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Allelopathic Potential of *Mesua ferrea* L. and *Schima wallichi* Reinw. ex Blume Leaf Extracts on Seedling Growth of Maize (*Zea mays* L.)

Paul Lalremsang*, C. Remlalpeka, Kalidas Upadhyaya and B. Gopichand

Department of Forestry, School of Earth Sciences and Natural Resources Management, Mizoram University, Post Box-190, Tanhril, Aizawl-796009, Mizoram, India
**Corresponding author*

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A B S T R A C T

Introduction of multipurpose trees plays an important role in agroforestry systems. It enriches the soil by providing soil cover thus providing habitat for soil flora and fauna. However, integration of trees with various crops needs to be evaluated for its allelopathic potential before its introduction into agroforestry system. The allelopathic potential of leaf extracts of *Mesua ferrea* and *Schima wallichi* was evaluated to examine its effect on the growth of Maize in laboratory bioassay as well as in pot culture. Fresh leaves of *M. ferrea* and *S. wallichi* were collected and the leaves were air dried for one week. The air dried leaves were ground and different concentrations (20%, 40%, 60% and 100%) were prepared and compared with distilled water used as control (T_0). Results showed an inhibitory effect with an increase in the concentration of both the leaf extracts. Highest inhibitory effect on root (92.71) and shoot (86.36) length was observed in T_4 and T_3 for *S. wallichi* leaf extracts and highest inhibitory effect on root (75.95) and shoot (70.06) length was observed in T_4 for *M. ferrea* leaf extracts when compared to control (T_0).

Introduction

Agroforestry is a land use system where agricultural crops are grown along with trees. This system plays an important role in improving soil quality, increase productivity, nutrient cycling, soil conservation and overall increase in productivity (Singh *et al.*, 2001). A number of trees are found to produce allelopathic effect when grown together with agricultural crops. *Leucaena leucocephala*, *Populus deltoides*, *Eucalyptus* and *Acacia* species are found to produced allelochemicals and affect the performance of crops (Bansal *et al.*, 1992; Ralhan *et al.*, 1999; Bora *et al.*, 1999). These allelochemicals are often released by decomposing litter affecting seed germination, growth and development of adjoining crops in agroforestry systems (Putnam, 1988). Decline in crop yields in agroforestry systems has been a result of allelopathic effects. It is important to determine the allelopathic compatibility of crops with trees before incorporating them into agroforestry systems as phytotoxins released by trees could affect the establishment of crops (King, 1979; Rice, 1979).

Due to paucity of information on the allelopathic effect of *Mesua ferrea* and *Schima wallichi* on agricultural crops, this study investigated the phytotoxic activity of aqueous leaf extracts of *M. ferrea* and *S. wallichi* on maize. *Mesua ferrea* L. belongs to the family Clusiaceae. The evergreen tree is native to wet tropical parts of Sri Lanka, India, South Nepal, Burma, Indo-China, Thailand, Sumatra and Malaysia.

It has a conical shape crown that can reach upto a height of 30 m. It is also a state tree of Mizoram, India. *Schima wallichi* Reinw. ex Blume is an evergreen tree with a cylindrical crown that grows up to a height of 10-20 m belongs to the family Theaceae. This evergreen tree is indigenous to Indo-China. It is also found in northern India, Nepal, Bhutan, Southwestern China, Myanmar, Thailand, Laos and Vietnam.

Zea mays L. belongs to family Poaceae. It is the second most important cereal crop cultivated worldwide. It also occupies an important place in Indian agriculture. It is the third most cultivated cereal in India after wheat and rice. Maize is also an important agricultural crop in the Northeast India, Mizoram in particular.

Materials and Methods

Bioassays

Leaves of *Mesua ferrea* Linn. and *Schima wallichi* Reinw. ex Blume were collected from Mizoram University Campus (23̊ 42` to 23̊ 46 ` N Latitude and 92̊ 38 ` to 92̊ 42 ` E Longitude, 950 above msl). The collected leaves were air dried for one week at room temperature. The air dried leaves were ground and aqueous extracts were prepared by adding 100g of ground leaf in 1l of distilled water and soak it for 24 h. The extracts were filtered and diluted with distilled water taken as control. Different concentrations (20%, 40%, 60% and 100%) were made from the stock solution. The experiments include five treatments including distilled water as control with three replications each.

