ISSN: 2456-2912
VET 2021; 6(4): 40-46

www.veterinarypaper.com
Received: 12-04-2021
Accepted: 15-05-2021

Md. Saiful Islam
Department of Animal Production and Management, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

M Raisul Alam
Department of Animal Science, Bangladesh Agricultural University, Mymensingh, Bangladesh

Md. Enayet Kabir
Department of Animal Production and Management, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

Falguni Dadok
Department of Animal Production and Management, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

Corresponding Author:
Md. Saiful Islam
Department of Animal Production and Management, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

Effect of supplementation of tree foliages on production performances of lactating cows in small-holding farming systems

Md. Saiful Islam, M Raisul Alam, Md. Enayet Kabir and Falguni Dadok

DOI: https://doi.org/10.22271/veterinary.2021.v6.i4a.366

Abstract
The study was conducted to investigate the effect of dietary supplementation of Dhaincha (*Sesbania aculeata*) and Ipil-ipil (*Leucaena leucocephala*) on milk production and growth performance of indigenous lactating cows and growth of calves in smallholding farming systems. Twenty-seven lactating cows weighing 138±2.55 kg and their calves were included in three locations within 15 kilometers of the Bangladesh Agricultural University campus. Animals of each area were divided into three equal groups: group T_1 (control) received a basal diet without any supplement, whereas the group T_2 and T_3 received the same basal diet but supplemented with *Sesbania* and *Leucaena* @ 25% of dry matter requirement, respectively. The feeding trial started just after parturition and continued for 45 days of lactation. The results revealed that the chemical composition of *Sesbania aculeate* and *Leucaena leucocephala* in respect of DM, OM, CP, NDF, ADF, lignin, total tannin, and condensed tannin were 26.82, 90.61, 21.13, 26.97, 20.54, 4.64, 4.16, 0.49, and 28.3, 92.95, 22.43, 24.59, 17.82, 5.32, 4.73, 0.72 percent respectively. There was no significant (p>0.05) difference among the areas as regards daily milk yield, daily weight gain of cows and calves. Tree foliage's supplementation resulted in significant improvement in milk yield and average daily body weight gain of cows and calves over the T_1 control group whereas the supplemented groups T_2 and T_3 were statistically at par. However, the highest milk yield and daily body weight gain of calves were found in *Leucaena* fed group. Therefore, it may be concluded that the production of *Sesbania* and *Leucaena* should be encouraged for feeding lactating cows in small-holding farming systems.

Keywords: *Leucaena*, *Sesbania*, growth performance, milk yield, indigenous dairy cows

Introduction
Smallholders' mixed crop-livestock farming system continues to be a dominant agricultural production system in Bangladesh. Dairy animal rearing is an inseparable and integrated part of the smallholder subsistence farming system (Khan *et al*., 2009) [1]. Indigenous dairy cows' production in the country is characterized by low productivity levels due mainly to genetic and nutritional constraints. These animals may not be able to fully express their genetic potentiality unless feeding management is improved. Farmers of our country always face a shortage of feed supply to make sustainable farming and that feed shortage is also common in most of the developing countries (Hove *et al*., 2001) [2].

In the situation of increasing human population in the country and scarcity of land, tree foliage's especially Dhaincha (*Sesbania aculeata*) and Ipil-ipil (*Leucaena leucocephala*) can be a potential source of protein and energy supplements to increase the productivity of ruminants. In recent years, there has been an increasing interest in many regions in the developing world in exploring the possibilities of including tree foliage's in the ruminant diet as a source of high-quality protein for strategic supplementation during their production period. Shrub forages and tree fodders are considered to be good and low-priced sources of protein and micronutrients that can be used to increase the quality and availability of ruminant animals feed (Manaye *et al*., 2009; Moyo *et al*., 2011; Bebeker and Abdalbagi, 2015; Babiker *et al*., 2017 [6]) [3, 4, 5, 6]. It has multiple advantages for resource-poor smallholder farmers as it can be grown locally, propagated efficiently, and is less demanding regarding the use of fertilizers, pesticides, or advanced technology (Mendieta-Araica *et al*., 201) [7].

