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Evaluating the Allelopathic Effect of *Jatropha curcas* Aqueous Extract on Germination, Radicle and Plumule Length of Crops

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ABSTRACT

Investigations to find out the effect of aqueous extracts of *Jatropha curcas* on four traditional crops (*Phaseolus vulgaris, Zea mays, Lycopersicon lycopersicum* & *Hibiscus esculentus*) was examined. Aqueous extracts from leaves (L) and roots (R) of *Jatropha curcas* were prepared at different concentrations of 2%, 4%, 6%, 8%, 10% and applied to the test crops. All the crops were affected by the different concentrations of aqueous extracts. The most pronounced effect was on *H. esculentus*, where germination, radicle and plumule length were reduced by a range of 58.34%-97.92%, 35.84-94.33% and 1.65-87.55%, respectively. Extract at higher concentrations of *J. curcas* had a strong inhibitory effect on germination, radicle and plumule length of all the test crops. The highest inhibition of seed germination was by 5.26% in R_8 for *Z. mays*, 24.28% in R_{10} for *L. lycopersicum*, 15.41% in R_{10} for *P. vulgaris* and 97.92% in L_{10} for *H. esculentus*. The highest reduction in radicle length of 65.34%, 91.03%, 65.95% and 94.33% was recorded at L_8, L_8, L_{10}, L_{10} for *Z. mays*, *L. lycopersicum, P. vulgaris* and *H. esculentus*, respectively. The highest inhibitory effect in plumule length was 70.08%, 87.15%, 66.35% and 87.55% at L_8, L_{10}, L_{10} and L_{10} for *Z. mays*, *L. lycopersicum*, *P. vulgaris* and *H. esculentus*, respectively. The inhibitory effect suggests the presence of allelochemicals that could inhibit the growth of the crops. © 2010 Friends Science Publishers

Key Words: *Jatropha curcas*; Roots aqueous extract; Leaves aqueous extract; Allelopathy; Crops

INTRODUCTION

Growing crops for biofuels is often critized because of the direct competition of land for food production. The recent price increases on world food markets are partly a result of this competition (Müller, 2008). *Jatropha curcas* has been found to be a highly promising biofuel species since it does not compete for human consumption. It is of short gestation period, hardy nature with high quality oil content. The *J. curcas* oil is close to cottonseed and better than rapeseed, groundnut and sunflower (Gübitz *et al*., 1997), which gives no pollution, when burnt. Agroforestry, which involves combining woody plants with annual or perennial crops or livestock, increases the biophysical and/or socioeconomic productivity of an agricultural enterprise (Bentley, 1985). It is suggested that the use of *J. curcas* in alleycropping could help reduce this scarcity of food. The failure of most crops in an agroforestry system has been attributed to allelopathic effect of the tree species. This phenomenon is as a result of phyto-chemical exuded by trees. These chemicals are largely classified as secondary metabolites (such as alkaloids, isoprenoids, phenolics, flavonoids, terpanoids & gluconolates etc) (Nazir *et al*., 2007). Swaminathan *et al.* (1989) reported that the potential compounds, which are able to induce inhibitory effect on germination are identified as phenolic acids. The release of phenolic compounds adversely affects the germination and growth of plants through their interference in energy metabolism, cell division, mineral uptake and biosynthetic processes (Rice, 1984). Since *J. curcas* stem extracts contain phytochemicals like saponins, tannins, glycosides, alkaloids and flavonoids (Akinpelu, 2009; Igbinosa, 2009) of phenolic nature, the present study was therefore carried to find allelopathic effect if any from aqueous extract of *J. curcas* roots and leaves on some crops. This would enable us to establish *J. curcas* as a good intercrop in agroforestry system.

Studies with other species have reported that the response to allelochemicals may be concerning on the concentration dependent (Ashrafi *et al*., 2008). Allelochemicals that inhibit the growth of some species at certain concentrations might stimulate the growth of the same or different species at different concentrations (Narwal, 1994). It is therefore necessary to identify concentration at which *J. curcas* aqueous extract would affect the germination and growth of crops.

