Original Research Article

Allelopathic Effects of *Litchi Chinensis* on Mungbean and Soybean in Agroforestry System

Comment [W11]: Lower case

Abstract

Background: A pot experiment was conducted to demonstrate the allelopathic effect of the litchi tree (Litchi chinensis) on two crops such as mung bean (Vigna radiata) and soybean (Glycine max). The experiment was conducted at the Agroforestry Research field of Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. Five treatments were applied in this experiment, and they are: T1 (topsoil at the base of litchi trees), T2 (soil in the root zone of litchi trees), T3 (soil mulched with dry litchi leaves), T4 (soil irrigated with aqueous litchi leaf extract) and T5 (cosntrol, i.e., fresh garden soil). A factorial randomized complete block (RCBD) design with four replicates was used in this experiment. There were 40 pots in total.

Comment [W12]: Italize scientific names

Results: The results of the study showed that all treatments in the experiment inhibited the germination and growth of both mung beans and soybeans compared to controls. The germination inhibition and growth parameters of mung bean and soybean varied according to soil collected from different plant parts and root zone locations of different trees. The allelopathic effect of litchi trees was in the following order: T3 (soil mulched with dry leaves) > T4 (soil irrigated with aqueous leaf extract) > T1 (topsoil at the base of the tree) > T2 (tree root zoon soil) > T5 (control).

Conclusions: Litchi leaves have a stronger allelopathic effect than litchi ground or root zone soil. Again, dried leaves have stronger allelopathic effects than green (fresh) leaves. Therefore, regular washing of dried leaves is very important for litchi-based agroforestry systems. On the other hand, between the two crops, soybeans were more suppressed than mung beans.

Key words:

1. Allelopathic effects;
2. Agroforestry;
3. Litchi based agroforestry

Comment [W13]: Soybean and mungbean should be among the key words

1.1 Introduction

Any direct or indirect effect of one plant is called Allelopathy (Abbas *et al.,* 2021, Rice, 1984). Allelopathic properties have been reported in many species, especially trees (Jalali et al, 2020). Allelopathy affect the growth, survival, and reproduction of adjacent species (Singh, & Patni, 2020). Allelochemicals when released, so they do not disrupt the balance as catastrophically as chemicals (Einhellig, 2004). Allelochemicals are found in any parts of the plant.

Agroforestry trees generally serve multiple purposes, such as protecting or strengthening soil fertility or producing one or more products (Cooper *et al.* 1996). Mismatches in tree and crop combinations in agroforestry result in low crop yields. Allelopathic effects on leaves, roots, or other parts of the tree cause a suppressive effect on crops. Allelopathy is becoming a potential field of study in both developed and developing countries. Farmers have been observing allelopathy-related problems since the beginning of agriculture (Rice 1984 and Vladimirovna, 2020).

Litchi chinensis is a common tree species grown on crops. B. Mung beans, soybeans, wheat, corn, rice, vegetables, etc (Rerkasem et al, 2020). Litchi is a woody perennial fruit tree species. It has a wide variety of uses. Mung bean (*Vigna radiata*) is an important legume with high protein content. It is cultivated in agroforestry as a single or mixed crop. Like mung beans, soybeans (*Glycine max*) are intentionally cultivated using trees. Soybean is an oilseed crop that meets both protein and fat and oil requirements. There must be a significant interaction (positive or negative) between these elements like Wood perennials (litchi trees) and crops (mung beans and soybeans) in agroforestry system. Therefore, it was essential to check the allelopathic effect of crops with trees in the Agroforestry System (Khan and Alam 1996).

In 1937, Molisch first used the definition of allelopathy. According to him, allelopathy is the direct or indirect effect of the transfer of biochemical components from one plant to another. Allelopathy refers to the adverse or beneficial effects of a chemical produced by another plant species on one plant species. Several types of chemicals have been identified to have allelopathic properties, including phenols.

Comment [W14]: This paragraph should be at the top to align with the earlier stated meaning of allelopathy

1.2 Research Objectives

i. To measure the allelopathic effects of *Litchi chinensis* tree species on mung bean and soybean.

ii. To identify which parts of trees possess more allelopathic potentiality.

