Productivity of tree fodder banks in a typical homegarden of Central Kerala

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ABSTRACT : Acute scarcity of green fodder, crude protein deficit and high feeding cost are the major deterrents for profitable livestock production in homesteads. Cultivation of protein rich tree fodder banks is a promising option for overcoming feed deficit, but warrants further research to assess their productivity in homesteads with light and space constraints. The present study aimed to assess the forage yield and nutritive value of five fodder tree species *viz*., *Morus indica* (mulberry), *Sesbania grandiflora* (agathi), *Moringa oleifera* (moringa), *Gliricidia sepium* (gliricidia) and *Calliandra calothyrsus* (calliandra) under hedgerow planting (45 × 45 cm spacing) in the interspaces of homegarden, in randomized block design replicated four times. The trees were harvested at 1 m height at the interval of two months during rainy season and three months during summer. Initial growth and coppice parameters were better for gliricidia, followed by agathi and calliandra. The annual green and dry forage yields were better for gliricidia (26.82 and 5.38 Mg ha^{-1}) and calliandra (21.08 and 6.61 Mg ha^{-1}), respectively. Gliricidia and calliandra had higher protein content and leaf-stem ratio. Agathi and mulberry showed intermediate performance with respect to yield and quality. Moringa was inferior in forage yields but rich in quality attributes like ash and mineral contents. Mulberry and calliandra showed better survival percentage. Hence, gliricidia, calliandra, and mulberry with good yield and quality are found to be ideal for hedgerow planting in the understorey of homesteads. PAR transmittance in the homestead was below 60% indicating shady nature. Pruning of overhead trees in homesteads to enhance light transmission can further elevate the yield levels of fodder banks.

Key words: Agathi, calliandra, forage quality, forage yield, gliricidia, moringa and mulberry.

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1. INTRODUCTION

Homegardens are considered as a resource system of multiple functions and an important wheel of vehicle for food and nutritional security, environmental and ecological benefits, biodiversity and soil conservation, socio-cultural benefits and job creation as well as mitigation of impact of climate change in both developing and under developed countries. Homegardens are recognized worldwide as an epitome of a sustainable agroforestry system (Kumar and Nair, 2004). Homegardens constitute the prominent land-use system in Kerala that addresses the livelihood security and nutritional demands of small and marginal farmers.

However, increasing human population, urbanization and other socio-economical changes have resulted in the breakdown of these traditional agroforestry systems of Kerala, accompanied with increasing economic, cultural, nutritional and environmental problems. Unless concerted efforts are made to improve the economic prospects of the traditional homegardens, farmers will deter from practice of homegardening and shift to other profitable land-use activities. In this context, suitable interventions through an effective blend of tree/crop/animal components of demand in an integrated farming system mode are need of the hour for successful revitalization of existing homesteads.

Livestock plays a very pertinent role in maintaining soil health and sustainability of homesteads, in addition to nutritional benefits, revival of livestock population in homesteads needs urgent attention. However, scarcity of quality fodder and high cost of purchased concentrate feeds are the major hindrance to successful livestock production in Kerala (Ajith *et al*., 2012). Earlier the fodder materials available within the homesteads and from paddy fields were sufficient to meet the feed requirements of livestock. However, the change in cropping pattern of homesteads coupled with decline of paddy fields led to acute shortage of fodder. Hence, to meet the high nutrient demand of high yielding crossbred cattle, the homestead farmers had to depend entirely on expensive commercial concentrate feeds, which drastically reduced their net returns. In this context, cultivation of quality fodder trees on farm itself is highly warranted for promoting profitable livestock production in homesteads.

Morus indica (mulberry), *Calliandra calothyrsus* (calliandra), *Sesbania grandiflora* (agathi), *Gliricidia sepium* (gliricidia) and *Moringa oleifera* (moringa) are promising fodder trees by virtue of their nutritive foliage, fast growing nature, ability to withstand heavy pruning, good coppicing ability and higher biomass production (Raj *et al.*, 2016; Sagaran, 2017). These trees have good shade tolerance and are found to be suitable components in agroforestry systems. Since the agro-climatic requirement of these trees suits well to that of Kerala, there is a good possibility of utilizing these trees as nutrient rich fodder source in our state.

