Allelopathic effects of aqueous leaf extract of *Jatropha curcas* L. on food crops in the Himalayan foothills

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Abstract

Jatropha (oil producing plant) is widely growing with many food crops in Tarai area of the Himalayan foothills. The present investigation is aimed at assessing the allelopathic effects of *Jatropha curcas* Linn. on two varieties each of the three intercropping food crops, *viz.* rice, soybean and mustard. Different concentrations (5%, 10%, 15% and 20% (w/v)) of *Jatropha* leaf aqueous extract were bio-assayed against germination and seedling growth (plumule and radicle length) of the crop varieties. Four treatments with three replications in each treatment (T0 control and T1, T2, T3 and T4 testing 5, 10, 15 and 20% w/v concentrations of the *Jatropha* leaf extracts, respectively) were taken. Both varieties of each of the three crops were affected by leaf aqueous extracts in varying concentrations. The maximum seed germination reduction was observed for mustard in variety Kranti (70.38%) at T4 treatment and minimum in Kranti (8.20%) at T1 treatment. In soybean, reduction in seed germination was greater in variety PS-1042 (44.53%) in T4 treatment and for rice variety PB-1 also the T4 treatment had higher seed germination reduction. The response index value (RI) for all crop varieties ranged from 0.076 (Kranti) to 0.625 (Krishna) at T1 and T4 treatments, respectively and germination relative index (GRI) ranged from 12.25 (Kranti) to 40.54 (PB-1). The plumule length reduction was maximum in mustard variety Kranti (72.40%) and RI value ranged from 0.067 (PS-1042) to 0.727 (Kranti). Maximum radicle length reduction was recorded in rice variety PB-1 (4.40) and RI values ranged between 0.044 (PB-1) and 0.818 (BP-1). Higher concentrations of *Jatropha curcas* had a strong inhibitory effect on germination, plumule and radicle length of all varieties of intercropped food crops. The level of inhibition of aqueous leaf extract of *Jatropha curcas* varied with the concentration and type of varieties of intercropped food crops.

Keywords: Allelopathy, Food crops, Intercropping, *Jatropha curcas* L., Leaf aqueous extract

INTRODUCTION

Jatropha, has been considered as a potential candidate for biofuels (daSchio, 2010), or a bio-diesel plant, has been rapidly introduced and intercropped with common food crops in many regions of the word, including the countries where land area is a critical factor for food security. Producing biodiesel as an "eco-friendly" alternative to the diesel and petrol has been the key objective of large-scale *Jatropha* plantation. This biodiesel crop has been reported with some allelopathic effects on food crops (Abugre and Sam 2010). Allelochemicals are the secondary metabolite compounds (Nazir et al. 2007). Presently, *Jatropha curcus* is being intercropped with many food crops as many regions cannot afford to spare cultivated land exclusively to raise the biodiesel crop. The observed allelopathic effect is plausibly due to Jatropha's alkaloid, flavonoids, terpanoids, phenolics, isoprenoids, gluconolates etc. Ma et al. (2011) reported that leaves and roots of *Jatropha* contain azelaic acid that suppresses the germination and initial growth of corn and tobacco.

Policymakers do consider biofuel for carbon replacement in fossil fuels as a strategy to address energy security and climate change related issues (GOI, 2009; Phalan, 2009; Achten et al., 2010b). In the countries with limited cultivated area, like India, *Jatropha* is being used as the base crop for agroforestry systems.

The current practice of production and use of *Jatropha* in a system of agroforestry appears to have several knowledge gaps, which need to be bridged before large scale cultivation of both *Jatropha* and food crops

intercropped with it. This paper attempts to examine allelopathic effects of the *Jatropha* plantation raised in intercropping pattern in the Tarai area of the Central Himalayan region in India.

RESEARCH METHODOLOGY

Healthy and seemingly uniform seeds of different varieties of rice, soybean and mustard were collected from the Crop Research Center (CRC) of the G.B. Pant Agriculture & Technology University Pantnagar (29^o N, 79^o E) , and mature leaves of *Jatropha* were collected from Medicinal Research and Development Centre (MRDC).

