The Pharma Innovation Journal 2022; 11(12): 3737-3742

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 3737-3742

www.thepharmajournal.com
Received: 09-10-2022
Accepted: 12-11-2022

Allelopathic influence of *Melia composita* Willd. on the performance of vegetable crops

Uday Bhanu Pratap, KS Pant, Deepshikha Nirala and Prabhat Tiwari

Uday Bhanu Pratap
Guest Faculty, Department of Silviculture and Agroforestry, Collage of Horticulture & Forestry, Neri, Hamirpur, Himachal Pradesh, India

KS Pant
Professor, Department of Silviculture and Agroforestry, Dr Y S Parmar University of Horticulture and Forestry, Himachal Pradesh, India

Deepshikha Nirala
Consultant (Forestry), Forest Research Institute Deemed to be University, Dehradun, Uttarakhand, India

Prabhat Tiwari
Assistant Professor Department of Silvicultureand Agroforestry, College of Horticulture and Forestry, Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh, India

Corresponding Author:
Uday Bhanu Pratap
Guest Faculty, Department of Silviculture and Agroforestry, Collage of Horticulture & Forestry, Neri, Hamirpur, Himachal Pradesh, India

Abstract
Present investigations were undertaken to assess the phytotoxic effects of aqueous leaf extract and leaf litter of *Melia composita* willd. on germination, growth, biomass and yield of *Raphanus sativus* and *Abelmoschus esculentus* in laboratory as well as in pot culture. The extract and leaf litter of *M. composita* suppress the germination, early growth and biomass of both the test crops. Suppression in germination and early growth increased sharply with the increasing concentration of aqueous extract or leaf litter quantity of *M. composita*. Nonetheless, pot test, revealed that there was no significant negative effect of leaf litter on later growth, biomass and yield of both test crops. This demonstrates that the secondary plant metabolites known as allelochemicals present in *M. composita* are ephemeral in nature and their impact is temporary which got alleviated over time. Consequently, *M. composita* is recommended for growing in different agroforestry systems.

Keywords: Allelopathy, radish, okra, germination, laboratory bioassay, *Melia composita*, pot culture, yield

1. Introduction

Agroforestry is broadly rehearsed in Himalayan region particularly, the Indian Himalayas represent 18 percent of the India's land area. Indian Himalayas occupy a special place in the mountain ecosystems of the world. This region is not only important from the point of view of climate and as a provider of life, giving water to a large part of the Indian subcontinent, however it additionally harbours a rich assortment of flora, fauna, human communities and cultural diversity. Agroforestry has numerous beneficial effects on farming system and also supporting rural livelihood. These points of interest have been menaced because of some negative variables *viz.*, Shade effect of trees on field crops and competition for resources are harmful to understory crops. These negative factors have distress the farmers from practicing agroforestry; however, these negative factors can be bring down by selecting suitable tree species along with agricultural crops.

Melia composita Willd. (Syn.*Melia dubia* Cav.) commonly known as Malabar neem, is an indigenous, fast growing, multipurpose, short rotation and valuable timber species rose as one of the most suitable tree species for agroforestry. It is being planted in agroforestry systems either in block plantation or along the farm boundaries. It occurs chiefly in tropical moist deciduous forests of the Sikkim, Himalaya, north Bengal, upper Assam, Khasi hills, north circle, Deccan and Western Ghats at an altitude of 1200 to 1800 meters. It is indigenous to Western Ghats of Southern India and is common in moist deciduous forests of Kerala (Saravanan *et al*. 2013) [20]. It is esteemed for its high-quality fungus and termite resistant, timber for furniture, agricultural implements (Suprapti *et al*., 2004) [27], as substitute pulp wood species, fuel wood and leaves are used as a fodder (Parthiban *et al*., 2009) [14]. The flowers are said to provide incredible bee forage. The industrial and ecological significance of *M. composita* has urged the farmers to take large scale plantations with different intercrops (Parthiban *et al*., 2009; Nuthan *et al*., 2009) [14, 12]. In mid- Himalayan range is being favoured by the farmers to meet for fuel, charcoal, device handles and making agricultural implements.

