

Allelopathic effects of *Melia azedarach* L. on germination, growth and yield of black gram and chickpea

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ABSTRACT

We analysed the allelochemicals in leaf litter of Indian lilac (*Melia azedarach* L.) by Gas chromatography mass-spectrometry (GC-MS). The allelopathic effects of leaf aqueous extracts (control, 25, 50, 75 and 100% concentration) and leaf litter (control, 12.5, 25.00, 37.50 and 50 g/pot) on germination and growth and biomass of black gram (*Vigna mungo* L. Hepper var. 'Gujarat Urd-1') and chickpea (*Cicer arietinum* L.; var. 'Kabuli') were determined in laboratory and pot culture. To understand the allelopathic effects of leaf litter on later stages of growth, biomass and grain yield of test crops, pot experiments were done. GC-MS analysis of leaf litter revealed different compounds [phenolic acids, alkaloids, methyl ketones (volatile allelochemical), unsaturated fatty acids, benzofuran, propargyl acid, benzoxepine, fluorobenzoic acid, silicyclobutane, palmitic acid]. The leaf aqueous extract and leaf litter inhibited the germination, initial growth and biomass of black gram and chickpea (Kabuli variety) in laboratory and pot culture bioassays. However, the results of pot experiment done till maturity of test crops, did not show allelopathic effects of leaf litter on growth, biomass and grain yield.

Keywords: Allelopathy, black gram, chickpea, *Cicer arietinum*, GC-MS, germination, grain yield, laboratory bioassay, *Melia azedarach*, pulses, seedling growth, *Vigna mungo*

INTRODUCTION

Melia azedarach L. is multipurpose fast growing deciduous tree grown in 36-countries (25). It is planted in agroforestry systems (block or boundary plantations) and also as ornamental purpose. It improves the soil fertility through leaf litter addition and its decomposition (16,22). It is grown with different intercrops [coffee, abaca (*Musa textilis*) plantations, sugarcane, vegetables, pulses and grain crops (22,25,27). Beneficial or harmful effects of one plant on another plant through release of biochemicals (allelochemicals) from plant parts by leaching, root exudation, volatilization, residue decomposition and other processes in both natural and agricultural systems is termed as allelopathy (12,23). Agroforestry is advocated to provide higher productivity without deleterious effects on other plants, hence, there is need to determine the allelopathic effects of woody and non woody components. Several crops are grown under agroforestry systems in India. Among these pulses are important leguminous intercrops. Among these, black gram (*Vigna mungo* L. Hepper) and chickpea (*Cicer arietinum* L.) are important ones. Black gram and chickpea are good source of protein, minerals (Ca, Fe, Cu and Mo) and lysine. Black gram grain contains 24% protein, 60% CHO, 1.3% fat and is the richest source of phosphoric acid among pulses (5-6% richer than others). Similarly, chickpea is major crop in rainfed areas in India (4,11,37). This study aimed to investigate the allelopathic effects of *M. azedarach* leaf aqueous extracts and leaf litter on germination, growth, biomass and yield of black gram black gram (*Vigna mungo* L. Hepper var.

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'Gujarat Urd-1') and chickpea (*Cicer arietinum* L.; var. 'Kabuli') in laboratory bioassay and pot culture till crop maturity.

MATERIALS AND METHODS

The studies were done during 2014 to 2015 in Agroforestry laboratory and green houses 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). The average maximum and minimum temperatures are 40 °C and 18 °C, respectively. The average annual rainfall is 122 cm.

***M. azedarach* leaf litter collection:** Leaf litter of *M. azedarach* was collected during October-November, 2014. Leaf litter was air dried at room temperature and later at 65 °C in hot air oven until constant dry weight was reached (28). The dried leaf litter was stored at room temperature and used for both petriplate bioassay and pot experiments.

Preparation of *M. azedarach* leaf aqueous extracts: 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°C) for 24 h. The filtrate was centrifuged, supernatant was decanted (30) and was considered 100 % extract (24). From this 25, 50, 75, 100 % concentrations were prepared with distilled water. The distilled water was used as control (0%) (16). The treatments were replicated five times in completely randomized design (CRD).

Phytochemical analysis of leaf litter

Allelochemicals in test leaf litter samples of *M. azedarach*, were detected by Gas Chromatography-Mass Spectrometry (GC-MS) analysis following Murugesan *et al.* (21).

Petridish bioassay: The pre-treated seeds (with Thiram @ 2g/kg) of black gram (*Vigna mungo* L. Hepper) and chickpea (*Cicer arietinum* L.) were used as test crops. The treatments were replicated five times. Twenty five seeds of each test crop were placed on filter paper in sterilized petridishes (15 cms dia). Five ml aqueous extracts of 0, 25, 50, 75, 100% concentrations were applied as per treatment on first day and afterwards, 2 ml on alternate days to keep the filter paper moist till the completion of experiment (7). Seeds were considered germinated upon radicle emergence (>1 cm length) from seeds. Germination was counted daily till 11 days after start of experiment. The seedling shoot and root length and biomass were recorded after 11 days from 10-randomly selected seedlings per petridish of each test crop. Germination (%) and Germination Rate Index (GRI) were calculated as per Association of Official Seed Analysts (5). Root and shoot were separated and dried in hot air oven at 60⁰ C for 48 h and weighed to estimate dry biomass.