MATERIALS AND METHODS

Aqueous extract was prepared from dried leaves and roots ground in powder form. 10 g powered sample of *J. curcas* was added to 100 mL distilled water and left for 48 h at room temperature (20-30°C). The extracts were filtered through three layers Whatmann No. 1 filter paper. The

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extract was considered as stock solution and a series of solution with different strengths (2%, 4%, 6%, 8% & 10%) were prepared by dilution for both roots and leaves (Maharjan *et al*., 2007). Seeds of *P. vulgaris, Z. mays, L. lycopersicum and Hibiscus esculentus* were placed for germination in sterilized petri-dishes of 90 mm diameter and 15 mm height, between two layers of Whatmann No. 1 filter paper using 5 mL of different concentration of *J. curcas* leaves (L) and roots (R) extracts. Each treatment had four replicates. Germination of seeds was counted after one week and measured for radicle and plumule growth. The procedure adopted is similar to that of Nazir *et al.* (2007) and Maharjan *et al*. (2007).

RESULTS AND DISCUSSION

Allelopathy is considered as both harmful and beneficial interactions between the plants (Rizvi & Rizvi, 1986). The results show an increase in germination at lower concentration of *J. curcas* roots and leaves. Lower concentrations of L_2%, R_2% and R_4% did promote the germination of *Phaseolus vulgaris* and *Zea mays* even though it was not significantly different from the control (Fig. 1). An increase in growth of 7.74% and 3.86% was recorded for L_2 and R_2, respectively in *P. vulgaris*. R_2 and L_2 concentration did promote the germination of *Z. mays* and *Lycopersicon lycopersicum* by 5.26% and 7.14%, respectively. This is in line with findings from other studies. Purvis *et al*. (1985) and Cheema (1988) reported that lower concentration show promoting effect, while higher concentration had inhibitory effect. Randhawa *et al*. (2002) found that the germination of *Trianthema portulacastrum* was suppressed by higher concentration of the sorghum water extract. Generally, there was a decrease in germination as the concentration of the extract increased. The exception was in *Z. mays*, where there was an increase in germination for all the treatments except R_8%. The most pronounced effect was realized in *H. esculentus*, where germination was reduced to maximum of 97.92%. The reduction in germination could be attributed to inhibitory effect of allelopathic substances present in the extract. According to EL Diwani *et al*. (2009) *J. curcas* contain substances such as phenolic compounds, which succeeded to be used as natural anti-oxidant for the protection of oils and their corresponding biodiesel against oxidative deterioration. The regression analysis between germination percentage and concentration of leaf extract showed that 96% of variation in germination of the test crops could be explained by the concentration of leaf extracts (R^2 = 0.96, Fig. 2). The root extract also showed 98% of variation in germination of the test crops, which could be explained by the concentration of root extracts (R^2 = 0.986, Fig. 3). Radicle length was strongly inhibited by aqueous extracts of leaves and roots of *J. curcas* for all the test crops. The reduction ranges from 22.42%-65.95% for *P. vulgaris*, 22.02%-60.64% for *Z. mays*, 33.90%-91.05% for *L. lycopersicum* and 27.54%-94.33% for *H. esculentus* (Table I). The regression analysis showed a co-efficient of determination (R^2) to be 0.77. This implies that 77% of variation in radicle length of the test crops could be explained by the concentration of leaf extracts (Fig. 4). The co-efficient of determination (R^2) in radicle length and