The test crop selected was *Zea mays* L. which is a common cash crop of the state. Ten seeds of test crop were surface sterilized with 0.5% NaClO and the treated seeds were kept in each Petri-dishes lined with filter paper wetted with different concentration of extracts. The Petri-dishes were kept in growth chamber for 10 days at 20±2̊ C.

The root length, shoot length, fresh weight and dry weight of root and shoot were measured and recorded. Percentage of inhibition/stimulation effect on germination over control (T_0) was calculated using the formula given by Surendra and Pota (1978), $I = 100 - (E_2 \times 100/E_1)$, where I is the % inhibition/stimulation, E_1 the response of control and E_2 the response of treatment. The percentage of germination was calculated using the formula:

Percentage of germination = No. of seeds germinated / Total number of seeds X 100

Relative elongation ratio (RER) of shoots and roots of crops was also calculated with the formula suggested by Rho and Kil (1986): $R = (T/Tr) \times 100$; where, R is the relative elongation ratio, T is the ratio of treatment crop and Tr the test ratio of control.

Pot culture

For polypot culture, 2 kg of soil was mixed with 5g (T_1), 10g (T_2) and 15g (T_3) of ground leaves sample to make it into four treatments including control and three seeds of test crop were sown in each polypot. The experimental design was Completely Randomized Design (CRD) with three replications. The growth parameters were recorded at 28 days after sowing.

Statistical analysis

To determine statistical difference between the treatments, variance analysis and least significant difference (LSD) tests were performed using MS Excel software.

Results and Discussion

Bioassay

The results of the study shows that the root and shoot length of maize is concentration dependent, inhibitory effect increases with an increase in the concentration of both the extracts. The root and shoot length decreases with an increase in the level of extracts concentration. It was also observed from the study that application of higher concentration extracts on test crop is more prone to fungal attack that inhibits the growth of the tested crop. The percentage of germination was reduced with increase in the concentration of extracts (Table 1). This finding corroborate the report by Bora *et al.,* (1999) that, the inhibitory effect of *A. auriculiformis* leaf extract on seed germination and seedling growth is concentration dependent. Highest inhibitory effect on root (75.94) and shoot (70.06) was found in T_4 for *Mesua* leaf extract, while highest inhibitory effect on root (92.71) and shoot (86.36) was found in T_4 and T_3 for *Schima* leaf extract (Table 2). Maximum root and shoot elongation was observed in T_1 for both the extracts when compared to control (T_0). Similar findings were observed by Kumar *et al.,* 2009 where leaf leachates of *Melia azaderach*, *Morus alba* and *Moringa oleifera* inhibited the radical and plumule growth of soybean. Oudhia and Tripathi (1999) have also observed that *Parthenium* extracts inhibited the root and shoot length of wheat when compared to control. A decreased in the fresh and dry weight was also observed with an increase in the concentration of the leaf extracts, wherein the highest inhibitory effect was shown by T_4 (Table 4). The findings also conform to the findings by Sahoo *et al.,* 2007 in which the aqueous leaf extracts of *Leucaena leucocephala* and *Tectona grandis* reduces the fresh and dry weights of maize over control. Chon *et al.,* 2000 also reported that phenolic compounds derived from alfalfa exhibit a decrease in fresh weight with increase in the concentration of extracts. Das *et al.,* (2012) also observed a reduction in the dry weight of root and shoot at various level of leachate.

Table.1 Germination percentage of Maize treated with *Mesua ferrea* and *Schima wallichi* leaf extracts (10 DAS)

Treatments	GP of Maize (%) with *Mesua ferrea*	GP of Maize (%) with *Schima wallichi*
T_0	96.67±0.33	96.67±0.33
T_1	90±0.00	96.66±0.33
T_2	96.66±0.33	90±0.6
T_3	100±0.00	86.66±0.7
T_4	86.66±0.9	80±1
LSD@5%	**1.7**	**2.4**

Values are means± SE of different observations

Table.2 Effect of aqueous leaf extracts of *Mesua ferrea* and *Schima wallichi* on root length and shoot length of Maize