Pot experiments: Pot experiments were done in green house to ascertain the effects of leaf litter of *M. azedarach* on germination, GRI, initial growth and biomass of both the test crops. Fifty seeds of each crop were sown per plastic pot [18 cms dia x 16 cms height] containing approximately 2.5 kg field soil (N, P and K contents were 84.82, 17.85 and 80.35 ppm, respectively). Course grounded leaf litter at 5, 10, 15 and 20 g was mixed in the upper soil layer in pots (40). Pots without leaf litter were considered as control. The litter treatments were prepared as per the annual average litter fall (20). We recorded leaf litter fall of 3- months by placing the 1 m² traps under 6-years old plantation of *M.*

azedarach. The average litter fall was 446.43 g/m² (4.46 tonne/ha), i.e. about 11.61 g/pot. The leaf litter treatments were calculated based on the range of litter fall as mentioned above. The treatments were replicated 4-times in complete randomised design. Pots were watered one day prior to sowing and approx. 500 ml daily on subsequent days to keep the soil moist. The seed germination (seedlings emergece from the soil) and seedling growth were recorded (on 11th day from start of experiment). The germination (%) and GRI were calculated as per standard procedure followed in petridish bioassays.

To evaluate the plant growth, biomass and yield of each test crop, a separate pot experiment was done in green house. For each leaf litter treatment, total 15 plants were used (five replications x three plants per replication). At maturity (90 days after sowing), fresh and dry biomass of plant and grains were recorded.

Statistical analysis

The experimental data were subjected to the statistical analysis following completely randomized design (CRD) and ANOVA was constructed following Sheoran et al. (38). Treatment means were compared at $P \leq 0.05$. Further, Duncan's multiple range test (DMRT) was used to compare the sets of means of each treatment.

RESULTS AND DISCUSSION

Leaf litter composition

With GCMS analysis, we detected 18 compounds in leaf litter of *M. azedarach* used for bioassay and pot culture (Table 1, Fig. 1). The detected compounds were phenolic acids and their derivatives, alkaloids, methyl ketones (volatile allelochemical), unsaturated fatty acids, aromatic ketone, alkaloids, methyl ketones (volatile allelochemical), unsaturated fatty acids, benzofuran, propargyl acid, benzoxepine, fluorobenzoic acid, silicyclobutane, palmitic acid. These compounds were also reported earlier (36). The phytochemicals like benzoic acids, benzofuran and benzopyran, cyclohexanone, octanoate, dicarboxylic acid, icosapentaenoic acid, 5-methyl (5-8 dihydro 1-4 Naphthoquinone), cyclohexanone, 3-hydroxy-3-phenyl-, 1-Pentanone, 1-(4-methoxyphenyl)-Oxim Or 1-(4-Methoxyphenyl)-1-pentanone oxime etc., are harmful to many plant species germination and growth as leaf litter extract (10,15,31,32,44).

Germination

The aqueous leaf extract concentrations and leaf litter significantly inhibited the germination (%) and germination rate index, of black gram and chickpea than control. In pot culture, black gram germination was not inhibited at 5 g litter treatment. The inhibitory effects gradually increased with incremental extract concentrations or leaf litter amount (Table 2, 3 and Fig. 2 A to D). The inhibition (%) increased with increase in extract concentration and leaf litter dose (Fig. 3 and 4). The inhibition (%), in both test crops, was higher in aqueous extracts than leaf litter applied in pots. In petri plate bioassay, the seeds come in direct contact with aqueous extract allelochemicals, whereas, in pot culture the allelochemicals are released slowly and may alleviate with cultural practices like irrigation (23).

Table 1. Chemical compounds, their retention times and area under curve detected through GC-MS analysis in *M. azedarach* leaf litter¹⁷

| Sr. No. | Compound name | Retention time | Area under Curve |
|---------|---|----------------|------------------|
| 1 | 1-benzofuran-2,3-dione | 5.49 | 192729 |
| 2 | 4 methylbenzoic acid, Propargyl acid | 9.71 | 90293 |
| 3 | 2,3-Benzofurandione,2-oxime | 10.34 | 143614 |
| 4 | 2,3,4,5-tetrahydro-1-benzoxepine | 10.57 | 815388 |
| 5 | 3-Fluorobenzoic acid, 4-nitrophenyl ester | 11.04 | 117505 |
| 6 | 1-cyclohexyloxy-1-methyl-1-silicyclobutane | 11.30 | - |
| 7 | 4H-Pyrazino[2,3-b]indole, 6,7,8,9-tetrahydro- | 11.41 | 237741 |
| 8 | Cyclohexanone, 3-hydroxy-3-phenyl- | 12.14 | 138784 |
| 9 | 1,4-Dithiepan-2-one, 3-phenyl | 12.93 | 74168 |
| 10 | 1,4,7,10,13,16-Hexaoxacyclooctadecane-2,5,9-trione,3-(phenylmethyl)- | 14.24 | - |
| 11 | 1-Decen-3-yne | 14.33 | - |
| 12 | 2-Methyl-3,5-dodecadiyne | 15.14 | 3884632 |
| 13 | Methyl 5,7 hexadeadiynoate (Palmitic acid methyl ester; Hexadecanoic acid, methyl ester; Palmitic acid) | 16.23 | 191202 |
| 14 | Methyl 8-(5-octyl-1,2,4-trioxolan-3-yl) octanoate | 16.79 | 115882 |
| 15 | Methyl (4E,7E,10E)-Hexadeca-4,7,10-Trienoate | 21.83 | 1157941 |
| 16 | 1,3-Dioxolane-4-methanol, 2-pentadecyl-, acetate, cis- | 24.02 | 162408 |
| 17 | Spiro [adamantine-2,2-(1,3) dithiolane]-1,5-dicarboxylic acid, 6 oxo | | |
| 18 | 1-Pentanone, 1-(4-methoxyphenyl)-Oxim or 1-(4-Methoxyphenyl)-1-pentanone oxime or p-Methoxy valerophenone oxime | 27.20 | 1370885 |