Table I: Effect of leaf and root extract on radicle length (cm) of crops

Treatments	*Phaseolus vulgaris*	*Zea mays*	*Lycopersicon lycopersicum*	*Hibiscus esculentus*
Control	6.11 efg	15.12 f	8.14 e	2.65 f
L_2%	4.74 cd (-22.42)	11.79 de (-22.02)	5.38 d (-33.90)	1.16 bcde (-56.22)
L_4%	3.99 bc (-34.69)	11.40 de (-24.60)	2.46 b (-69.77)	0.82 abcd (-69.05)
L_6%	3.12 ab (-48.94)	9.09 cd (-39.88)	1.18 a (-85.50)	0.68 abc (-74.33)
L_8%	2.61 a (-57.28)	5.24 a (-65.34)	0.75 a (-90.78)	0.28 ab (-89.43)
L_{10}%	2.08 a (-65.95)	5.95 ab (-60.64)	0.73 a (-91.03)	0.15 a (-94.33)
R_2%	5.17 cde (-15.30)	13.30 ef (-12.03)	6.03 d (-25.92)	1.70 de (-35.84)
R_4%	5.232 cdef (-14.40)	10.71 cde (-29.16)	5.24 d (-35.62)	1.92 ef (-27.54)
R_6%	6.54 fg (+7.03)	9.09 cd (-39.88)	3.97 c (-51.22)	1.34 cde (-49.43)
R_8%	6.58 g (+7.69)	10.44 cd (-30.95)	3.25 c (-60.07)	1.11 bcde (-58.11)
R_{10}%	5.66 defg (-7.36)	8.31 bc (-45.03)	2.21 b (-72.85)	1.32 cde (-50.18)
C.V. (%)	17.1	16.3	13.7	45

R=Roots, L=Leaves; Values with similar letter (s) within a column are not significantly different at P=5% by Duncan's Multiple Range Test (DMRT); *Data in parenthesis indicate % reduction (-) or increase (+) over control

Table II: Effect of leaf and root extract on plumule length (cm) of crops

Treatments	*Phaseolus vulgaris*	*Zea mays*	*Lycopersicon lycopersicum*	*Hibiscus esculentus*
Control	4.34 d	5.85 f	6.09 de	2.41 bc
L_2%	2.42 c (-44.24)	4.82 e (-17.60)	5.99 f (-1.75)	1.38 ab (-42.73)
L_4%	1.33 ab (-69.35)	2.89 bc (-50.59)	3.39 bc (-44.33)	0.85 a (-64.73)
L_6%	1.09 a (-74.88)	2.21 ab (-62.22)	2.48 ab (-59.27)	0.80 a (-66.80)
L_8%	2.02 bc (-53.45)	1.75 a (-70.08)	2.43 ab (-60.09)	0.52 a (-78.42)
L_{10}%	1.46 ab (-66.35)	3.29 cd (-43.76)	2.03 a (-66.66)	0.30 a (-87.55)
R_2%	2.42 c (-44.20)	4.08 de (-30.25)	5.96 ef (-2.13)	2.37 bc (-1.65)
R_4%	2.48 c (-42.85)	2.95 bc (-49.57)	5.18 d (-14.9)	2.91 c (-3.73)
R_6%	1.91b c (-55.99)	2.49 abc (-57.43)	5.14 d (-15.59)	2.03 bc (-15.76)
R_8%	1.86 bc (-57.14)	2.89 bc (-50.59)	3.99 c (-34.48)	1.42 ab (-41.07)
R_{10}%	1.65 ab (-61.98)	2.21 ab (-62.22)	2.97 abc (-51.23)	2.22 bc (-7.88)
C.V. (%)	19.3	17.0	15.9	44.3

R=Roots, L=Leaves; Values with similar letter (s) within a column are not significantly different at P=5% by Duncan's Multiple Range Test (DMRT); *The data in parenthesis indicate % reduction (-) or increase (+) over control

