



Allelopathic effects of *Jatropha curcas* stem extracts on food crops in Tarai area

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ABSTRACT

Allelopathic effects of *Jatropha curcas* L. aqueous stem extracts on two varieties each of five food crops, viz. *Triticum aestivum* (wheat), *Zea mays* (corn), *Oryza sativa* (rice), *Glycine max* (soybean) and *Brassica juncea* (mustard) were observed in the Tarai area of Uttarakhand in 2017-18. Different concentrations (0%, 5%, 10%, 15% and 20% w/v indicated as T0, T1, T2, T3 and T4, respectively) of *Jatropha* stem aqueous extract were bio-assayed against germination and seedling growth (plumule and radicle length) of the experimental crops. Significant differences in the normal germination between crops as well as their varieties were observed. Seed germination was significantly reduced ($P < 0.05$) in all crop varieties in all the treatments. However, the reduction was more significant in T4 treatment in all the crops. The Response Index (RI) values ranged from minimum (-0.006) in mustard variety Kranti to maximum (-0.412) in rice variety Govind. The plumule length was significantly reduced ($p < 0.05$) in all the crop varieties and in all the treatments except in T1 treatment. RI values ranged from -0.021 in soybean variety PS-1225 to 0.634 in rice variety Govind at T1 and T4 treatments, respectively. Some crop varieties showed stimulation effect on plumule length, i.e. +0.038 (Govind variety of rice) and +0.237 (UP-2526 variety of wheat) at T1 and T2 treatments, respectively. The radicle length was significantly ($p < 0.05$) reduced in all the crop varieties and in all the treatments. Higher concentrations of the stem aqueous extract had a strong inhibitory effect on germination of all varieties.

Key words: Allelopathy, Food crops, Intercropping, *Jatropha curcas*, Stem aqueous extract

In recent decades *Jatropha*, an agro-fuel plant, has been rapidly introduced in cultivated areas in the Tarai area of the Uttarakhand State of India. Production of biodiesel as a viable alternative to the conventional fossil fuels has been the main objective of large-scale *Jatropha* plantations (Rastogi and Singh 2019). Almost all the food and non-food crops being cultivated in the Tarai area of the Himalaya have been tried in *Jatropha*-based intercropping systems. However, the following systems are dominant in this fertile area of the Himalayan foothills: *Jatropha*-Wheat, *Jatropha*-Mustard, *Jatropha*-Rice, *Jatropha*-Maize, and *Jatropha*-Soybean.

This agro fuel crop has been reported with some allelopathic effects on food crops (Abugre and Sam 2010, Rastogi *et al.* 2019). Allelochemicals are the secondary metabolite compounds (such as alkaloids exuded by different parts of a plant). The observed allelopathic effects are plausibly due to its alkaloid, flavonoids, terpanoids, phenolics, isoprenoids, gluconolates etc.

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 up to justify and/ or reject the large scale plantation of this exotic species

on the basis of scientific logic. The allelochemicals may be released from any part of a plant species, but in this experiment we have attempted to examine allelopathic effects of the allelochemicals present in the stem (shoot) part of the *Jatropha curcas* plant on the crops which are being raised in the *Jatropha*-based intercropping systems in the Tarai area of the Indian Himalayan State of Uttarakhand.

MATERIALS AND METHODS

Seeds of two varieties each of the five crops, viz. *Triticum aestivum* (wheat), *Oryza sativa* L. (rice), *Zea mays* L. (corn or maize), *Glycine max* L. (soybean) and *Brassica juncea* L. (mustard) were obtained from the Crop Research Center (CRC), of G B Pant University of Agriculture and Technology. Laboratory experiments were conducted in the Environmental Science department of the university during 2017-18.

Aqueous extract of *Jatropha* stem was prepared following the method given by Maharjan *et al.* (2007). Healthy and seemingly uniform 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. Ten sterilized seeds were placed at proper space in each sterilized glass Petri dishes (90 mm diameter and 15 mm height) containing two sterilized blotting papers. The seeds were moistened with sterilized distilled water

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(control) and with aqueous extracts of different strengths (5%, 10% and 15%, 20%) of *Jatropha* stem (treatments). The emergence of radicle was considered as the index for seed germination. The observations were made at an interval of one day (24 h) up to 15 days for rice, maize, wheat and soybean and 7 days for mustard. Numbers of germinated seeds were counted after ten days and radicle and plumule lengths were recorded with the help of meter scale.

