Global Journal of Science Frontier Research
Agriculture and Veterinary
Volume 13 Issue 13 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Fodder Productivity of *Flemingia Macrophylla* under Different Planting Density, Defoliation Management and Fertilizer Application

By R. P. Ghimire, K. P. Kayastha, N. R. Devkota & M. R. Tiwari
Nepal Agricultural Research Council Kind Regards, Nepal

Abstract- Flemingia macrophylla (Willd) Merril is a perennial leguminous shrub with higher potential of fodder use. The objective of the study was to identify its appropriate planting density, defoliation management, and fertilizer doses to the mature stands. The planting density experiment consisted of five treatments of different planting densities (15873, 18518, 22222, 27777 and 37037 plants ha-1) with four replications in a Randomized Complete Block Design (RCBD). Similarly, the defoliation management experiment was conducted in a 2x3 factorial combination using RCBD. The combinations of different levels of two factors; defoliation frequency (8 and 12 weeks interval) and defoliation intensity (0.25, 0.50 and 0.75 m defoliation height above the ground level), were used as treatments and replicated five times. Subsequent experiment was conducted on the three-year old mature stands of F. macrophylla for testing the treatments of five graded levels of phosphorus (P), viz. 0, 10, 30, 50 and 70 kg ha-1. Each level of P was combined with 30 kg N ha-1. The experiment was conducted in RCBD with four replications.

Keywords: biomass, defoliation height, defoliation interval, planting density, digestibility.

GJSFR-D Classification : FOR Code: 070101

FODDER PRODUCTIVITY OF FLEMINGIA MACROPHYLLAUNDER DIFFERENT PLANTING DENSITY, DEFOLIATIONANAGEMENT AND FERTILIZER APPLICATION

Strictly as per the compliance and regulations of :

Fodder Productivity of *Flemingia Macrophylla* under Different Planting Density, Defoliation Management and Fertilizer Application

R. P. Ghimire [α], K. P. Kayastha [σ], N. R. Devkota [ρ] & M. R. Tiwari [ω]

Abstract- Flemingia macrophylla (Willd) Merril is a perennial leguminous shrub with higher potential of fodder use. The objective of the study was to identify its appropriate planting density, defoliation management, and fertilizer doses to the mature stands. The planting density experiment consisted of five treatments of different planting densities (15873, 18518, 22222, 27777 and 37037 plants ha^{-1}) with four replications in a Randomized Complete Block Design (RCBD). Similarly, the defoliation management experiment was conducted in a 2x3 factorial combination using RCBD. The combinations of different levels of two factors; defoliation frequency (8 and 12 weeks interval) and defoliation intensity (0.25, 0.50 and 0.75 m defoliation height above the ground level), were used as treatments and replicated five times. Subsequent experiment was conducted on the three-year old mature stands of F. macrophylla for testing the treatments of five graded levels of phosphorus (P), viz. 0, 10, 30, 50 and 70 kg ha^{-1}. Each level of P was combined with 30 kg N ha^{-1}. The experiment was conducted in RCBD with four replications. The results of the planting density experiment revealed that the F. macrophylla yielded highest fodder dry matter (DM) at very low plant density ($p<0.001$), without affecting nutrient composition ($p>0.05$). Likely, the results of the defoliation management experiment showed that higher fodder DM was obtained from the treatment of 12 weeks defoliation interval. The fodder DM was found higher while the defoliation was done in 0.75 m from the ground level. The interaction effects of defoliation intervals and defoliation heights were similar ($p>0.05$). The results from the P fertilization experiment had revealed that the fertilization by 50 kg P ha^{-1} with 30 kg N had significantly higher ($p<0.001$) fodder DM than lower levels of P application, whereas fertilization of different levels of P had similar nutrient composition on the fodder. The results of these experiments suggested that F. macrophylla could produce higher biomass at low level of planting density (15873 plants ha^{-1}); with delayed defoliation interval of 12 weeks maintaining 0.75 m defoliation height. Likewise, the fodder yield of mature stands of F. macrophylla could be substantially increased by the fertilization with 50 kg P and 30 kg nitrogen per hectare. The information could be used for the preparation of cultivation practices of F. macrophylla to increase the fodder productivity.

Keywords: biomass, defoliation height, defoliation interval, planting density, digestibility.

Authors α ω : Nepal Agricultural Research Council, Kathmandu, Nepal. e-mail: realyahaya@yahoo.com
Author σ : Department of Livestock Service, Harihar Bhawan, Lalitpur.
Author ρ : Institute of Agriculture and Animal Science/Tribhuvan University, Chitwan, Nepal.