Aqueous extract of *Jatropha* leaves was prepared following the method given by Maharjan *et al.* (2007). Collected fresh leaves of *Jatropha* were dried in an oven at $60^0C \pm 2^0C$ for two days and then the dried leaves were ground homogeneously in Wiley Mill (40 mesh). Then 10 g powered sample of leaves was taken and mixed with 100 ml distilled water and left for 48 h at room temperature (20-30^{0}C). Then the mixture was filtered through three layers of Whatman No. 1 filter paper and was centrifuged at 4500 rpm for 10 minutes. This extract was considered as stock solution and different concentrations (5%, 10% and 15%, 20%) were prepared by dilution with distilled water and kept at 4°C till further use. All the collected seeds were sterilized by soaking in 0.01% $HgCl_2$ solution for 3 to 5 min and then washed thoroughly with sterilized distilled water and dried with an absorbent. The 10 sterilized seeds were taken and placed at proper space in each sterilized glass Petri dishes (90 mm diameter and 15 mm height) containing two sterilized blotting papers for each species in triplicates. The seeds were moistened either with sterilized distilled water (control) or with aqueous extracts of different strengths (5%, 10% and 15%, 20%) of *Jatropha* leaf concentrations (treatments) and kept under laboratory conditions. The emergence of radicle was considered as the index for seed germination (Jarn and Amen, 1977; Rao and Singh, 1985). The observations were made at an interval of one day (24 h) up to 15 days for rice, soybean and 7 days for mustard. Numbers of germinated seeds were counted after ten days and radicle and plumule length was recorded with the help of metered scale. The experiment was carried out with three replications with the following treatments: T0: Seeds of receptor crops varieties grown in distill water only (Control); T1: 5.0% aqueous extract; T2: 10% aqueous extract; T3: 15% aqueous extract; T4: 20% aqueous extract. The plumule (shoot) and radicle (root) length (mm) of the seedlings from each Petri dish *i.e.*, a total of nine seedlings from control and treatment for each plant species, were measured at the end of the germination experiments up to nearest mm/cm either with the help of a scale or with a thread. Per cent seed germination for different crops varieties were calculated. Germination Relative Index (GRI) was calculated according to Srivastava and Sareen (1972):

$$\sum Xn\ (h\text{-}n)$$

where Xn, h, n represent number of seeds germination at n^{th} count, total number of counts and count number, respectively. The Response Index (RI) was calculated according to Williamson and Richardson (1988) using the following formula:

1. When germination of treatments (T) is lower than the control (C)

   RI = (T/C- 1)

2. When germination of treatments (T) is higher than the control (C)

RI = (1 – C/T)

If RI > 0; Treatments stimulated germination.

If RI = 0; No effect.

If RI <0; Treatments inhibited germination.

The data of various observations were analysed statistically by using standard methods (Snedecor and Cochrom, 1969).

RESULTS AND DISCUSSION

The results showed the allelopathic potential of different concentrations of *Jatropha curcas* leaf aqueous extract on seed germination, radicle length and plumule length of two varieties of each intercropped food crops, *viz. Oryza sativa* (rice), *Glycine max* (soybean) and *Brassica juncea* (mustard). Different concentrations (treatments) of *Jatropha* leaf aqueous extract expressed different patterns of inhibition on different varieties of food crops.

In general, maximum germination percentages of the seeds were observed in the control treatments (T0) where no extract was used, whereas the lowest seed germination was observed with the highest concentration (T4 treatment). All the concentrations of the different extracts had inhibitory effect on the germination (Figures 1 and 2) of both the varieties of all the intercropped food crops compared to control. The maximum seed germination reduction was observed for mustard in variety Kranti (70.38%). For soybean, the maximum seed germination reduction was in variety PS-1042 (44.53%) and for rice, maximum seed germination reduction was in variety PB-1 in the T4 treatment.