2. Materials and Methods

An experiment was taken in pots at the demonstration farm of Rural Development Academy, Bogura, performed with a single factor. RCBD was applied in four replications. Five treatments were applied namely i) T_1=Topsoil (The depth of the topsoil is 15 cm. from the base of the litchi tree), ii) T2 = root zone soil (root zone soil depth is 2 feet of litchi tree), iii) T_3 = soil mulched with dry litchi tree leaves (sun drying) iv) T_4 = water irrigated soil litchi tree leaf extract (5% fresh aqueous leaf extract) and v) T_5= common/fresh outdoor garden soil. Mung bean (*Vigna radiata*) and soybean (*Glycine max)* were the test crops. A total of 40 pots were used and the experimental pot size was 28.5 cm × 22.5cm, each pot contains 5kg of soil as germination medium. After the field was cleaned and weeded, all the pots were transported to the experimental field.

Eight pots were filled with topsoil and eight pots with litchi root zone soil. Fresh litchi leaves were washed with 5% water in 8 pots containing garden soil, and 100 ml of this extract was added to each of 8 pots containing garden soil. Leaves were dried in the sun for 5 days. As mulch 20 g of crushed litchi leaves was added to each of the eight pots. Another eight pots were filled with normal garden soil and used as controls. The two crop varieties were BINA Mung 5 and BARI Soybean 5 Seeds were collected from BADC office in Dinajpur. 20 seeds were sown in each pot. The pot was watered regularly. Weeds were also pulled when necessary. Germination rate (%) was recorded 14 days after sowing.

All but five plants in each pot were then transplanted. Seedling attributes such as shoot length (cm), number of leaves, leaf length (cm), and shoot diameter (cm) were measured at 26, 36, 46, and 56 days after sowing, and root length (cm) and root fresh weight (gm) were recorded 62 days after sowing. Fresh roots and shoots were oven dried for 3 days and recorded the dry weight 65 days after sowing. To find the statistical significance of the treatment effects, the data collected at various parameters within the experimental framework were statistically analyzed using the statistical program MSTAT. Analysis of variance was performed by F-test and significance of differences was measured using the least significant difference test (Gomez and Gomez 1984).

Comment [W16]: delete

Comment [W17]: emergence

Comment [W18]: transplanted where, all test plants should remain in the pot?

Comment [W19]: The figure and table shows DMRT ranking, LDS values were not presented on the tables and figures

3. Results

The results obtained from the present experiment along with statistical analysis of data have been presented here.

3.1 Allelopathic effects of *Litchi chinensis* on Mungbean (*Vigna radiata*)

3.1.1 Germination percentage

Crop germination rates varied significantly compared to controls (Fig. 1). A significantly higher inhibition (-11.14) was seen by treatment T_3 (soil mulched with dry leaves). This was statistically similar to treatments T_4 (soil irrigated with aqueous leaf extract), T_1 (topsoil) and T_2 (root zone soil).

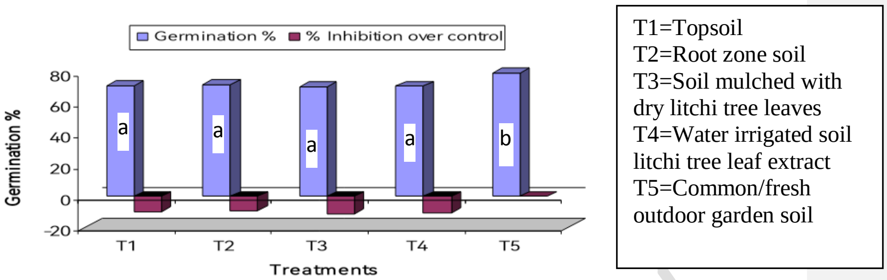

Figure 1. Allelopathic effects of *Litchi chinensis* on germination of Soybean

Comment [W110]: emergence

3.1.2 No. of Leaf

The number of mung bean leaves differed significantly with different DAS for all treatments compared to controls (Fig. 2). Significantly, the greatest inhibition (-28.06 at 26 DAS; -34.96 at 36 DAS; -41.17 at 46 DAS and -41.28 at 56 DAS) was obtained with treatment T_3 (soil mulched with dry leaves) and the lowest (-26.08) at 26 DAS. DAS; -29.92 at 36 DAS; -29.89 at 46 DAS and -12.91 at 56 DAS) were observed in treatment T_2 (root zone soil).