Due to intensive multi-tier cropping in homesteads, the scope for large scale tree fodder cultivation is limited. Fodder tree cultivation is not popular among farmers mainly because of insufficient knowledge on suitable fodder trees and their nutritive aspects, as well as on the standard management practices. Information exists on the performance of tree species as fodder banks under open conditions and partially shaded coconut gardens. On-station trials conducted in Kerala Agricultural University revealed the productivity of 9.91 and 11.73 Mg ha^{-1} yr^{-1} of dry forage from mulberry and calliandra fodder banks, respectively in coconut garden (Raj *et al.*, 2016; Sagaran, 2017). However, there is paucity of research on their yield and nutrient outputs under homesteads with constraints in light and space availability. Hence, it is important to validate this research along with some other promising fodder tree species on farmers' homesteads in Kerala for popularizing fodder tree cultivation. With this background, a field study was envisaged to evaluate the initial growth and survival, forage yield and nutritive parameters of selected tree fodders as hedge rows under high density planting and intensive harvest management in a typical homestead of Central Kerala.

2. MATERIALS AND METHODS

The proposed study was conducted in a typical homegarden with livestock component located in Arimboor panchayat, Thrissur district, Kerala. Arimboor is a mid-land area lying within the geographical extremes of 10° 29′ 0″ N and 70° 80′ 0″ E, spanning an area of about 22.65 km^2. Arimboor enjoys typical warm humid tropical climate of Kerala with mean maximum and mean minimum temperature 36.7 and 24.8 °C, respectively. Annual rainfall of 3752 mm was received during 2017-18. The dry season is from December to May.

The selected homegarden was a multi-tier system with an area of 32 cents (0.32 acre) comprising of 7 livestock. The dominant arboreal components and their abundance in the homegarden include trees such as *Cocos nucifera* (6), *Artocarpus heterophyllus* (3), *Mangifera indica* (3), *Gliricidia indica* (4), *Trema orientalis* (1), *Bridelia retusa (1)*, *Ficus hipsida* (2) and *Ficus exasperata* (1). Other components include *Macaranga peltata*, *Costus speciosus*, *Colocasia esculenta*, *Manihot esculenta* and *Hibiscus rosa-sinensis*. The understorey was less intensive with good scope for intercropping in the unutilized area. The soil of the selected homegarden was sandy loam in nature with acidic pH (5.4), low level of organic carbon (0.65%), low available nitrogen (N; 220 kg ha^{-1}), phosphorous (P; 62 kg ha^{-1}) and high level of exchangeable potassium (K; 235 kg ha^{-1}).

The proposed intercropping trial was established in the understorey area of the selected homestead during 2017-18. Mulberry, agathi, moringa, gliricidia and moringa were the fodder tree species selected for hedgerow planting in the homesteads. Seedlings of calliandra, moringa and agathi were raised in nursery beds of standard size (12 m × 1.2 m). Healthy and uniform seedlings were transplanted to polythene bags after one month and later transplanted to selected homestead on attaining 20-30 cm height. Mulberry (variety V1) was raised from uniform stem cuttings of 6-8 months maturity, 20 cm length, having three nodes and of pencil thickness diameter, and gliricidia was raised using mature stem cuttings of 50 cm length and 3-3.5 cm diameter in polybags and transplanted to homestead at three months stage.

The available field area within the homestead was cleared during April-May and the weeds, stubbles and roots were removed. Land was prepared by ploughing twice to bring the soil to fine tilth. A crop free zone of 1-1.5 m radius was maintained around existing trees in the homestead. The layout was done allocating a plot size of 3 m × 2 m (6 m^2) for each treatment. Pits were taken at prescribed spacing of 45 cm × 45 cm within each plot. Seedlings/cuttings of mulberry, agathi, moringa, gliricidia and calliandra were transplanted to the main field with the onset of pre-monsoon laid out in randomized block design, replicated four times. Farm yard manure (FYM) @ 20 t ha^{-1} and N P_2O_5 K_2O each @ 50 kg ha^{-1} were applied uniformly for all treatments. Fertilizers were applied through N:P:K mixture (18:18:18). FYM was applied as basal and fertilizer in two split doses before South-West and North-East monsoons.

