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Arila W Sangtam
Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Rajiv Umrao
Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Lipi Rina
Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Imkumnaro Kichu
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India

Corresponding Author:
Arila W Sangtam
Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Allelopathic effect of Jatropha leaf leachate on growth and yield of tomato and pea

Arila W Sangtam, Rajiv Umrao, Lipi Rina and Imkumnaro Kichu

Abstract
The experimental study was conducted to evaluate the allelopathic effects of *Jatropha curcas* on two vegetable crops tomato (*Lycopersicon esculentum)* and pea (*Pisum sativum*). Fresh leaves of Jatropha were collected, sundried and soaked for 24 hrs; the filtrate was diluted with tap water to make different concentrations. There were five treatments *viz.,* T_0 (tap water); T_1 (25% concentration); T_2 (50% concentration); T_3 (75% concentration); T_4 (100% concentration). The experiments were laid out in the Randomized Block Design (RBD) with three replications. Leaf leachates of *Jatropha curcas* at 25%, 50%, 75% and 100% concentrations were applied to determine their effect on seed germination and growth parameters of test crops in open field condition. Germination was significantly higher in tomato and pea when they were treated with 25% and 50% concentration. Similarly, the gross return, net return and higher cost: benefit ratio was reported maximum when the crops were treated with 25% and 50% concentration. The results showed that allelochemical stress caused by *Jatropha curcas* aqueous was much pronounced in 100% concentration i.e. T_4 in both tomato and pea. From this we can predict that *Jatropha curcas* might possess allelochemicals that causes both suppressive and stimulatory ability.

Keywords: Allelopathy, Jatropha leaf leachate, tomato, pea

Introduction
In the present world, various types of ecological and environmental disasters are taking place due to highly use of synthetic chemical compounds in agriculture. These toxic chemicals are damaging the ecological balance to a severe extent and introducing many fatal diseases. Synthetic fertilizers often contain toxins that can be destructive to the soil, and the chemicals in these fertilizers can be poisonous to humans, wildlife, and marine life if they reach the oceans. Fertilizers can also leach through soil into groundwater, making it very harmful to the surrounding environment. That's why the demand of sustainable agriculture and eco-friendly alternatives to chemical compounds has been increased. Allelopathy is a natural ecology process of chemical inhibition of one species by another species, where substances acting as germination or growth inhibitors are released into the environment, influencing the development and growth of nearby plants. The term Allelopathy was introduced by professor Hans Molisch in 1937, which is derived from two separate Greek words *allelon* which means "of each other" and *pathos* which means "to suffer" literally meaning 'mutual suffering'. Allelopathic chemicals can be present in any part of the plant. They can be found in leaves, flowers, roots, fruits, or stems.

Jatropha curcas L. is a perennial plant belonging to the family Euphorbiaceae. It is originally native to the tropical areas of the Americas from Mexico to Argentina, and has been spread throughout the world in tropical and subtropical regions around the world, becoming naturalized or invasive in many areas. It is reported that Jatropha seeds contain 27-40% oil that presents many different utilities, in addition to providing biodiesel of high quality. In India, there is a vast potential for the production of biodiesel from Jatropha curcas (called *Janglia randi* in Hindi and *Kattukkotai* in Tamil) and *Pongamia pinnata* (The Indian Beech called *Karanj* in Hindi and *Pungai* in Tamil) as they occur in plenty in forests and wastelands.

In December 2009, the Union Government launched the National Biodiesel Mission (NBM) identifying Jatropha as the most suitable tree-borne oilseed for biodiesel production to help achieve a proposed biodiesel blend of 20 per cent with conventional diesel by 2017. Biodiesel procurement started in 2014 and a pilot programme was started in August 2015. It has extended to six states.

Tomato (*Solanum lycopersicum*) belongs to the large and diverse Solanaceae family also called Nightshades which includes more than three thousand species. The species originated in western South America. Tomato is the second most important vegetable crop after Potato (*Solanum tuberosum*).

Pea (*Pisum sativum*) also called a garden pea, herbaceous annual plant in the family Fabaceae, Peas are an important protein source for people in parts of Asia; However like any other legumes, peas are low in the essential amino acid, methionine. They are grown globally for its edible seeds. It is one of the oldest cultivated crops. It is one of the important vegetables in the world and ranks among the top 10 vegetable crops.

