Print : ISSN 0970 – 7662
Online : ISSN 2455 – 7129

# Journal of Tree Sciences

*online available at www.ists.in*

Volume 39 | No. 2 | December, 2020

## Allelopathic Potential of Aqueous Leaf Extract and Leaf Litter of *Melia dubia* Cav. on Tomato and Okra

**Avinash G. Parmar, N S Thakur*, Dinesh Kumar and R P Gunaga**

*Department of Silviculture and Agroforestry, College of Forestry, Navsari Agricultural University, Navsari – 396450, Gujarat, India*
*E-mail: drnsthakur74@gmail.com

DOI: 10.5958/2455-7129.2020.00019.9

**ABSTRACT**

The leaf aqueous extract and leaf litter of *M. dubia* inhibited the germination traits (germination per cent, mean daily germination, peak value, germination value and germination rate index), initial growth and biomass of both the test species. The allelochemicals present in leaf litter might have inhibited the germination, initial growth and biomass of test crops in laboratory and pot culture bioassays. However, the results of the pot experiment carried out till crop maturity, showed that final growth, biomass and fruit yield was not affected due to leaf litter. The allelochemicals might have diluted through cultural practices or ephemeral nature of allelochemicals and hence, there was no allelopathic effect of leaf litter of *M. dubia* on later growth, biomass and yield of tomato and okra.

**Key Words:**

Allelopathy, Gaschromatography, germination, *Melia dubia*, okra, tomato

## INTRODUCTION

Allelopathy may occur through release of allelochemicals from plant parts through leaching, root exudation, volatilization, residue decomposition and other processes both in natural and agricultural systems (Gupta et al. 2007; Narwal et al. 2011; Gunarathne and Perera 2016). Research on allelopathy has been carried out to a great extant, however new tree-crop models are evolving with time and are adopted farmers. *Melia dubia* is an industrially and economically important fast growing short rotation tree species. Outside India, it is found in Australia, Sri Lanka, Malaysia, Java and China. It is indigenous to the Western Ghats of Southern India and is common in moist deciduous forests of Kerala (Saravanan et al. 2013). It is valued for its high-quality termite and fungus resistant timber for furniture, agricultural implements and house construction, as alternative pulp wood species, fuel wood and fodder and has medicinal properties as well (Vijayan et al. 2004; Parthiban et al. 2009; Sinha et al. 2019; Singh et al. 2019, Dhaka et al. 2020 ). The industrial and ecological importance of *M. dubia* has encouraged the farmers to take large scale plantations with different intercrops (Parthiban et al. 2009, Nuthan et al. 2009). This species is need to be tested for its allelopathic effects, if any, on crops to be integrated in agroforestry models. Hence, keeping in view the increasing popularity of *M. dubia* the present study was undertaken to investigate the alleged allelochemicals in leaf litter of *M. dubia* and to bring out the beneficial or antagonistic effect on germination, growth, biomass and yield test crops through laboratory bioassays and pot cultures.

## MATERIALS AND METHODS

This study was accomplished in the laboratory and green house complex of College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India, (20.95° N latitude, 75.90° E longitude with an altitude of 10 m above MSL) during November 2014 to April 2015.

### *Donor plant material and preparation of aqueous extracts*

The leaves (mixture of young and mature leaves showing signs of senescence) of *Melia dubia* were collected from 3-year old plantations in October 2014. The leaves were initially dried at room temperature and later at 65$^o$ C in hot air oven until constant dry weight was reached. The dried leaf litter was stored at room temperature and was used for both peteriplate bioassay and pot experiments. Aqueous extracts were prepared by soaking 200 g grounded dried leaf litter in 1L distilled water. The solution was stirred and kept at room temperature (20-25$^o$C) for 24 h. The filtrate was centrifuged and supernatant was decanted and the filtrate was considered as 100 % extract. From this 25, 50, 75, 100 % concentrations were prepared and distilled water was used as control 0 (%) (Kumar et al. 2017a). The treatments were replicated five times in completely randomized design (CRD).

### *Petridish bioassay*

The pre-treated seeds (treated with Thirum @ 2g/kg) of tomato (*Lycopersicon esculentum* Mill.) and okra [*Abelmoschus esculentus* (L.) Moench] were procured from Agricultural Technology Information Centre (ATIC), Navsari Agricultural University, Navsari, Gujarat, India. In laboratory experiment, 5-treatments [$T_1$ (0), $T_2$ (25%), $T_3$ (50%), $T_4$ (75%) and $T_5$ (100%)] of aqueous extracts of *M. dubia* were used and replicated five times. Each petridish (90 mm dia) was considered as replication. Fifty seeds of each test crop were placed on filter paper in sterilized petridishes. Five ml aqueous extracts were applied on first day and afterwards, 2 ml on alternate days to keep the filter paper moist till the completion of experiment (Parmar et al. 2019a). Seeds were considered germinated when > 1 cm radicle emerges from the seed. Germination was counted daily till 15 and 13 days, for tomato and okra, respectively after the start of experiment. The seedlings growth shoot and root length and biomass were recorded from 10-randomly selected seedlings per petridish on 15$^{th}$ and 12$^{th}$ day for tomato and okra, respectively after sowing. Germination (% and Germination Rate Index (GRI) were calculated following AOSA (1983). Root and shoot portion were separated and dried in hot air oven at 60$^0$ C for 48 h and then sample were weighed.