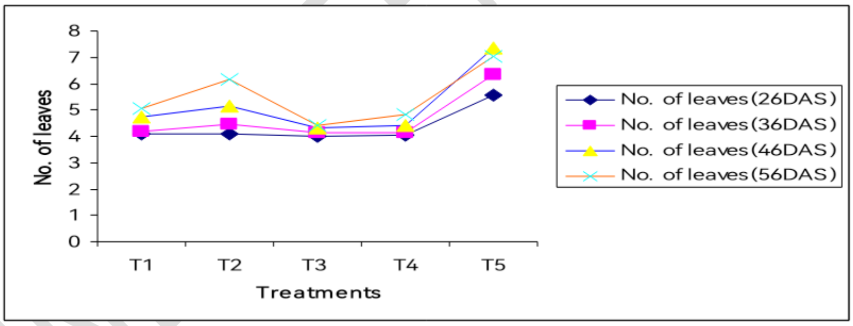

Figure 2. Allelopathic effects of *Litchi chinensis* on no. of leaf of mungbean

3.1.3 Leaf Length (cm)

Mung bean leaf length varied significantly with different DAS for all treatments compared to controls (Figure 3). Importantly, the highest inhibition (-24.95 at 26 DAS, -26.84 at 36 DAS, -34.07 at 46 DAS, -35.81 at 56 DAS) was found in treatment T_3 (dry leaf mulch soil) and the lowest (26 DAS at -16.30). -23.45 at 36 DAS; -31.79 at 46 DAS and -30.74 at 56 DAS) were observed in treatment T_2 (root zone soil).

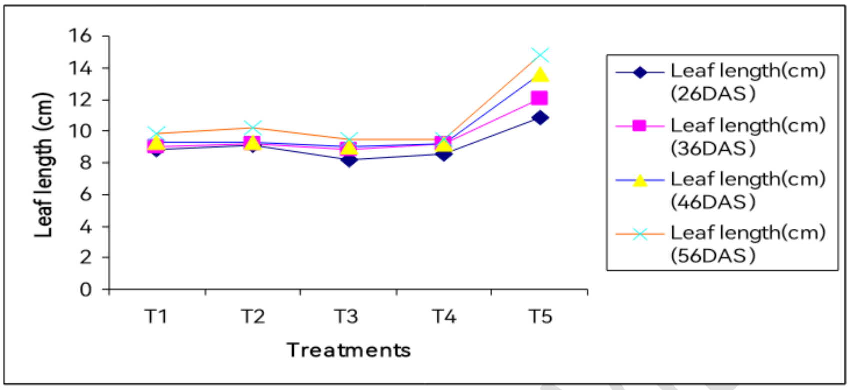

Figure 3. Allelopathic effects of *Litchi chinensis* on Leaf Length of mungbean

3.1.4 Shoot Length (cm)

Mung bean shoot length varied significantly with different DAS for all treatments compared to controls (Figure 4). Maximum (−12.55 at 26 DAS; −16.79 at 36 DAS; −34.09 at 46 DAS and −33.47 at 56 DAS) and minimum (−12 at 26 DAS) in treatment T_3 (soil mulched with dry leaves) .09; -12.09 at 26 DAS) were significant. -15.60 at 36 DAS, -27.27 at 46 DAS, -25.41 at 56 DAS) were detected in treatment T_2 (root zone soil).