Details of treatment

The experiment was carried out with three replications with the following treatments:

T0: Seeds of receptor crops varieties grown in distilled water only (Control)

T1: 5.0% stem aqueous extract

T2: 10% stem aqueous extract

T3: 15% stem aqueous extract

T4: 20% stem aqueous extract

Seedling growth

The plumule (shoot) and radicle (root) length (cm) 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 cm either with the help of a scale or with a

thread. Per cent seed germination for different crops varieties were calculated. The Response Index (RI) was calculated as elaborated by Rastogi and Singh (2019).

Statistical treatment of the data

The replicates were designed in Completely Randomized Block Design (CRD) and analysed using Statistical Software STPR 15 & STPR 2.

RESULTS AND DISCUSSION

Effect on germination percentage

Maximum germination percentages of the seeds were observed in all the control treatments (T0), whereas the minimum seed germination was recorded with the highest concentration of the extract (T4 treatment). Seed germination percentage was maximum in wheat variety UP-2338 (99.11±0.930) and rice variety PB-1 (99.03±0.860) and minimum in maize variety Gourav (84.66±0.233) under T0 treatment. There were significant differences in the normal germination between crops as well as between varieties (Table 1). Seed germination was significantly reduced ($p < 0.05$) in all crop varieties in all the treatments. However, the reduction was more significant in T4 treatment in all the crops.

Table 1 Effect of different concentrations of *Jatropha curcas* stem aqueous extract on seed germination (%) and reduction (% of control) on different crop varieties (Mean ± SE)

Crops and varieties		Concentration of stem extract				
		T0	T1	T2	T3	T4
Wheat	UP 2526	97.73±1.047	95.37±0.742 (-2.42)	87.90±0.892 (-10.06)	84.70±1.331 (-13.34)	67.80±0.921 (-30.63)
	UP 2338	99.11±0.930	86.88±0.510 (-12.33)	85.00±0.447 (-14.23)	76.92±1.001 (-22.38)	68.85±0.772 (-30.50)
Maize	Gourav	84.66±0.233	89.56±2.787 (+5.79)	90.30±1.241 (-6.65)	70.73±1.676 (-16.46)	58.90±0.669 (-30.43)
	Pragati	87.3±1.323	91.6±0.763 (+4.93)	82.6±2.450 (-5.38)	70.9±1.091 (-18.79)	57.83±1.126 (33.76)
Rice	PB-1	99.03±0.860	95.43±0.580 (-3.62)	87.33±0.870 (-11.81)	82.80±1.033 (-16.39)	60.40±0.854 (-39.01)
	Govind	97.47±0.589	99.60±1.1054(+2.19)	80.53±0.096 (-17.38)	71.66±1.126 (-26.48)	57.30±1.450 (-41.21)
Soybean	PS-1225	90.3±0.187	93.3±0.306 (+3.32)	80.07±0.580 (-11.33)	70.43±1.564 (-22.00)	60.94±1.410 (-32.51)
	PS-1042	89.46±0.088	95.1±1.251 (+6.30)	78.1±2.300 (-12.70)	70.63±2.160 (-21.05)	59.37±1.495 (33.64)
Mustard	Krishna	87.33±0.874	86.8±1.251 (-0.61)	78.56±1.121 (-10.04)	64.27±0.987 (-26.41)	60.57±0.240 (-30.65)
	Kranti	74.93±0.066	72.47±0.240 (-3.29)	68.30±0.153 (-8.85)	66.27±0.219 (-11.57)	60.67±0.685 (-19.04)

CD (P=0.05) a = 0.93, b = 0.59, c = 0.93, a x b = 1.32; a = crops, b = varieties, c = treatments

CV (%) 2.28

Values in parentheses indicate percent reduction (-) or stimulation (+)

Table 2 Response Index (RI) values for germination (A) and plumule length (cm) (B) in different crop varieties due to different concentrations of stem extract of *Jatropha curcas*