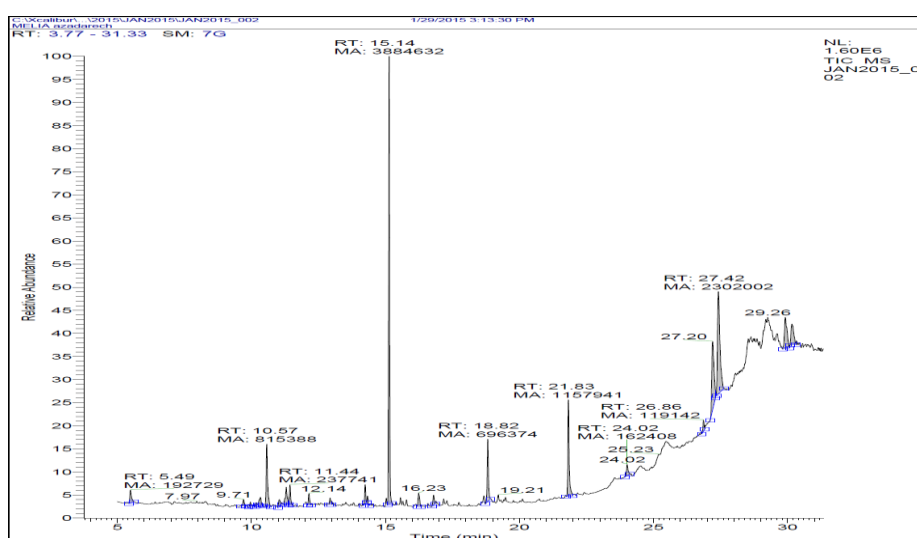
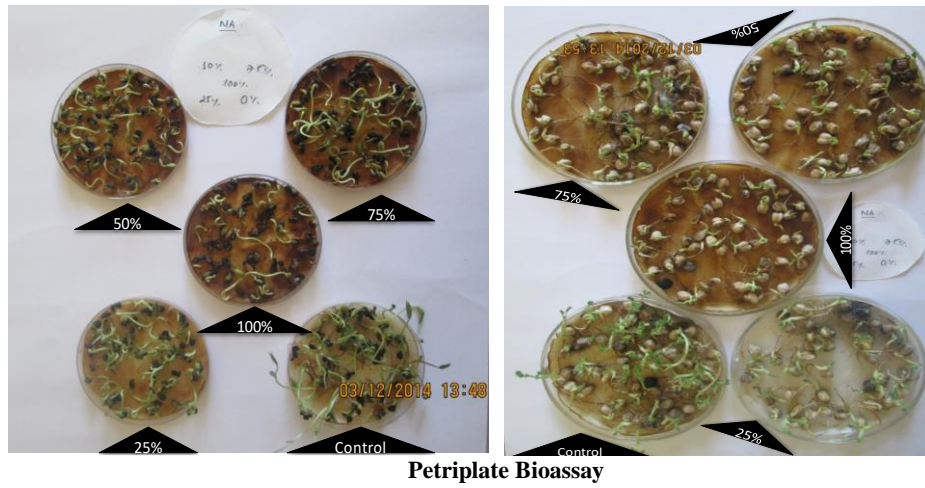


Figure 1. GC-MS chromatogram showing retention time and peaks of different chemical compounds in *Melia azedarach* leaf litter¹⁷

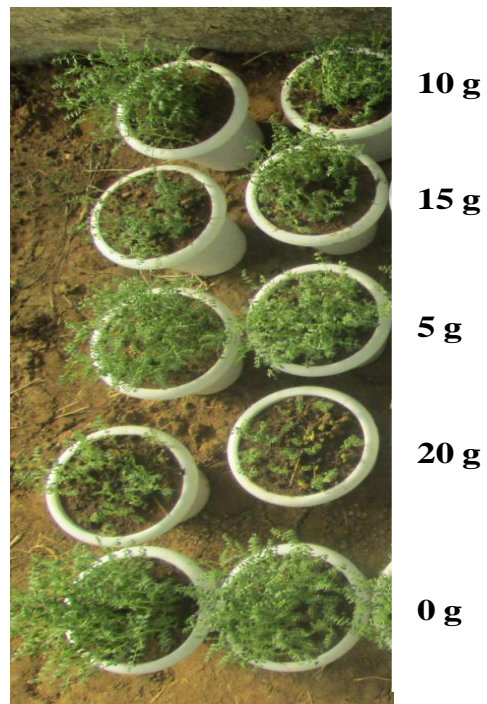


A (*Vigna mungo*)

B (*Cicer arietinum*)



C (*Vigna mungo*)



Pot Culture

D (*Cicer arietinum*)

Figure 2. Allelopathic effects of aqueous leaf extracts [0 (distilled water), 25, 50, 75 and 100%] and leaf litter [0 (no leaf litter), 5, 10, 15 and 20 g/pot] of *M. azedarach* on germination and initial growth of black gram and chickpea in laboratory (A and B) and pot culture bioassays (C and D).