Materials and Methods

The research work which comprised of a field experiment was carried out in the nursery of College of Forestry SHUATS, Prayagraj 2018. Prayagraj is situated at an elevation of 98 meters above sea level at 25.87^0 North latitude and 81.15^0 E longitudes. The experiment was laid out in Randomized Block Design (RBD) with three replications. The collected leaves were sun dried for 4-5 days and later the dried leaves were crushed and soaked in tap water for 24 hours at 1:10 proportion on weight by volume. After 24 hours of soaking the leaf leachates was filtered with the help of muslin cloth and the leachate of different concentration i.e. 25, 50, 75 and 100 per cent was prepared accordingly.

Thus, there were five treatments including Control water as follows:

T_0 - Control water (Tap water)
T_1- Leachates of 25% Concentration
T_2 - Leachates of 50% Concentration
T_3 - Leachates of 75% Concentration
T_4– Leachates of 100% Concentration

Treatment combinations

Sl. No	Treatments	Particulars
1	T_0	P_1=100% (tap water) Control water
2	T_1	P_1 =25%leaves extract
3	T_2	P_1 =50% leaves extract
4	T_3	P_1 = 75% leaves extract
5	T_4	P_1= 100% leaves extract
6	T_0	P_2 = 100% (Tap water) Control water
7	T_1	P_2 = 25% leaves extract
8	T_2	P_2 = 50% leaves extract
9	T_3	P_2 = 75% leaves extract
10	T_4	P_2 = 100% leaves extract

P_1 = Variety of Tomato & P_2= Variety of Pea

Results and Discussion

A. Allelopathic effects of *Jatropha curcas* L. on Tomato (*Solanum lycopersicum*)

1. Germination Percentage (%)

The highest percentage of germination was found at treatment T_2 (80.00%) followed by T_3 (76.67%), T_1 (63.33%) and T_0 (60.00%), respectively. The lowest germination percentage of 56.67% was recorded in T_4. The studies with other species have reported that the response to allelochemicals may be concerning on the concentration dependent (Ashrafi *et al.*, 2009) [4]. 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) [20]. It is therefore necessary to identify concentration at which J. curcas aqueous extract would affect the germination and growth of crops.

2. Plant height (cm)

The plant height was recorded at 30, 60 and 90 DAS respectively as influenced by different percentage of Jatropha leaf leachates.

At 30 DAS, it was observed that plant height was significantly affected by different concentration of leachates. The maximum plant height was found in treatment T_2 (20.08 cm) followed by T_3 (17.57cm) and minimum plant height was observed in T_4 (15.50 cm).

At 60 DAS, it was observed that plant height was significantly affected by different concentration of leachates. The maximum plant height was found in T_2 (27.17 cm) followed by T_3 (26.47 cm) and minimum plant height was observed in T_4 (18.93).

At 90 DAS, it was observed that plant height was significantly affected by different concentration of leachates. The maximum plant height was found in treatment T_2 (51.78 cm) followed by T_3 (50.67 cm) and minimum plant height was found in T_4 (37.78 cm).

Different allelochemicals have different sites of action in a plant. Thus, the sensitivity to allelochemicals and the extent of inhibition varied with species and organs (Maharjan *et al.*, 2007). Kanchan and Jayachandra (1980) [6, 12] observed that leaf extracts had more impact on the radicle growth of crops than root extracts. This implies that inhibitory chemicals had higher concentrations in leaves than in the roots. Macias *et al.* (2004) [17] found higher phytotoxic effects of aqueous extracts from bark than from leaves of *Tectona grandis* on the germination, root and shoot lengths of five species namely *Lepidium sativum*, *Lactuca sativa*, *Lycopersicum esculentum*, *Allium cepa* and *Triticum aestivum*. The root length of *Lycopersicum esculentum*, *Allium cepa* and *Triticuma estivum* was the most affected parameter.