Fig. 1: Effect of leaf and root extract on germination of crops

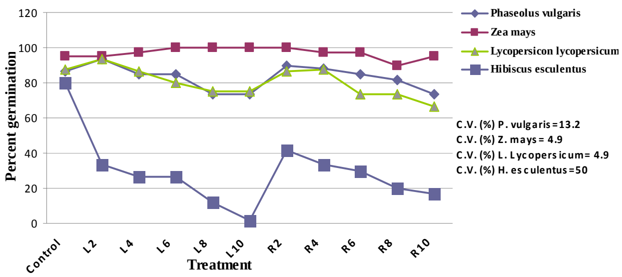


Fig. 2: Regression analysis showing variation in seed germination of all test crops with concentration of leaf aqueous extracts of *Jatropha curcas*

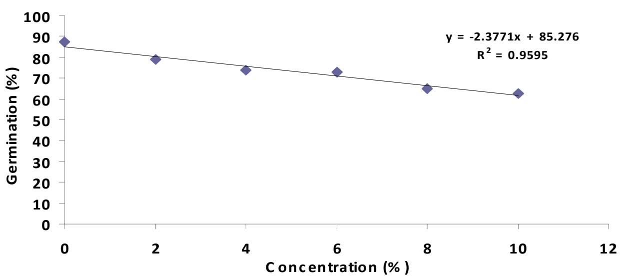


Fig. 3: Regreesion analysis showing seed germination of all test crops with concentration of root aqueous extracts of *Jatropha curcas*

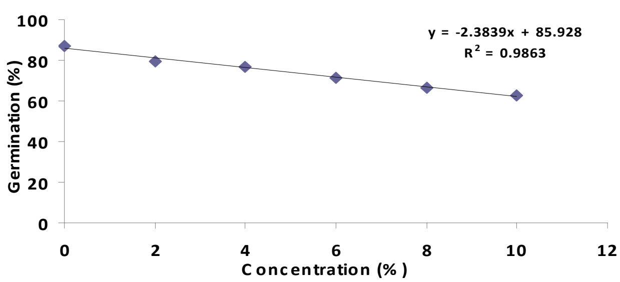
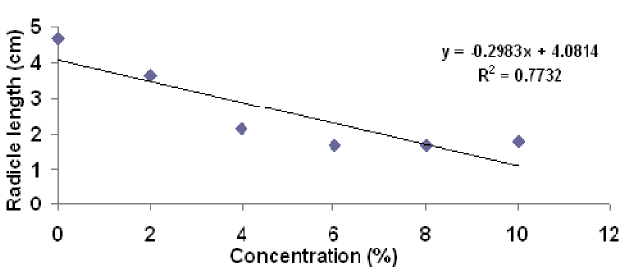


Fig. 4: Regression analysis showing radicle length of all test crops at different concentration of leaf aqueous extracts of *Jatropha curcas*



concentration of root extract was 0.94 (Fig. 5).

A similar trend in reduction of plumule length was also observed for all the crops. Higher concentrations of aqueous extract had a strong inhibitory effect on both radicle and plumule length (Table II). Plumule length

Fig. 5: Regression analysis showing radicle length of all test crops at different concentration of root aqueous extracts of *Jatropha curcas*

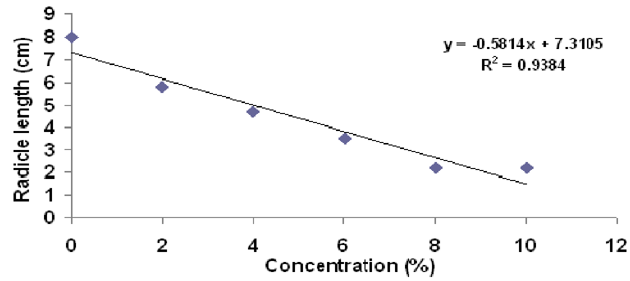


Fig. 6: Regression analysis showing plumule length of all test crops at different concentration of leaf aqueous extracts of *Jatropha curcas*