### *Pot experiments*

Pot experiments were done in green house to find the effects of leaf litter of *M. dubia* on germination, GRI, initial growth and biomass of test crops. Fifty seeds were sown in plastic pots [28 cm dia x 12 cm height (16007 cc)] containing 10 kg soil (N, P and K content were 84.82, 17.85 and 80.35 ppm). Course grounded leaf litter was applied at 0, 12.5, 25, 37.5, 50 g per pot and mixed in upper soil layer (Thakur 2014) and a control ($T_1$) without leaf litter was used. The replications and statistical design was same as used in petridish bioassay. The litter dose was calculated on the annual average litter fall (Thakur et al. 2017d). We recorded the leaf litter fall of 3-months by placing the 1 m$^2$ traps under 3 years old plantation of *M. dubia.* It was 216.45 g/m$^2$ (2.16 t/ha), which comes to 13.42 g/ pot (used in present study).

Hence, the mulch treatments fixed fall within the range of natural litter fall.

Pots were irrigated 2L/ pot) with water (pH 7.71, electrical conductivity 1.752dS/m) a day prior to seed sowing. Approx. 1 L on subsequent days or as and when required to keep the soil moist. Daily germination count was made up to the last seed to germinate *i.e.,*14 days for both the test species. The growth and biomass of test crops were recorded on the day when last germination count was made. The seed germination and seedlings growth and biomass were recorded and calculated as done in laboratory bioassay, except that here seedling emergence from the soil was recorded.

To evaluate the plant growth, biomass and yield, till crop maturity, a separate pot experiment was done in green house (50 per cent relative shading). Each litter treatment was replicated five times (3-plants per replication). In each pot, only 5-seeds were sown and one healthy seedling was retained 2-weeks after sowing. At maturity (90 days after sowing), fresh and dry biomass of plant and fruit yield were recorded.

### *Statistical analysis*

The experimental data recorded for all the parameters in different experiments were the statistically analysed following completely randomized design (CRD) and F-test was done and ANOVA was constructed following Sheron et al. (1998). Treatment means were compared at $P<0.05$

## RESULTS AND DISCUSSIONS

### *Allelopathic effects on germination attributes of test crops*

Petridish and pot culture bioassays revealed that, aqueous leaf extract concentrations (0, 25, 50, 75, 100%) and leaf litter quantities (0, 12.5, 25, 37.5 and 50 g/pot) of *M. dubia* significantly ($P<0.05$) suppressed the germination (%) and germination rate index (GRI) of tomato and okra (Table 1 and 2 ), relative to control. The inhibitory effect gradually increased with increase in extract concentrations (Fig. 1a and b) or litter leaf litter amount (Fig. 1c and d), over the control in each test crop. The per cent inhibition, over control, in all the germination traits of tomato and okra (Fig. 2 and 3) increased with increase in extract concentrations and leaf litter quantities as well, and was greatest at maximum extract concentration (100%) or litter amount (50 g/pot). The per cent inhibition on the germinations attributes was higher in laboratory bioassays as compared to pot culture in both the test crops.

### *Initial growth and biomass of test crops*

The leaf aqueous extracts, in laboratory and leaf litter in pot culture, exhibited significant ($P<0.05$) inhibitory effect on shoot and root length of germinated seedlings of tomato and okra (Table 1 and 2). The growth parameters had gradual inhibitory effect as the extract concentration or litter quantity increased ($T_2$ to $T_5$) compared to control ($T_1$). The magnitude of per cent inhibition, over control, gradually increased with increase in aqueous extract concentration or leaf litter quantity, showing maximum reduction at 100% extract or 50 g leaf litter/pot (Fig. 2 to 3). The per cent diminution was higher on shoot growth of tomato and okra against leaf litter and extract application, respectively. Whereas, it was more marked on root growth of tomato and okra against aqueous extract in laboratory and against leaf litter in pot culture bioassays, respectively.

The aqueous leaf extracts and leaf litter exhibited significant inhibitory effect on shoot, root and total dry biomass of germinated seedlings of both the test crops (Table 1 and 2). The magnitude of diminution progressed gradually with increase in extract concentration or litter amount, with maximum at 100% extract concentration and 50 g leaf litter/pot in tomato as well as okra.

The intensity of per cent suppression in growth and biomass parameters increased with incremental extract concentration or litter quantity (Fig. 3 to 4). The percent diminution was pronounced on root biomass in laboratory bioassays as compared to shoot and it was reverse in pot culture in both the test crops. The growth attributes experienced greater magnitude of reduction in laboratory bioassays, as compared litter application, over control treatments. The magnitude of inhibition on germination traits and initial seedlings growth and biomass increased with incremental extract concentration or leaf litter quantity in present study.