Table 1: Effect of different concentrations of *Jatropha curcas* leaf leachates on Tomato plant height (cm)

Treatment	30 DAS	60 DAS	90 DAS
T_0	16.53	22.97	45.67
T_1	17.31	23.87	48.56
T_2	20.08	27.17	51.78
T_3	17.57	26.47	50.67
T_4	15.50	18.93	37.78
F-test	S	S	S
S.Ed.	0.63	2.13	2.18
C.D.(0.05)	1.46	4.92	5.02

3. 50 days taken to flowering

The maximum days taken to flowering was observed in T_4 (100% leaf leachates) with 53.67 respectively. Different allelochemicals have different sites of action in a plant. Thus, the sensitivity to allelochemicals and the extent of inhibition varied with species and organs (Mahajan *et al.*, 2007). Kanchan and Jayachandra (1980) [6, 12] observed that leaf extracts had more impact on the radicle growth of crops than root extracts. This implies that inhibitory chemicals had higher concentrations in leaves than in the roots. Macias *et al.*, (2004) [17] found higher phytotoxic effects of aqueous extracts from bark than from leaves of *Tectona grandis* on the germination, root and shoot lengths of five species namely *Lepidium sativum*, Lactuca sativa, *Lycopersicum esculentum*, *Allium cepa* and *Triticum aestivum*. The root length of *Lycopersicum esculentum*, *Allium cepa* and *Triticum aestivum* was the most affected parameter.

4. Number of cluster per plant

The highest number of cluster per plant was observed in treatment T_2 (50% leaf leachates) with 10.96 and followed by T_3 (75% leaf leachates) with 10.84 and the leased was observed in T_4 (100% leaf leachates) with 9.46 respectively.

This result conform with the findings of (Oluwafemi, 2014). Ferguson and Rathinasabapathi, (2003) [21, 8] reported that allelochemicals can affect all ecological factors including growth, plant survival, canopy succession and extension and crop production. The physical and chemical processes important for growth and development of plants are frequently modified by chemicals released from neighboring plants, which can affect the plant negatively or positively in some cases (Iqbal *et al.*, 2013) [10].

5. Number of fruit per cluster

The highest number of fruits per cluster was observed in treatment T_2 (50% leaf leachates) with 4.70 and followed by T_3 (75% leaf leachates) with 4.51 and the leased was observed in T_4 (100% leaf leachates) with 4.09 respectively. This result conform with the findings of (Oluwafemi, 2014) [21]. Ferguson and Rathinasabapathi, (2003) [8] reported that allelochemicals can affect all ecological factors including growth, plant survival, canopy succession and extension and crop production. The physical and chemical processes important for growth and development of plants are frequently modified by chemicals released from neighboring plants, which can affect the plant negatively or positively in some cases (Iqbal *et al.*, 2013) [10].

6. Number of tomato per plant (g)

The highest number of fruits per cluster was observed in treatment T_2 (50% leaf leachates) with 48.50g and followed by T_3 (75% leaf leachates) with 44.83g and the leased was observed in T_4 (100% leaf leachates) with 33.33g respectively.

According to Aoki *et al*. (1997) [2], the intensity of allelopathic effects depends on the concentration of substances that are present in the extract, what was proven in this work, in which the concentration of 15% showed significant inhibition effect over the aerial part and the root, while the other concentrations did not present the same result, what highlights the specificity of the allelopathic effect. This relation is also described by Reigosa *et al*. (1999) [7], who points out that allelopathic compounds may act in synergism, causing effects that may activate or inhibit the growth of other plants, depending on the concentration being tested. Significant growth inhibitor effects on lettuce roots were also observed by Soares *et al*., (2002) [9].

7. Tomato yield per plot (kg)

The highest number of tomato yield per plot was observed in treatment T_2 (50% leaf leachates) with 2.35 kg and followed by T_1 (25% leaf leachates) with 2.05 kg and the leased was observed in T_4 (100% leaf leachates) with 1.35 kg respectively.

8. Tomato yield (q ha^{-1})

The highest number of tomato yield (q ha^{-1}) was observed in treatment T_2 (50% leaf leachates) with 104.44 q ha^{-1} and followed by T_1 (25% leaf leachates) with 90.99 q ha^{-1} and the leased was observed in T_4 (100% leaf leachates) with 60.21 q ha^{-1} respectively.The process by which a plant species either stimulate or inhibit the growth and development of other neighboring plant species by producing certain chemicals that are released into the environment is referred to as allelopathy (Rice, 1984; Khattak *et al.*, 2015) [25, 4]. The donor plant species may affect germination, growth and development of the recipient plant species. Allelopathic compounds / allelochemicals are released into the environment by various means such as leaching, volatilization, root exudation and decomposition of the plant residue in the soil (Einhelling The findings of the present investigation established that higher concentrations of the leaf aqueous extracts suppressed the seed germination and growth of *Parthenium hysterophorus*. Therefore, it is inferred that leaf can yield adequate amount of allelochemicals to effectively control *Parthenium hysterophorus*.