Keeping in view the importance and increasing popularity of this species, present investigation was carried out to evaluate the allelopathic influence of *M. composita* on performance of vegetable crops.

Materials and Methods

The present experiments were accomplished in the laboratory and experimental farm of College of Forestry, Department of Silviculture and Agroforestry, Dr. Y S Parmar University of Horticulture and Forestry, Nauni (H.P) during Rabi and Kharif season, 2020. The experimental site is located in the mid-hill zone of Himachal Pradesh at 30° 51' N Latitude and 76° 11' E Longitude, with an elevation of 1200 m above mean sea level having a slope of 7-8 percent.

The experiment was comprised of three components *viz*., (a) a tree species (*M. composita)* (b) extract and mulch type (leaves & leaf litter, respectively), (c) two varieties of vegetable crops (i) *R. sativus cv*. Japanese white), (ii) *A. esculentus cv*. P-8.

Collection of plant material and preparation of aqueous extract

Mature leaves showing signs of senescence were collected from 12 years old plantation of *M. composita* from the experimental farm of College of Forestry, UHF Nauni (Solan). The collected leaves were sun dried for about a week and made into a fine powder by using an electrical grinder. The aqueous extract was prepared by soaking 200 g of grounded leaves in 1 litre distilled water (Pratap *et al*., 2020) [7]. The resulting brownish and dark extract was filtered through Muslin cloth and filtrates were considered as 100% concentration. Further dilutions of 10%, 25%, 50%, and 75% were prepared with distilled water. The extract concentrations used were 10%, 25%, 50%, 75% and 100%, respectively.

Laboratory bioassays

The seeds of *R. sativus* and *A. esculentus* were collected from the Department of Seed Science and Technology, Dr. Y S Parmar UHF Nauni, Solan. The laboratory experiment was comprised of 6 different treatments *viz*., 10, 25, 50, 75, 100% and distilled water as control and named treatment T_1 to T_6. Each treatment was replicated thrice. The experiment was conducted in completely randomized design (CRD). 25 seeds of each test crop were placed on filter paper in sterilized Petri plate. In each Petri plate, 5 ml of aqueous extract was applied on first day and later, 2 ml/ Petri plate on alternate days to keep the filter paper moist till the completion of experiment. A separate series of control (T_6) was run using distilled water. Seeds were considered germinated upon radicle emergence. Day by day germination check was made up to 14 and 21 days for *R. sativus* and *A. esculentus*, respectively. Germination percent [(Number of normal seeds germinated/number of seeds sown) × 100)] was calculated following ISTA, (2014). Further, radicle and plumule length was measured by randomly selecting five seedlings per replication.

Pot experiment

The pot experiment was carried out to evaluate the effect of leaf litter of *M. composita* on germination, early growth and biomass of *R. sativus* and *A. esculentus*. Fifty seeds per replication of each test crop were sown in plastic pots of 36 cm diameter and 30 cm height containing approximately 15.00 kg soil. Leaf litter (treatments) of 15 g (T_2), 30 g (T_3), 45 g (T_4) and 60 g (T_5) were mixed separately in the top layer of the soil in the pots (Thakur, 2014) [29]. Further, pots were filled with soil without leaf litter was used as a control treatment (T_1). The replications and statistical design followed here were similar to those for lab bioassay. Litter treatments were given by considering average annual leaf litterfall under *Melia composita* based agroforestry system (Perez-Corona *et al*., 2013) [16]. Annual average leaf litterfall was recorded by placing 1 m^2 trap under *M. composita* based agrisilvicuture system at the experimental farm of the Department of Silviculture and Agroforestry UHF Nauni, Solan. The mean litterfall of *M. composita* was 250 g m^2, which comes approximately 16.65 g per pot with a top area of 0.0666 m^2. Therefore, the litter treatments were fallen within the range of average litterfall. Before seed sowing, pots were irrigated with two litre of water per pot. Later on, pots were irrigated with one litre of water 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 *R. sativus* and 21 days for *A. esculentus*. The growth and biomass of test crops were recorded on the day when the last germination count was made. Germination and early growth were calculated as per standard procedure as given in the laboratory bioassays experiment whereas, root and shoot portions were dried separately in a hot air oven at 60 °C for minimum 48 h or till the constant weight to estimate dry biomass.