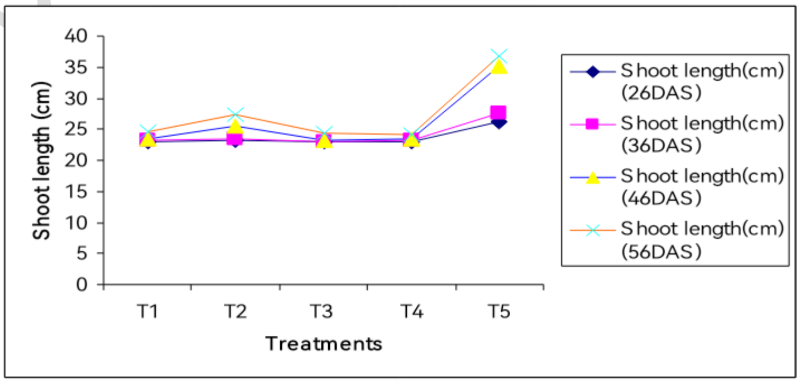

Figure 4. Allelopathic effects of *Litchi chinensis* on Shoot Length of mungbean

3.1.5 Shoot Diameter (cm)

At different DAS shoot diameters of mung bean, there was a significant variation in the three treatments (Fig. 5). Variation in shoot diameter was not significant at 26 DAS. Importantly, maximum inhibition (-46.73 at 36 DAS, -47.73 at 46 DAS, -41.42 at 56 DAS) was obtained with treatment T_3 (soil mulched with dry leaves) and minimum (-32.71 at 36 DAS, -31.36) at 46 DAS and 56 DAS) were observed in treatment T_2 (root zone soil).

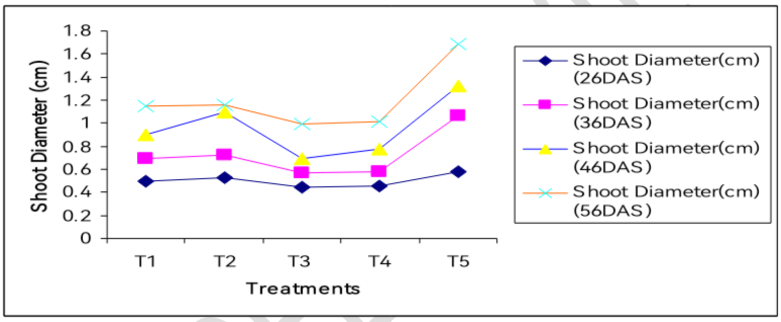

Figure 5. Allelopathic effects of *Litchi chinensis* on Shoot diameter of mungbean

3.1.6 Root length (cm)

All treatments were found to significantly suppress root length in this culture (Table 1). Treatment T_3 (dry leaf mulch soil) shows the highest inhibitory effect (-27.91) on mung bean root length compared to control. The lowest inhibitory effect (-25.13) was seen with treatment T_2 (root zone soil), followed by T_1 (topsoil) and T_4 (soil mulched with leaf aqueous extract).

3.1.7 Shoot Fresh Weight (g)

All treatments were found to significantly suppress root length in this culture (Table 1). Treatment T_3 (dry leaf mulch soil) shows the highest inhibitory effect (-27.91) on mung bean root length compared to control. The lowest inhibitory effect (-25.13) was seen with treatment T_2 (root zone soil), followed by T_1 (topsoil) and T_4 (soil mulched with leaf aqueous extract).

3.1.8 Shoot dry weight (g)

The dry weight of mung bean sprouts was significantly suppressed by all treatments (Table 1). The dry weight inhibition rate (-32.00) of mung bean sprouts was higher in treatment T_3 (dry leaf mulch treated soil), followed by T_4 (soil with aqueous leaf extract), T_1 (surface soil), and T_2 (root zone soil).

3.1.9 Root Fresh Weight (g)

All treatments suppress fresh weight of mung bean roots to a greater extent than controls (Table 1). The significantly highest inhibition of root fresh weight (−50.19) was observed with treatment T_3 (dry leaf mulch soil). A significantly lower inhibition (-43.23) was seen with treatment T_2 (root zone soil), which was statistically similar to treatments T_1 (topsoil) and T_4 (soil with aqueous leaf extract).

3.1.10 Root dry weight (g)

Root dry weight was suppressed by all treatments (Table 1). A maximal suppression of root dry weight of (-62.03) was shown for treatment T_3 (dry leaf mulch soil) versus control, treatment T_4 (soil with aqueous leaf extract), T_1 (topsoil), and T_2 (root mulch soil).) was statistically similar to zonal soil).