Crops and varieties		A				B			
		Concentrations of stem extract							
		T1	T2	T3	T4	T1	T2	T3	T4
Wheat	UP-2526	-0.024	-0.119	-0.151	-0.321	-0.196	+0.237	-0.289	-0.330
	UP-2338	-0.123	-0.142	-0.234	-0.305	-0.008	--0.118	-0.292	-0.407
Maize	Gourav	+0.055	+0.062	-0.165	-0.304	-0.037	-0.169	-0.231	-0.398
	Pragati	+0.047	-0.054	-0.188	-0.338	-0.054	-0.202	-0.279	-0.432
Rice	PB-1	-0.036	-0.118	-0.164	-0.390	-0.052	-0.152	-0.396	-0.626
	Govind	+0.021	-0.174	-0.265	-0.412	+0.038	-0.182	-0.341	-0.634
Soybean	PS-1225	+0.032	-0.113	-0.220	-0.325	-0.021	-0.072	-0.149	-0.462
	PS-1042	+0.059	-0.127	-0.211	-0.336	-0.013	-0.104	-0.150	-0.427
Mustard	Krishna	-0.006	-0.100	-0.264	-0.306	-0.296	-0.134	-0.430	-0.522
	Kranti	-0.033	-0.089	-0.116	-0.190	-0.292	-0.355	-0.440	-0.581

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

The ANOVA values for seed germination indicated that the differences between crops and varieties and varieties and treatments were significant at $p < 0.05$. This finding of the present study is in line with the results of other reported studies like Abugre and Sam (2010) and Rastogi *et al.* (2019) who recorded similar reduction pattern in seed germination by aqueous leaf extract of *Jatropha* in several crops.

The Response Index values ranged from minimum (-0.006) in mustard variety Krishna in T1 to maximum (-0.412) in rice variety Govind in T4 (Table 2) indicating that

the allelopathic effect increased with increased concentration of the stem aqueous extract.

Effect on seedling growth

The seedling growth (shoots and root lengths), the parameter quite frequently used to present the results of allelopathic effects, was measured at the end of the germination experiment. The lengths of shoots and roots were measured in three randomly selected seedlings from each Petri dish, i.e. a total of 15 seedlings for each species in each treatment.