	Treatments	Root length (cm)	Shoot length (cm)	Root:Shoot
Mesua ferrea	T_0	13.72±0.72	10.56±0.23	1.29±0.04
	T_1	9.17±0.51(-33.16)	8.46±0.74(-19.88)	1.09±0.04
	T_2	7.50±0.50(-45.33)	7.28±1.54(-31.06)	1.10±0.16
	T_3	6±0.96(-56.26)	4.71±0.16(-55.39)	1.28±0.23
	T_4	3.30±0.63(-75.94)	2.95±0.44(-70.06)	1.11±0.06
LSD	**@5%**	**2.55**	**2.97**	**0.49**
Schima wallichi	T_1	3.28±0.08(-76.09)	3.27±0.36(-69.03)	1.03±0.15
	T_2	2.17±0.10(-84.18)	1.90±0.15(-82)	1.15±0.05
	T_3	1.24±0.26(-90.96)	1.44±0.25(-86.36)	0.92±0.25
	T_4	1±0.06(-92.71)	1.47±0.23(-86.07)	0.70±0.10
LSD	**@5%**	**1.30**	**0.94**	**0.52**

Values in the parenthesis indicates the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0)

Table.3 Effect of aqueous leaf extracts of *Mesua ferrea* and *Schima wallichi* on root length and shoot length of Maize (Pot culture)

	Treatments	Root length (cm)	Shoot length (cm)	Root:Shoot
Mesua ferrea	T_0	6.92±1.21	5.6±0.26	1.25±0.25
	T_1	10.33±3.66(+49.3)	2.46±2.46(-56.1)	2.05±0.41
	T_2	16±1.52(+131.21)	7.03±0.03(+25.54)	2.27±0.22
	T_3	19.13±1.13(+176.45)	8.07±0.07(+44.11)	2.36±0.15
LSD	**@5%**	**8.37**	**4.82**	**1.09**
Schima wallichi	T_1	14.05±4.93(+103.03)	5.71±1.35(+2)	2.25±0.43
	T_2	16.48±0.86(+138.15)	6.77±0.61(+21)	2.44±0.11
	T_3	16.08±2.21(+132.4)	5.63±0.34(+13)	2.83±0.29
LSD	**@5%**	**10.91**	**3.01**	**1.15**

Values in the parenthesis indicates the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0)

Table.4 Effect of aqueous leaf extracts of *Mesua ferrea* and *Schima wallichi* on fresh weight and dry weight of Maize

	Treatments	Fresh weight root (g)	Fresh weight shoot (g)	Dry weight root (g)	Dry weight shoot (g)	Root:Shoot (Dry wt.)
Mesua ferrea	T_0	2.10±0.20	3.34±0.16	0.31±0.03	0.41±0.00	0.74±0.08
	T_1	1.97±0.12 (-6.19)	2.63±0.14 (-21.25)	0.28±0.01 (-9.67)	0.33±0.03 (-19.51)	0.88±009
	T_2	1.96±0.22 (-6.66)	2.08±0.43 (-37.72)	0.31±0.02 (0)	0.27±0.05 (-34.14)	1.20±0.16
	T_3	1.91±0.27 (-9.04)	1.43±0.07 (-57.18)	0.29±0.03 (-6.45)	0.19±0.00 (-53.65)	1.54±0.20
	T_4	1.02±0.21 (-51.42)	0.75±0.10 (-77.54)	0.22±0.03 (-29.03)	0.14±0.02 (-65.85)	1.56±0.13
LSD	**@5%**	**0.78**	**0.82**	**0.09**	**0.10**	**0.51**
Schima wallichi	T_1	1.11±0.19 (-47.14)	1.12±0.16 (-66.46)	0.21±0.01 (-32.25)	0.19±0.02 (-53.65)	1.12±0.06
	T_2	0.58±0.07 (-72.38)	0.71±0.11 (-78.74)	0.14±0.01 (-54.83)	0.14±0.02 (-65.85)	0.99±0.06
	T_3	0.27±0.08 (-87.14)	0.57±0.11 (-82.93)	0.08±0.02 (-74.19)	0.13±0.02 (-68.29)	0.61±0.11
	T_4	0.23±0.05 (-88.04)	0.62±0.16 (-81.43)	0.07±0.01 (-77.41)	0.15±0.04 (-63.41)	0.49±0.06
LSD	**@5%**	**0.50**	**0.52**	**0.07**	**0.08**	**0.29**

Values in the parenthesis indicates the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0)

Table.5 Effect of aqueous leaf extracts of *Mesua ferrea* and *Schima wallichi* on fresh weight and dry weight of Maize (Pot culture)