Leucaena leucocephala is a legume, readily consumed, and nutritious (Yami *et al*., 2000) [8] fodder found throughout the tropics, subtropics, and arid region for ruminants. *Leucaena* is an excellent source of Ca, P, and other nutrients (Helal *et al*., 2013) [9] and it can also be effectively introduced with grass to supply high-quality forage for livestock (Rivera *et al*., 2009; Murgueitio *et al*., 2011) [10, 11]. *Sesbania aculeate* is another leguminous plant suitable as fodder for livestock and was tried in India (Katiyer and Ranjhan, 1969) [12]. It is considered to be a quick-growing, high yielding having recurring cuts and high in nitrogen content. It is also said that the milk yield of livestock increases by feeding Dhaincha in its green stage.
Leucaena and *Sesbania* can easily be grown abundantly in Bangladesh with little cost and agronomical care. The tree foliages, thus available, are much cheaper than other essential feed ingredients. In Bangladesh, the use of these alternative feed resources for cattle is poorly documented and has not been disseminated among smallholder farmers. Therefore, the present study was undertaken to evaluate the effect of feeding *Sesbania aculeata* and *Leucaena leucocephala* as green fodder on indigenous lactating cows' milk production and growth performance along with their newborn calves' growth performance. Nutritive values of *Sesbania aculeata* and *Leucaena leucocephala* were also assessed.

2. Materials and Methods

This study was conducted at the three villages named Boira, Sutiakhali, and Darikathal located within 15 km of Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

2.1 Animals, diets, and management

Twenty-seven indigenous lactating cows (nine from each area) were used in this experiment. Animals were randomly divided into three groups (3 in each) balanced in terms of their live weight. The control group-T_1 was fed a basal diet without any supplement, whereas the experimental treated groups (group-T_2 and group-T_3) were fed the same basal diet but group T_2 was supplemented with Dhaincha (*Sesbania aculeata*) and group T_3 was supplemented with Ipil-ipil (*Leucaena leucocephala*) for a period of 45 days of lactation immediately after calving. The basal diet composed of straw forages, and locally available concentrate ingredients. Straw and forages (native green grasses) were supplied *ad libitum*, and the concentrate feed mixture consisted of wheat bran, rice polish, mustard oil cake, vitamin-mineral premix, DCP (*Di-calcium Phosphate*), and salt feeding was limited to 1.5 kg per day per animal throughout the trial. The cows were offered foliage's in an amount of 25% of their required DM intake per day. The leaves collected from the trees were mixed with straw and green grasses and offered to cows. Cattle were identified with an ear tag.

2.2 Cultivation and collection of *Leucaena* and *Sesbania*

Sesbania aculeata and *Leucaena leucocephala* were cultivated for the production of tree foliage at the selected farmer's plot under 3 locations within 15 km of the University campus named Boira, Sutiakhali, and Darikathal. The farmers were trained to cultivate and use the foliage's. The plants were harvested when attained the height of about 2.5 meters by 60 days. Top cutting of the *Sesbania aculeata* and *Leucaena leucocephala* plant were collected and their leaves were separated from the stems. These fresh leaves were used for feeding the lactating cows. A fresh cutting of the top plant was always maintained by rotational cuttings of the top of the plant in the field.

2.3 Proximate analysis of the foliage

Proximate analyses of the selected foliage's were done in the *Animal Science Laboratory* of the Department of Animal Science, Bangladesh Agricultural University, Mymensingh, Bangladesh. Representative samples of foliage's were collected during the feeding trial from the selected areas, mixed thoroughly, dried, ground by grinding machine (CYCLOTEC 1093 Sample mill Tecator, Sweden) at the size of 0.5 mm for chemical analysis according to the methods of AOAC (2004) [13] and Makkar (2000) [14] and estimated dry matter (DM), organic matter (OM), CP (crude protein), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin and Tannins.

2.4 Milk yield

Daily milk yield of individual cows recorded after complete hand milking in the morning and evening. The calves were tied up at night and after morning milking, they were set free for 8 hours to have access to suckle their mother.