Pot experiment up to crop maturity

A separate experiment was established to examine the effect of leaf litter on growth, biomass and yield of vegetable crops, up to the crop maturity following the procedure as adopted in pot experiment for germination and early growth mentioned above. Each leaf litter treatment was replicated three times. In each pot, 5 seeds were sown and single seedling was retained after 2 weeks of sowing for further observations. At maturity (60 and 90 days after sowing for *R. sativus* and *A. esculentus*, respectively), plant height, yield and dry biomass of plants were recorded. *R. sativus* root and *A. esculentus* fruits were harvested from the plants when they attained marketable size.

Statistical Analysis

The average data of all the parameters obtained from above experiments were statistically analyzed in Completely Randomized Design (CRD) by using R-4.0.0 statistical computing software. One way ANOVA was applied at the $p<0.01$ level.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

Laboratory and pot culture bioassays

Allelopathic effect of *Melia composita* on germination of *Abelmoschus esculentus* and *Raphanus sativus*

Laboratory and pot culture bioassays revealed that aqueous leaf extract and leaf litter of *M. composita* significantly hindered the germination of *R. sativus* and *A. esculentus* as compared to control (distilled water or no litter).

In laboratory bioassay, the higher (96.67%) seed germination of *R. sativus* was recorded in control (T_6), whereas minimum (52%) was recorded in treatment T_5. On the other hand, in pot experiment, the leaf litter of *M. composita* also affected seed germination of *R. sativus* and was recorded maximum (91.67%) in control (T_1) while minimum (68.33%) was recorded in treatment T_5. Similarly, seed germination of *A. esculentus* was affected by leaf extract and leaf litter of *M. composita* where the higher seed germination was found in control (T_6) though minimum was observed in treatment T_5. On the other hand, in case of leaf litter, the maximum (86.67%) germination was recorded in control (T_1) while minimum (64%) was recorded in treatment T_5 (Table 1).

Table 1: Allelopathic effect of aqueous leaf extract of *Melia composita* on germination of *Raphanus sativus* and *Abelmoscus esculentus* in laboratory and pot bioassays

Treatments	Germination percent in laboratory	
	Raphanus sativus	*Abelmoschus esculentus*
T_1 (10%)	90.67	84.00
T_2 (25%)	80.00	73.33
T_3 (50%)	72.00	69.33
T_4 (75%)	64.00	48.00
T_5 (100%)	52.00	32.00
T_6 (Control)	96.67	88.00
SEm (±)	2.08	3.36
CD (p< 0.05)	8.97	14.49
	Germination percent in pot	
T_1 (control)	91.67	86.67
T_2 (15g)	86.67	81.33
T_3 (30g)	85.00	78.67
T_4 (45g)	83.33	70.67
T_5 (60g)	68.33	64.00
SEm (±)	2.98	3.62
CD (*p*<0.01)	13.36	16.25

Allelopathic effect of *Melia composita* on early growth and biomass production of *Abelmoschus esculentus* and *Raphanus sativus*

Aqueous leaf extract in laboratory and leaf litter in pot experiment, displayed significant inhibitory impact on growth parameters *viz.*, root and shoot length /radicle and plumule length and biomass of sprouted seedlings of *R. sativus* and *A. esculentus*.