9. Total Soluble Solids (^{0}Brix)

The total soluble solids (TSS) content in the Tomato juice was determined with the help of Hand Refractometer, the data were subjected to statistical analysis and analysis is given in appendix. It is clear that the different concentration of leaf leachates produce significantly TSS content. The significantly higher total soluble solids 5.13 ^{0}Brix is recorded in T_2 followed by T_3 with 5.12 ^{0}Brix. The minimum TSS content is recorded under T_4 (100% leaf leachates) with 4.26 ^{0}Brix. Allelochemicals affect all functions of plant life including photosynthesis, respiration, transpiration, resistance and growth (Rice, 1984; Saxena *et al.*, 2004) [25, 8],

Table 2: Effect of different concentrations of aqueous extract of *Jatropha curcas* on germination (%), days taken to flowering, number of cluster per plant, number of fruit per cluster, number of tomato per plant, tomato yield per plot (kg), tomato yield (q ha^{-1}) and TSS (^{0}Brix)

Treatment	Germination percentage (%)	Days taken to flowering	Number of cluster per plant	Number of fruit per cluster	Number of tomato per plant	Tomato yield per plot (kg)	Tomato yield (q ha^{-1})	TSS
T_0	60.00	49.67	10.24	4.24	40.17	1.67	74.07	4.90
T_1	63.33	49.33	10.64	4.25	41.17	2.05	90.99	4.98
T_2	80.00	47.33	10.96	4.70	48.50	2.35	104.44	5.13
T_3	76.67	49.00	10.84	4.51	44.83	1.95	86.81	5.12
T_4	56.67	53.67	9.49	4.09	33.33	1.35	60.21	4.26
F-test	S	S	S	S	S	S	S	S
S.Ed.	9.07	0.81	0.17	0.13	1.43	0.34	14.95	0.12
C.D.(0.05)	20.91	1.87	0.38	0.30	3.29	0.78	34.47	0.28

B. Allelopathic effects of *Jatropha curcas* L. on Pea (*Pisum sativum*)

1. Germination percentage (%)

The highest percentage of germination was observed in treatment T_1 (76.67%) followed by T_2 (66.67%), T_0 (63.33%) and T_3 (60.00%), respectively. The lowest germination percentage of 56.67% was recorded in T_4. The release of phenolic compounds adversely affects the germination and growth of receiver plants through their interference in energy metabolism, cell division, mineral uptake and biosynthetic processes (Rice, 1984) [25]. Several researchers reported similar allelopathic effects of jatropha on other crops also. For example, Hassan *et al.*, (2013) [3], reported that aqueous leaf extract of jatropha could inhibit seed germination, shoot and root growth in millet. Abugre and Sam (2010) [1] reported

negative allelopathic effects of jatropha leaf extract on several receiver plants.

2. Plant height (cm)

At 30 DAS maximum plant height (32.30 cm) was obtained at T_1followed by T_2 (30.92 cm), T_0 (30.18 cm), T_3 (29.59 cm) and a minimum plant height (27.21 cm) was obtained at T_4 (100% leaf leachates). The increase in plant height at 30 DAS was found significant.

At 60 DAS maximum plant height (44.51 cm) was obtained at T_1 (25% leachates) while the minimum plant height (38.22 cm) was recorded at T_4 (100% leachates). The plant height at 60 DAS was found to be significant.

At 90 DAS maximum plant height (53.41 cm) was obtained at T_1 (25% leachates) while the minimum plant height (47.11 cm) was recorded at T_4 (100% leachates). The plant height at 90 DAS was found to be significant.

Similar inhibitory effects in poplar were recorded as a result of increased concentration of secondary metabolites (Joshi and Prakash 1992; Singh *et al.*, 2001) and on *Jatropha curcus* [11, 28].

Table 3: Effect of different concentration of leaf leachates on Pea plant height

Treatment	30 DAS	60 DAS	90 DAS
T_0	17.31	23.87	48.56
T_1	20.08	27.17	51.78
T_2	17.57	26.47	50.67
T_3	16.53	22.97	45.67
T_4	15.50	18.93	37.78
F-test	S	S	S
S.Ed.	1.68	2.38	2.19
C.D.(0.05)	3.87	5.49	5.04

3. Number of leaves per plant

At 30 DAS, It was observed that the number of leaves was significantly affected by different concentrations of leaf leachates. The maximum number of leaves was found in T_1 (25% leaf leachates) with 35.60 followed by T_2 (50% leaf leachates) with 34.87 respectively. The minimum number of leaves was found in T_4 (100% leaf leachates) with 25.20 respectively.