**Table 1**. Allelopathic influence of leaf aqueous extract of *M. dubia* on germination traits, growth and biomass of tomato and okra in laboratory bioassay.

| Extract concentrations (%) | Germination traits | | Growth (cm) | | Biomass (DM mg/plant) | | |
|---|---|---|---|---|---|---|---|
| | G (%) | GRI | Shoot length | Root length | Shoot | Root | Total |
| | Tomato | | | | | | |
| $T_1$ (0% control) | 82.80 (65.57) | 5.40 | 6.40 | 3.86 | 20.01 | 9.34 | 29.27 |
| $T_2$ (25%) | 66.00 (54.33) | 3.91 | 5.94 | 2.93 | 18.13 | 9.22 | 27.35 |
| $T_3$ (50%) | 59.60 (50.54) | 3.25 | 4.91 | 2.36 | 15.75 | 8.04 | 24.03 |
| $T_4$ (75%) | 57.20 (49.16) | 2.83 | 4.29 | 2.00 | 13.03 | 6.31 | 19.34 |
| $T_5$ (100%) | 54.80 (47.74) | 2.81 | 3.72 | 1.79 | 11.37 | 4.78 | 16.15 |
| CD at 5% | 5.19 | 0.39 | 0.18 | 0.12 | 5.52 | 1.42 | 5.84 |
| SE(m) | 1.75 | 0.13 | 0.06 | 0.04 | 1.86 | 0.48 | 1.97 |
| | Okra | | | | | | |
| T1 (0% control) | 83.60 (66.16) | 15.98 | 6.21 | 3.86 | 50.23 | 18.89 | 69.12 |
| T2 (25%) | 80.80 (64.03) | 14.59 | 5.05 | 3.70 | 45.51 | 16.12 | 61.63 |
| T3 (50%) | 62.00 (51.94) | 9.23 | 4.65 | 3.18 | 41.32 | 12.35 | 53.67 |
| T4 (75%) | 52.80 (46.60) | 6.72 | 3.61 | 2.77 | 35.88 | 9.88 | 45.77 |
| T5 (100%) | 46.00 (42.69) | 4.66 | 2.62 | 2.48 | 28.60 | 7.95 | 36.55 |
| CD at 5% | 3.42 | 1.97 | 0.21 | 0.66 | 12.64 | 5.55 | 16.76 |
| SE(m) | 1.15 | 0.66 | 0.07 | 0.22 | 4.26 | 1.87 | 5.64 |

*Transformed values; **G**=Germination; **GRI**=Germination Rate Index **DM**=Dry Matter

**Table 2.** Allelopathic influence of leaf litter of *M. dubia* on germination traits, initial growth and biomass of tomato and okra in pot culture.

| Leaf litter (g/pot) | Germination traits | | Growth (cm) | | Biomass (DM mg/plant) | | |
|---|---|---|---|---|---|---|---|
| | G (%) | GRI | Shoot length | Root length | Shoot | Root | Total |
| | Tomato | | | | | | |
| $T_1$ (No litter) | 91.20 (73.09) | 6.30 | 6.39 | 4.82 | 82.00 | 31.70 | 113.70 |
| $T_2$ (12.5 g) | 84.40 (66.80) | 5.40 | 4.93 | 4.63 | 65.20 | 26.60 | 91.80 |
| $T_3$ (25 g) | 75.60 (60.42) | 4.60 | 4.28 | 3.98 | 54.00 | 22.80 | 76.80 |
| $T_4$ (37.5 g) | 64.80 (53.61) | 3.90 | 3.37 | 3.07 | 46.90 | 21.00 | 67.90 |
| $T_5$ (50 g) | 61.20 (51.47) | 3.80 | 2.38 | 2.08 | 42.10 | 19.70 | 61.90 |
| CD at 5% | 3.76 | 0.40 | 0.7 | 0.69 | 2.30 | 2.00 | 3.50 |
| SE(m) | 1.27 | 0.10 | 0.2 | 0.23 | 0.80 | 0.70 | 1.20 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Okra | | | | | | | |
| T1 (No litter) | 91.60 (73.19) | 13.87 | 13.46 | 6.46 | 116.15 | 40.00 | 156.14 |
| T2 (12.5 g) | 90.00 (71.84) | 12.92 | 12.42 | 5.42 | 101.14 | 35.15 | 136.29 |
| T3 (25 g) | 81.60 (64.63) | 10.36 | 11.64 | 4.64 | 91.12 | 31.92 | 123.04 |
| T4 (37.5 g) | 74.80 (60.10) | 8.85 | 10.91 | 3.91 | 84.75 | 29.87 | 114.62 |
| T5 (50 g) | 68.00 (55.55) | 7.43 | 10.27 | 3.27 | 80.47 | 28.48 | 108.95 |
| CD at 5% | 4.05 | 0.89 | 0.43 | 0.43 | 2.09 | 0.68 | 2.77 |
| SE(m) | 1.36 | 0.30 | 0.14 | 0.14 | 0.71 | 0.23 | 0.93 |