Table 1. Allelpoathic effects of *Litchi chinensis* on Growth of Mung bean

Treatments	Root length (cm)	Shoot Fresh Weight (g)	Shoot Dry Weight (g)	Root Fresh Weight (g)	Root Dry Weight (g)
T_1 (Topsoil)	34.14b (-26.42)	4.10b (-50.48)	2.63b (-34.25)	4.27b (-44.90)	2.29b (-58.59)
T_2 (Root zone soil)	34.74b (-25.13)	4.43b (-46.50)	2.72b (-32.00)	4.40b (-43.23)	2.32b (-58.05)
T_3 (Soil mulched with dry litchi tree leaves)	33.45c (-27.91)	3.93c (-52.54)	2.18b (-45.50)	3.86c (-50.19)	2.10b (-62.03)
T_4 (Water irrigated soil litchi tree leaf extract)	34.27b (-26.14)	4.00b (-51.69)	2.48b (-38.00)	4.05b (-47.74)	2.21b (-60.03)
T_5	46.40a	8.28a	4.00a	7.75a	5.53a

(Common/fresh outdoor garden soil)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Level of significance	*	*	*	*	*
CV%	10.28	16.31	8.92	7.38	15.40

32 Allelopathic effects of *Litchi chinensis* on soybean (*Glycine max*)

3.2.1 Germination percentage

Crop germination rate was significantly suppressed by all treatments compared to the control (Figure 6). Statistically, the highest inhibition (-11.28) was found in treatments T3 (soil mulched with dry leaves), T_4 (soil with aqueous leaf extract), T_1 (topsoil), and T_2 (root zone soil).

Comment [W111]: emergence rate not germination

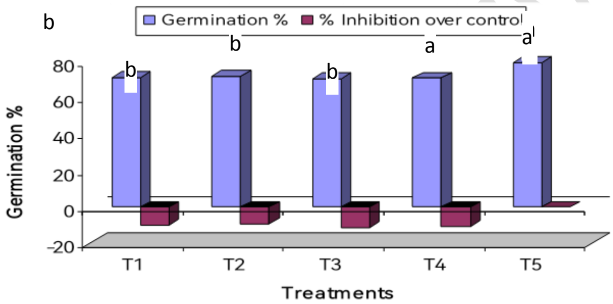

Figure 6. Effects of allelopathy of *Litchi chinensis* on germination of Soybean

3.2.2 No. of Leaf

Comment [W112]: number of leaves/plant

Soybean leaf numbers varied significantly with different DAS for all treatments compared to controls (Fig. 7). Importantly, maximal inhibition (-34.21 at 26 DAS; -41.50 at 36 DAS; -47.64 at 46 DAS and -43.63 at 56 DAS) was obtained with treatment T_3 (soil mulched with dry leaves) and minimal (-31.80 at 26 DAS). DAS; -35.51 at 36 DAS; -65.47 at 46 DAS and -15.04 at 56 DAS) were observed in treatment T_2 (root zone soil).

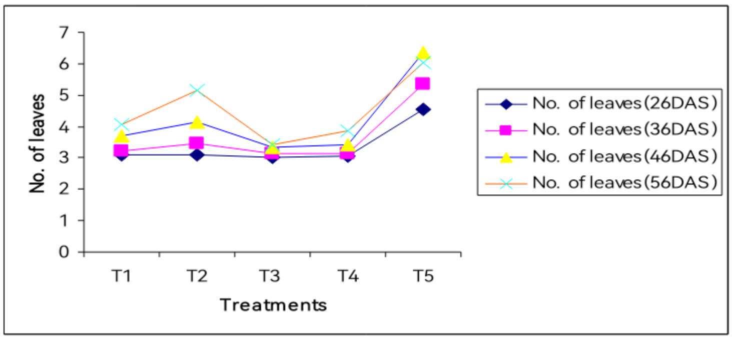

Figure 7. Allelopathic effects of *Litchi chinensis* on no. of leaf of Soybean

3.2.3 Leaf Length (cm)

Soybean leaf length varied significantly with different DAS for all treatments compared to controls (Figure 8). Importantly, the greatest inhibition (-27.48 at 26 DAS, -29.26 at 36 DAS, -36.75 at 46 DAS, -38.40 at 56 DAS) was found in treatment T_3 (dry leaf mulch soil) and the lowest (26 DAS at -17.95). -25.56 at 36 DAS; -34.30 at 46 DAS and -32.97 at 56 DAS) were observed in treatment T_2 (root zone soil).