The first harvesting was done three months after planting when trees attained more than 1 m height. Subsequent harvests were taken at 2 months interval during rainy season and 3 months interval during summer season. Pruning height of 1 m from the ground was maintained for all the harvests. Altogether 5 harvests were taken in a year at the interval of two months during rainy season and three months during summer. Five trees/plot were selected at random, avoiding border plants for taking observations on yield and quality parameters. For each cut, biomass from 5 trees/plot was separated into leaf and stem and their individual fresh weights and total biomass was determined. Thereafter, yield from all harvests in a year was pooled to get annual gross yields. Using net harvested area and fresh weight, annual gross fodder yield was scaled up to a hectare basis and adjusted with survival percentage. The typical homegarden had unutilized net area of 8253 m^2 when extrapolated on hectare basis. Sub-samples (200 g) of the two components (leaf and stem) were oven dried at 70 ^{0}C for 48 hours for dry matter (DM) determination. The fresh fodder yields from each harvest were multiplied with the DM content, summed up to get annual dry fodder yield and expressed on hectare basis. The annual dry leaf yield was divided with annual dry stem yield for various treatments and expressed as leaf-stem ratio.

Proximate composition of oven dried leaf and stem fractions were analyzed following standard procedures. Total N was determined by the micro Kjeldahl procedure and crude protein (CP) was calculated from N content (CP=N×6.25) according to the official methods of AOAC (1995). Oven dried leaf and stem samples were refluxed first with acid and then alkali for 30 minutes, and the oven dried residue containing crude fibre (CF) was ignited in muffle furnace (550 °C). Loss of weight on ignition was calculated to express it as CF in percentage. Oven dried samples were ignited in muffle furnace at 550 °C to burn all the organic matter and left over was weighed as ash and expressed as percentage (AOAC, 1995).

Diurnal variation in photosynthetically active radiation (PAR) in the understorey of the homestead was measured using Line Quantum Sensor (LQI 2404, K131). A battery powered data logger integrated the mean PAR at hourly intervals from 8 am to 5 pm from each plot. PAR above canopy of homegardens was recorded from the nearby open area. PAR below the canopy was recorded from the center of each fodder tree plot. PAR was then converted to canopy transmittance, which is the light available below the canopy.

The data were subjected to statistical analysis by analysis of variance (ANOVA) using general linear model procedure in SPSS version 21.0 (SPSS Inc., USA) to ascertain the significance of various parameters. The Duncan's Multiple Range Test (DMRT) was used to test the differences among treatment means at 5% significance level.

3. RESULTS AND DISCUSSION

Initial growth and coppice parameters

All the fodder tree species established well after planting in understorey of the homestead. Initial growth up to one year was faster in agathi which was found to be significantly taller than all other tree species (Table 1). This could be due to its species character as agathi have extremely rapid growth in the first year and grows fast enough to be used as an annual green manure crop (Duke, 1983). Rapid early growth and erect habit of *S. grandiflora* usually enables to access sunlight by overtopping neighboring plants (Gutteridge and Shelton, 1994). In addition, studies on sesbania spacing and population density indicated increased height at high densities (Dutt and Pathania, 1986). The next taller species was found to be calliandra. Earlier study indicates that calliandra seedlings grow quickly up to 2.5-3.5 m in 180 days and up to 3-5 m within the first year (Sebuliba *et al.*, 2012). Mulberry, moringa and gliricidia were found to be comparatively shorter. Slow growth of mulberry in the initial year of planting was reported by Raj *et al.* (2016). Lower height of moringa may be due to shaded conditions, as moringa grows well with more sunlight. Lower plant height of gliricidia could be attributed to its branching nature instead of growing erect (Nygren and Cruz, 1998).

Coppice parameters like number, length and weight of coppices varied significantly in different fodder tree species (Table 1). In general, gliricidia and calliandra showed better coppice shoots and was at par with agathi. Mulberry showed medium coppicing whereas coppice number was significantly lower in moringa. Similar to coppice number, coppice length was also higher in agathi and moringa compared to other tree species. Coppice length was least in mulberry. Weight of coppices was significantly highest in gliricidia, followed by agathi and moringa, and least was recorded in mulberry (Table 1). In general, coppice parameters were better for gliricidia, followed by agathi and calliandra, whereas mulberry and moringa showed poor performance. Waddington (2003) reported that species such as gliricidia have good coppicing ability and produce large amount of high quality biomass. Agathi species also have excellent coppice producing capacity and coppiced stands of sesbania exhibited better sprouting, greater height increment and canopy spread at 25,000 plants/ha than at 50,000 or 75,000 plants/ha (Desai and Halepyati, 2010). Profuse coppicing of calliandra species has been reported by Sagaran (2017).

