curcas* as a biodiesel source have resulted in the increased cultivation and domestication of the plant because of government interest in renewable energy. For this reason, *Jatropha* is an attractive crop and it is being contributed to augmenting the income of farmers by improved agronomic procedures like selection of the suitable intercropping systems and by increasing the efficiency of rural agricultural processes [14]. Throughout the world, including India, *Jatropha* has been cultivated along with other crops; in particular, it is cultivated along with groundnut, sunflower, green gram, green chilli, sesame etc.

Allelochemicals have a variety of chemical structures and actions. However,

their effects on biochemical and physiological processes of target plants have not been investigated thoroughly [15]. Therefore, it is necessary to evaluate the phytotoxic effects of *J. curcas* on agricultural crops before its introduction into the agroforestry system especially with the common practice among local farmers to combine trees and or shrubs with annuals or perennials.

In the present work, an attempt has been made to evaluate the allelopathic effect of *Jatropha curcas* aqueous leaf extracts on the seed germination and shoot-growth of four (4) pepper species locally grown in Keffi Local Government Area of Nasarawa state.

2. Materials and Methods

2.1. Study Area

A laboratory study was carried out at the Department of Plant Science and Biotechnology laboratory, Nasarawa State University Keffi, Nigeria. Longitude 8.8558˚N and Latitude 7.8694˚. The temperature range is between 25˚C - 30˚C and at about 602 mm of precipitation fall annually. It is in the northwest of Lafia, the state capital of Nasarawa State, Nigeria [16].

2.2. Sample Collection and Preparation

Fresh and matured leaves of *J. curcas* were collected from the botanical garden of the Department of Plant Science and Biotechnology, Nasarawa State University. The procedure for the preparation of aqueous leaf extracts was adopted from [17]. The leaf samples were dried under shade in the laboratory, powdered (2 mm mesh sieve) and used for bioassay treatment. Seeds of Bell pepper (*Capsicum annum*), Cayenne pepper (*C. frutescens*), Bird-eye pepper (*C. frutescens*) and Tatase (*C. annum*) were obtained from the Institute for Agricultural Research Samaru, Zaria, Kaduna State, Nigeria.

2.3. Preparation of Aqueous Leaf Extract

The dried leaves were ground to a fine powder in a mortar (2 mm mesh sieve). Using this powder, aqueous extracts were prepared by the method of [17]. Different amounts; 100 g/500ml, 80 g/500ml, 60 g/500ml, 40 g/500ml, 20 g/500ml and 0 g/500ml (control) of ground leaf sample were dissolved in autoclaved distilled water in 1000 ml conical flask. These gave a percentage leaf extract in 100 ml of water of 20%, 16%, 12%, 8%, 4%, and 0% (control) respectively.

2.4. Bioassay Studies

The seeds of crops were primed in distilled water for 1hour. Bioassay studies were carried out following the method of [14]. Ten seeds of crop (each pepper species) were placed on Whatman No1 filter paper in petriplates (9 cm × 2 cm). Petriplates were moistened with 2 ml/plate of leaf extract, distilled water (control) and incubated under laboratory condition. Seeds from each pepper were subjected to the five (5) treatments. Percentage Inhibition and shoot length were

measured after 15 days. (Five seedlings were randomly harvested from each petriplate to determine average shoot length).

2.5. Data Analysis

The data were analysed by one way analysis of variance (ANOVA). Different means were considered statistical significant at $p < 0.05$.

2.6. Treatment and Concentrations Used

1) Control (T_o) seeds supplied with autoclaved distilled water.
2) T_1 seeds supplied with 4% extract solution.
3) T_2 seeds supplied with 8% extract solution.
4) T_3 seeds supplied with 12% extract solution.
5) T_4 seeds supplied with 16% extract solution.
6) T_5 seeds supplied with 20% extract solution.

3. Result

Table 1 shows percentage inhibitory effect of *Jatropha curcas* L. aqueous leaf extract on germination of four pepper species studied. The treatments (T_3-T_5) recorded 100% inhibition in all the cases.

Table 2 shows the allelopathic effect of aqueous leaf extract of *Jatropha curcas* L., on the shoot length of Cayenne pepper (*Capsicum annum*). Based on the average length of shoots per treatment, T_0 recorded 4.04 mm, T_1 2.04 mm, T_2 1.88 mm while highest inhibitory effect was recorded at higher concentrations (T_3-T_5).

Also, Table 3 shows the effect of aqueous leaf extract of *Jatropha curcas* L., on the shoot length of Red pepper (*Capsicum frutescense* L.). Based on the average length of shoots per treatment, T_0 recorded 5.24 mm, T_1 1.47 mm, T_2 1.31 mm, and T_3 1.35 mm while the highest inhibitory effect was recorded at higher concentrations (T_4-T_5).

The effect of aqueous leaf extract of *Jatropha curcas* L., on the shoot length of bell-pepper (*Capsicum annum* L.) is as shown in Table 4. Based on the average length of shoots per treatment; T_0 recorded 3.82 mm, T_1 2.59 mm, T_3 1.66 mm and also the highest inhibitory effect was recorded at higher concentrations

Table 1. Percentage inhibitory effect of *Jatropha curcas* L. leaf aqueous extract on shoot length of cayenne pepper, red pepper, bell pepper and bird-eye pepper.