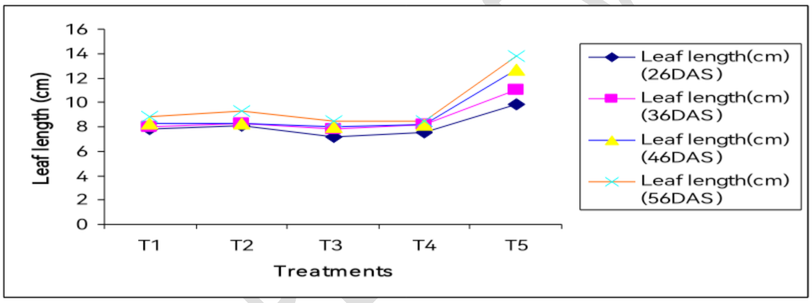

Figure 8. Allelopathic effects of *Litchi chinensis* on Leaf Length of Soybean

3.2.4 Shoot Length (cm)

All the treatments had significant effects on soybean sprout length at different DAS compared to controls (Figure 9). Importantly, the highest inhibition (-13.04 at 26 DAS, -17.41 at 36 DAS, -35.08 at 46 DAS, -34.40 at 56 DAS) was found in treatment T_3 (dry leaf mulch soil) and the lowest (26 DAS at -12.57). -16.18 at 36 DAS; -28.07 at 46 DAS and -1.84 at 56 DAS) were observed in treatment T_2 (root zone soil).

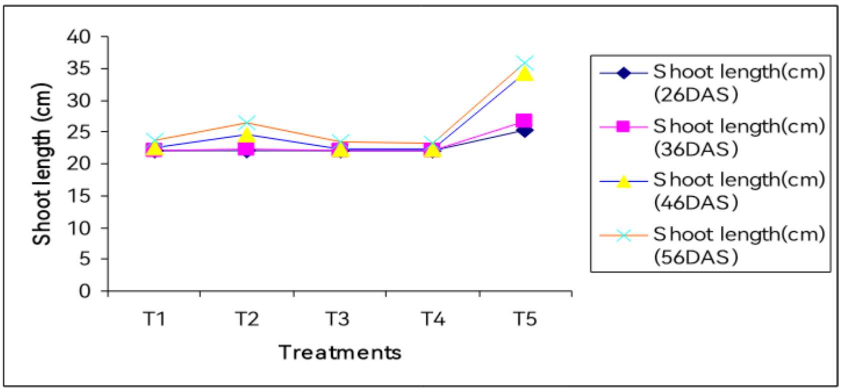

Figure 9. Allelopathic effects of *Litchi chinensis* on Shoot Length of Soybean

3.2.5 Shoot Diameter (cm)

Different DAS among the three treatments significantly altered the shoot diameter of soybean relative to the control (Figure 10). Variation in shoot diameter was not significant at 26 DAS. Importantly, the highest inhibition (-47.16 at 36 DAS; -51.07 at 46 DAS and -41.66 at 56 DAS) was in treatment T_3 (soil mulched with dry leaves) and the lowest (-33.01 at 36 DAS; 46 DAS). -16.80) on DAS. DAS was detected and -31.54 at 56 DAS was observed in treatment T_2 (root zone soil).

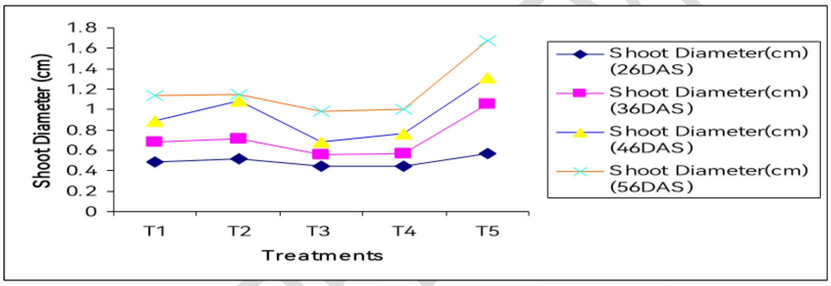

Figure 10. Allelopathic effects of *Litchi chinensis* on Shoot diameter of Soybean

3.2.6 Root length (cm)

All treatments were found to significantly suppress root length in this culture (Table 2). Importantly, treatment T_3 (dry leaf mulch soil) has the highest inhibitory effect on soybean root length (−28.53) versus control (Table 2). The lowest inhibitory effect (-25.68) was seen with treatment T_2 (root zone soil), followed by T_1 (topsoil) and T_4 (soil with aqueous leaf extract).