**Transformed values; **G**=Germination; **GRI**=Germination Rate Index **DM**=Dry Matter

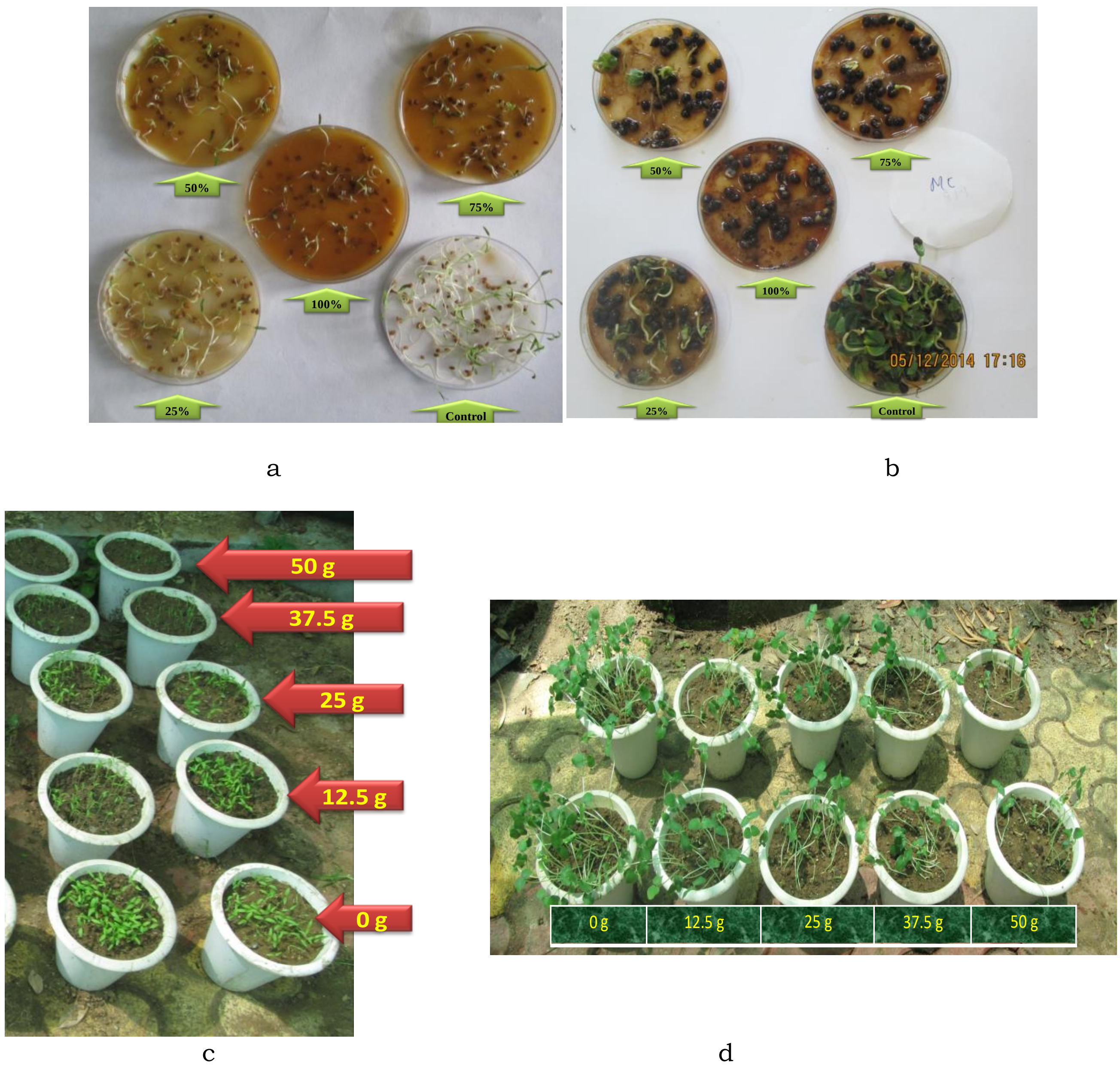


**Fig. 1** Showing the allelopathic influence of aqueous leaf extracts [0 (distilled water), 25, 50, 75 and 100%] and leaf litter [0 (no leaf litter), 12.5, 25, 37.5 and 50 g/pot] of *M. dubia* on germination and initial growth of tomato and okra in laboratory (a and b) and pot culture bioassays (c and d), respectively.