The crop-wise comparison revealed that the maximum reduction in germination percentage was observed in both the varieties of mustard (62.53, 70.38%), while the soybean varieties recorded the minimum seed germination reduction (37.19, 44.53%) at T4 treatment. Mustard variety *Kranti* showed stimulation effect at the T1 treatment. The response index value (RI) for all crop varieties ranged from 0.076 (Kranti) to 0.625 (Krishna) at T1 and T4 treatments, respectively. The germination relative index (GRI) ranged from 12.25 (Kranti) to 40.54 (PB-1). This finding of the present study is in line with the results of other reported studies like that of Abugre and Sam (2010) who also recorded similar reduction pattern in seed germination by aqueous leaf extract of *Jatropha* in crops such as *Phaseolus vulgaris*, *Zea mays*, *Lycopersicon lycopersicum* and *Hibiscus esculentus*.

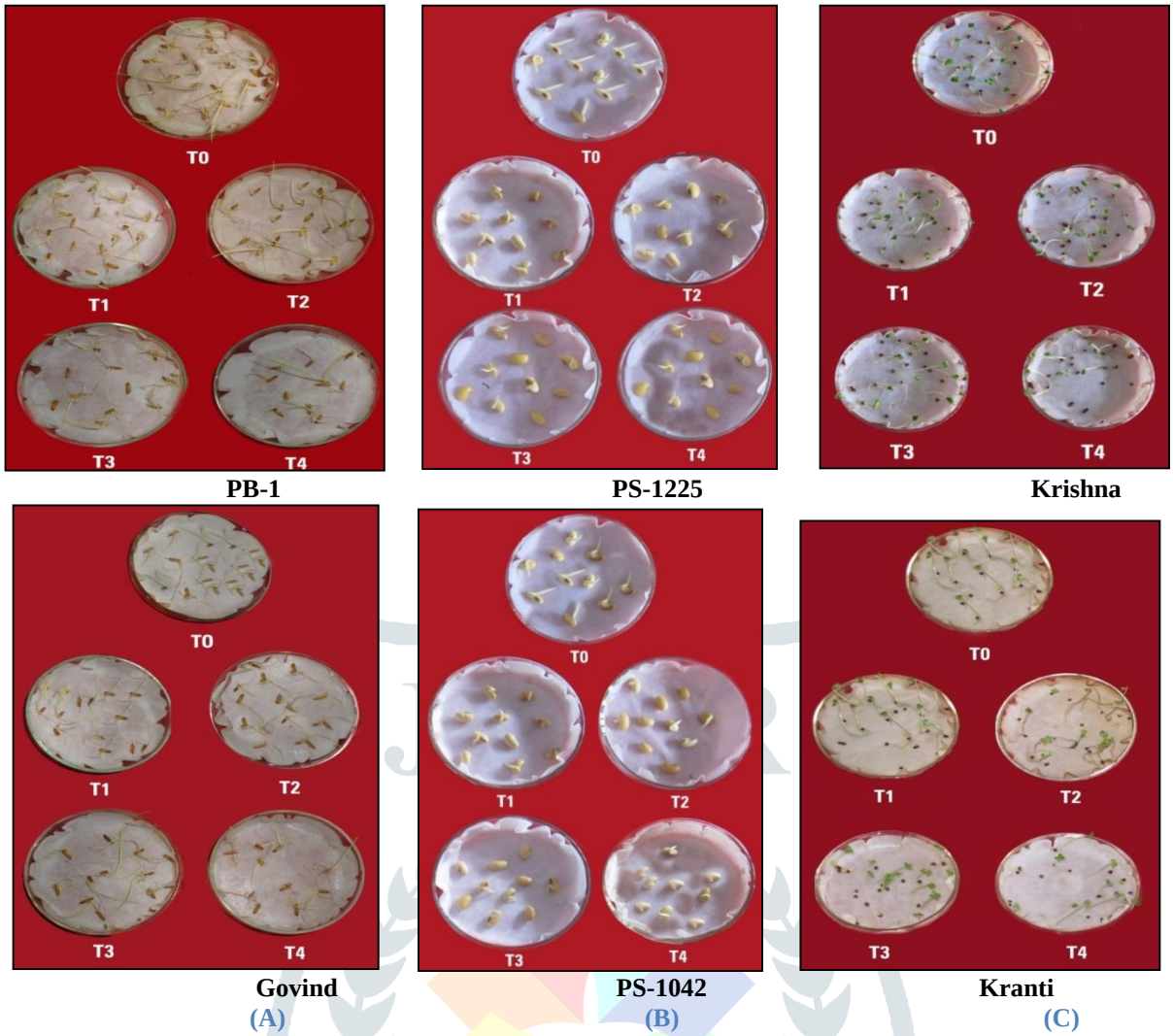

Figure 1. Experiment revealing the allelopathic effects of *Jatropha* leaf aqueous extract of varying concentrations (T0: control; T1: 5%: T2: 10%, T3: 15%; T4: 20%) on germination of rice (A), soybean (B) and mustard (C) varieties

Table 1. Response Index (RI) values for seed germination (%) in different crop varieties due to different concentrations of *Jatropha curcas* leaf extract

Crops and varieties		Concentration of leaf extract								
		Response Index (RI) values				Germination Relative Index (GRI)				
		T1	T2	T3	T4	T0	T1	T2	T3	T4
Rice	PB-1	-0.128	-0.211	-0.276	-0.523	40.54	31.26	45.12	40.23	30.45
	Govind	-0.084	-0.163	-0.187	-0.579	38.12	30.12	29.56	28.33	33.45
Soybean	PS-1225	-0.137	-0.166	-0.192	-0.372	35.33	28.95	22.55	20.22	19.55
	PS-1042	-0.124	-0.210	-0.245	-0.445	36.33	35.26	33.44	30.11	22.12
Mustard	Krishna	-0.134	-0.305	-0.375	-0.625	32.10	30.45	25.22	22.54	14.12
	Kranti	-0.076	-0.334	-0.530	-0.571	28.75	30.12	22.33	20.12	12.25