3.2.7 Shoot Fresh Weight (g)

Soybean fresh germ weight was significantly suppressed in all treatments compared to controls (Table 2). The highest inhibition (-59.75) was observed with treatment T_3 (dry leaf mulch soil). The lowest inhibition (-25.68) was in T_2 (root zone soil), followed by T_1 (topsoil) and T_4 (soil with aqueous leaf extract).

3.2.8 Shoot dry weight (g)

All treatments significantly suppressed the dry weight of soybean stalks (Table 2). Importantly, the suppression of dry weight of sprouts (-60.67) was higher for treatment T_3 (dry leaf mulch soil), which was higher for treatments T_4 (soil with aqueous leaf extract), T_1 (topsoil), and T_2 (root floor) were statistically similar.

3.2.9 Root Fresh Weight (g)

All treatments significantly suppressed the fresh weight of soybean roots compared to controls (Table 2). The greatest inhibition of root fresh weight (-58.52) was observed with treatment T_3 (dry leaf mulch soil). The lowest inhibition (-49.63) was seen with treatment T_2 (root zone soil), followed by T_1 (topsoil) and T_4 (soil with aqueous leaf extract).

Table 2. Allelpoathic effects of *Litchi chinensis* on Germination and Growth of Soybean

Comment [W113]: No germination data on the table

Treatments	Root length (cm)	Shoot Fresh Weight (g)	Shoot Dry Weight (g)	Root Fresh Weight (g)	Root Dry Weight (g)
T_1 (Topsoil)	33.14b (-27.06)	3.10b (-57.42)	1.63b (-45.67)	3.27b (-51.56)	1.29b (-71.52)
T_2 (Root zone soil)	33.74b (-25.68)	3.43b (-52.88)	1.72b (-42.67)	3.40b (-49.63)	1.32b (-70.86)
T_3 (Soil mulched with dry litchi tree leaves)	32.45c (-28.53)	2.93c (-59.75)	1.18b (-60.67)	2.86c (-58.52)	1.10b (-75.72)
T_4 (Water irrigated soil litchi tree leaf extract)	33.27b (-26.72)	3.00b (58.79)	1.48b (-50.67)	3.05b (-54.81)	1.21b (-73.51)
T_5 (Common/fresh outdoor garden soil)	45.40a (0.00)	7.28a (0.00)	3.00a (0.00)	6.75a (0.00)	4.53a (0.00)
Level of sig.	*	*	*	*	*
CV%	12.41	13.24	5.68	6.58	13.26

3.2.10 Root dry weight (g)

Table 2 shows that root dry weight was significantly suppressed by all treatments. The greatest inhibition of root dry weight (-75.72) was shown in treatments T_3 (soil mulched with dry leaves), T_4 (soil irrigated with aqueous leaf extract), T_1 (topsoil), and T_2 (soil mulched with aqueous leaf extract) versus control root zone soil) followed.

4. Discussion

Allelopathic effect on test crops varied significantly with different treatments. Inhibition of seed germination and growth of both crops were more in dry leaf. Leaf extracts of litchi has less allelopathic effects on the test crops. Rizwan Ali Khan *et al.* 2014 found that aqueous leaf extract suppresses the germination, root and shoot growth of maize and Wheat. Another experiment was conducted by Islam *et al.* in 2013 and observed that the germination of lettuce were inhabited by the dry leaf and aqueous methanol extract of Litchi (*L. chinensis*) leaves. It is similar in accordance to the experiment of Arshad-Javaid *et al*. (2006) who found that aqueous extracts of *Mangifera indica* suppress all the growth characters of crops. The result is similar to Allolli *et al*. (2000) who found that *Eucalyptus tereticornis* leaf, bark and root extracts have allelopathic on garlic. Inhibition of growth of the test crops by the root zone soil and dry leaf as mulch of *Litchi chinensis* compared to control. From the experiment it was said that the dry leaf of *Litchi chinensis* had highest allelopathic effects on mungbean and soybean.