Under the laboratory bioassay, in case of *R. sativus*, the maximum (8.17 cm) radicle and plumule (9.80 cm) length was found under 0% concentration (T_6) followed by T_1, while minimum (5.06 cm) radicle and plumule (5.60 cm) length was recorded under 100 percent leaf extract (T_5). Similarly, in case of *A. esculentus*, the maximum (6.81, 13.30 cm) radicle and plumule length was recorded in control (T_6), whereas minimum (2.82, 5.35 cm) radicle and plumule length respectively, was recorded in treatment T_5 (Table 2).

Table 2: Allelopathic effect of aqueous leaf extract of *Melia composita* on early growth performance of *Raphanus sativus* and *Abelmoschus esculentus* in laboratory bioassay

Treatments	*Raphanus sativus*		*Abelmoschus esculentus*	
	Radicle length (cm)	Plumule length (cm)	Radicle length (cm)	Plumule length (cm)
T_1 (10%)	7.90	9.50	6.71	13.15
T_2 (25%)	7.17	9.54	5.73	11.40
T_3 (50%)	6.63	7.49	5.71	9.43
T_4 (75%)	6.29	6.05	3.61	6.15
T_5 (100)	5.06	5.60	2.82	5.35
T_6 (Control)	8.17	9.80	6.81	13.30
SEm (±)	0.37	0.36	0.38	0.32
CD (*p*<0.01)	1.63	1.59	1.64	1.40

On the other hand, in pot culture, the highest (4.91 cm and 9.35 cm, respectively) root and shoot length of *R. sativus* was recorded in treatment T_1 (control) whereas, minimum (2.84 cm and 5.03 cm) root and shoot length respectively, was recorded in T_5. Similarly, the maximum (5.53 cm and 19.13 cm) root and shoot length of *A. esculentus* was recorded in treatment T_1 (control) whereas, minimum (3.43 cm and 12.43 cm) root and shoot length, respectively was recorded in T_5 (Table 3).

Table 3: Allelopathic effect of aqueous leaf extract of *Melia composita* on early growth performance of *Raphanus sativus* and *Abelmoschus esculentus* in pot culture

Treatments	*Raphanus sativus*		*Abelmoschus esculentus*	
	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)
T_1 (control)	4.91	9.35	5.53	19.13
T_2 (15g)	4.09	6.68	5.05	18.60
T_3 (30g)	3.81	6.81	4.79	17.40
T_4 (45g)	3.22	6.40	4.15	14.70
T_5 (60g)	2.84	5.03	3.43	12.43
SEm (±)	0.30	0.59	0.38	0.39
CD (*p*<0.01)	1.43	2.65	1.64	1.78

Analysis revealed that the early growth parameters had a gradual inhibitory effect as the extract concentration or litter quantity increased. The extent of suppression in early growth parameters of *R. sativus* and *A. esculentus* against aqueous extract and leaf litter sharply increased with increase in extract concentration or litter amount with a maximum at 100 percent extract concentration or maximum litter application *i.e.* 60 g/pot. Results of the present study are corroborated with the findings of Singh *et al.* (2016) [24] and Pratap *et al.* (2020) [17], as leaf and bark extracts of *Quercus leucotrichophora* revealed a concentration-dependent inhibitory effect on germination and seedling growth of field crops. They further reported that leaf extract was found more toxic than other plant parts.

The contents of data presented in Table 4 revealed that the effect of leaf litter of *M. composita* had a significant inhibitory effect on the seedling dry weight of both test crops. The minimum (0.23 g and 0.53 g) value of dry weight was recorded in T_5 for *R. sativus* and *A. esculentus*, respectively while maximum (0.83 g and 0.47 g) values of dry weight was recorded in control (T_1)

Table 4: Allelopathic effect of aqueous leaf extract of *Melia composita* on seedling dry matter production of *Raphanus sativus* and *Abelmoschus esculentus* in pot culture