I. Introduction

Ruminant livestock production systems in many of the Asian and African countries rely on the green fodders. Feed deficit, especially the green fodders, is the foremost problem of ruminant livestock enterprises in those countries (Younas and Yahoob, 2005; Upreti and Shrestha, 2006; Pariyar *et al.*, 2013). To tackle with this situation, it has thus been necessary to promote possible shrubs, trees and herbs which may produce larger biomass of quality fodders (Yadav and Devkota, 2005).

Flemingia macrophylla (Willd.) Merrill is a multipurpose perennial leguminous shrub that can supply fodders all the year round. It is a woody deep rooting shrub naturally distributed in Southeast Asia, Southern China, Taiwan, India and Sri Lanka in the sub-humid to humid. It is relatively high yielding legume fodder with high calcium and protein content (Dzowela *et al*., 1995). Where adopted and once established, the species grows very vigorously (Singh, 2000) and has an excellent coppicing capacity and re-growth after cutting. When cut, the plant forms a tussock by producing numerous shoots from buds at the lower part of the stem near the base (FFTC, 2004). *F. macrophylla* is receiving the significant attention as a fodder in recent years due to its higher biomass productivity (Kharel, 2000) and better fodder quality (Sharma, 2006; Chaudhari, 2007). But, the information on appropriate cultivation practices, especially planting density, defoliation management and fertilization to mature stands are scanty. Therefore, the experiments were conducted during 2003/04 to 2006/07 at Rampur, Chitwan, Nepal with the objectives of investigation in appropriate cultivation practices of *F. macrophylla*.

II. Materials and Methods

The experiments were carried out on upland site of Rampur, Chitwan district, Nepal at 27°40' N, 84°19' E and 228 masl. The soil was sandy loam, fairly well drained with medium fertility having 5.4 pH. The maximum temperature on the experimental site was ranged from 24.34°C (December) to 36.04°C (May) and minimum temperature was from 7.8°C (January) to 26.2°C (July). Likely, the annual rainfall varied from

2105.8 to 2468.5 mm during the experimental years with higher precipitation in June to September.

A couple of experiments were carried out from 2010 to 2012. Planting density experiment was conducted by using Randomized Complete Block Design (RCBD) with five treatments and three replications. Five different planting densities; 15873, 18518, 22222, 27777 and 37037 plants ha^{-1}, were used as treatments. Constant row to row (RR) of 0.9 m distance were maintained for every treatment and plant to plant (PP) distance was varied. The treatments were: very low plant density (0.9×0.7 m^2), quite low plant density (0.9×0.6 m^2), normal plant density (0.9×0.5 m^2), high plant density (0.9×0.4 m^2), and very high plant density (0.9×0.3 m^2) . The plot size was 37.80 m^2 and the numbers of plants were adjusted for different densities. The nutrient content of the soil was 2.83% organic matter, 0.15% nitrogen (N), 43.7 kg ha^{-1} P and 183.4 kg ha^{-1} potash (K). Three months old saplings, which were raised in the polythene pots, were transplanted. The saplings were 20 to 25 cm in height and three to six leaf-stage with thin-stem. The fodder was harvested at the height of 50 cm above ground level. Three harvestings were monitored during the study and their cumulative DM production was calculated.

The subsequent experiment on defoliation management was conducted by using RCBD in 2×3 factorial arrangements, with five replications. The treatment combinations of two levels of defoliation frequency (8 and 12 weeks defoliation interval), and three levels of defoliation intensity (defoliation height of 0.25, 0.50, and 0.75 m from the ground level) were used for the study. The plot size was 7.56 m^2 $plot^{-1}$ and each plot consists of 12 plants. The RR and PP distances were maintained 0.90 m and 0.70 m, respectively. The fresh green fodder mass were monitored in three harvestings and cumulative DM yield was calculated.

Phosphorus fertilization experiment was conducted during June 2010 to January 2012 to assess the effect of different levels of P fertilization on the fodder yield of three-years-old mature stands of *F. macrophylla*. Five treatments of different graded P levels were compared with four replications in RCBD. The treatments (0, 10, 30, 50 and 70 kg P ha^{-1}) were used with uniform basal dose of N (30 kg ha^{-1}). The experiment was executed by maintaining the spacing of 0.90 m RR and 0.70 m PP. Before setting of the experiment, average number of branches of the three-year old mature stands of *F. macrophylla* was 17.33 $plant^{-1}$; average branch height was 1.21 m and average number of compound leaves $plant^{-1}$ was 305. The observations were taken by defoliating at 0.75 m height from the ground level at 12 weeks defoliation interval. Two harvests of fodders were monitored during the study and the cumulative DM yield was calculated.