Initial growth and biomass

The leaf aqueous extract and leaf litter significantly inhibited the seedling growth and shoot, root biomass (Table 2 and 3) of both test crops. The inhibition (%), over control, in petri plate and pot culture, increased with increase in aqueous concentration and leaf litter quantity (Fig. 3 and 4) and maximum inhibition was at 100 % extract concentration and 20 g litter dose. The inhibition (%) was more in roots than shoot in laboratory and in pot culture experiments.

Table 2. Allelopathic effect of aqueous leaf extract of *M. azedarach* on germination traits, initial growth and biomass of black gram and chickpea (Kabuli variety) in bioassay culture

| Extract concentration (%) | Germination (%) | GRI | Growth | | Biomass (DM mg/plant) | | |
|---------------------------|----------------------------|--------------------------|--------------------------|-------------------|-----------------------|--------------------|--------------------|
| | | | Shoot length (cm) | Root length (cm) | Shoot | Root | Total |
| Black gram | | | | | | | |
| Control | 92.80 (74.80) ^a | 24.20 ^b | 6.95 ^a | 3.67 ^a | 18.16 ^a | 9.95 ^a | 28.11 ^a |
| 25 | 85.80 (68.00) ^b | 23.94 ^a | 6.04 ^b | 2.44 ^b | 16.37 ^b | 8.67 ^b | 25.03 ^b |
| 50 | 79.40 (63.00) ^c | 20.35 ^b | 5.42 ^c | 1.87 ^c | 13.68 ^c | 7.50 ^c | 21.18 ^c |
| 75 | 69.80 (56.60) ^d | 19.35 ^{bc} | 4.42 ^d | 1.71 ^c | 11.66 ^d | 5.95 ^d | 17.60 ^d |
| 100 | 62.20 (52.08) ^e | 16.83 ^c | 3.58 ^e | 1.51 ^d | 9.98 ^e | 5.11 ^e | 15.09 ^e |
| SEm(±) | 0.86 | 0.94 | 0.081 | 0.064 | 0.30 | 0.14 | 0.31 |
| Chickpea (Kabuli variety) | | | | | | | |
| Control | 92.00 (74.80) ^a | 23.83 ^a ±0.88 | 5.21 ^a ±0.062 | 6.48 ^a | 29.60 ^a | 28.30 ^a | 57.91 ^a |
| 25 | 87.60 (69.60) ^b | 20.84 ^b ±0.81 | 4.72 ^b ±0.020 | 5.09 ^b | 26.73 ^b | 25.84 ^b | 52.57 ^b |
| 50 | 80.80 (63.80) ^c | 20.82 ^b ±0.41 | 3.75 ^c ±0.081 | 4.16 ^c | 23.60 ^c | 22.81 ^c | 46.41 ^c |
| 75 | 74.40 (59.60) ^d | 17.78 ^c ±0.66 | 3.12 ^d ±0.057 | 3.14 ^d | 20.31 ^d | 19.63 ^d | 39.95 ^d |
| 100 | 65.20 (54.00) ^e | 16.73 ^c ±0.60 | 2.56 ^d ±0.044 | 2.74 ^e | 16.59 ^e | 16.04 ^d | 32.64 ^e |
| SEm(±) | 1.01 | 0.69 | 0.057 | 0.058 | 0.55 | 0.55 | 1.09 |

DM=Dry Matter; GRI= Germination rate index; Figures in parenthesis are arc-sin transformed values; SEm= Standard error of mean, Letter different in same vertical column are significantly different according to Duncan's multiple range test ($P \leq 0.05$).

Inhibitory effects observed in this study agrees with earlier findings of laboratory studies showing effects of *M. azedarach* on seed germination (2,18,29). The inhibitory effects of aqueous leaf extract and leaf litter of persian lilac on germination and seedlings growth are due to the water soluble allelochemicals present in leaf litter (33). The present study evinced that the magnitude of inhibition on germination traits, initial growth and biomass increased with incremental extract intensity. Similar concentration depended inhibitory effects of aqueous leaf extracts of *M. azedarach* on *Echinochloa crusgalli* and radish have been reported earlier (2,29). Similar results leaf litter aqueous extract of *Melia dubia* are also reported on various vegetable and pulse crops (26,41,42).

The percent inhibitory effects of aqueous leaf extract and leaf litter is were more on initial root growth than shoot growth. In laboratory bioassays, similar organ specific effects of *M. azedarach* leaf aqueous extracts have been reported on *E. crusgalli* and radish (2,29). Shapla et al. (35) have reported inhibitory effects of *M. azedarach* leaf litter on germination, initial growth and biomass of mung bean in pot culture. The roots first come in direct contact with allelochemicals (33), hence, are first to absorb them from the

petri plates. This may also be ascribed to the fact that, cell death and tissue browning frequently occur in the root apical zone (area with active cell division), when roots are exposed to allelopathic agents (9). Several studies have shown that young seedlings, especially the roots, are more sensitive to allelopathic agents than adult plants or other plant organs (45). Leaf leachates hamper the physiological processes of the growing seedlings in such environment. *M. azedarach* allelochemicals produce an imbalance in the oxidative status of cells and changes the activity of catalase (CAT), ascorbate peroxidase (APX), guaiacol peroxidase (GPX) and in the levels of H₂O₂ and assimilatory pigments (2). There were changes in membrane lipid peroxidation and electrolytes leakage in radish seedlings. The aqueous extracts and their water soluble allelochemicals cause inhibition during germination process compared to control (29). Most seeds require adequate moisture to activate the metabolism in seeds (8). However, seeds which inhibited the water have poor seed germination. Germination inhibition is also the result of induction of oxidative stress (14). All these findings of this study may be ascribed to the inhibitory effects of *M. azedarach* aqueous extracts on seed germination of black gram and chickpea.