Treatments	Seedling dry weight (g)	
	Raphanus sativus	*Abelmoschus esculentus*
T_1 (Control)	0.47	0.83
T_2 (15g)	0.44	0.73
T_3 (30g)	0.37	0.70
T_4 (45g)	0.25	0.57
T_5 (60g)	0.23	0.53
SEm (±)	0.034	0.039
CD (*p*<0.01)	0.154	0.176

The degree of inhibition of different plant parameters sharply increased as the concentration increased. Several earlier studies have revealed that the degree of inhibition increases with increasing extract concentrations (Laosinwattana *et al.*, 2009; Teerarak *et al.*, 2010; Singh *et al.*, 2010; Singh *et al.*, 2016 and Pratap *et al.*, 2020) [23-24, 17]. In a field plot with a Rye cultivar exuding hydroxamic acid, the total biomass of the mixed population of the following species was reduced: *Veronica persica*, *Chenopodium album*, *Lamium amplexicaule*, *Polygonum aviculare* and *Bilderdykia convulvulus* (Perez and Nunez, 1993) [15]. Numerous species, *i.e.*, *Rhododendron albiflorum*, *Quercus leucotrichophora*, *Cedrus deodara*, *Quercus falcata*, *Quercus alba*, *Quercus* *floribunda*, *Quercus serrata* and *Myrica esculenta* have been reported to have allelopathic effects (Rice, 1974, Melkania, 1983 and Pratap *et al*., 2020) [18, 10, 17].

Lab bioassay and pot experiments revealed that the inhibitory effect was more prominent on root growth in lab bioassay as well as in pot experiments. Similar plant part-specific effects of *Melia azedarach* leaf extracts have been addressed earlier by Akacha *et al*. (2013) [1]. Findings of present investigation concerning germination and growth of both vegetable crops are in line with the earlier findings of Singh *et al.* (2008, 2009) [25-26]. In contrast, Shapla *et al.* (2011) [22] pointed out that the mulch application of *Melia azedarach* suppresses the growth and biomass of test crops at an early stage.

In our study, leaf extracts and leaf litter of *M. composita* were found toxic with respect to germination, growth as well as seedling dry weight of test crops. Earlier results were reported by Kaletha *et al*. (1996) [7], where they observed the aqueous extracts of leaf and bark of *Grewia oppositifolia*, *Bauhinia variegata*, *Ficus roxburghii* and *Kydia calycina* on *E. frumentacea*, *Zea mays*, *E. coracana*, *Vigna unguiculata*, and *Glycine max* and pointed out that the leaf and bark are most toxic to food crops. Associated results were stated by Bhatt and Chauhan (2000) [3], where phytotoxic effect of *Quercus* species on *T. aestivum*, *Brassica campastris,* and *Lens culinaris* inhibited the germination, root and shoot length of food crops. Likewise, aqueous leaf extract of *Acacia nilotica* have inhibitory phytotoxic effects on seed germination and radicle length of *T. aestivum* (Sazada *et al.*, 2009) [21]. Gas Chromatography Mass-Spectrometry (GC-MS) screening of *M. dubia* Cav. (Syn. *M. composita* Willd.) leaf litter carried out by Thakur *et al.* (2017) [8] revealed the presence of 18 different types of phytochemicals such as phenolic acids and its derivatives, alkaloids, unsaturated fatty acid, methyl ketones (volatile allelochemical), aromatic ketone, chromene etc. This pointed out that leaf litter of *M. composita* contains many phytochemicals which may be responsible for the inhibitory effects of *M. composita* on test crops.

Allelopathic effect of leaf litter of *Melia composita* on growth, biomass and yield of *Abelmoschus esculentus* and *Raphanus sativus* till crop maturity

The statistical analysis revealed that the data on growth, biomass and yield (till crop maturity) attained by *A. esculantus* and *R. sativus* (Table 5 and 6) clearly indicate that there was no significant effect of leaf litter on later growth, biomass and yield of both the test crops.

