Short communication

Allelopathic effect of leaf loppings of homestead trees on turmeric (*Curcuma longa* Linn.)

P.G. Sruthi Lakshmi[1]* and Jacob John[2]

[1]*College of Agriculture, Padannakkad Kerala Agricultural University, Kasaragod 671328, Kerala, India*
[2]*Cropping Systems Research Centre, Karamana, Kerala Agricultural University, Trivandrum 695 002, Kerala, India*

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Abstract

A pot culture study was undertaken to assess the allelopathic compatibility of leaves of certain homestead trees, viz. coconut (*Cocos nucifera* L.), cashew (*Anacardium occidentale* L.), jack (*Artocarpus heterophyllus* Lamk.), mango (*Mangifera indica* L.), tamarind (*Tamarindus indica* L.) and teak (*Tectona grandis* L.f.), commonly planted in the home gardens of Kerala, when applied as mulch in turmeric (*cv.* Sobha). At 6 months after planting (MAP), the number of leaves was significantly less in plants mulched with leaves of coconut, mango and teak. Rhizome yield was significantly higher when mulched with cashew (660 g plant^{-1}), jack (557 g plant^{-1}) and teak (565 g plant^{-1}) leaves. However, mulching with mango leaves resulted in significantly lower yield (346.7 g plant^{-1}). These findings will be useful for farmers in selecting suitable tree leaves for mulching in turmeric and also laying out compatible tree-crop combinations in their homesteads.

Key words: Agroforestry, Allelopathy, Homestead, Leaf lopping, Trees, Turmeric

Homestead agroforestry is the most widely prevalent land use system in Kerala. However, the low productivity of crops in the homesteads is one of the major problems faced by farmers, which is often attributed to competition for resources like light, water and nutrients. The possible role of allelopathy in causing inhibition of growth and decline in yield has not been elaborately dealt by researchers. In home gardens, where a multitude of crops are grown below the canopy of trees, allelopathic interactions are implicit. Phytochemicals present in trees commonly found in home gardens of tropics have been reported to allelopathically retard the growth of associated crop species (Suresh and Rai, 1987 & 1988; Tawata and Hongo, 1987; Swaminathan et al., 1989; Jacob et al., 2007). The possible interactions between tree species and crop plants grown in agroforestry systems have received little attention (Nandal et al., 1994). Coconut (*Cocos nucifera* L.), cashew (*Anacardium occidentale* L.), jack (*Artocarpus heterophyllus* Lamk.), mango (*Mangifera indica* L.), tamarind (*Tamarindus indica* L.) and teak (*Tectona grandis* L.f.) are certain multipurpose trees commonly planted in the home gardens of Kerala.

Turmeric (*Curcuma longa* Linn.) is an important tropical spice crop that is grown on different types of soils under irrigated and rainfed conditions in about 2430 ha in Kerala with a total production of 6523 tonnes (GOK, 2015). Turmeric is a shade tolerant crop suited for intercropping beneath the canopy of trees in the homesteads where low to medium shade is available. Mulching turmeric immediately after planting with green leaves and subsequently after 50 days is recommended (KAU, 2011). Although allelochemicals are released from all plant parts, leaves are the most potential sources

*Author for correspondences: Phone: 09400648706; E-mail: sruthilakshmiagri@gmail.com

(Horsley, 1977). The suitability of the leaves of different trees for mulching and its effect on establishment, growth and yield of turmeric vis-à-vis alleloapthy has not been investigated much. Hence, this study was undertaken to assess the allelopathic influence of fresh tree leaf loppings of common trees in the home gardens of Kerala on growth and yield of turmeric.

An open field pot culture experiment was carried out at the College of Agriculture, Kerala Agricultural University (KAU), Padannakkad, Kerala, during April 2014 to January 2015. The mean maximum and minimum temperatures during the entire crop growth period were 29.2^0 C to 34.5^0C and 19.3^0C to 24.6^0C respectively. The mean maximum and minimum relative humidity were 82.5% to 93.6% and 57.9% to 84.6% respectively, during the cropping period. The total rainfall received during the crop cycle was 3481.7 mm.

Leaves were collected directly from fully mature trees and were selected from different parts of the tree (lower, middle and top portions) to get a representative sample of the entire tree canopy. Leaves that were dry, or in senescent stage and ready to shed were avoided. The pot culture was conducted using UV stabilized grow bags of 25 cm height and 30 cm diameter capable of holding upto 15 kg of growing media. The experiment comprising of 7 treatments (leaves of 6 trees + control), replicated thrice, was laid out in completely randomized design. The grow bags were filled with potting mixture containing sand, soil and cow dung in the ratio 1:1:1 exposed to sunlight for one week to eliminate any allelochemicals as suggested by Jacob et al. (2006). In each bag, healthy turmeric rhizomes of near-uniform size (cv. Sobha) were planted. Fresh leaf loppings of all 6 test trees were applied as mulch @ 15 Mg ha^{-1} immediately after planting and again after 50 days as recommended (KAU, 2011). The quantity of tree leaf loppings applied in a single grow bag was 112.5 g. Mulching with coconut leaflets was done by bending and coiling the leaflets so as to completely cover the soil surface and fit within the grow bag. Manures (40 Mg ha^{-1}) and fertilizers ($N:P_2O_5:K_2O$ @ 30:30:60 kg ha^{-1}) were applied for 15 kg growing media in each grow bag as recommended for Kerala (KAU, 2011). In control pot, old newspaper, an inert material, was used as mulch.