2.5 Measurement of growth

The weight of cows was measured with weighing tape (Cattle and Pig Weighing Tape, manufactured by Dulton Supplies Ltd. England, Approved by IAEA) once a week. The birth weight of calves was taken on the same day of birth, then bodyweight of all calves was taken once a week in the morning by spring weighing balance (Trademark: Sheng chan, made in Taiwan) to estimate weight gain. This practice was continued till the experiment was over.

2.6 Statistical analysis

The experimental data were analyzed using "MSTAT" statistical programme to compute analysis of variance and treatment means for each parameter were compared using the least significant difference (LSD) test. Data related to growth performance and milk yield were adjusted for initial live weight and initial milk yield respectively, as covariates and were analyzed accordingly.

3. Results

3.1 Chemical composition

The chemical composition of *Sesbania* and *Leucaena* grew in three different areas has been presented in Table 1. The dry matter (DM), organic matter (OM) and crude protein (CP) contents were 5.22%, 2.52%, and 5.79% higher in *Leucaena* than that of *Sesbania* in all areas respectively. The digestible fraction of fibers as neutral detergent fiber (NDF) and acid detergent fiber (ADF) were found 9.67% and 15.26% low in *Leucaena* than that of *Sesbania*. *Leucaena* contained a higher value of lignin, total tannin, and condensed tannin than *Sesbania* and these were 12.87%, 12.05%, and 31.94% higher respectively.

Table 1: Chemical composition (%) of the experimental foliages

Area	Foliages	DM	DM basis						
			OM	CP	NDF	ADF	Lignin	Total tannin	Condensed tannin
Sutiakhali	*Sesbania*	27.06	91.34	20.3	26.74	20.14	5.14	3.1	0.48
	Leucaena	28.66	92.87	21.7	24.35	18.63	5.39	4.9	0.75
Boira	*Sesbania*	26.67	89.85	21.6	28.28	21.19	3.72	4.8	0.51
	Leucaena	28.36	93.24	22.9	25.60	16.78	5.27	4.2	0.81
Dariakathal	*Sesbania*	26.73	90.64	21.5	25.90	20.3	5.06	4.6	0.49
	Leucaena	27.89	92.73	22.7	23.81	18.06	5.29	5.1	0.72
Average	*Sesbania*	26.82	90.61	21.13	26.97	20.54	4.64	4.16	0.49
	Leucaena	28.30	92.95	22.43	24.59	17.82	5.32	4.73	0.72

DM, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber

3.2 Milk yield

Daily milk yield did not differ significantly among the three areas of Sutiakhali, Boira and Darikathal (Table 2). The average daily milk yield of cows supplemented with *Sesbania* and *Leucaena* was significantly (p<0.01) higher than that of control group (Table 3). Average daily milk yield for *Sesbania* and *Leucaena* supplemented groups were 25% and 32.8% higher than control group respectively. This improvement was tended to be higher in cows supplemented with *Leucaena* than those supplemented with *Sesbania.* Trend of increasing milk yield (l/d) of cows fed different experimental diets at different weeks during the experimental period has been shown in figure 1.

Table 2: Milk yield (l/d) of cows at different experimental areas

Parameter	Area			SED	Level of Significance
	Sutiakhali	Boira	Dariakanthal		
Initial milk yield (l/d)	1.563	1.682	1.662		NS
Milk yield at different weeks (l/d)					
1st	1.733	1.888	1.836	0.175	NS
2nd	1.9	2.023	1.966	0.169	NS
3rd	1.964	2.082	2.021	0.166	NS
4th	2.011	2.132	2.066	0.166	NS
5th	2.062	2.188	2.113	0.164	NS
6th	2.117	2.247	2.163	0.161	NS
Average milk yield (l/d)	1.981	2.105	2.038		NS