- = Inhibition; 0 = No effect; and + = stimulation

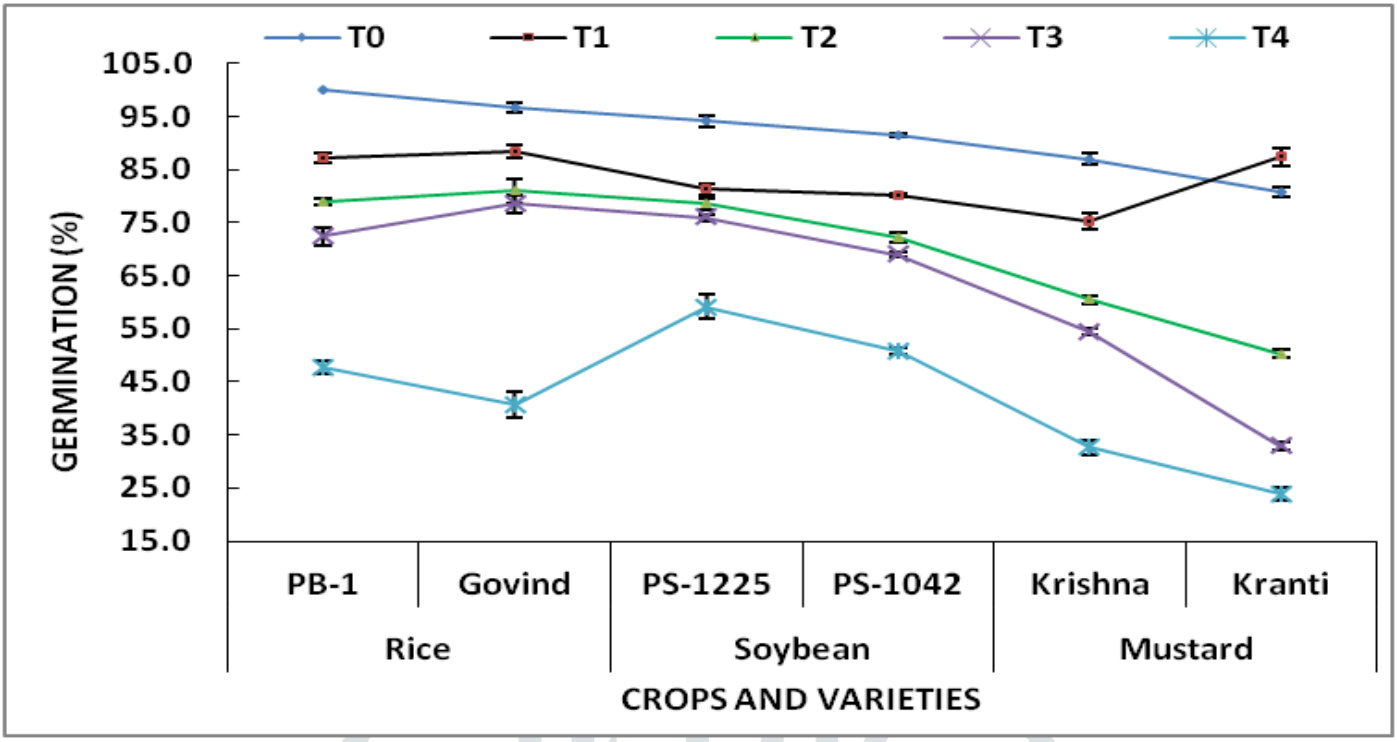

Figure 2. Effect of different concentrations of leaf extract of *Jatropha curcas* on seed germination (%) and per cent reduction (-) or increase (+) over control on different crop varieties (Mean ± SE)

The shoot and root lengths have been the most frequently used parameters for the expression of allelopathic effect (Khaliq *et al*., 2013). The seedlings of two varieties each of the three different crops, *viz.*, *Oryza sativa* (rice), *Glycine max* (soybean) and *Brassica juncea* (mustard) were measured at the end of the germination experiment, *i.e.*, after 10 days for all crop varieties, and 7 days for the mustard. The length of shoots and roots was measured in three randomly selected seedlings from each Petri dish, *i.e.*, a total of nine seedlings for each species and treatments. The plumule length was significantly reduced in all the crop varieties in all the treatment (Figures 3 and 5). The plumule length (cm) in different crop varieties ranged from 1.14±0.039 (mustard) to 9.16±0.123 (PS-1225) at T4 and T0 treatments, respectively (Figure 3).

Table 2. Response Index (RI) values for plumule and radicle length (cm) in different crops varieties due to different concentrations of *Jatropha curcas* leaf extract

Crops and varieties		Concentration of leaf extract							
		Plumule length				Radicle Length			
		T1	T2	T3	T4	T1	T2	T3	T4
Rice	PB-1	-0.103	0.293	0.410	0.692	-0.044	-0.242	-0.294	-0.818
	Govind	-0.249	0.286	0.433	0.723	-0.105	-0.282	-0.414	-0.774
Soybean	PS-1225	-0.089	0.174	0.254	0.584	-0.157	-0.370	-0.442	-0.614
	PS-1042	-0.067	0.313	0.376	0.545	-0.128	-0.382	-0.428	-0.610
Mustard	Krishna	-0.254	0.397	0.514	0.709	-0.293	-0.346	-0.533	-0.753
	Kranti	-0.293	0.370	0.455	0.727	-0.403	-0.503	-0.730	-0.782