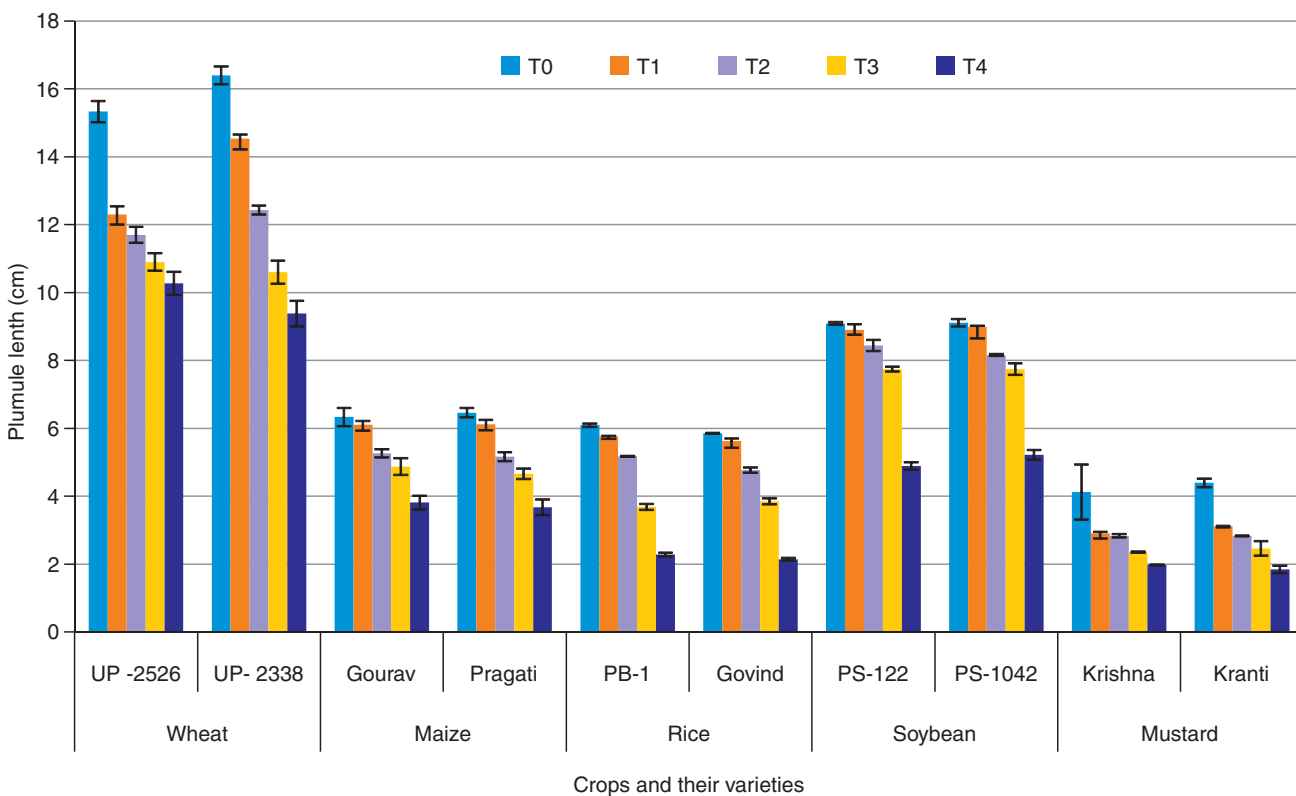


Fig. 1 Effect of different concentrations of stem extract of *Jatropha curcas* on plumule length.

Plumule and radicle length

The plumule length was significantly reduced in all the crop varieties and in all the treatments except in T1 treatment in which rice crop varieties showed the positive values. Decrease in the plumule length in different crops ranged from a minimum value of 1.32% in PS-1042 variety of soybean to a maximum value of 63.38% in Govind variety of rice at T1 and T4 treatment respectively (Fig 1).

RI values ranged from -0.634 in rice variety Govind to -0.021 in soybean variety PS-1225 at T4 and T1 treatments respectively (Table 2). Some crop varieties showed stimulation effect on plumule length, i.e. +0.038 (Govind variety of rice) and +0.237 (UP-2526) variety of wheat at T1 and T2 treatments. The results reveal that the inhibition effect of the stem aqueous extract increases with increasing its concentration. The data obtained are in conformity with those reported by Rastogi *et al.* (2019) who observed the inhibitory effects of leaf aqueous extract of *Jatropha curcas* on rice, soybean and mustard. The stimulation effect might be variety specific or due to certain soil-relating factors.

The radicle length was significantly ($p < 0.05$) reduced in all the crop varieties and in all the treatments. Different crop varieties recorded a reduction ranging from 0.45% in wheat variety UP-2526 at T1 to about 65% in PB-1 variety of rice. The reduction in the radicle length went on increasing with an increase in the concentration of *Jatropha* stem aqueous extract and no stimulating effect on any variety was observed (Fig 2).

The results revealed that the inhibition effect of the stem aqueous extract increased with an increase in the

concentration of allelochemicals.

This study revealed that the allelopathic potential of the *Jatropha curcas* stem extract was highly pronounced in the germination study. Root length was strongly inhibited by the aqueous stem extract of *Jatropha* in all the tested crops. A similar reduction of shoot length was also observed. It was also noticed that the decrease in root and shoot lengths seemed to increase with increase in extract concentrations.

Several other researchers also reported similar pattern of allelopathic potential of *Jatropha* on other receiver crops. For example, Hassan *et al.* (2013) reported that aqueous leaf extract of *Jatropha* could inhibit seed germination, shoot and root growth in millet food crops, and Abugre and Sam (2010) reported negative allelopathic effects of *Jatropha* leaf extract on four traditional crops. Aqueous extracts of *Jatropha* inhibited germination and initial growth of corn and tobacco at increasing concentration (Ma *et al.* 2011). Baruah *et al.* (2018) also mentioned the allelopathic effect of *Jatropha* extract on chilli (*Capsicum annum*) and greengram (*Vigna radiata*) and found that germination and seedling growth in chilli, compared to that of greengram, appeared to be less sensitive to aqueous extract of *Jatropha* leaf, so they suggested that chilli may be grown as an intercrop with *Jatropha* plant. Experiments conducted by Rastogi *et al.* (2019) brought to the fore the allelopathic effects of *Jatropha* aqueous leaf extracts on seed germination and seedling growth of rice, soybean and mustard crops and their data corroborated with those generated in the present experiment.