NS, non-significant; SED, standard error of difference

Table 3: Milk yield of cows fed different experimental diets

Parameter	Dietary groups			SED	Level of significance
	T_1 group	T_2 group	T_3 group		
Initial milk yield (l/d)	1.572	1.653	1.682		NS
Milk yield at different weeks (l/d)					
1st	1.581[b]	1.924[a]	1.952[a]	0.175	*
2nd	1.610[b]	2.093[a]	2.186[a]	0.169	*
3rd	1.632[b]	2.156[a]	2.280[a]	0.166	*
4th	1.647[b]	2.210[a]	2.352[a]	0.166	*
5th	1.668[b]	2.270[a]	2.426[a]	0.164	*
6th	1.684[b]	2.339[a]	2.503[a]	0.161	*
Average milk yield (l/d)	1.637 [b]	2.165 [a]	2.283 [a]		**

[a,b] Means with different superscripts within a row differ significantly; NS, non-significant; *, p<0.05; **, p<0.01; SED, standard error of difference; T_1= Control group without supplement, T_2= *Sesbania* supplemented group, T_3= *Leucaena* supplemented group.

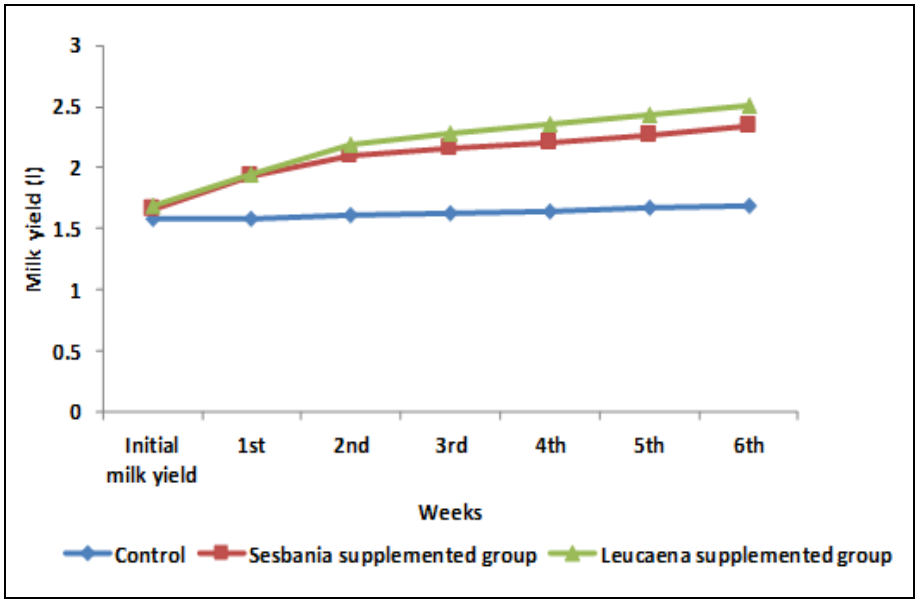

Fig 1: Trend of milk yield (l/d) of cows fed different experimental diets at different weeks

3.3 Growth performance

The average live weight gain of cows did not differ significantly among the three areas (Table 4). The average daily live weight gain of cows supplemented with *Sesbania* and *Leucaena* was significantly ($p<0.05$) higher than that of the control group (Table 5). The highest live weight gain was found in *Sesbania* supplemented group. Birth weight, final live weight, and average live weight gain of calves did not differ significantly among the three experimental areas (Table 6). The influences of supplementing tree foliage's on the growth performance of calves have been presented in Table 7. The average daily live weight gain of calves differed significantly ($p<0.01$) among the treatment groups and the highest live weight gain was recorded in *Leucaena* fed group (239 g/d).

Table 4: Live weight change (kg) of cows in different experimental areas

Parameter	Area			SED	Level of significance
	Sutiakhali	Boira	Dariakanthal		
Initial live weight (kg)	139.88	135.44	138.88		NS
Final live weight (kg)	141.11	136.5	139.83		NS
Average live weight gain (kg/d)	0.027	0.024	0.021	0.009	NS

NS, non-significant; SED, standard error of difference

Table 5: Live weight change (kg) of cows fed different experimental diets

Parameter	Dietary groups			SED	Level of significance
	T_1 group	T_2 group	T_3 group		
Initial live weight (kg)	138.11	137.77	138.33		NS
Final live weight (kg)	138.83	139.22	139.66		NS
Average live weight gain (kg/d)	0.016^b	0.032^a	0.029^a	0.009	*

^{a,b} Means with different superscripts within a row differ significantly; NS, non-significant; *, $p<0.05$; SED, standard error of difference; T_1= Control group without supplement, T_2= *Sesbania* supplemented group, T_3= *Leucaena* supplemented group.