The average nutrient content (NPK) of tree leaves used for mulching was *viz*. coconut (1.12:0.095:1.88 % NPK), cashew (1.12:0.113:2.46% NPK), jack (1.12:0.092:2.80 % NPK), mango (1.68:0.113:1.20 % NPK), tamarind (1.12:0.103:1.38% NPK) and teak (1.12:0.167:2.28 % NPK).

The height of the plants, number of tillers and number of leaves were measured at bimonthly intervals from 2 MAP (months after planting). SPAD value was recorded using chlorophyll meter (Konica Minolta Model SPAD 502), which represents the greenness of the leaf and thereby is an indication of the chlorophyll content in the leaf. Canopy temperature and stomatal conductance were measured using steady state porometer (Spectro Analytical). The horizontal spread and diameter of rhizome, root length, root spread, and root weight per plant and root volume per plant were measured at the time of harvest (9MAP). The yield of fresh rhizome and above ground portion was recorded at that time. Subsequently, the dry turmeric recovery (%) was estimated. The data were subjected to analysis of variance for completely randomized design using Statistical Analysis Software (SAS) (Hatcher, 2003).

Plants mulched with coconut leaves had significantly lower plant height at 2 MAP while all other treatments were at par with control (Table 1). Plant height was significantly higher when mulched with cashew and tamarind leaves, whereas it was lower with jack leaves at 4 MAP. At 6 MAP, plants mulched with teak leaves were considerably taller when compared to the control. The different tree leaves did not significantly influence tiller production. However, the least number of tillers was recorded when mulched with tamarind leaves.

Table 1. Effect of tree leaf loppings on plant height, number of tillers and number of leaves of turmeric

Treatment	Plant height (cm)			Number of tillers			Number of leaves		
	2MAP*	4MAP	6MAP	2MAP	4 MAP	6 MAP	2MAP	4 MAP	6 MAP
T_1 Coconut	29.7	93.7	126.0	0	0.6	2.5	3.8	8.6	13.6
T_2 Cashew	44.4	121.8	133.0	0	0.3	2.1	5.3	8.5	15.6
T_3 Jack	48.3	86.3	141.6	0	0.6	2.3	5.5	8.5	17.0
T_4 Mango	40.3	99.6	133.6	0	0.6	2.0	5.8	8.3	13.5
T_5 Tamarind	39.1	112.7	138.8	0	0.0	1.8	5.3	8.6	15.6
T_6 Teak	51.2	86.6	148.3	0	0.0	3.1	6.0	9.3	13.6
T_7 Control	45.8	97.1	133.8	0	1.3	2.0	5.5	8.3	17.6
SEm (±)	4.30	4.90	5.79	-	0.39	0.74	0.64	0.70	0.99
CD (0.05)	9.23	10.51	12.43	-	NS	NS	NS	NS	2.13

* MAP- Months after planting

Table 2. Effect of tree leaf loppings on rhizome characters and yield

Treatment	Rhizome spread (cm)	Rhizome Thickness (cm)	Rhizome yield per plant (g)	Top yield per plant (g)	Dry turmeric (recovery %)
T_1 Coconut	24.4	4.0	469.4	59.5	14.6
T_2 Cashew	25.6	4.0	660.2	68.8	14.1
T_3 Jack	24.4	3.9	557.7	60.0	14.8
T_4 Mango	23.5	4.0	346.7	60.5	14.5
T_5 Tamarind	24.5	3.9	449.0	65.0	15.7
T_6 Teak	26.0	4.2	565.0	62.3	14.6
T_7 Control	23.7	3.8	463.7	61.8	15.0
SEm (±)	1.57	0.15	16.20	4.03	1.02
CD (0.05)	NS	NS	34.75	NS	NS

Leaf production was not significantly affected at 2 and 4 MAP. At 6 MAP, the number of leaves was less in plants mulched with leaves of coconut, mango and teak (Table 1). There was no significant difference in rhizome spread between the treatments (Table 2). Rhizome thickness was not influenced by the tree leaves.

The root length was considerably less in plants mulched with leaves of coconut, jack, mango and tamarind (Table 3). The plants mulched with tamarind leaves had significantly greater root spread whereas, jack leaves resulted in lesser root spread. Root weight was significantly more when mulched with coconut leaves while it was less under mango and teak. Mulching with coconut leaves resulted in significantly higher root volume.