In case of *A. esculentus*, the maximum (118 cm) plant height, number of fruit (7.67) per plant, fruit yield (97 g) per plant, stem biomass (71.67 g) and root biomass (10.33 g) was recorded in control (T_1), whereas, minimum (91.15 cm) plant height, number of fruits (5.33) per plant, fruit yield (78.33 g) per plant, stem biomass (44.67 g) and root biomass (6.67 g) was recorded in T_5 (Table 5). On the other hand, in *R. sativus*, the maximum (22 cm) plant height, leaf length (19.67 cm), leaf width (8.23 cm), root length (16.33 cm), root diameter (28.67 mm), yield (130 g) per plant, root biomass (11 g) and leaves biomass (5 g) was recorded in control (T_1) while minimum plant height (15.83 cm), leaf length (14 cm), leaf width (7.47 cm), root length (11.50 cm), root diameter (18 mm), yield (98.67 g) per plant, root biomass (7.83 g) and leaves dry biomass (2.47 g) was recorded in T_5 (Table. 6).

Table 5: Allelopathic effect of leaf litter of *Melia composita* on growth, biomass (g plant^{-1}) and yield of *Abelmoschus esculentus* in pot culture

Treatments	***Abelmoschus esculentus***				
	Plant height (cm)	**Number of fruits (Plant^{-1})**	**Fruit yield (g plant^{-1})**	**Stem biomass (g plant^{-1})**	**Root biomass (g plant^{-1})**
T_1 (control)	118.00	7.67	97.00	71.67	10.33
T_2 (15g)	107.23	6.33	86.33	68.33	9.67
T_3 (30g)	100.84	6.00	84.67	59.33	9.00
T_4 (45g)	98.55	5.67	79.67	47.67	7.00
T_5 (60g)	91.15	5.33	78.33	44.67	6.67
SEm (±)	8.09	0.53	8.17	7.55	0.96
CD (p<0.01)	NS	NS	NS	NS	NS

Table 6: Allelopathic effect of leaf litter of *Melia composita* on growth, biomass (g plant^{-1}) and yield of *Raphanus sativus* in pot culture

Treatments	***Raphanus sativus***							
	Plant height (cm)	**Leaf length (cm)**	**Leaf width (cm)**	**Root length (cm)**	**Root diameter (mm)**	**Yield (g plant^{-1})**	**Root biomass (g plant^{-1})**	**Leaves biomass (g plant^{-1})**
T_1 (control)	22.00	19.67	8.23	16.33	28.67	130.00	10.33	5.00
T_2 (15g)	19.67	17.67	8.00	15.00	28.33	115.00	9.50	3.27
T_3 (30g)	19.17	17.00	7.83	14.67	23.94	106.00	8.67	3.13
T_4 (45g)	17.00	16.67	7.93	14.17	20.00	101.00	7.33	2.67
T_5 (60g)	15.83	14.00	7.47	11.50	18.00	98.67	6.33	2.47
SEm (±)	1.41	1.18	0.27	1.04	3.87	5.63	0.66	0.42
CD (p<0.01)	NS	NS	NS	NS	NS	NS	NS	NS