At 60 DAS, It was observed that the number of leaves was significantly affected by different concentrations of leaf leachates. The maximum number of leaves was found in T_1 (25% leaf leachates) with 58.80 followed by T_2 (50% leaf leachates) with 55.40 respectively. The minimum number of leaves was found in T_4 (100% leaf leachates) with 39.33 respectively.

At 90 DAS, It was observed that the number of leaves was significantly affected by different concentrations of leaf leachates. The maximum number of leaves was found in T_1 (25% leaf leachates) with 222.93 followed by T_2 (50% leaf leachates) with 215.33 respectively. The minimum number of leaves was found in T_4 (100% leaf leachates) with 140.60 respectively. Similar results were reported by Reddy *et al.*, (2004) [23].

Table 4: Effect of different concentration of leaf leachates on number of leaves per plant

Treatment	30 DAS	60 DAS	90 DAS
T_0	32.73	54.40	209.27
T_1	35.60	58.80	222.93
T_2	34.87	55.40	215.33
T_3	27.33	44.53	177.73
T_4	25.20	39.33	140.60
F-test	S	S	S
S.Ed.	1.08	2.50	19.15
CD (0.05)	2.49	5.76	44.15

4. Number of branches

At 30 DAS, It was observed that the number of branch was significantly affected by different concentrations of leaf leachates. The maximum number of branch was found in T_1 (25% leaf leachates) with 3.80 followed by T_2 (50% leaf leachates) with 3.60 respectively. The minimum number of branch was found in T_4 (100% leachates) with 2.80 respectively.

At 60 DAS, It was observed that the number of branch was significantly affected by different concentrations of leaf leachates. The maximum number of branch was found in T_1 (25% leaf leachates) with 6.80 followed by T_2 (50% leaf leachates) with 6.53 respectively. The minimum number of branch was found in T_4 (100% leachates) with5.13 respectively.

At 90 DAS, It was observed that the number of branch was significantly affected by different concentrations of leaf leachates. The maximum number of branch was found in T_1 (25% leaf leachates) with 8.33 followed by T_2 (50% leaf leachates) with 8.07 respectively. The minimum number of branch was found in T_4 (100% leachates) with 6.47 respectively. There was an inhibitory effect on length of root with the increase in leaf leachate concentration. Similar results were reported by Aga *et al.*, (2004) and Kumar *et al.*, (2004) [2, 8].

Table 5: Effect of different concentration of leaf leachates on number of branch pea plant

Treatment	30 DAS	60 DAS	90 DAS
T_0	3.47	6.33	7.73
T_1	3.80	6.80	8.33
T_2	3.60	6.53	8.07
T_3	3.13	5.40	7.13
T_4	2.80	5.13	6.47
F-test	S	S	S
S.Ed.	0.10	0.13	0.10
C.D.(0.05)	0.23	0.30	0.24

5. Days taken to flowering

The minimum days taken to flowering was observed in T_1 (25% leaf leachates) with 37.86 respectively. The maximum days taken to flowering was observed in T_4 (100% leachates) with 42.26 respectively. Allelochemicals affect all functions of plant life including photosynthesis, respiration, transpiration, resistance and growth (Rice, 1984; Saxena *et al.*, 2004) [25, 8].

6. Number of pods per plant

T_1 (25% leaf leachates) was recorded maximum number of pods per plant (18.11), followed by T_2 (50% leaf leachates) with 17.09. Whereas, T_4 (100% leachates) was recorded the minimum with 15.87. Allelochemicals affect all functions of plant life including photosynthesis, respiration, transpiration, resistance and growth (Rice, 1984; Saxena *et al.*, 2004) [25, 8].

7. Number of seeds per pod

The maximum number of seeds per pod was recorded in T_1 (25% leaf leachates) with 8.83, followed by T_2 (50% leaf leachates) with 8.57 respectively. Whereas, T_4 (100% leachates) was recorded the minimum with 7.53.

Sufficiently availability of nutrients (NPK and FYM) and their adsorption by the plants, proper light and spacing between the plants may have increased the plant growth. Hence, resulting in the maximum number of seeds per pod. These findings are similar to the results by Lal (2004), Battaria *et al.*, (2003), Nadeem *et al.*, (2003) and Prasad *et al.*, (2005) [16, 19, 22].