- = Inhibition; 0 = No effect; and + = stimulation

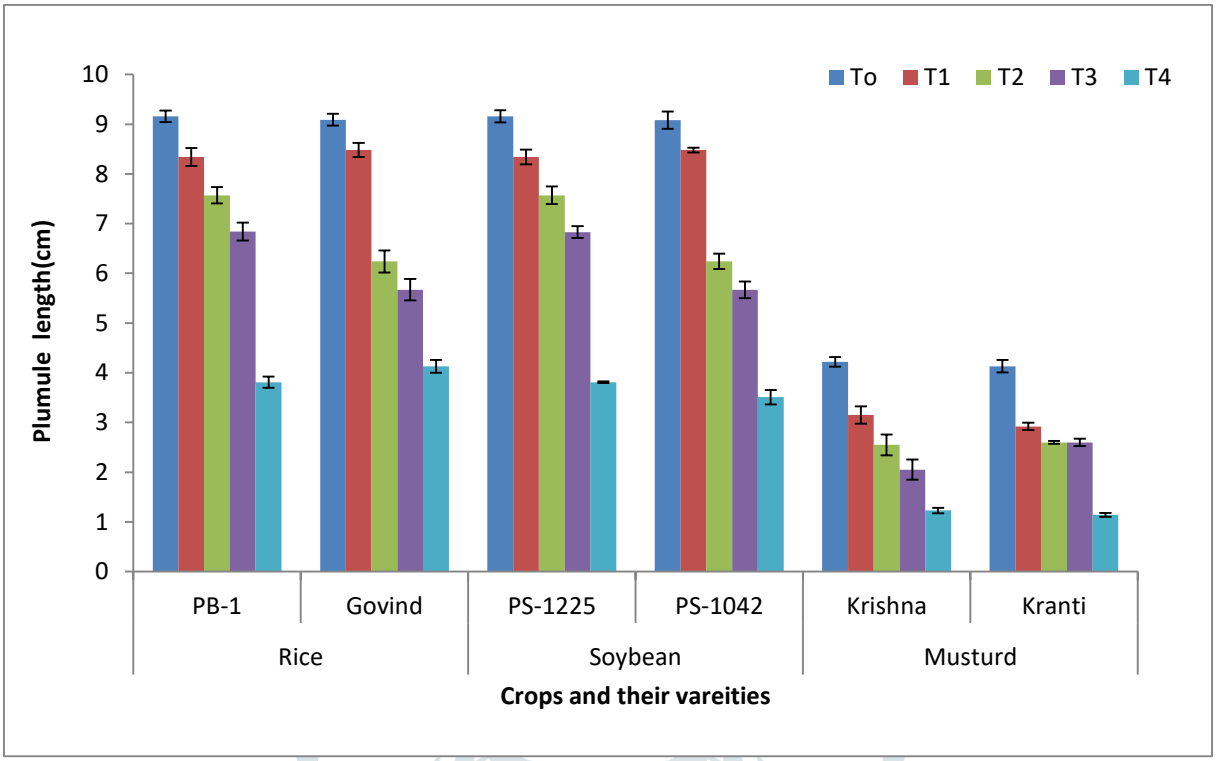

Figure 3. Plumule length (cm) in different crop varieties due to different concentrations of *Jatropha curcas* leaf extract