a) Herbage Analysis

The nutrient analysis of green leaf samples were done in the laboratory of Animal Nutrition Division, Khumaltar, Lalitpur, Nepal and Animal Nutrition Laboratory, IAAS, Rampur, Chitwan, Nepal. Samples from each experiment were dried at 70°C for 24 hours and dry matter (DM) content calculated. The proximate constituents; crude protein (CP), ether extract (EE), crude fiber (CF), total ash (TA), nitrogen free extract (NFE) were determined according to the conventional method (AOAC, 1990). Estimation of neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) (sulfuric acid lignin) was carried out according to the methods suggested by Van Soest *et al.* (1991).

b) Statistical Analyses

The data were analyzed by using analysis of Variance (ANOVA) for all of three experiments. The statistical analyses were carried out by using GenStat Discovery Edition (2011). The multiple comparisons among treatment means were performed by using Duncan's Multiple Range Test (DMRT).

III. Results and Discussion

a) Effect of planting density to fodder production

Dried fodder yields for the different planting density of *F. macrophylla* were significantly different ($p<0.001$). Plants under very low plant density had produced significantly higher fodder mass than other treatments ($p<0.001$), where as very high plant density produced lower fodder dry matter (Table 1). The fodder DM yield under quite low density, normal density and high density were statistically similar ($p>0.05$).

Table 1 : Effects of planting density on fodder yield of *F. macrophylla*

Treatments	Fodder yield (DM, t ha^{-1})
Very low density (0.9 × 0.7m^2)	4.46^{a}
Quite low density (0.9 × 0.6 m^2)	3.06^{b}
Normal density (0.9 × 0.5 m^2)	2.93^{b}
High density (0.9 × 0.4 m^2)	2.73^{bc}
Very high density (0.9 × 0.3 m^2)	2.26^{c}
S.E.	0.14

The mean within the same column with different superscripts differ significantly.

The Nutrient compositions of *F. macrophylla* fodder produced under different planting density are presented in Table 2. The proportions of CP, CF and TA were not significantly affected by the variation in planting densities ($p>0.05$). The CP, CF and TA contents of the fodders were ranged from 15.96 to 16.91%, 23.46 to 23.79% and 6.05 to 6.35%, respectively.

Table 2 : Effect of different planting density on nutrient composition of *F. macrophylla*, %

Treatments	Crude protein	Crude fibre	Total Ash
Very low density (0.9 × 0.7m²)	16.91	23.62	6.34
Quite low density (0.9 × 0.6 m²)	16.37	23.54	6.35
Normal density (0.9 × 0.5 m²)	16.57	23.79	6.19
High density (0.9 × 0.4 m²)	16.37	23.66	6.05
Very high density (0.9 × 0.3 m²)	15.96	23.46	6.21
S.E.	0.26	0.89	0.14

b) Effect of defoliation frequency and defoliation intensity to fodder production

Both defoliation interval and defoliation height had significant effect ($P<0.001$) to the fodder yield of *F. macrophylla*, where as the interaction effects of defoliation intervals and defoliation height were obtained non significant ($p>0.05$).

The effect of defoliation interval was significant to the fodder DM yield ($p<0.001$). Accordingly, the fodder yield of *F. macrophylla* defoliated at 12 weeks interval was significantly higher ($p<0.001$) in comparison to the fodder defoliated at 8 weeks interval. Similarly, the plant defoliated at the 0.75 m height above the ground level had produced significantly higher fodder yield ($p<0.001$). The experimental plants defoliated at lowest regime (0.25 m above ground level) had yielded lowest fodder DM.

Table 3 : Effects of defoliation interval and defoliation height on the yield of *F. macrophylla*

Treatment	Fodder yield (DM, t ha^{-1})
Defoliation interval*	
8 weeks	4.42
12 weeks	9.46
S.E.	1.07
Defoliation height*	
0.25 m from the ground	4.84
0.50 m from the ground	6.55
0.75 m from the ground	9.80
S.E.	1.31

**The values are significantly different at $p<0.001$).*

c) Effect of different levels of phosphorus application to the mature stands

The dried fodder yield of *F. macrophylla* for different graded levels of P fertilization is presented in Table 4. The fodder DM yield was obtained higher for the treatments of 70 and 50 kg P ha^{-1} compared to lower levels of P fertilization ($p<0.001$). But, the fodder yield was statistically similar for those two higher levels of P fertilization ($p>0.05$), viz. 70 and 50 kg P ha^{-1}.