Table 6: Live weight gain (kg/d) of calves belong to cows at different experimental areas

Parameter	Area			SED	Level of significance
	Sutiakhali	Boira	Dariakanthal		
Birth weight (kg)	10.97	11.24	11.04	-	NS
Final live weight (kg)	20.38	21.14	20.77	-	NS
Live weight gain at different weeks (kg/d)					
1st	0.229	0.231	0.232	0.014	NS
2nd	0.252	0.252	0.247	0.005	NS
3rd	0.216	0.228	0.223	0.014	NS
4th	0.220	0.218	0.251	0.005	NS
5th	0.217	0.214	0.234	0.005	NS
6th	0.206	0.201	0.209	0.005	NS
Average live weight gain (kg/d)	0.223	0.224	0.232		NS

NS, non-significant; SED, standard error of difference

Table 7: Live weight gain (kg/d) of calves belong to cows fed different experimental diets

Parameter	Dietary groups			SED	Level of significance
	T_1 group	T_2 group	T_3 group		
Birth weight (kg)	10.41	11.24	11.6	-	NS
Final live weight (kg)	19.08	21.05	21.67	-	NS
Live weight gain at different weeks (kg/d)					
1st	0.209[b]	0.240[ab]	0.243[a]	0.014	*
2nd	0.226[b]	0.259[a]	0.267[a]	0.005	*
3rd	0.197[b]	0.230[a]	0.240[a]	0.014	*
4th	0.210[b]	0.237[a]	0.242[a]	0.005	*
5th	0.204[b]	0.227[a]	0.234[a]	0.005	*
6th	0.193[b]	0.209[a]	0.213[a]	0.005	*
Average live weight gain (kg/d)	0.206 [b]	0.233 [a]	0.239 [a]		**

[a,b] Means with different superscripts within a row differ significantly; NS, non-significant; *, $p<0.05$; **, $p<0.01$; SED, standard error of difference; T_1= Control group without supplement, T_2= *Sesbania* supplemented group, T_3= *Leucaena* supplemented group.

4. Discussion

4.1 Nutrient content of *Sesbania* and *Leucaena*

Sesbania and *Leucaena* contained more CP than other tree foliage's based on the report of Chellapandian *et al.* (2016) [15], Maselema *et al.* (2017) [16], and therefore, these tree leaves may be provided fermentable N in the rumen, which can be helpful in better microbial digestion. *Leucaena leucocephala* is a highly nutritious forage with an average crude protein content of 237g/kg of dry matter (Damothiran and Chandrasekaran, 1982 [17]; Kanani *et al*., 2006 [18]). A high proportion of dietary NDF can suppress dry matter and net energy intake (Arelovich, 2008) [19] but these tree foliage's yield small particle-sized ingesta, resulting in more rapid passage through the rumen than grass ingesta with a similar NDF content. Thus, intake of these tree leaves is less affected by NDF than grass roughages. Among the anti-nutritional compounds identified in fodder trees, tannins and mimosine are present in *Leucaena leucocephala* (Simon, 2012 [20]; Adedeji *et al*., 2013 [21]). It has been recognized that tannin above 5% can become an anti-nutritional factor in plant materials. But the level of tannin content in *Sesbania* and *Leucaena* found in this experiment is less to cause any detrimental effect. It appears from their composition that feeding these foliage's adequately is likely to provide nutrients and utilized by ruminants without any adverse effect.