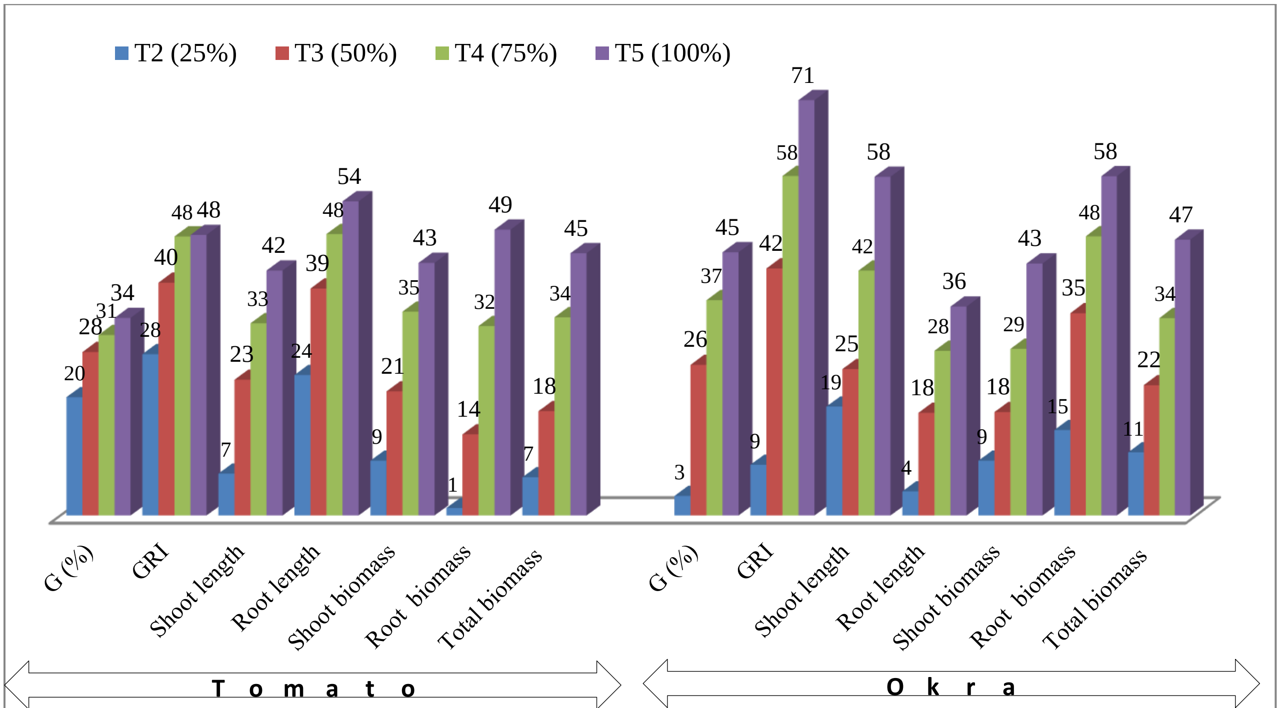


**Fig. 2.** Inhibitory effect (% over control) of aqueous leaf extract of *M. dubia on* germination, growth and biomass of toamto and okra in laboratory bioassay

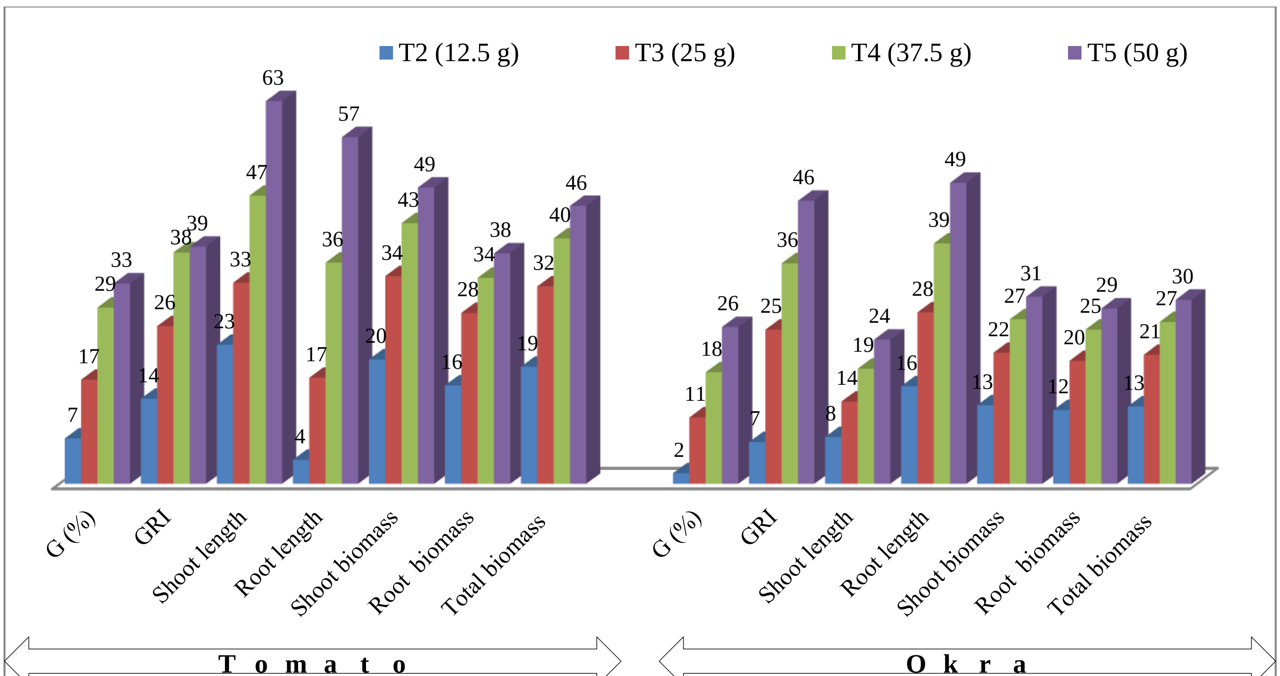


**Fig. 3.** Inhibitory effect (% over control) of leaf litter of *M. dubia on* germination, growth and biomass of toamto and okra in pot culture

***Effects of leaf litter on growth, biomass and fruit yield***

There was no significant effect of different litter treatments (12.5, 25, 37.5 and 50 g/pot) and that of no litter treatment on growth, biomass and fruit yield of tomato (Table 3) and okra (Table 3). Despite validation of allelochemicals in *M. dubia* through GC-MS analysis (Kumar et al. 2017b; Parmar et al. 2019b), the leaf litter did not exhibit inhibitory or stimulatory effect on final growth and yield of tomato and okra.

Through gas Chromatography Mass-Spectrometry (GCMS) analysis 18 different chemical compounds have detected in leaf litter of *M. dubia*, which are phenolic acids and their derivatives, alkaloids, methyl ketones (volatile allelochemical), omega-3 fatty acid, unsaturated fatty acids, aromatic ketone and chromene (Kumar et al. 2017; Parmar et al. 2019b).