There was no significant difference in SPAD values between the treatments thereby implying that

Table 3. Effect of tree leaf loppings on root characteristics of turmeric

Treatment	Root length (cm)	Root spread (cm)	Root weight per plant (g)	Root volume per plant (cm^3)
T_1 Coconut	27.90	27.80	3.83	30.33
T_2 Cashew	42.96	25.40	3.30	24.66
T_3 Jack	30.16	23.30	2.96	24.83
T_4 Mango	35.80	24.53	2.16	21.50
T_5 Tamarind	36.96	30.86	2.83	28.33
T_6 Teak	41.40	29.80	2.23	23.66
T_7 Control	40.10	27.66	3.03	24.33
SEm (±)	1.33	1.46	0.25	1.92
CD (0.05)	2.86	3.14	0.55	4.13

chlorophyll development was not influenced (Table 4). Highest canopy temperature was recorded in plants mulched with coconut, cashew and jack leaves. Significantly lower stomatal conductance was recorded with coconut, cashew and jack leaf mulching.

Though top yield and dry turmeric yield was not influenced, rhizome yield was significantly higher when mulched with cashew (660 g $plant^{-1}$), jack (557 g $plant^{-1}$) and teak (565 g $plant^{-1}$) leaves. However, mulching with mango leaves resulted in significantly lesser yield (346.7 g $plant^{-1}$) (Table 2).

Nitrogen content was slightly higher in mango leaf, phosphorus in teak and potassium in jack. However, the differences in nutrient content were only marginal and not significant to cause any difference in yield. Moreover, the quantum of leaves applied as mulch per grow bag was also very less (112.5 g $plant^{-1}$).

The leaves of cashew, jack and teak are relatively larger and also thicker and hence, are likely to reduce soil temperature and conserve soil moisture better than the other tree leaves. The higher yield obtained by mulching with cashew, jack and teak leaves may be due to the favourable influence on soil moisture and soil temperature. Babu et al. (2015) recorded that mulching in turmeric with green leaves is critical to improve germination of seed rhizomes. It also adds organic content to the soil and conserves moisture during the later part of the crop growth period.

Mulching with mango leaves resulted in reduced yield of turmeric. This can be partly attributed to the remarkably lesser leaf production, root length and root weight in turmeric when mulched with mango leaves. Though not significant, root volume was also less. This is supported by the findings of Sahoo et al. (2010) who reported that, water soluble leachate from the mature fresh leaves of mango has allelopathic potential to reduce the germination as well to suppress the growth and development of crops. They recorded that the root lengths were more sensitive to allelochemicals than the shoot length thereby ultimately affecting the yield. Mango leaves are reported to contain 43-46.7 % euxanthin acid ($C_{19}H_{16}O_{10}$) and also some euxanthon ($C_{13}H_8O_4$), hippuric acid and benzoic acids and 4% mangin (Bhatt and Todaria, 1990). A HPLC analysis showed that phytochemicals like caffeic acid, ferulic acid, coumaric acid, benzoic acid, vanillic, chlorogenic, gallic, hydroxybenzoic and cinnamic acid were present in mango leaf extract (El-Rokiek

Table 4. Effect of tree leaf loppings on physiological parameters of turmeric

Treatment	SPAD reading	Canopy temperature (^{0}C)	Stomatalconductance (milli mol m^{-2} s^{-1})
T_1 Coconut	42.06	30.66	43.13
T_2 Cashew	42.46	30.53	31.86
T_3 Jack	41.93	30.76	36.56
T_4 Mango	41.76	30.30	72.93
T_5 Tamarind	45.83	30.13	114.90
T_6 Teak	43.73	30.13	49.96
T_7 Control	47.96	29.73	144.20
SEm (±)	2.928	0.278	10.875
CD (0.05)	NS	0.596	23.328

et al., 2010). These might have been released into the soil during the process of leaf decomposition and might have had a role in the observed effect of mango leaves on turmeric.

The fresh turmeric rhizome yield of upto 660 g was obtained from a single grow bag when mulched with leaves of cashew. At the current market price of Rs.100/- per kg of fresh turmeric rhizome, this generates a return of Rs.66/- per grow bag. The cost of a grow bag was only Rs.15/- and cost of potting mixture and fertilizer was Rs.15/-, thus totaling to Rs.30/-. The grow bag and potting mixture (after enriching) can be used for at least three years. Similarly, high returns can be realized when mulched with teak and jack. This highlights the immense opportunity for growing turmeric in grow bags in terrace gardens in the homesteads of Kerala and urban households, using the leaves of cashew, jack and teak for mulching.

The leaf loppings of mango inhibited growth and yield and hence, cannot be recommended for mulching in turmeric. Leaf loppings of cashew, jack and teak enhanced yield and hence, can be recommended to farmers for applying as mulch in turmeric @ 15 t ha^{-1} (112.5 g per grow bag of 25 cm height and 30 cm diameter, capable of holding 15 kg potting mixture comprising of soil: sand: cow dung in 1:1:1 ratio) immediately after planting and again after 50 days.

Detailed field studies need to be undertaken to ascertain whether the inhibitory effects noticed in the pot culture experiments are expressed in the field too. Further, studies should be undertaken to explore ways to alleviate the inhibitory effect of leaves of mango on turmeric as mango is a preferred fruit tree for Kerala. It is also essential to identify the chemical causing the inhibition. Identifying such a phytochemical and using it at higher concentration could offer an opportunity for utilizing it as a natural herbicide for turmeric cultivation.

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