8. Length of pods (cm)

The longest pod with 10.48 cm was obtained in treatment T_1 (25% leaf leachates), followed by T_2 (50% leaf leachates) with 10.15 cm and the minimum pod length was recorded in T_4 (100% leachates) with 9.79 cm. Allelochemicals affect all functions of plant life including photosynthesis, respiration, transpiration, resistance and growth (Rice, 1984; Saxena *et al.*, 2004) [25, 8].

9. Pea yield per plot

T_1 (25% leaf leachates) was recorded maximum pea yield per plot (1.16 kg), followed by T_2 (50% leaf leachates) with 1.10 kg. Whereas, T_4 (100% leachates) was recorded the minimum with 0.81 kg. These results were in confirmation with those of Rizvi *et al.*, (2000) [26] who investigated allelopathic effects of wheat straw on growth of wild oat.

10. Pod yield (q ha^{-1})

The maximum pod yield (62.41) was recorded at T_1 (25% leaf leachates), while the minimum pod yield (43.30) was recorded at T_4 (100% leachates). These results were in confirmation with those of Rizvi *et al.*, (2000) [26] who investigated allelopathic effects of wheat straw on growth of wild oat.

11. Test weight (g)

Treatment T_1 (25% leaf leachates) was recorded maximum test weight (17.87) followed by T_2 (50% leaf leachates) with 16.17 and the minimum was recorded at T_4 (100% leachates) with 14.35 respectively. These results were in confirmation with those of Rizvi *et al.*, (2000) [26] who investigated allelopathic effects of wheat straw on growth of wild oat.

12. Protein test (%)

Treatment T_1 (25% leaf leachates) was recorded maximum test weight (7.16%) followed by T_2 (50% leaf leachates) with 7.14% and the minimum was recorded at T_4 (100% leachates) with 7.04% respectively.

Allelopathic stress may either elevate the level or induce the inhibition of carbohydrates and protein contents of target plant which build up more proline content as stress indicator; consequently plant growth is either increased or reduced (Batish *et al.*, 2007; Al-Johani *et al.*, 2012) [6, 3].

Table 6: Effect of different concentrations of aqueous extract of *Jatropha curcas* on germination (%), days taken to flowering, number of pods per plant, number of seeds per pod, length of pods (cm), pea yield per plot (kg), pod yield (q ha^{-1}), test weight (g) and protein test (%).

Treatment	Germination %	Days taken to flowering	Number of pods per plant	Number of seed per pod	Length of pods (cm)	Pea yield per plot (kg)	Pod yield (q ha^{-1})	Test weight (g)	Protein test (%)
T_0	63.33	39.72	16.84	8.33	9.97	1.00	54.00	16.11	7.13
T_1	76.67	37.86	18.11	8.83	10.48	1.16	62.41	17.87	7.16
T_2	66.67	39.62	17.09	8.57	10.15	1.10	54.62	16.17	7.14
T_3	60.00	40.80	16.44	8.10	9.92	0.94	43.44	15.90	7.09
T_4	56.67	42.26	15.87	7.53	9.79	0.81	43.30	14.35	7.04
F-test	S	S	S	S	S	S	S	S	S
S.Ed.	3.80	0.65	0.33	0.16	0.19	0.12	5.42	0.98	0.02
C.D.(0.05)	8.76	1.51	0.76	0.37	0.44	0.27	12.49	2.27	0.05

Conclusion

The germination percentage, number of leaves, growth and yield parameters were recorded maximum at T_1 (25% leaf leachates) for Pea, While the maximum germination percentage, height of plant, growth and yield parameters were recorded at T_2 (50% leaf leachates) for Tomato under Jatropha leaf leachates.

The allelochemicals present in the *Jatropha curcas* can have an allelopathic inhibitory effect on different agricultural crops including vegetables associated with Jatropha plantations and also different agroforestry system in field conditions.

It can also be concluded that, the closer the planting of any crop (vegetable) near the Jatropha tree (i.e. within the immediate canopy), the lesser the performance of the crop and consequently the lower the productivity. However, this fact might need further exploration by considering different age groups of Jatropha.

Since these conclusions are on bias of only one season experiment and under only one tree leaf leachates, further experimentation with the same factors should be conducted to substantiate the results for further future research in expanding the horizons.

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