Table 3. Allelopathic effect of leaf litter of *M. azedarach* on germination traits, initial growth and biomass of black gram and chickpea (Kabuli variety) in pot culture

| Leaf litter (g/pot) | Germination (%) | GRI | Growth | | Biomass (DM mg/plant) | | |
|---------------------------|-----------------------------|--------------------|--------------------|--------------------|-----------------------|--------------------|---------------------|
| | | | Shoot length (cm) | Root length (cm) | Shoot | Root | Total |
| Black gram | | | | | | | |
| 0 control | 100.00 (90.00) ^a | 96.93 ^a | 16.40 ^a | 13.40 ^a | 54.44 ^a | 29.86 ^a | 84.30 ^a |
| 5 g | 100.00 (90.00) ^a | 86.61 ^b | 15.50 ^b | 12.50 ^b | 49.48 ^b | 27.14 ^b | 76.62 ^b |
| 10 g | 98.00 (83.74) ^a | 65.28 ^c | 14.60 ^c | 11.00 ^c | 43.39 ^c | 23.80 ^c | 67.19 ^c |
| 15 g | 88.80 (70.85) ^b | 52.79 ^d | 13.80 ^d | 9.60 ^d | 38.01 ^d | 20.85 ^d | 58.86 ^{d±} |
| 20 g | 70.40 (57.29) ^c | 41.26 ^e | 13.00 ^e | 8.30 ^e | 32.07 ^e | 17.59 ^e | 49.66 ^e |
| SEm(±) | 2.25 | 3.18 | 0.126 | 0.193 | 1.31 | 0.72 | 2.04 |
| Chickpea (Kabuli variety) | | | | | | | |
| 0 control | 100.00 (90.00) ^a | 54.60 ^a | 18.73 ^a | 20.63 ^a | 65.49 ^a | 37.42 ^a | 102.91 ^a |
| 5 g | 96.80 (83.60) ^a | 47.41 ^a | 17.26 ^b | 19.16 ^b | 58.32 ^b | 33.32 ^b | 91.64 ^b |
| 10 g | 85.20 (70.20) ^b | 24.60 ^b | 16.58 ^c | 18.49 ^c | 53.52 ^c | 30.58 ^c | 84.11 ^c |
| 15 g | 51.60 (45.80) ^c | 14.89 ^b | 15.65 ^c | 17.55 ^d | 50.47 ^c | 28.85 ^d | 79.32 ^d |
| 20 g | 48.80 (44.60) ^c | 14.00 ^b | 14.70 ^e | 16.60 ^e | 48.44 ^e | 27.67 ^e | 76.11 ^e |
| SEm(±) | 3.94 | 4.40 | 0.21 | 0.12 | 0.31 | 0.18 | 0.49 |

DM=Dry Matter; GRI= Germination rate index; Figures in parenthesis are arc-sin transformed values; SEm= Standard error of mean, Letter different in same vertical column are significantly different according to Duncan's multiple range test ($P \leq 0.05$).

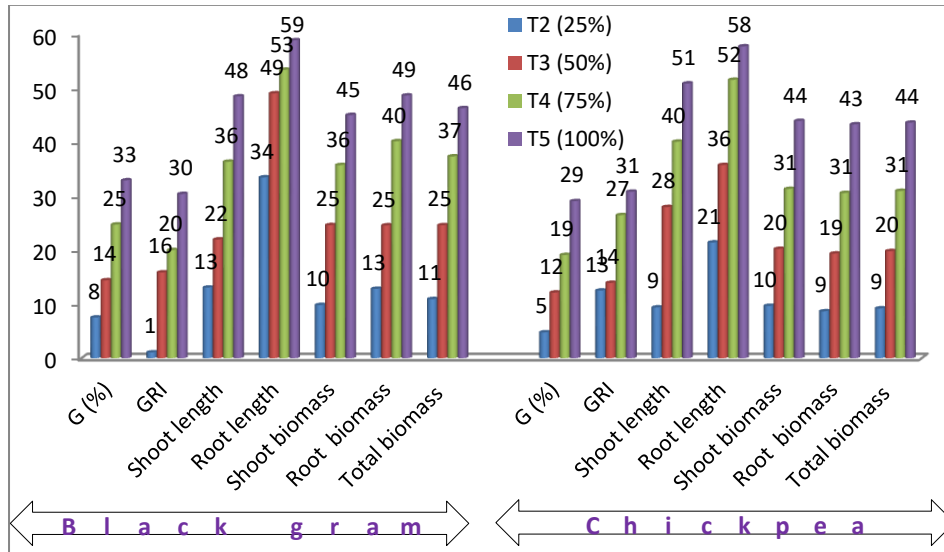


Figure 3. Inhibitory effects of aqueous leaf extracts of *M. azedarach* on germination, GRI, growth and biomass of blackgram and chickpea (Kabuli variety) over the Control in Lab. bioassay.