Annual green and dry fodder yield

It is pertinent from Table 2 that forage yield varied significantly among different tree species. Gliricidia yielded significantly higher total fresh fodder biomass yield, followed by calliandra and agathi. Moringa and mulberry produced significantly lower yields. Yield from leaf and stem fractions also showed similar trends. Higher yields from gliricidia could be attributed to its faster growth, profused branching and higher biomass production in short period of time. Due to its high biomass production, gliricidia is known as better fodder crop in almost all the homesteads of Kerala (KAU, 2016). Gunasekaran *et al*. (2018) reported higher edible fresh fodder biomass yield from *G. sepium* (4 harvests/year) from silvipasture model in degraded wastelands. Similarly, better establishment, faster growth and higher yield outputs from calliandra as an intercrop in coconut gardens of Kerala has been reported in the initial year of planting (Sagaran, 2017). An annual yield of 42 Mg/ha of coconut garden has been obtained from calliandra plantation spaced at 60 × 60 cm and from four harvests scheduled at three months interval. In Java, agathi produced 55 t/ha of green material in 6.5 months (Gutteridge and Shelton, 1994). However, poor yields of mulberry could be attributed to its slow growing nature in the initial year of establishment. Raj *et al.* (2016) reported comparatively lower yield in mulberry during initial year of planting than the subsequent years. Poor performance of moringa in the homegarden could be attributed to its poor shade tolerance and its low survival under competitive environment.

Calliandra yielded more dry forage, followed by gliricidia, agathi and mulberry (Table 3). Higher DM content in calliandra (30-33%) has also been reported by other workers (Jayaprakash *et al., 2016;* Sagaran, 2017*).* Agathi had almost double fresh fodder yield than mulberry but there was not much difference in dry forage yield which could be due to high DM content in mulberry (32.07%) compared to agathi (20.36%). Dry forage yield was significantly lower in moringa (1.68 Mg ha^{-1}) when compared to all other species. Due to lower biomass production and less DM content in moringa resulted in least fodder yield.

PAR transmittance in understorey of the homestead

Table 1. Plant height and coppice parameters at the stage of initial cut in selected homegardens of Central Kerala.

Treatments	Plant height (m)	Coppice parameters		
		Number of coppices	Coppice length (cm)	Coppice weight (g $plant^{-1}$)
Mulberry	1.34^{b}	2.00^{bc}	44.43^{d}	57.13^{b}
Agathi	1.87^{a}	2.75^{ab}	96.73^{a}	150.00^{a}
Moringa	1.38^{b}	1.50^{c}	80.85^{ab}	130.86^{a}
Gliricidia	1.30^{b}	3.25^{a}	58.51^{cd}	175.33^{a}
Calliandra	1.41^{b}	3.00^{a}	64.51^{bc}	124.66^{a}
P-value	0.000***	0.007**	0.000***	0.002**

Table 2. Annual green fodder yields, survival and PAR transmittance in understorey of the selected homegardens.

Treatments	Fractional and total fresh fodder biomass (Mg ha^{-1})			Survival	PAR transmittance
	Leaf	Stem	Total	(%)	(%)
Mulberry	5.76^{c}	1.91^{c}	7.67^{d}	85.71^{a}	45.50
Agathi	6.71^{c}	5.36^{b}	12.23^{c}	45.54^{b}	49.67
Moringa	5.19^{c}	3.17^{bc}	8.37^{d}	29.46^{b}	58.57
Gliricidia	16.99^{a}	9.94^{a}	26.82^{a}	41.96^{b}	54.58
Calliandra	12.51^{b}	8.57^{ab}	21.08^{b}	70.54^{a}	50.83
P-value	0.000***	0.002**	0.000***	0.001***	0.065^{ns}

ranged from 45.50 to 58.57% in different tree plots with no significant variation. This indicates shady nature of the homestead. In Arimboor panchayat, the land holdings were classified as small with an area of less than 25 cents, medium with an area 25-50 cents and large holdings with an area less than 1 hectare (GoK, 2011).

A marginal reduction in transmittance was observed in mulberry (45.50%) when compared to other species (Table 2). Productivity and income from mulberry was higher in open than from the partially shaded coconut garden (Meerabai, 1997). More shady situations might have caused yield reduction in mulberry. Poor shade tolerance of agathi was reported by Gutteridge and Shelton (1994). Sagaran (2017) reported a yield of 27 Mg ha^{-1} from calliandra fodder banks in coconut garden. The yield of calliandra in homegarden was found to be less than under coconut gardens which could be due to higher shade levels in homegardens.