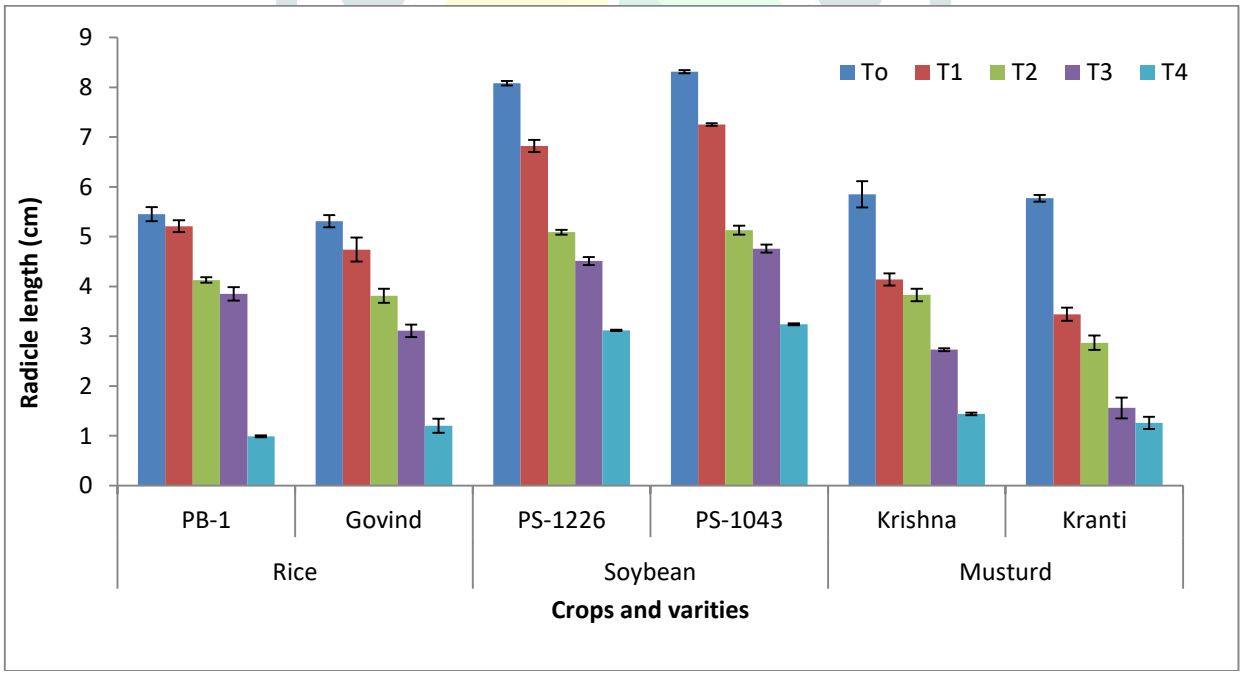

Figure 4. Radicle length (cm) in different crop varieties due to different concentrations of *Jatropha curcas* leaf extract

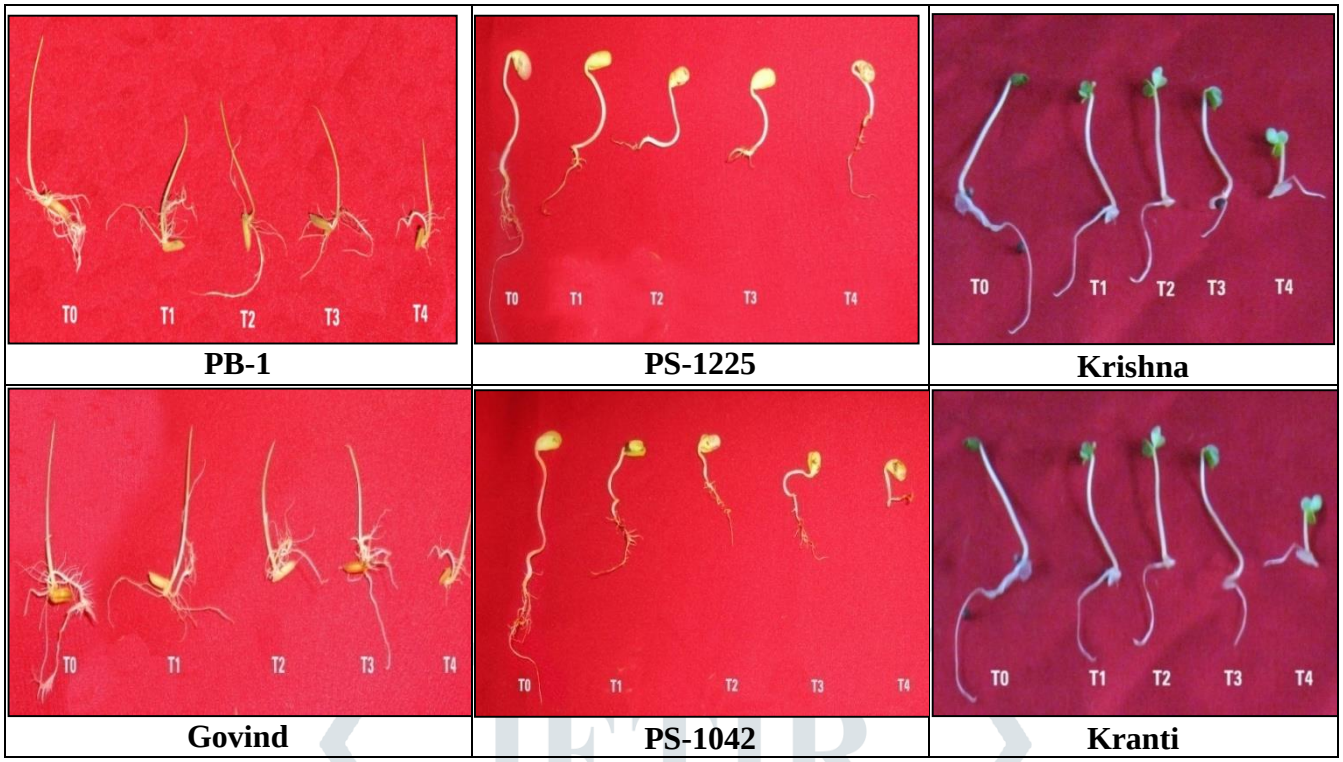

Figure 5. Experiment revealing the allelopathic effects of *Jatropha* leaf aqueous extract of varying concentrations (T0: control; T1: 5%; T2: 10%; T3: 15%; T4: 20%) on radicle and plumule length (cm) in rice (A), Mustard (B) and soybean varieties (C)