The experiment reveals the facts that *Jatropha curcas*

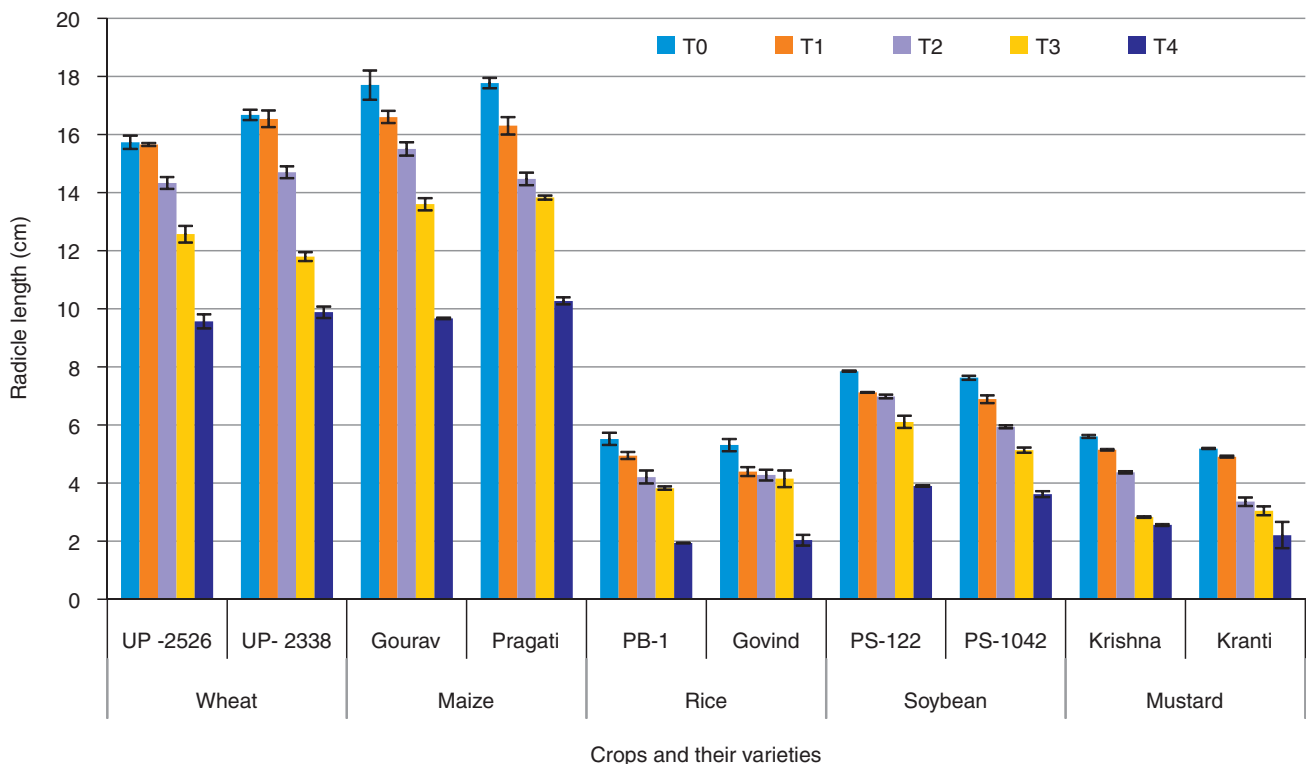


Fig 2 Effect of different concentrations of stem extract of *Jatropha curcas* on radicle length.

has well pronounced allelopathic effects on food crops. The higher the concentration of the aqueous stem extract the greater the allelopathic effects. Introduced in the Tarai area of the Himalayas in recent years, *Jatropha curcas* cannot be recommended as a base crop for raising food crops in agroforestry systems. However, the aqueous stem extract of this introduced agro-fuel crop can be a promising material for future field experiments and for use as natural herbicides.

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