4.2 Effect of feeding *Sesbania* and *Leucaena* on milk yield

The animals receiving the *Sesbania* and *Leucaena* foliage's through supplementation or mixed with the grass and/or straw showed higher milk yield than that of the pure grass and/or straw alone. This improvement was possibly due to the higher crude protein levels and higher forage intake compared with grass and/or straw alone, as reported by Stobbs (1975) [22] and Muinga *et al*. (1992) [23]. Suphawadee *et al.* (2015) [24] reported that milk yield of cows improved by the supplement of *Leucaena leucocephala.* Dhaincha and ipil-ipil could be used as alternative sources of protein for ruminants, which may result in better milk yield in indigenous cows (Alam *et al*., 2009) [25]. Although, higher milk yield was observed in supplemented groups, it was not satisfactory. A question may arise that milk production was not promising as compared to feeding. This might be due to the low genetic potential and low digestibility of diets.

In the present experiment, results on milk production are slightly different to the reports published earlier (Alam *et al*., 2009 [25]; Mesfin and Ledin, 2004 [26]) which might be due to variation in feed and methods used for conducting present trial in on farm condition. In addition, important reasons attributed could be short duration of trial, use of limited number of cows and difficulties in measuring actual milk yield of cows. Here milk yield in the morning and evening was recorded and no accurate estimates of milk consumed by calves were possible other than assumption based on farmers experience on milk consumption by calves. These limitations had to be taken into account in on farm trial.

Apart from the limitation, the present experiment reaffirmed the trend of increasing milk yield by provision of better nutrition through the supply of energy and protein found in the foliage's. This supports the views of Knegsel *et al*. (2007) [27] and Knegsel *et al*. (2014) [28] that favourable milk yield response depends on the presence of adequate dietary energy. Several authors have observed better milk yield in cows fed *Sesbania* and *Leucaena* as supplement (Wambui *et al*., 2006 [29]; Trung *et al*., 1987 [30]; Wong *et al*., 1987 [31]) as a result of improving the utilization of basal diet and availability of nutrients for milk synthesis.

4.3 Effect of feeding *Sesbania* and *Leucaena* on growth performance

The increase of body weight in *Sesbania* and *Leucaena* supplemented groups probably would have been due to the supply of high-quality energy and protein from these feed sources and better assimilation of protein from them and better conversion to body tissue. The findings are in line with the observation of Khan *et al*. (1990) [32] who found the beneficial effect of Dhaincha and Ipil-ipil on performance in local Zebu cows. This result is also corroborated by findings of Alam *et al*. (2009) [25], Rahman *et al*. (2015) [33], Hidosa (2017) [34]. However, live weight gain recorded in cows supplemented with *Sesbania* and *Leucaena* in the present study was lower than the reports of Piggin and Parera (1984) [35] and Moog (1984) [36]. This variation might be due to variation in the amount of supplement offered, breed, age, and management condition of the animals. Another reason could be that the bodyweight of cows was measured by Weigh band Tape which provided an estimated live weight compared to calves weight measured by actual weight and might have contributed to this difference.

However, the rate of growth and milk yield were low. The lactating cows in their lactation period needed adequate nutrients to sustain milk production. The amount of supplement provided may be inadequate to exhibit potential milk yield and maintain body condition.

5. Conclusion

The results showed the importance of high-quality forage supplementation in improving milk production, maintaining good body condition, and higher growth of calves in the present smallholding dairy farming system. Therefore, the

provision of an adequate amount of tree foliage's to the basal diet may increase the supply of nutrients and improve their performance. Finally, it can be concluded that tree foliage's have better prospects as an alternative feed resource in smallholding farming systems.