Comment [W114]: Arshad & Shazia (2006)

Comment [W115]: All the citations supporting the work were not earlier mentioned in the introductory aspect of the work.

5. Conclusions

Proper managed agroforestry system may decrease the adverse effects of allelochemicals produced from trees and crops. From this study it was found that different parts of plants and soil from different place causes variation of inhibition of growth parameters of mungbean and soybean. The allelopathic effects of the treatments were as the following the order: T_3 (soil mulched with dry leaf)>T_4 (soil watered with aqueous leaf extracts)>T_1 (topsoil)>T_2 (root zone soil)>T_5 (control/fresh garden soil). Therefore, for litchi-based agroforestry systems, regular cleaning of dry leaf is very important. On the other hand, between the two crops, soybean was more inhibited than mungbean.

List of abbreviations

Not applicable

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

Data will be available by correcsponding author

References

Abbas, T., Ahmad, A., Kamal, A., Nawaz, M. Y., Jamil, M. A., Saeed, T., ... & Ateeq, M. (2021). Ways to use allelopathic potential for weed management: a review. *Int. J. Food Sci. Agric*, *5*, 492-498.

Allolli, T. B., Reddy, P. N., & Mahadeva, R. (2000). Allelopathic potential of eucalyptus (E. tereticornis) plant parts on germination and seedling growth of garlic (Allium sativum L.). *Vegetable Science*, *27*(1), 96-98.

Arshad, J., Sobiya, S., & Shazia, S. (2006). Herbicidal potential of aqueous leaf extract of allelopathic trees against Phalaris minor. *Pakistan Journal of Weed Science Research*, *12*(4), 339-346.

Cooper, P. J. M., Leakey, R. R., Rao, M. R., & Reynolds, L. (1996). Agroforestry and the mitigation of land degradation in the humid and sub-humid tropics of Africa. *Experimental agriculture*, *32*(3), 235-290.

Einhellig, F. A., Galindo, J. C. G., Molinillo, J. M. G., & Cutler, H. G. (2004). Mode of allelochemical action of phenolic compounds. *Allelopathy: chemistry and mode of action of allelochemicals*, 217-238.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research*. John wiley & sons.

Islam, A. M., & Kato-Noguchi, H. (2013). Plant growth inhibitory activity of medicinal plant Hyptis suaveolens: could allelopathy be a cause?. Emirates Journal of Food and Agriculture, 692-701.

Jalali, I., Abbas, S. H. A. H., Farooq, M., Jabeen, T., Khan, K. R., & Zohra, L. (2020). Assessment of allelopathic prospective of agriculture land trees on morphological and yield attributes of wheat varieties of Pakistan. *Journal of Agriculture Science*, *35*(2), 45-50.

Khan, M. S., & Alam, M. K. (1996). Elaeocarpus floribundus. *Homestead flora of Bangladesh. Forestry Div. BRAC. Dhaka, Bangladesh*, *57*.

Khan, R. A., Iqbal, K., Hussain, A., & Azeem, S. (2014). Effect of different concentrations of aqueous leaf extracts of some plants on the germination and seedling growth of maize, z. mays l. and wheat (t. aestivum l.). *International Journal of Environment*, *3*(3), 264-274.

Rerkasem, B., Jamjod, S., & Pusadee, T. (2020). Productivity limiting impacts of boron deficiency, a review. *Plant and soil*, *455*(1), 23-40.

Rice EL (1984): *Alelopathy*, Second Edition, Orlando, Florida: Academic Press. 422pp.

Singh, P. S., & Patni, B. (2020). Comprehensive study on role of allelopathic potential in medicinal plants. *BIOINFOLET-A Quarterly Journal of Life Sciences*, *17*(4a), 533-539.

Vladimirovna, R. V. (2020). How Tropospheric Ozone Influences the Allelopathy of Woody Species: Some Experimental Approaches. *Journal of Plant Sciences*, *8*(4), 71-79.

Comment [W116]: The following citations are missing on the reference list; Jalali et al., 2020
Molish 1937
Rizvan et al., 2006

Khan et al was mentioned in the discussion aspect but missing on the reference list