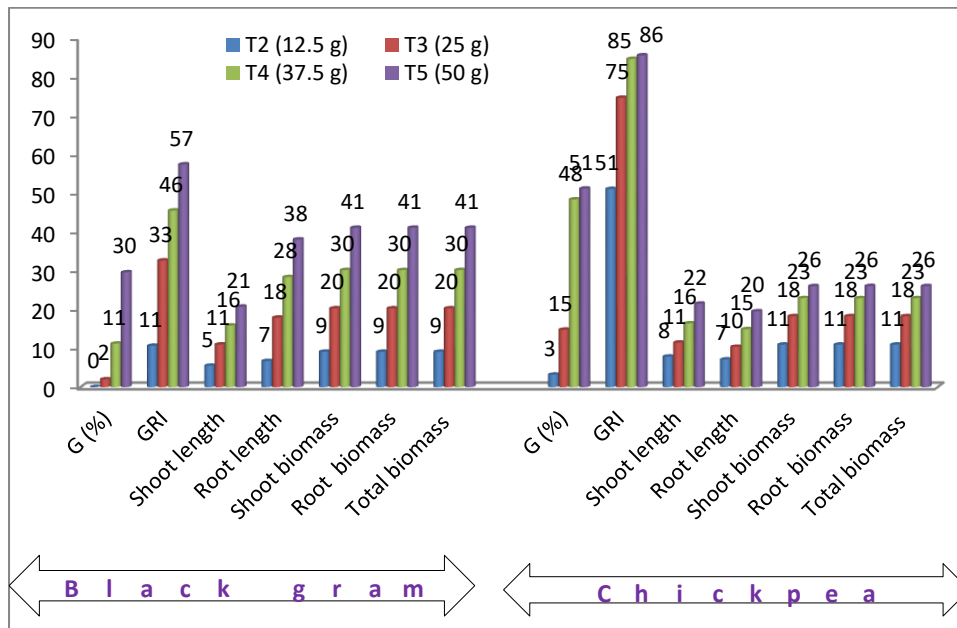


Figure 4. Inhibitory effects of leaf litter of *M. azedarach* on germination, GRI, growth and biomass of blackgram and chickpea in pot culture.

Allelochemicals decreases the stomatal conductance by inducing ABA production, which indirectly impacts the rates of photosynthesis and transpiration (2), decrease respiration and uncouple the oxidative phosphorylation (1). The phenolics cause multiple physiological effects [reduction in plant growth, absorption of water and mineral nutrients, ion uptake, leaf water potential, shoot turgor pressure, physiological drought and osmotic potential (6,33)] which inhibits the germination and seedling growth. Incorporation of plant residues into the growth environment of another plant may inhibit the germination and seedling growth. These may be attributed to reduced growth and biomass traits of both test crops by the leaf litter of *M. azedarach* in our study.

Growth, biomass and grain yield

Despite validation of alleged allelochemicals in *M. azedarach* through GC-MS analysis, there were no significant allelopathic effects of leaf litter applications (5,10,15 and 20 g/pot) on later growth, biomass and grain yield of both test crops (Table 4). However, in other studies, *M. azedarach* leaf litter application of 20 g/pot inhibits the growth and biomass of mung bean and soybean (35). Similar adverse effects of leaf litter of several tree species have been reported on millet and soybean till 30-days (34,40). Whereas, our study reports the results of growth, biomass and grain yield of test crops till maturity *i.e.* 90 days after sowing.

Similarly, there are no significant effects of leaf litter of *Melia dubia* on vegetable and pulse crops (18,41,42,35). This may be attributed to faster leaf litter decomposition, leaching out of allelochemicals due to frequent irrigation done to maintain the moisture in pots, ephemeral nature of allelochemicals present in leaf litter of donor species especially phenolics. Leaf litter of *M. azedarach* decompose quickly than other tree species due its higher decay constant (13). Phytotoxicity of crop residue disappears quickly after the decomposition. The phytotoxic effects of leaf litter addition are less under field conditions because the phytotoxic compound degrade faster in field than in laboratory, besides some allelochemicals are adsorbed by the soil particles (43).

Further, it is observed that highest concentrations of allelochemicals are near the soil surfaces and are rapidly lost from the soil through volatilization. Allelopathic or phytotoxic compounds are mainly phenolic acids and they are released during the decay of plants residues, resulting in phytotoxicity of decomposing plant residues (3). It is advocated that addition of readily decomposable organic matter of wide C:N ratio to soil, enhances the microbial activity leading to nitrogen immobilization, thereby reducing the plant growth, however, irrigation and addition of nitrogen, overcome such growth decreases (23).

Table 4. Allelopathic effects of leaf litter of *M. azedarach* on growth, biomass (DM g/ plant) and grain yield (at 90 days old) of black gram and chickpea (Kabuli variety) in pots.

| Leaf litter (g/pot) | Plant Height (cm) | Root length (cm) | No. of pods/plant | Grain yield (g/ plant) | Biomass (DM g/ plant) |
|----------------------------|-------------------|------------------|-------------------|------------------------|-----------------------|
| Black gram | | | | | |
| 0 control | 27.94 | 9.20 | 5.63 | 2.05 | 7.02 |
| 5 g | 26.31 | 9.44 | 5.38 | 1.97 | 5.62 |
| 10 g | 27.84 | 9.60 | 5.08 | 1.89 | 5.28 |
| 15 g | 30.36 | 8.69 | 4.85 | 1.77 | 5.50 |
| 20 g | 29.47 | 10.30 | 5.65 | 2.07 | 6.40 |
| CD ($P \leq 0.05$) | N.S. | N.S. | N.S. | N.S. | N.S. |
| SEm(\pm) | 1.20 | 0.63 | 0.53 | 0.18 | 0.83 |
| Chick pea (Kabuli variety) | | | | | |
| 0 control | 36.89 | 6.28 | * | * | 3.98 |
| 5 g | 37.19 | 6.52 | * | * | 3.69 |
| 10 g | 36.76 | 6.69 | * | * | 3.41 |
| 15 g | 36.22 | 5.53 | * | * | 3.83 |
| 20 g | 35.12 | 6.53 | * | * | 3.27 |
| CD ($P \leq 0.05$) | N.S. | N.S. | * | * | N.S. |
| SEm(\pm) | 1.13 | 0.42 | * | * | 0.27 |

DM=Dry Matter; * Did not flower; CD= Critical difference; SEm= Standard

Management practices like frequent irrigations resulted in faster decomposition of leaf litter of *M. azedarach*, hence, were less inhibitory to growth, yield and dry matter production of pulse crops in present study. The leaf litter used in this study was powdered before application, which might have resulted in quick decomposition, thus alleviating the allelochemicals. Similar conclusions have also been drawn in earlier studies (3). These evidences may be attributed to non-significant effects of leaf litter treatments of *M. azedarach* on growth, biomass and grain yield of tested pulse crops in our study.