6. Acknowledgement
The study was supported by a grant from International Atomic Energy Agency (IAEA), Vienna, Austria.

7. Conflict of Interest
All authors declare no conflict of interest in the accomplishment of this study.

8. References
1. Khan MJ, Peters KJ, Uddin MM. Feeding strategy for improving dairy cattle productivity in small holder farm in Bangladesh. Bangladesh Journal of Animal Science 2009;38(1-2):67-85.
2. Hove L, Topps JH, Sibanda S, Ndlovu LR. Nutrient intake and utilization by goats fed dried leaves of the shrub legumes *Acacia angustissima*, *Calliandra calothyrsus* and *Leucaena leucocephala* as supplements to native pasture hay. Animal Feed Science and Technology 2001;91:95-106.
3. Manaye T, Tolera A, Zewdu T. Feed intake, digestibility and body weight gain of sheep fed Napier grass mixed with different levels of *Sesbania sesban*. Livestock Science 2009;122(1):24-29.
4. Moyo B, Masika PJ, Hugo A, Muchenje V. Nutritional characterization of Moringa (*Moringa oleifera* Lam.) leaves. African Journal of Biotechnology 2011;10:12925-12933.
5. Bebeker EA, Abdalbagi YMA. Effect of feeding different levels of Moringa oleifera leaves on performance, hematological, biochemical and some physiological parameters of Sudan Nubian goats. Online Journal of Animal Feed Research 2015;2:50-61.
6. Babiker EE, Juhaimi FAL, Ghafoor K, Abdoun KA. Comparative study on the feeding value of Moringa leaves as a partial replacement for alfalfa hay in ewes and goats. Livestock Science 2017;195:21-26.
7. Mendieta-Araica B, Sporndly R, Reyes-Sánchez N, Sporndly E. Moringa (*Moringa oleifera*) leaf meal as a source of protein in locally produced concentrates for dairy cows fed low Protein diets in tropical areas. Livestock Science 2011;137:10-17.
8. Yami A, Litherland AJ, Davis JJ, Sahlu T, Puchala R, Goetsch AL. Effects of dietary level of *Leucaena leucocephala* on the performance of Angora and Spanish doelings. Small Ruminant Research 2000;38:17-27.
9. Helal HG, Eid EY, Nassar MS, Shaer HME. Some nutritional studies of four salt tolerant fodder crops fed to goats under saline conditions in Egypt. Egyptian Journal of Nutrition and Feeds 2013;16(1):65-78.
10. Rivera JE, Cuartas C, Naranjo JF, Barahona-Rosales R. Comparison of productive performance and quality of milk in cows under an intensive silvopastoral system and a conventional production system in the river Cesar valley. Revista Colombiana Ciencias Pecuarias 2009;22:514.
11. Murgueitio E, Calle Z, Uribe F, Calle A, Solorio B. Native trees and shrubs for the productive rehabilitation of tropical cattle ranching lands. Forest Ecology and Management. 2011;261:1654-1663.
12. Katiyer RC, Ranjhan SK. Yield and chemical composition of Dhaincha (*Sesbania aculeata*) its nutritive value for sheep. Indian Journal of Dairy Science 1969;22:33-37.
13. AOAC. Official Methods of Analysis (17th Edn.), Association of Official Analytical Chemists, Arlington, VA, USA 2004.
14. Makkar HPS. Quantification of tannins in tree foliage. A laboratory manual for the FAO/IAEA co-ordinated research project on Use of nuclear and related techniques to develop simple tannin assays for predicting and improving the safety and efficiency of feeding ruminants on tanniniferous tree foliage. FAO/IAEA working document. IAEA, Vienna, Austria 2000.
15. Chellapandian M, Arulnathan N, Thirumeignanam D. Chemical composition of tree leaves for small ruminants in Southern Tamilnadu. International Journal of Science, Environment and Technology 2016;5(3):1303-1305.
16. Maselema D, Chigwa FC. The potential of *Richardia scabra* and fodder tree leaf meals in reducing enteric methane from dairy cows during dry season. Livestock Research for Rural Development 2017;29(3):51 ref.14.
17. Damothiran L, Chandrasekaran NR. Nutrition studies with Leucaena forage. Research Reports 1982;3:21-22.
18. Kanani J, Lukefahr SD, Stanko RL. Evaluation of tropical forage legumes (*Medicago sativa*, *Dolichos lablab*, *Leucaena leucocephala* and *Desmanthus bicornutus*) for growing goats. Small Ruminant Research 2006;65:1-7.
19. Arelovich HM, Abney CS, Vizcarra JA, Galyean ML. Effects of dietary neutral detergent fiber on intakes of dry matter and net energy by dairy and beef cattle: analysis of published data. The Professional Animal Scientist 2008;24(5):375-383.
20. Simon MK. Growth response and carcass characteristics of rabbit fed graded levels of *Leucaena leucocephala* diets. Canadian Journal of Veterinary Science 2012;6:10-13.
21. Adedeji OS, Amao SR, Ameen SA, Adedeji T, Ayandiran TA. Effects of varying levels of *Leucaena Leucocephala* leaf meal diet on the growth performance of weaner rabbit. Journal of Environmental Issues and Agriculture in Developing Countries 2013;5:5-9.
22. Stobbs TH. Factors limiting the nutritional value of grazed tropical pastures for beef and milk production. Tropical Grasslands 1975;9:141-150.
23. Muinga RW, Thorpe W, Topps JH. Voluntary food intake, live-weight change and lactation performance of crossbred dairy cows given ad libitum *Penniselum purpureum* (napier grass var. Sana) supplemented with leucaena forage in the low land semi-humid tropics. Animal Production 1992;55:331-337.
24. Suphawadee Y, Hiep T, Thang CM. Effects of *Leucaena leucocephala* supplemental levels in the diet for dairy cattle on animal productivity and enteric methane production. Journal of Animal Husbandry Sciences and Technics 2015;8:50-59.
25. Alam MGS, Rahman MA, Khatun M, Ahmed JU. Feed supplementation and weight change, milk yield and post-partum estrus in *Desi* cows. The Bangladesh Veterinarian 2009;26(2):39-47.
26. Mesfin R, Ledin I. Comparison of feeding urea-treated teff and barley straw based diets with hay based diet to crossbred dairy cows on feed intake, milk yield, milk