Despite the presence of allelochemicals in *M. composita* reported by Thakur *et al.* (2017) [8], the leaf litter treatments did not showed inhibitory effect on later growth of *A. esculentus* and *R. sativus*. The outcomes of present experiment are in line with the findings of Thakur *et al.* (2017) [8] who reported that the leaf litter treatment of *M. composita* does not exhibit inhibitory or stimulatory impact on later phase of development of green gram and black chickpea. Similar results were also observed Parmar *et al.* (2018) [13]. The finding of present examination are additionally in accordance with Kumar *et al.* (2017) [8] who detailed no inhibitory or stimulatory effect of *M. azedarach* leaf litter on vegetable and pulse crops in pot culture experiments carried out upto plant maturity. In opposition to present findings, Shapla *et al.* (2011) [22] revealed that *M. azedarach*, mulch application @ 20 gm/pot hindered the root and shoot length as well as biomass of Mung bean and soybean. Comparative unfavourable impact of leaf litter of fruit and timber tree species on other pulse and cereal crops have additionally been reported (Sale & Oyun 2013; Thakur, 2014) [29]. Studies on pot culture carried out by Divya *et al.* (2004) [4] and Hossain *et al.* (2002) [5] are likewise in opposition to the present findings. These examinations have featured inhibitory impact of leaf litter application only up to a month or so. However, in present examination, results on growth, biomass and yield are accounted till maturity. This might be credited to quicker mulch disintegration, leaching out of allelo-chemicals due to frequent irrigation done to maintain the moisture in the pots, transitory nature of allelo-chemicals, and misfortune from soil through volatilization, particularly phenolics (Ampofo 2009; Narwal *et al.* 2011) [2, 11]. Management practices like, continuous watering may have brought about quicker disintegration leaf mulch of *M. composita*, consequently did not displayed any significant inhibitory effect on later growth, yield and dry matter production of vegetable crops in present investigation. The leaf litter mulch utilized in the current investigation was squashed and diminished in size before application, which may have brought about quick decay therefore, alleviating the allelochemicals. These findings might be ascribed to a non-significant effect in present study of litter treatments of *M. composita* on growth and yield of *A. esculantus* and *R. sativus* at later stage of development.

Conclusions

The laboratory bioassay and pot culture studies revealed that leaf litter compounds of *M. composita* had inhibitory potential on seed germination, early growth and biomass of *A. esculentus* and *R. sativus*. However, pot culture studies, carried out till maturity on both the test crops revealed that the leaf litter treatments did not show a significant negative effect on growth, biomass and yield of test crops. It can be concluded from the present investigation that the *M. composita* satisfy the criteria of good agroforestry ideotypes for example, tree species ought not to have any allelopathic impact on field crops. In this way, vegetable crops particularly *R. sativus* is suggested for intercropping under *M. composita*.

References

1. Akacha M, Boughanmi NG, Haouala R. Effects of *Melia azedarach* leaves extracts on radish growth and oxidative status. International Journal of Botany and Research. 2013;3:29-42.
2. Ampofo KG. Effect 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, 2009, p 72.
3. Bhatt BP, Chauhan DS. Allelopathic effects of *Quercus* spp. on crops of Garhwal Himalaya. Allelopathy Journal. 2000;7:265- 272.
4. Divya MP, Ayyaswamy M, Bhavanisankar K. Allelopathic influence of *Acacia holosericea* on annual crops. Indian Journal of Agroforestry. 2004;6:47-51.
5. Hossain MKM, Dhali AH, Hossain MS. Effects of forest soil and leaf litter on germination and initial growth of *Leucaena leucocephala.* Allelopathy Journal. 2002;10:13-20.
6. International Seed Testing Association (ISTA). Seed vigour testing. International Rules for Seed Testing, Zurich. 2014.
7. Kaletha MS, Bhatt BP, Todaria NP. Tree crop interaction in traditional agroforestry systems of Garhwal Himalaya. 1. Phytotoxic effect of farm trees on food crops. Allelopathy Journal. 1996;3(2):247-250.
8. Kumar D, Thakur NS, Gunaga RP. 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. 2017;6(10):2669-2683.
9. Laosinwattana C, Poonpaiboonpipat T, Teerarak M, Phuwiwat W, Mongkolaussavaratana T, Charoenying P. Allelopathic potential of Chinese rice flower (*Aglaia odorata* Lour.) as organic herbicide. Allelopathy Journal. 2009;24:45-54.
10. Melkania NP. Influence of certain selected tree species on ground flora. Ph.D. Thesis, Kumaun University, Nainital. 1983, p. 442.
11. Narwal SS, Pavlovic P, John J. Forestry and Agroforestry- Research Methods in Plant Science, Studium Press Houstan Taxas USA, 2011;2:249.
12. Nuthan D, Reddy KMC, Kumar SP, Vajranabhaiah SN, Yogeesha TD. Cultivation of *Melia dubia* on 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. 2009.
13. Parmar AG, Thakur NS, Gunaga RP. 2018. *Melia dubia* Cav. leaf litter allelochemicals have ephemeral allelopathic proclivity. Agroforest System. 10.1007/s10457-018-0243-5.
14. Parthiban KT, Bharathi AK, Seenivasan R, Kamala K, Rao MG. Integrating *Melia dubia* in agroforestry farms as an alternate pulpwood species. APA News. 2009;34:3–4.
15. Perez, Nunez. Weed growth interference from temperate cereals: The effect of a hydroxamic-acid exuding rye cultivar. Weed Research. 1993;33:115-119.
16. Perez-Corona ME, de las Heras P, Vazquez de Aldana BR. Allelopathic potential of invasive *Ulmus pumila* on understory plant species. Allelopath Journal. 2013;32:101-112.
17. Pratap UB, Kukreti A, Singh B, Khanduri VP. Allelopathic influence of *quercus* species on performance of traditional food crops of the western Himalayan region. Indian Forester. 2020;146:688-696.
18. Rice EL. Some role of allelopathic compounds in plant communities. Biochemical Systematics and Ecology, 1974;5:201-206.
19. Sale FA, Oyun MB. Inhibitory effect of leaf extract and leaf mulch from selected tree species on physiology of millet under nursery condition. Journal of Biology, Agriculture and Healthcare. 2013;3:80-85.
20. Saravanan V, Parthiban KT, Kumar P, Marimuthu P. Wood characterization studies on *Melia dubia* Cav. For pulp and paper industry at different age gradation. Research Journal of Recent Sciences. 2013;2:183-188.
21. Sazada S, Khan SS, Meghvanshi MK, Bhardwaj S.