CONCLUSIONS

The GC-MS analysis showed that leaf litter of *M. azedarach* contains phenolic acids and their derivatives. Laboratory bioassay and pot culture studies revealed that detected allelochemicals have putative inhibitory effects on seed germination, initial growth and biomass of black gram and chickpea. However, in pot culture studies, (done to examine the effects of leaf litter) it was found that, different litter treatments did not show any significant allelopathic effects on later growth (near maturity), biomass and grain yield of test crops. Hence, this important species could be advocated in agroforestry.

REFERENCES

1. Abraham, D., Takahashi, L., Kelmer-Bracht, A.M. and Ishii-Iwamoto, E.L. (2003). Effects of phenolic acids and monoterpenes on the mitochondrial respiration of soybean hypocotyls axes. *Allelopathy Journal* **11**: 21-30.

2. 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.
3. Ampofo, K.G. (2009). *Effects of Tectonagrandis Leaf Extract, Leaf litter and Woodlot Soil on Germination and Growth of Maize*. M.Sc. Thesis. Kwame Nkrumah, University of Science and Technology, Kumasi, Ghana. pp. 72.
4. Anonymous. (2018). [www.http://dpd.gov.in/Urdbean.pdf](http://dpd.gov.in/Urdbean.pdf), accessed on 20-11/2018.
5. Association of Official Seed Analysts (AOSA) (1983) *Seed Vigour Testing Handbook*. AOSA, Ithaca, NY, USA. (Handbook of Seed Testing, 32)
6. Barkosky, R.R. and Einhellig, F.A. (2003). Allelopathic interference of plant-water relationships by parahydroxybenzoic acid. *Botanical Bulletin, Academia Sinica* **44**: 53-58. (Chinese)
7. Bhat, J.A., Kumar, M. and Singh, B. (2011). Effects of leaf and bark aqueous extract of *Anogeissus latifolia* on growth of *Vigna unguiculata*. *Agricultural Sciences* **4**: 432-434.
8. Chong, C., Bible, B.B. and Ju, H.Y. (2002). Germination and emergence. In: *Handbook of Plant and Crop Physiology* (Ed., M. Pessarakli), II Ed. Marcel Dekker, New York, pp. 57-115.
9. Ding, J., Sun, Y., Xiao, C.L., Shi, K., Zhou, Y.H. and Yu, J.Q. (2007). Physiological basis of different allelopathic reactions of cucumber and figleaf gourd plants to cinnamic acid. *Journal of Experimental Botany* **58**: 3765-3773.
10. Franco, D.M., Saldanha, L.L., Neto, Jose-de-Sousa L., Santos, L.C.D., Dokkedal, A.L. and Almeida and Luiz Fernando Rolim de. (2016). Seasonal variation in allelopathic potential of the leaves of *Copaifera langsdorffii* Desf. *Acta Botanica Brasilica* **30**: 157-165. <http://dx.doi.org/10.1590/0102-33062015abb0296>
11. Fred, J.M. and Sarker, A. (2017). Economic importance of chickpea: Production, value, and world trade. In: *The Chickpea Genome, Compendium of Plant Genomes*. (Eds., R.K. Varshney et al.), DOI 10.1007/978-3-319-66117-9-2.
12. 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.
13. Hossain, M., Siddique, M.R.H., Rahman, M.S., Hossain, M.Z. and Hasan, M.M. (2011). Agroforestry tree species (*Azadirachta indica*, *Dalbergia sissoo* and *Melia azedarach*) of Bangladesh. *Journal of Forestry Research* **22**: 577-582.
14. 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**: 14465-14477.
15. Koder, K.D. (2011). Black walnut allelopathy: Tree chemical warfare. *Allelopathy Series* **10-11**: 1-13.
16. Krishnan, K.M., Neeraja, G., Subrahmanyam, M.V.R. and Bheemaiah, G. (2009). Production potential of sunflower alley cropped with neem and melia under dry land condition. *Annals of Agricultural Science* **30**: 14-18.
17. Kumar, D. (2015). *Studies of Effect of Leaf Leachates of Melia composita Cav. and Melia azedarach L. on Germination, Growth and Yield of Some Pulse Crops*. M.Sc. These, Navsari Agricultural University, Navsari, Gujarat, India. 134+xli pp.
18. Kumar, D., Thakur, N.S. and Gunaga, R.P. (2017). Effects of leaf aqueous extract and leaf litter of *Melia composita* Willd. on black gram [*Vigna mungo* (L.) Hepper]. *Allelopathy Journal* **41**: 127-140. <https://doi.org/10.26651/allelo.j/2017-41-1-1089>
19. Lawan, S.A., Suleiman, M. and Yahaya, S.U. (2011). Inhibition of germination and growth behavior of some cowpea varieties using neem (*Azadirachta indica*) leaf water extracts. *Bayero Journal of Pure and Applied Science* **4**(2): 169-172. <http://dx.doi.org/10.4314/bajopas.v4i2.34>
20. Li, Y., Hu, T., Duan, X., Zeng, F., Chen, H. and Wu, X. (2013). Effects of decomposing leaf litter of *Eucalyptus grandis* on the growth and photosynthetic characteristics of *Lolium perenne*. *Journal of Agricultural Science* **5**(3): 123-131. <http://dx.doi.org/10.5539/jas.v5n3p123>
21. Murugesan, S., Senthilkumar, N., Rajeshkannan, C. and Vijayalakshmi, K.B. (2013). Phytochemical characterization of *Melia dubia* for their biological properties. *Der Chemica Sinica* **4**(1): 36-40.
22. Nandal, D.P.S. and Kumar, R. (2010). Influence of *Melia azedarach* based land use system on economics and reclamation of salt affected soil. *Indian Journal of Agroforestry* **12**: 23-26.
23. Narwal, S.S., Pavlovic, P. and John, J. (2011). *Forestry and Agroforestry- Research Methods in Plant Sciences*, Vol. 2: Studium Press, Houston, Texas, USA. 249 pp.
24. Nikneshan, P., Hassan, K., Morteza, M. and Nayereh-al-sadat, H. (2011). Allelopathic potential of sunflower on weed management in safflower and wheat. *Asian Journal of Crop Science* **5**: 1434-1440.
25. Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Anthony, S. (2009). *Agroforestry Database: A tree reference and selection guide version 4.0*.