We found that the magnitude of inhibition on germination and initial seedlings growth and biomass increased with incremental extract concentration or leaf litter quantity in present study. Similar concentration dependent inhibitory trend has been reported earlier on various test crops against *M. azedarach* (Akacha et al. 2013; Phuwiwat et al. 2012, Thakur et al. 2017d), another species of same family, and other donor species (Zhang et al. 2015). This is the result of water soluble allelochemicals in the extracts or leaf litter and their allelopathic effect on the measured parameters of test crops (Rezaeinodehi et al. 2006).

Petridish and pot culture experiments revealed that the per cent inhibiotry effect was more pronounced on root growth of tomato and okra. However, shoot growth of tomato, in pot culture, and okra, in petridish bioassays, experienced more suppression as compared to root growth.

**Table 3.** Allelopathic influence of leaf litter of *M. dubia* on growth, biomass (DM g/plant) and yield of tomato and okra in pot culture.

| Leaf litter (g/pot) | Plant height (cm) | Collar diameter (mm) | Root length (cm) | No. of fruits/ plant | Fruit yield (FW g/plant) | Biomass (DM g/ plant) |
|---|---|---|---|---|---|---|
| | | | Tomato | | | |
| $T_1$ (No mulch) | 89.83 | 7.13 | 38.04 | 7.19 | 112.62 | 94.68 |
| $T_2$ (12.5 g) | 85.71 | 6.41 | 38.58 | 8.41 | 131.74 | 102.67 |
| $T_3$ (25 g) | 82.85 | 7.24 | 38.19 | 8.17 | 128.04 | 107.35 |
| $T_4$ (37.5 g) | 86.79 | 7.16 | 37.98 | 8.29 | 129.98 | 128.90 |
| $T_5$ (50 g) | 75.03 | 7.15 | 37.29 | 8.94 | 140.13 | 111.93 |
| CD at 5% | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |
| SE(m) | 2.84 | 0.39 | 0.92 | 0.78 | 12.16 | 11.94 |
| | | | Okra | | | |
| T1 (No mulch) | 28.87 | 3.29 | 13.55 | 5.36 | 28.85 | 37.63 |
| T2 (12.5 g) | 31.03 | 3.74 | 14.16 | 5.53 | 29.76 | 45.44 |
| T3 (25 g) | 28.63 | 3.35 | 13.79 | 5.70 | 30.68 | 36.93 |
| T4 (37.5 g) | 31.52 | 2.99 | 13.67 | 4.95 | 26.61 | 43.19 |
| T5 (50 g) | 32.52 | 3.84 | 14.31 | 5.52 | 29.68 | 45.34 |
| CD at 5% | N.S. | 0.61 | N.S. | N.S. | N.S. | N.S. |
| SE(m) | 2.507 | 0.20 | 1.12 | 0.42 | 2.27 | 3.09 |

MAS= Months after sowing; FW= Fresh Weight; DM=Dry Matter

Similar organ specific effects of *M. azedarach* leaf aqueous extracts have been reported earlier (Phuwiwat et al. 2012; Akacha et al. 2013, Thakur et al. 217d). This may be attributed to the fact that, roots first come in contact with allelochemicals and absorb them from the environment in which they are growing. The young seedlings, especially the roots, are more sensitive to allelopathic agents than adult plants or other plant organs (Zhang et al. 2015).

The aqueous leaf extracts of plant species hamper physiological processes of germinating seeds and growing seedlings (Kaushal et al. 2011). Phuwiwat et al. (2012) observed that water uptake and α-amylase activity of test species was inhibited by aqueous extracts of young leaves of *M. azedarach*. Studies show that germination inhibition is the result of induction of oxidative stress (Javed 2011). All these findings may be ascribed to the inhibitory effect of *M. dubia* aqueous extracts on seed germination of tomato and okra in the present study.

Addition of leachates or incorporation of plant residues into the growth environment of another plant result in inhibition effect on germination and growth due to depletion of the nitrogen content and impeding of the physiological processes of the seedlings growing in such environment (Al-Khatib et al. 1997). Akacha et al. (2013) reported that allelo-chemicals produce an imbalance in the oxidative status of cells and they observed changes in activity of catalase, ascorbate peroxidase, guaiacol peroxidase as well as in the levels of $H_2O_2$ and assimilatory pigments. Allelochemicals decrease the stomatal conductance by inducing ABA production, which indirectly impacts on the rates of photosynthesis, transpiration, respiration and uncoupling oxidative phosphorylation. Multiple physiological effects, which include reduction in plant growth, absorption of water and mineral nutrients, ion uptake, leaf water potential, shoot turgor pressure, physiological drought and osmotic potential (Rezaeinodehi et al. 2006; Bagavathy and Xavier 2007) are attributed to reduction in germination, growth and biomass seedlings both in laboratory bioassay and pot experiments. Similar effects might have resulted in reduced germination, growth and biomass of test crops in present study against leaf litter of *M. dubia* as compared to control.

Unlike allelochemicals obtained directly by extraction from living organs or tree litter, allelochemicals released from decomposed leaf litter are influenced by soil; thus their concentration, composition, structure, and activity might be extremely different. The important circumstances in which allelopathic effects appear occur when allelochemicals reach the recipient plant in their active structure and at their effective concentration, thus extracts of litter and decomposed litter (or the decomposed medium) often show different allelopathic effects (Zhang et al. 2015).