Allelopathy effect of aqueous extract of *Acacia nilotica* on seed germination and radicle length of *Triticum aestivum* var. Lok-1. Indian Journal of Applied and Pure Biosciences. 2009;24(1):271-220.
22. Shapla TL, Parvin R, Amin MHA, Rayhan SM. Allelopathic effects of multipurpose tree species *Melia azedarach* with emphasis on agricultural crops. Journal of innovation and development strategy. 2011;5:70–77.
23. Singh B, Bhat S, Uniyal P. Allelopathic effect of *Phyllanthus emblica* on germination and growth of field Crop. Range Management and Agroforestry. 2010;31(1):27-30.
24. Singh B, Pratap UB, Gusain YS, Dhanai CS. *In vitro* bioassay to study phytotoxicity effects of *Quercus leucotrichophora* on some small millets varieties. Asian Journal of Biological Sciences. 2016;11:136-140.
25. Singh B, Singh V, Kumar M. Effect of *Tinospora cordifolia* aqueous extract on traditional food crops of Garhwal Himalaya. International Journal of Agricultural Sustainability. 2009;1(2):36-40.
26. Singh B, Uniyal AK, Todaria NP. Allelopathic effect of three *Ficus* species on field Crop. Range Management and Agroforestry. 2008;29(2):104-108.
27. Suprapti S, Djarwanto H. The resistance of five wood species against several wood destroying fungi. International Journal of Production Research. 2004;22:239–246.
28. Teerarak M, Laosinwattana C, Charoenying P. Evaluation of allelopathic, decomposition and cytogenetic activities of *Jasminum officinale* L.f. var. *grandiflorum* (L.) Kob on bioassay plants. Bioresource Technology. 2010;101:5677-5684.
29. Thakur MK. Studies on allelopathic effects of some agroforestry tree species on soybean. International Journal of Farm Sciences. 2014;4:107-113.
30. Thakur NS, Parmar AG, Gunaga RP, Patel DP. Allelopathic influence of leaf and leaf litter of white cedar (*Melia azedarach* L.) on eggplant and okra. Allelopath Journal. 2017;42(2):295-305.