Survival percentage

Among the tree species, survival percentage was significantly higher in mulberry and calliandra, followed by agathi (Table 3). Least survival was recorded for moringa. Raj *et al.* (2016) also reported better establishment and survival of mulberry fodder banks in coconut garden and reported 100% survival even after frequent harvesting during initial year of planting. Similarly, better establishment, growth and survival (98%) of calliandra were reported even with repeated pruning in the initial year of planting by Sagaran (2017). Yamoah (1987) reported that survival of gliricidia declined with time in the entire establishment methods used and was closely related to the occurrence of rainfall, especially in the case of 0.5 m cuttings. Karmakar *et al.* (2016) reported that in agathi, harvesting leaves for fodder must be done selectively, to avoid complete defoliation, and cannot be done more than a few times per year. More intensive harvesting, such as managing as a hedgerow, reduces the life of the tree. Cutting at 1 m high five times a year can result in tree mortality. This could be the reason for severe mortality of agathi in our fields which were harvested five times in a year.

Leaf-stem ratio

Fodder tree species showed significant variation on the leaf-stem ratio (Table 3). In general, higher leaf-stem ratio was observed in mulberry, followed by gliricidia, agathi, calliandra and moringa (Table 3). Wong (1986) reported that gliricidia produced the highest leaf-stem ratio, followed by leucaena and cassava. Similarly, higher leaf-stem ratio was reported by Raj *et al.* (2016) in mulberry and by Sagaran (2017) in calliandra.

Nutritive value of fodder

Fodder tree species showed significant variation in the CP content in fodder biomass (Table 4). In general, foliage fraction had higher CP level than the stem for all tree species. Comparing tree species, calliandra recorded highest CP content, followed by gliricidia, mulberry, agathi and moringa. Raj *et al.* (2016) reported pruning frequencies had profound influence on nutritive value of the forage. Harvesting at shortest pruning interval of 8 weeks yielded fodder with maximum CP content from mulberry. A study conducted by Jayal and Kehar (1962) reported that on dry basis, mulberry leaves contained an average of 20-23% CP content. According to Islam *et al.* (1995), younger shoots of fodder trees contain higher CP content than matured ones. Sagaran (2017) reported 18.10% CP content in calliandra fodder when harvested at an interval of two months. In our study, the CP content was recorded significantly lower in agathi and moringa. Karmakar *et al.* (2016) also reported 25-30% CP content in agathi leaves. Nouman *et al*. (2013) reported 15.31% CP content in moringa.

The CF content in total fodder varied from 24.83-

Table 3. Annual dry fodder yield and leaf-stem ratio in homegardens.

Treatments	Annual dry fodder yield (Mg ha^{-1})			Leaf-stem ratio
	Leaf	Stem	Total	
Mulberry	1.68^{c}	0.78^{b}	2.46^{b}	2.15^{a}
Agathi	1.30^{c}	1.19^{b}	2.49^{b}	1.09^{b}
Moringa	0.67^{d}	1.02^{b}	1.68^{b}	0.66^{b}
Gliricidia	3.05^{b}	2.33^{a}	5.38^{a}	1.31^{b}
Calliandra	3.31^{a}	3.31^{a}	6.61^{a}	1.00^{b}
P-value	0.000***	0.001***	0.000***	0.000**

45.94%. Comparing tree species, moringa contained highest CF content, followed by agathi, calliandra and gliricidia (Table 4). Mulberry showed significantly lower CF content. The above results are in conformity with the findings of Oduro *et al.* (2008) in moringa, Raj *et al.* (2016) in mulberry and Sagaran (2017) in calliandra. Higher CF content in agathi and moringa fodder is due to higher stem fraction in the fodder as indicated by their low leaf-stem ratio coupled with high fibre content in the stem fraction. Gunasekaran *et al.* (2018) reported 19.24% CF in gliricidia.

In general, mulberry, gliricidia and moringa showed higher ash content, followed by calliandra (Table 4). Its least value was observed in agathi. Raj *et al.* (2016) reported higher ash content in mulberry leaf (9.97%). Mahima *et al.* (2014) also reported 9.15% ash content in moringa. Karmakar *et al.* (2016) reported an ash content of 6% in agathi. Sagaran (2017) observed lower ash content of 3.30% in calliandra. Gunasekaran *et al*. (2018) reported 8.96% ash content in gliricidia.