Most of the allelopathic studies allege the donor species as potential allelopathic based on the laboratory bioassays. Our study, confirm the allelopathic nature till maturity of the test crops. Despite validation of allelochemicals in *M. dubia* through GC-MS analysis in our study, and their corroboration for allelopathic potential from other plants with earlier studies, the leaf litter did not exhibit inhibitory or stimulatory effect on final growth and yield of tomato and okra. Similar to present study no significant allelophatic effect of *M. azedarach* leaf litter was reported on eggplant and okra (Thakur et al. 2017d). In contrary, Shapla et al. (2011) reported that *M. azedarach* mulch application inhibited the growth and biomass of test crops. Similar adverse effects of leaf mulch, in pot culture studies, of donor species on other test crops have also been reported earlier (Sale and Oyun 2013; Thakur 2014). These workers have reported inhibitory effect of leaf litter only up to a month or so. However, our study, results of growth, biomass and yield of the test crops are recorded till maturity. This may be attributed to faster mulch decomposition, leaching out of allelo-chemicals due to frequent irrigation done to maintain the moisture in the pots, ephemeral nature of allele-chemicals, loss from soil through volatilization, especially phenolics (Ampofo 2009; Narwal et al. 2011, Thakur et al, 2017d). These evidences may be attributed to non-significant effect of litter treatments of *M. dubia* on growth, biomass and fruit yield of tomato and okra in the present study. Similar results have been reported earlier on pulse and other vegetable crops using same donor species (Kumar et al. 2017b, Thakur et al. 2017a,b; Parmar et al. 2019b). This expresses that, over the longer period, the effect of leaf litter allelochemicals of *M. dubia* got alleviated.

**CONCLUSIONS**

The study revealed that, the leaf litter of *M. dubia* contain different types of phytotoxic chemicals with putative inhibitive potential on seed germination, initial growth and biomass of tomato and okra. However, pot culture studies carried out till maturity of test crops, revealed that, there was no inhibitory effect of leaf litter treatments on later growth, biomass and fruit yield. Hence, allelopathic potential of *M. dubia* leaf litter are transient in nature and their effect alleviated over of time.

**REFERENCES**

Akacha M., Boughanmi N.G. and Haouala R. 2013. Effects of *Melia azedarach* leaves extracts on radish growth and oxidative status. International Journal of Botany and Research 3(2): 29-42.

Al-khatib K., Libbey C. and Boydston R. 1997. Weed suppression with brassica green manure crops in green pea. Weed Science 45: 439-445.

Ampofo K.G. 2009. *Effects of Tectona grandis Leaf Extract, Mulch and Woodlot Soil on Germination and Growth of Maize.* M.Sc. Thesis. Kwame Nkrumah, University of Science and Technology, Kumasi, Ghana. pp. 72.

Association of official seed analysis (AOSA). 1983. *Seed Vigor Testing Handbook*. Contribution no. 32 to the handbook on seed testing. Association of Official Seed Analysis, Springfield, IL.

Bagavathy S. and Xavier G.S.A. 2007. Effects of aqueous extract of *Eucalyptus globulus* on germination and seedling growth of sorghum. Allelopathy J 20: 395-402.

Dhaka R.K., Gunaga R.P., Sinha S. K., Thakur N. S. and Dobriyal M.J. 2020. Influence of tree height and diameter on wood basic density, cellulose and fibre characteristics in *Melia dubia* Cav. families. Journal of The Indian Academy of Wood Science, https://doi.org/10.1007/s13196-020-00265-x.

Gunarathne R.M.U.K. and Perera G.A.D. 2016. Does the invasion of *Prosopis juliflora* cause the die-back of the native *Manilkara hexandra* in seasonally dry tropical forests of Sri Lanka? Tropical Ecology 57: 475-488.

Gupta B., Thakur N.S. and Das B. 2007. Allelopathic effect of leaf leachates of *Pinus roxburghii* Sargent on seeds of some grasses. Indian Forester 133: 997-1000.

Javed K. 2011. Impact of allelopathy of sunflower *(Helianthus annuus* L.) roots extract on physiology of wheat (*Triticum aestivum* L.). African Journal of Biotechnology 10(65): 14465-14477.

Kaushal Rajesh, Verma K.S, Panwar P and Chaturvedi O.P. 2011. Allelopathic effect of important agroforestry tree species of Western Himalaya on field crops. Journal of Tree Sciences, 30(4): 385-388.

Kumar D., Thakur N.S. and Gunaga R.P. 2017a. Allelopathic influence of leaf aqueous extract and leaf litter of Indian lilac (*Melia azedarach* L.) on germination, growth, biomass and grain yield of green gram (*Vigna radiata* L.) and black Chickpea (*Cicer arietinum* L.). International Journal of Current Microbiology and Applied Sciences, 6(10): 2669-2683.

Kumar D., Thakur N.S. and Gunaga R.P. 2017b. Effects of leaf aqueous extract and leaf litter of *Melia composita* Willd. on black gram [*Vigna mungo* (L.) Hepper]. Allelopathy Journal 41(1): 127-140.

Narwal S.S., Pavlovic, P. and John, J. 2011. *Forestry and Agroforestry-Research Methods in Plant Sciences,* Vol. 2: Studium Press, Houstan, Taxas, USA. 249 pp.