Treatments	Concentration (%)	Cayenne pepper	Red pepper	Bell pepper	Bird-eye pepper
T_1	4	−49.05%	−71.95%	−32.19%	−66.41%
T_2	8	−53.47%	−74.24%	−56.54%	−69.27%
T_3	12	−100%	−75.00%	−100%	−100%
T_4	16	−100%	−100%	−100%	−100%
T_5	20	−100%	−100%	−100%	−100%

Table 2. Effects of aqueous leaf extract of *Jatropha curcas* L. on the shoot length of cayenne pepper (*Capsicum annum*).

Treatment	Concentration (%)	Averages shoot length per treatment (mm)
T_0	-	4.04
T_1	4	2.04
T_2	8	1.88
T_3	12	-
T_4	16	-
T_5	20	-
L. S. D (0.05)		0.610

Table 3. Effect of aqueous leaf extract of *Jatropha curcas* L. on the shoot of red pepper (*Capsicum frutescens*).

Treatment	Concentration (%)	Averages shoot length per treatment (mm)
T_0	-	5.24
T_1	4	1.47
T_2	8	1.31
T_3	12	1.35
T_4	16	-
T_5	20	-
L. S. D (0.05)		0.599

Table 4. Effect of aqueous leaf extract of *Jatropha curcas* L. on the shoot length of bell-pepper (*Capsicum annum*).

Treatment	Concentration (%)	Averages shoot length per treatment (mm)
T_0	-	3.82
T_1	4	2.59
T_2	8	1.66
T_3	12	-
T_4	16	-
T_5	20	-
L. S. D (0.05)		1.571

(T_3-T_5).

Also the effect of aqueous leaf extract of *Jatropha curcas* L., on the shoot length of Bird-eye pepper (*Capsicum frutescense* L.) is as shown in **Table 5** based on the average length of shoots per treatment; T_0 recorded 4.20 mm, T_1 1.41 mm, T_2 1.29 mm while the highest inhibitory effect was recorded at higher concentrations (T_3-T_5).

4. Discussion

The bioassay study of leaf aqueous extracts of *Jatropha curcas* L. on four pepper

Table 5. Effect of aqueous leaf extract of *Jatropha curcas* L. on the shoot length of bird-eye pepper (*Capsicum frutescents*).

Treatment	Concentration (%)	Averages shoot length per treatment (mm)
T_0	-	4.20
T_1	4	1.41
T_2	8	1.29
T_3	12	-
T_4	16	-
T_5	20	-
L. S. D (0.05)		1.351

species (*Capsicum spp*) commonly grown in Keffi, Nasarawa State showed a gradual inhibition to seed germination. The inhibition of seed germination and shoot length of pepper in all cases was found to be concentration dependent and this was more profound at higher concentrations except for Red (*Capsicum frutescens*) which recorded 75.00% (inhibition) at 12% concentration.

Based on the inhibitory effect of leaf aqueous extract as determined on shoot length, the highest inhibitory effect was found to increase as the concentration increases (T_3-T_5) in all case respectively. This result agrees with the findings of [18] who reported inhibitory effect of leaf aqueous extract of *J. curcas* on crops to be concentration dependent. Similarly, [2] reported that in all extracts of sunflower allelopathicity increased with increase in concentration. This result to a significant extent corroborated the findings of [2], which showed that aqueous extracts of *J. curcas* at low concentration had little effect on seed germination and seedling growth, while higher concentration inhibited these processes. Investigation on the phytochemical screening of *J. curcas* (leaves, root and stem bark) extracts revealed the presence of saponins, steroids, tannins glycosides, alkaloids and flavonoids [19] These phenolic compounds could be responsible for this inhibition on germination and shoot length. Reference [18] suggested that the plant part that had strong effect on germination, plumule and radicle length was the leaves. This suggests that more allelochemicals may be found in the leaves than the roots of *J. curcas*. This was also supported by the findings of [20], where preliminary screening showed that leaf extract had the strongest allelopathic effect on seed germination, thus was selected for detailed experiments. Similarly, [21] reported that bioassay study and analysis of different extracts of leaves and roots of *J. curcas* revealed the main allelopathic substance as Azeliac acid. This compound was also reported to have inhibitory effect on the germination and shoot growth of test crops more pronounced at high concentration.

5. Conclusion

The study revealed that *Jatropha curcas* L. leaf aqueous extracts inhibited the germination and shoot lengths of pepper (*Capsicum spp*). Also allelopathy is a concentration dependent phenomenon. In line with the results of this study, it is

suggested that the presence of azelaic acid provides a competitive advantage to *Jatropha curcas* as defence mechanism and thus, can inhibit the growth of neighbouring crops in intercropping system. Based on this, *Jatropha* plant is recommended as not suitable for intercropping with pepper and this information is highly valuable for pepper cultivation. It is therefore recommended that further investigations on the endogenous activities of Azelaic acid in seeds of crops be carried out.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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