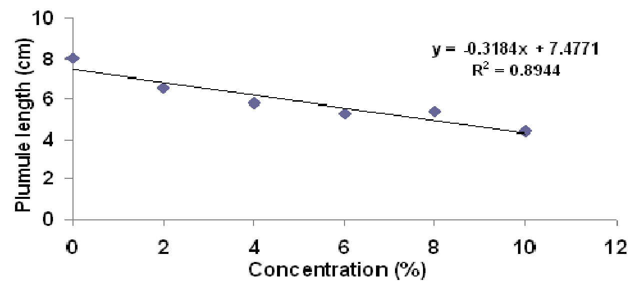
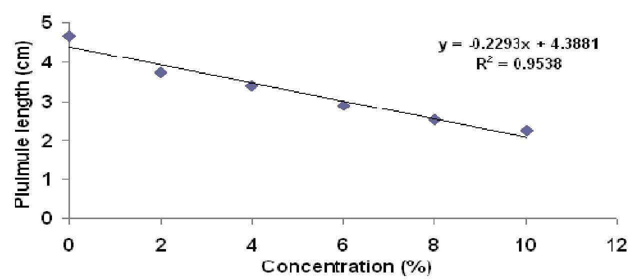


Fig. 7: Regression analysis of showing plumule length of all test crops at different concentration of root aqueous extracts of *Jatropha curcas*



reduction was highest (70.08%) in L_8 followed by L_6% leaf extract concentration (62.2%) in maize. With respect to *L. lycopersicum*, plumule length was reduced by 87.15%, 78.42% and 66.80% for L_{10}, L_8 and L_6, respectively (Table II). The highest inhibitory effect was in L_{10} (66.35%) followed by R_{10} (61.98%) and L_8 (53.45%) in *P. vulgaris*, however these treatments did not differ significantly ($P<0.05$) (Table II). The regression analysis between plumule length and concentration of leaf extract showed that 89% of variation in plumule length of the test crops could be explained by the concentration of leaf extracts (R^2 = 0.89, Fig. 6). The root extract on the other hand, had 95% of variation in plumule length of the test crops, which could be explained by the concentration of root extracts (R^2 = 0.95, Fig. 7). Randhawa *et al.* (2002) reported that root and shoot length of *Trianthema portulacastrum* was reduced by higher concentration of sorghum water extract. Ashrafi *et al.*

(2008) reported that in all extracts of sunflower allelopathicity increased with increases in concentrations. Ashrafi *et al*. (2008) further reported that radicle length appeared more sensitive to allelochemicals than hypocotyl length. Investigation on the phytochemical screening of *J. curcas* stem bark extracts revealed the presence of saponins, steroids, tannins, glycosides, alkaloids and flavonoids in the extract (Igbinosa, 2009). These phenolic compounds could be the cause for this reduction in radicle and plumule length. The plant part that had a strong effect on germination, radicle and plumule length was the leaves. It suggests that more allelochemicals can be found at the leaves than the roots of *J. curcas*. This is corroborated by findings of Maharjan *et al*. (2007), where preliminary screening shown that leaf extract had the strongest allelopathic effect on seed germination, thus was selected for detail experiments. Tefera (2002) also found that the inhibitory allelopathic impact of leaf extract was more powerful than other vegetative parts.

CONCLUSION

J. curcas provides a viable source of bio-diesel. However, the study revealed that higher concentrations (8% & 10%) of aqueous extract of *J. curcas* have an inhibitory effect on germination, radicle and plumule length of *P. vulgaris, Z. mays, L. lycopersicum and H. esculentus*. Germination of *Z. mays* was however promoted in all the treatments except R_8. The presence of phenolic compounds could be the cause of reduction in germination and growth of seedlings in the test crops. Germination and growth of *H. esculentus* was more suppressed by allelochemicals from *J. curcas*. The results also indicate that leaves of *J. curcas* had more inhibitory effect than the roots. The results obtained in this study would serve as a basis for further research under field conditions to confirm the allelopathic potential of *J. curcas*.

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