composition and economic benefits. Livestock Research for Rural Development 2004;16(12):104.
27. Knegsel ATMV, Brand HVD, Dijkstra J, Straalen WMV, Heetkamp MJW, Tamminga S *et al*. Dietary energy source in dairy cows in early lactation: Energy partitioning and milk composition. Journal of Dairy Science 2007;90(3):1467-1476.
28. Knegsel ATMV, Remmelink GJ, Jorjong S, Fievez V, Kemp B. Effect of dry period length and dietary energy source on energy balance, milk yield, and milk composition of dairy cows. Journal of Dairy Science 2014;97(3):1499-1512.
29. Wambui CC, Abdulrazak SA, Noordin Q. The effect of supplementing urea treated maize stover with *Tithonia*, *Calliandra* and *Sesbania* to growing goats. Livestock Research for Rural Development 2006;18(5):64.
30. Trung LT, Palo LP, Matias JM, Abenir EE, Lapinid RR, Atega TA. Dried poultry manure and leucaena in rice-straw based blended diets for dairy cattle. In: Dixon, R.M., ed. Ruminant feeding systems utilizing fibrous agricultural residues. International Development Program of Australian Universities, Canberra, Australia 1987, 119-210.
31. Wong CC, Wan Hassan WE, Tan KL. Milk production of Sahiwal x Friesian cow grazing on leucaena-B. Decumbens pasture with concentrate supplementation. Proc. of the 10th Annual Conference of Malaysian Society of Animal Production, held at Genting Highlands, Pahang, Malaysia 1987;2-4:280-286.
32. Khan MAS, Jabber MA, Akber MA, Topps JH. *Leucaena leucocephala* as an alternative protein supplement to fish meal for lactating cows in Bangladesh. Winter Meeting of British Society of Animal Production, Scarborough, UK 1990, 18-20.
33. Rahman MZ, Akbar MA, Hossain MA, Ali MY. Effect of tree forage supplementation on growth performance of goats. Asian Journal of Medical and Biological Research 2015;1(2):209-215.
34. Hidosa D. Review on: Role of legume forage meal supplementation on feed intake, weight gain, digestibility and carcass characteristics of ruminant livestock. Global Journal of Science Frontier Research 2017;17(4):37-42.
35. Piggin CM, Parera V. The use of leucaena in Nusa Tenggara Timur. *In* Shrub legumes in Indonesia and Australia. Australian Centre for International Agricultural Research, Canberra, Australia. Proceedings Series no 1984;3:19-27.
36. Moog FA. Utilization of ipil-ipil in feedlots and pastures. *Leucaena* Research in Review 1984;14:67-74.