26. Parmar, A.G., Thakur, N.S. and Gunaga, R.P. (2018). *Melia dubia* Cav. leaf litter allelochemicals have ephemeral allelopathic proclivity. *Agroforestry Systems* <https://doi.org/10.1007/s10457-018-0243-5/>.
27. Patil, S.J., Mutanal, S.M. and Patil, H.Y. (2012). *Melia azedarach* based agroforestry system in transitional tract of Karnataka. *Karnataka Journal of Agricultural Sciences* **25**: 460-462.
28. Perez-Corona M.E., de las Heras P. and Vazquez de Aldana B.R. (2013). Allelopathic potential of invasive *Ulmus pumila* on understory plant species. *Allelopathy Journal* **32**: 101-112.
29. 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.
30. Prasad, B., Lavania, S.K. and Sah, V.K. (2011). Allelopathic effects of walnut leaf extracts on seed germination and seedling growth of wheat (*Triticum aestivum* L.). *Indian Journal of Agroforestry* **13**: 87-90.
31. Ramalakshmi, S. and Muthuchelian, K. (2013). Studies on cytotoxic, phytotoxic and volatile profile of the bark extract of the medicinal plant, *Mallotus tetracoccus* (Roxb.) Kurz. *African Journal of Biotechnology* **12**: 6176-6184.
32. Razavia, M.S. and Ebrahimib, S.N. (2010). Phytochemical analysis and allelopathic activity of essential oils of *Ecballium elaterium* A. Richard growing in Iran. *Natural Products Research* **24** : 1704-1709.
33. 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 *Setariaglauca* (L.) P. Beauv. *Journal of Plant Diseases and Protection* **20**: 447-454.
34. Sale, F.A. and Oyun, M.B. (2013). Inhibitory effects of leaf extract and leaf litter from selected tree species on physiology of millet under nursery condition. *Journal of Biology, Agriculture and Healthcare* **3**(15): 80-85.
35. 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.
36. Sharma, D. and Paul, Y. (2013). Preliminary and pharmacological profile of *Melia azedarach* L.: An overview. *Journal of Applied Pharmaceutical Science* **3**(12): 133-138.
37. Sharma, O.P., Bambawale, O.M., Gopali, J.B., Bhagat, S., Yelshetty, S., Singh, S.K., Anand, R. and Singh, O.P. (2011). *Field Guide to Mungbean & Urdbean*. Pp 40.
38. Sheoran, 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. P. 139-143.
39. Singh, D., Singh, N.B., Yadav, K., Kumar, S. and Lal, B. (2014). Allelopathic effects of *Solanum melongena* L. on *Vigna radiata* L. *Journal of Stress Physiology and Biochemistry* **10**: 287-296.
40. Thakur, M.K. (2014). Studies on allelopathic effects of some agroforestry tree species on soybean. *International Journal of Farm Sciences* **4**: 107-113.
41. 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.
42. 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. [http://dx.doi.org/10.18006/2017.5\(5\).644.655](http://dx.doi.org/10.18006/2017.5(5).644.655)
43. Tian, G. (1992). *Biological Effects of Plant Residues, with Contrasting Chemical Compositions on Plant and Soil Under Humid Tropical Conditions*. Ph.D. Thesis, Agric. Univ. Wageningen, The Netherlands.
44. Walsh, K.D., Sanderson, D., Hall, M., Mugo, S. and Hills, M.J. (2014). Allelopathic effects of camelina (*Camelina sativa*) and canola (*Brassica napus*) on wild oat, flax and radish. *Allelopathy Journal* **33**: 83-96.
45. Zhang, Y., Gu, M., Shi, K., Zhou, Y.H. and Yu, J.Q. (2010). Effects of aqueous root extracts and hydrophobic root exudates of cucumber (*Cucumis sativus* L.) on nuclei DNA content and expression of cell cycle-related genes in cucumber radicles. *Plants and Soil* **327**: 455-463.