Maximum plumule length reduction (in comparison with control) was observed in mustard variety Kranti (29.30%) and minimum in soybean variety PS-1042 (6.68) at T1 treatment. At T4 treatment, the plumule length reduction was greater in mustard variety *Kranti* (72.40) and minimum in soybean variety PS-1042 (54.55) (Figure 3). RI values however ranged from 0.067 (PS-1042) to 0.727 (Kranti) at T0 and T4 treatments, respectively (Table 2)

The radicle length was also reduced in both crop varieties of intercropped food crops in all the treatments (Figure 5). The radicle length (cm) in different crop varieties ranged from 0.99±0.124 for rice (PB-1) to 8.31 ±0.032 for soybean (PS-1225) at T4 and T0 treatments, respectively (Figure 4). Maximum radicle length reduction was recorded in rice variety PB-1 (81.83%) and RI values ranged between 0.044 (PB-1) and 0.818 (BP-1). This study also revealed that the allelopathic potential of the *Jatropha curcas* leaf extract was more pronounced in the germination study. Radicle length was strongly inhibited by the aqueous leaf extract of *Jatropha* in all the tested crops as compared to plumule length. It was also noticed that the decrease in root and shoot lengths seemed to increase with increasing concentrations of the extract.

Earlier, Hassan *et al.* (2013) reported that aqueous leaf extract of *Jatropha* could inhibit seed germination, shoot and root growth in millet food crops. Abugre and Sam (2010) reported negative allelopathic effects of *Jatropha* leaf extract on four traditional crops while Sanderson *et al.* (2013) found no negative effect on the germination of lettuce var. Grand Rapids treated with low leaf extract concentrations (1%, 5%, 10% and 15%). In another study, Reichel *et al.* (2013) observed some type of interference on the initial development of wheat (*Triticum aestivum*). For instance, some compounds *viz.* alkaloid, flavonoids, terpanoids, phenolics, isoprenoids, gluconolates are released by roots, stems and leaves through the process of exudation and

volatilization and showed the inhibitory effect on germination and seedling growth and this inhibitory effect depends on the tolerance of the test crops (Reigosa *et al*. 2013). The order of tolerance of crops being *viz. Vigna munga* > *Triticum aestivum* > *Brassica juncea* > *Sorghum orientale* against the concentration of *Jatropha* leaf extract (Venkatesh et al. 2011). A recent study by Baruah *et al.* (2018) revealed the less-sensitive allelopathic effect of *Jatropha* extract on germination and seedling growth of chilli (*Capsicum annum*) as campared to that in green gram (*Vigna radiata*). Based on these observations, it has been suggested that chilli may be grown as an intercrop with *Jatropha* plant. Earlier, Rejilia and Vijaykumar (2011) also reported inhibitory effect of *Jatropha* on germination and seedling growth of green chilli and sesame.

CONCLUSION

Over all, the present experiments revealed that *Jatropha curcas* has well pronounced allelopathic effects on intercropped food crops, namely rice, soybean and mustard. For instance, it is observed that radicle growth was strongly inhibited than the plumule length. It is concluded that *Jatropha curcas* can be recommended as a base crop for filter cropping in interspaces and it would change the trend of agriculture practicing (monoculture) and cope with the energy crisis along with the supply of food by bringing more wastelands under cultivation. Soybean crop can be intercropped with *Jatropha*, but mustard crop is not suitable as intercrop with Jatropha plant. The study also reopen, the aqueous leaf extract of *Jatropha. curcas* to be a promising material for future field experiments and for use as natural herbicides.

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