Mulberry and calliandra showed higher DM content, followed by other tree species (Table 4). Higher DM content in mulberry and calliandra has also been reported by Raj *et al.* (2016), Jayaprakash *et al*. (2016) and Sagaran (2017). The average DM of gliricidia and moringa are found to be 25.3% (Heuze *et al*., 2015) and 26.2% (Asaolou *et al.,* 2012), respectively.

4. CONCLUSION

The field study, assessing the performance of five fodder tree species in homegarden, indicated that trees like gliricidia, calliandra and mulberry with good yield/persistence are found to be ideal for hedgerow planting in the understorey of homesteads. Agathi was not amenable to heavy pruning; hence, frequent replanting is a management option due to its faster growth. Cultivation of moringa should be confined to light intensive as well as dry areas of homesteads. We need to examine the present species density and diversity and the possible stand management options. Also, there is a need to adopt tree management practices such as pruning, lopping etc. to improve the understorey light regimes.

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REFERENCES

Ajith, K.S., Kumar, A.K. and Dipu, M.T. 2012. How to improve the livestock sector in Kerala: Some nutritional thoughts. *Journal of Indian Veterinary Association Kerala*, 10(1): 66-68.

AOAC [Association of Official Analytical Chemists]. 1995. *Official Methods of Analysis of the Association of Official Analytical Chemists (16th Edn.).* AOAC International, Washington, USA.

Asaolou, V., Binuomote, R., Akinlade, J., Aderinola, O. and Oyelami, O. 2012. Intake and growth performance of West African dwarf goats fed with *Moringa oleifera*, *Gliricidia sepium* and *Leucaena leucocephala* dried leaves as supplements to cassava peels. *Journal of Biology, Agriculture and Healthcare, 2*(10): 76-88.

Desai, B.K. and Halepyati, A.S. 2010. Growth of *Sesbania grandiflora* and *Sesbania sesban* as influenced by plant densities and phosphorus levels with and without vesicular arbuscular mycorrhiza. *Karnataka Journal of Agricultural Sciences,* 20(4): 702-705.

Duke, J.A. 1983. *Handbook of Energy Crops*. New CROPS web site, Purdue University. (http://www.hort.purdue.edu/newcrop/duke_energy)

Dutt, A.K. and Pathania, U. 1986. Effects of nitrogen and phosphorus on seedling growth and nodulation. *Leucaena Research Reports*, 7: 38-39.

Table 4. Nutritive value of fodder biomass of different tree species in the homegardens.

Treatments	Crude protein content (%)	Crude fibre content (%)	Ash content (%)	Dry matter content (%)
Mulberry	17.51^{b}	24.83^{c}	8.58^{a}	32.07^{a}
Agathi	15.31^{c}	39.49^{b}	3.42^{d}	20.36^{b}
Moringa	13.76^{c}	45.94^{a}	7.05^{b}	20.07^{b}
Gliricidia	18.02^{b}	25.54^{c}	7.10^{b}	20.06^{b}
Calliandra	20.36^{a}	34.06^{b}	4.06^{c}	31.36^{a}
P-value	0.000***	0.000***	0.001***	0.001***

GoK (Government of Kerala). (2011): *Panchayat Level Statistics 2011, Thrissur District*. Department of Economics and Statistics, Thiruvananthapuam.

Gunasekaran, S., Bandeswaran, C., Valli, C. and Gopi, H. 2018. Effect of feeding *Gliricidia sepium* leaves from silvipasture model of agroforestry in degraded wastelands on milk yield and its composition in milch cows. *International Journal of Current Microbiology and Applied Sciences,* 6(10): 2420-2423.

Gutteridge, R.C. and Shelton, H.M. 1994. The role of forage tree legumes in cropping and grazing systems. *In: Forage Tree Legumes in Tropical Agriculture* (eds. R.C. Gutteridge and H.M. Shelton). CAB International, Wallingford, UK, pp. 3-11.