	Treatments	Fresh weight root (g)	Fresh weight shoot (g)	Dry weight root (g)	Dry weight shoot (g)	Root:Shoot (Dry wt.)
Mesua ferrea	T_0	0.34±0.05	2.03±0.29	0.09±0.01	0.19±0.02	0.45±0.00
	T_1	0.37±0.09 (+9)	1.58±0.34 (-22.2)	0.09±0.01 (0)	0.13±0.03 (-32)	0.67±0.08
	T_2	0.72±0.11 (+112)	2.68±0.33 (+32.02)	0.15±0.02 (+67)	0.23±0.02 (+21.1)	0.65±0.03
	T_3	0.62±0.08 (+82.4)	2.68±0.36 (+32.02)	0.14±0.01 (+56)	0.23±0.02 (+21.1)	0.64±0.13
LSD	**@5%**	**0.33**	**1.30**	**0.06**	**0.09**	**0.31**
Schima wallichi	T_1	0.61±0.17 (+79.41)	2.46±0.59 (+21.2)	0.13±0.03 (+44.44)	0.21±0.04 (+11)	0.63±0.03
	T_2	0.85±0.05 (+150)	2.81±0.26 (+38.42)	0.16±0.00 (+78)	0.23±0.01 (+21.1)	0.70±0.04
	T_3	0.57±0.13 (+68)	1.91±0.22 (-6)	0.11±0.01 (+22.22)	0.16±0.01 (-16)	0.66±0.02
LSD	**@5%**	**0.45**	**1.45**	**0.07**	**0.11**	**0.11**

Values in the parenthesis indicates the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0)

Table. 6 Effect of aqueous leaf extracts of *Mesua ferrea* and *Schima wallichi* on number of lateral roots of Maize (Pot culture)

	Treatments	Number of lateral roots
Mesua ferrea	T_0	8.33±0.57
	T_1	5.55±1.92(-33.4)
	T_2	7.77±0.96(-7)
	T_3	8.44±0.98(+1.32)
LSD	**@5%**	**4.75**
Schima wallichi	T_1	7.77±1.74(-7)
	T_2	9.99±0.33(+20)
	T_3	8.11±1.56(-3)
LSD	**@5%**	**4.74**

Values in the parenthesis indicates the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0)

Pot culture

The response of leaf extracts on the test crop in pot culture shows opposite trends when compared to bioassay. The root and shoot length increases with an increase in the concentration of both the leaf extracts. Highest stimulatory effect on root (176.45) and shoot (44.11) was shown by T_3 for *Mesua* leaf extract, while the highest stimulatory effect on root (138.15) and shoot (21) in T_2 for *Schima* leaf extract (Table 3). An inhibitory effect on the shoot length was observed in T_1 for *Mesua* leaf extract, which could be due to the reduction in cell division of the tested crop (Gholami *et al.,* 2011). The fresh and dry weight of roots and shoots also increase with the concentration of the extracts (Table 5). Stimulatory effects are more pronounce in *Mesua* leaf extract at higher concentration when compared to *Schima* leaf extract treatment which shows an inhibitory effect on the fresh and dry weights at T_3. However, a stimulatory effect was more pronounce when compared to overall inhibitory effect in pot culture. The production of lateral roots shows a stimulatory effect at higher concentration when compared to control but non-significant ($p<0.05$) Table 6. The above findings are in par with the finding by Mali and Kanade (2014) where extracts of *Cynodon dactylon* caused a stimulatory effect on the root and shoot length when compared to control. Dhole *et al.,* (2011) also found that an aqueous extract of *Portulaca oleracea* cause a stimulatory effect on seed germination, root-shoot length and seedling growth on *Sorghum vulgare*. Bharath *et al.,* (2014) reported that the dry weight of maize was found to be increased when the concentration of ginger aqueous extracts were increase. Jabeen and Ahmed (2009) also reported that the shoot extract of *Fumaria indica* enhanced the growth of maize and the fresh weight increases with an increase in the concentration of extracts. Musyimi *et al.,* 2015 also found that *T. diversifolia* leaf extract stimulates root and shoot dry weight.

This experiment was for the first time conducted to demonstrate the allelopathic potential of *Mesua ferrea* and *Schima wallici* on agricultural crops. The test crop used in this experiment is one of the most important crops grown in the state and an important cash crop of the region. Agroforestry includes growing of crops in combination with multipurpose tree species. Several crops are grown in between rows of trees in homegardens, to conserve soil moisture and act as cover crops in the field. Since, *Mesua* *ferrea* and *Schima wallichi* constitute a major component in the homegardens, there is a need to evaluate its allelopathic potential before its introduction into agroforestry systems. The study reveals that *Mesua ferrea* is a better component tree in agroforestry systems than *Schima wallichi* and a better multipurpose tree species to be introduced into agroforestry systems.

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Conflict of interest

Authors declared that there is no conflict of interest.

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