Nuthan D., Reddy K.M.C., Kumar S.P., Vajranabhaiah S.N. and Yogeesha T.D. 2009. Cultivation of *Melia dubia* farmlands of Kanakapura taluka Ramanagara district of Karnataka-A success story. Pbli. No 224, National Afforestation and Eco-development Board (NAEB) Ministry of Environment and Forests Goveronment of India University of Agricultural Sciences, GKVK Campus Banglore India, RC, NAEB.

Parmar A.G., Thakur N.S. and Gunaga R.P. 2019a. Effect of leaf aqueous extract and leaf litter of chinaberry tree as transient allelopathic influence on growth and yield of chilli and tomato. Indian Journal of Horticulture 76(1): 124-132.

Parmar A.G., Thakur N.S. and Gunaga R.P. 2019b. *Melia dubia* Cav. leaf litter allelochemicals have ephemeral allelopathic proclivity. Agroforestry Systems 93(4):1347-1360.

Parthiban K.T., Bharathi A.K., Seenivasan R., Kamala K. and Rao MG 2009. Integrating *Melia dubia* in agroforestry farms as an alternate pulpwood species. APA News 34: 3-4.

Phuwiwat W., Wichittrakarn W., Laosinwattana C. and Teerarak M. 2012. Inhibitory effects of *Melia azedarach* leaf extracts on seed germination and seedling growth of two weed species. Pakistan Journal of Weed Science Research 18: 485-492.

Rezaeinodehi A., Khangholi S., Aminidehaghi M. and Kazemi, H. 2006. Allelopathic potential of tea (*Camellia sinensis* (L.) Kuntze) on germination and growth of *Amaranthus retroflexus* L. and *Setaria glauca* (L.) P. Beauv. Journal of Plant Diseases and Protection XX: 447-454.

Sale F.A. and Oyun M.B. 2013. Inhibitory effects of leaf extract and leaf mulch from selected tree species on physiology of millet under nursery condition. Journal of Biology, Agriculture and Healthcare 3(15): 80-85.

Saravanan V., Parthiban K.T., Kumar P. and Marimuthu P. 2013. Wood Characterization studies on *Melia dubia* Cav. for Pulp and Paper Industry at different Age Gradation. Research Journal of Recent Sciences (2):183-188.

Shapla T.L., Parvin R., Amin M.H.A. and Rayhan S.M. 2011. Allelopathic effects of multipurpose tree species *Melia azedarach* with emphasis on agricultural crops. Journal of innovation and development strategy 5(1): 70 -77.

Sheron O.P., Tonk D.S., Kaushik L.S., Hasija R.C. and Pannu R.S. 1998. Statistical Software Package for Agricultural Research Workers. Department of Mathematics and Statistics, CCS HAU, Hisar, India. 139-143.

Singh Charan, Singh Rambir and Gulati Ajay. 2019. Performance of *Melia dubia* Cav. And yield of understory crops in Punjab, India. Journal of Tree Sciences. 38(2): 38-45.

Sinha S.K., Chaudhari P.A., Thakur N.S., Jha S.K., Patel D.P. and Dhaka R.K. 2019. *Melia dubia* Cav. wood properties vary with age and influence the pulp and paper quality. International Wood Products Journal, 10(4): 139-148.

Suzuki M., Wakana I., Takasi D. and Tatewaki M. 1996. An allelopathic polyunsaturated fatty acid from red algae. Phytochemistry 43(1): 63-65.

Swaminathan C., Vijendrarao R. and Shashikala S. 2012. Preliminary evaluations of variations in anatomical properties of *Melia dubia* Cav. wood. International Research Journal of Biological Science 4: 1-6.

Thakur N.S., Kumar D., Gunaga R.P. and Singh S. 2017b. Allelopathic propensity of the aqueous leaf extract and leaf litter of *Melia dubia* Cav. on pulse crops. Journal of Experimental Biology and Agricultural Sciences 5(5): 644-655.

Thakur N.S., Kumar D. and Gunaga R.P. 2017a.Transient allelopathic propensity of *Melia composita* Willd. leaf litter on chickpea (*Cicer arietinum* L.). Indian Journal of Ecology 44 (Special Issue-5): 443-450.

Thakur N.S., Parmar A.G., Gunaga R.P. and Patel D.P. 2017d. Allelopathic influence of leaf and leaf litter of white cedar (*Melia azedarach* L.) on eggplant and okra. Allelopathy Journal 42(2): 295-305.

Thakur M.K. 2014. Studies on allelopathic effects of some agroforestry tree species on soybean. International Journal of Farm Sciences 4(2): 107-113.

Vijayan P., Raghu C., Ashok G., Dhanaraj S. and Suresh B. 2004. Antiviral activity of medicinal plants of nilgiris including *Melia dubia.* Indian Journal of Medical Research 120: 24-29.

Zhang Y., Gu M., Shi K., Zhou Y.H. and Yu J.Q. 2015. Effects of aqueous root extracts and hydrophonc root exudates of cucumber (*Cucumis sativus* L.) on nuclei DNA content and expression of cell cycle-related genes in cucumber radicles. Plant and Soil 327: 455-463.

*Received: 13th August, 2020* *Accepted: 30th November, 2020*