Heuze V., Tran, G., Boudon, A. and Bastianelli, D. 2016. Nacedero (*Trichanthera gigantea*). Feedipedia, A Programme by INRA, CIRAD, AFZ and FAO. (http://www.feedipedia.org/node/7270)

Islam, M., Nahar, T.N. and Islam, M.R. 1995. Productivity and nutritive value of *Leucaena leucocephala* for ruminant nutrition-Review. *Asian-Australasian Journal of Animal Sciences*, 8(3): 213-217.

Jayal, M.M. and Kehar, N.D. 1962. A study on nutritive value of mulberry (*Morus indica*) tree leaves. *Indian Journal of Dairy Science,* 15(1): 21-27.

Jayaprakash, G., Shyama, K., Gangadevi, P., Ally, K., Anil, K.S., Raj, A.K., Sathiyabarathi, M. and Robert, M.A. 2016. Biomass yield and chemical composition of *Calliandra calothyrsus*, *Desmanthus virgatus* and *Stylosanthes hamata*. *International Journal of Science, Environment and Technology*, 5(4): 2290-2295.

Karmakar, P., Singh, V., Yadava, R.B., Singh, B., Singh. R. and Kushwaha, M. 2016. Agathi [*Sesbania grandiflora* L. (Agast)]: Current status of production, protection and genetic improvement. *In: Proceedings of National Symposium on Vegetable Legumes for Soil and Human Health held at ICAR-Indian Institute of Vegetable Research, Varanasi during 12-14th February, 2016,* pp. 153-161.

KAU [Kerala Agricultural University]. 2016. *Package and Practices Recommendations: Crops* (*15th Ed*.). Kerala Agricultural University, Thrissur.

Kumar, B.M. and Nair, P.R. 2004. The enigma of tropical homegardens. *Agroforestry Systems*, 61(1-3): 135-152.

Mahima, A.R., Mandil, R., Verma, A.K. and Kumar, V. 2014. Nutritional potentials of *Moringa olifera* leaves in Uttar Pradesh, India. *Research Journal of Medicinal Plants,* 8: 283-289.

Meerabai, M. 1997. Production Potential of Mulberry under Different Management Practices. Ph.D. Thesis, Kerala Agricultural University, Thrissur, Kerala.

Nouman, W., Siddiqui, M.T., Basra, S.M.A., Farooq, H., Zubair, M. and Gull, T. 2013. Biomass production and nutritional quality of *Moringa oleifera* as a field crop. *Turkish Journal of Agriculture and Forestry,* 37(4): 410-419.

Nygren, P. and Cruz, P. 1998. Biomass allocation and nodulation of *Gliricidia sepium* under two cut-and-carry forage production regimes. *Agroforestry Systems*, 41(3): 277-292.

Oduro. I., Ellis, W.O. and Owusu, D. 2008. Nutritional potential of two leafy vegetables: *Moringa oleifera* and *Ipomoea batatas* leaves. *Scientific Research and Essays,* 3(2): 57-60.

Raj, R.M., Raj, A.K., Kunhamu, T.K., Jammaludheen, V. and Prakash, A. 2016. Fodder yield and nutritive value of subabul (*Leucaena leucocephala* Lam.) under diverse management regimes in coconut garden. *Indian Journal of Agroforestry,* 18(2): 79-85.

Sagaran, 2017. Performance of Calliandra (*Calliandra calothyrsus*) under Diverse Management Regime in a Coconut based Hedgerow Fodder Production System. M.Sc. Thesis, Kerala Agricultural University, Thrissur.

Sebuliba, E., Nyeko, P., Majaliwa, M., Eilu, G., Kizza, C.L. and Ekwamu, A. 2012. Enhanced growth of multipurpose Calliandra (*Calliandra calothyrsus*) using arbuscular mycorrhiza fungi in Uganda. *The Scientific World Journal,* Article ID: 830357 (https://doi.org/10.1100/2012/830357).

Waddington, S.R. 2003. Grain legumes and green manures for soil fertility in Southern Africa: Taking stock of progress. *In: Proceedings of a Conference* held at the Leopard Rock Hotel, Vumba, Zimbabwe during 8-11th October, 2002, pp. 140-153.

Wong, C. and Sharudin, M. 1986. Forage productivity of three fodder shrubs in Malaysia. *MARDI Research Bulletin*, 14(2): 178-188.

Yamoah, C.F., Ay, P. and Agboola, A.A. 1987. The effects of some methods of establishing *Gliricidia sepium* on food crop performance, growth and survival rate of *Gliricidia*. *International Tree Crops Journal,* 4(1): 17-31.