Table 4 : Effect of different levels of P fertilization on the fodder yield of *F. macrophylla*

Treatments	Fodder yield (DM, t ha^{-1})
0 kg P ha^{-1} and 30 kg N ha^{-1}	2.96^{b}
10 kg P ha^{-1} and 30 kg N ha^{-1}	3.40^{b}
30 kg P ha^{-1} and 30 kg N ha^{-1}	3.19^{b}
50 kg P ha^{-1} and 30 kg N ha^{-1}	4.91 ^{a}
70 kg P ha^{-1} and 30 kg N ha^{-1}	4.96^{a}
S.E.	0.423

The mean within the same column with different superscripts differ significantly.

d) Effect of different levels of P application on the nutrient composition of fodders

The effect of different levels of P fertilization to the nutrient composition of *F. macrophylla* is presented in Table 5. The nutrients; CP, NDF, ADF, calcium (Ca) and P, were statistically similar for all the treatments ($p>0.05$). Accordingly, mean CP content was ranged from 16.43% to 18.09 %. Likewise, the range of NDF and ADF portions were 61.91 to 65.46% and 58.95 to 63.51%, respectively. Similarly, the Ca and P contents were ranged from 1.03 to 1.22% and 0.25 to 0.29%, respectively.

Table 5 : Effect of different levels of P fertilization on the nutrient composition of fodders, %

Treatments	CP	NDF	ADF	Ca	P
0 kg P ha^{-1} and 30 kg N ha^{-1}	17.00	61.91	60.23	1.19	0.29
10 kg P ha^{-1} and 30 kg N ha^{-1}	17.26	63.14	61.05	1.17	0.25
30 kg P ha^{-1} and 30 kg N ha^{-1}	18.16	62.76	58.95	1.22	0.29
50 kg P ha^{-1} and 30 kg N ha^{-1}	18.41	63.08	60.06	1.18	0.28
70 kg P ha^{-1} and 30 kg N ha^{-1}	17.19	65.46	63.51	1.03	0.26
S.E.	1.74	3.29	3.23	0.24	0.05

Global Journal of Science Frontier Research (D) Volume XIII Issue XIII Version I Year 2013
3

IV. Discussion

Maximum fodder DM yield was obtained from very low plant density (15873 plants ha^{-1} from the spacing of 0.9 ×0.7 m^2) of *F. macrophylla.* In deed the cumulative fodder DM yield was consistently increased with lowering the planting density. In consistent with the findings of present study, Buddleman and Siregar (1997) reported that the RR distance of 0.90 m and PP distance of 0.60 m would be best and the most effective planting geometry for *F. macrophylla* to produce higher biomass production in Indonesia. Increasing planting density might have increased the interplant competition, which could negatively affect the different fodder attributing characters. The influences on plant stature and number of leaves $plant^{-1}$ due to competition for light, aeration and nutrients availability was obtained in another study performed in the case of intercropping of maize and cowpea (Ibrahim *et al*., 2006). In the present study, the higher fodder yield of *F. macrophylla* under very low plant density could have been related to the lessen effect of competition for sunlight as well as water and soil mineral absorption.

The results of defoliation frequency and intensity showed that *F. macrophylla* responded well to the defoliation interval and defoliation height. Late cutting (12 weeks interval) produced comparatively higher fodder yield compared to early cutting (8 weeks interval) without affecting nutrient composition of the fodder. The results of other several studies on *Leucaena* agree with the findings of the present study. Longer cutting interval resulted larger branch size and higher fodder mass in the case of *Leucaena* (Goevarra *et al*., 1978) and had shown greater edible biomass production while defoliated at 12 weeks than defoliated in 6 weeks (Ella *et al*., 1989).

The result of the present study showed that fodder yield of *F. macrophylla* was obtained higher while defoliating at 0.75 m from the ground level compared to shorter heights indicating negative effects of shorter harvesting heights for fodder mass accumulation. Taller defoliation height improved the shoot development than lower heights (0.70 m vs. 0.30 m and 0.50 m) in another study in the case of *Gliricidia sepium,* a browse species (Asare, 1985). The similar results were found in the case of *Leucaena* too (Krishna Murthy and Munegowda, 1982; Isarasenee et al., 1984). The greater re-growth response of plants for higher defoliation height in the experiment might be due to the greater mass of active meristematic tissues (buds) leftover after defoliation, higher amount and photosynthetic capacity of residual leaf area and greater mobilization of available carbohydrates and other reserves from plant material which remains after defoliation. The factors perhaps favored better re-growth of the *F. macrophylla* as in the case of other legume fodder trees and shrubs as stated by Stur *et al*. (1998). The author reported that the lower cutting heights result reduced numbers of leaves, and prolonged lag phase before high growth phase, because new growth has to be supported initially by stored carbohydrate reserves.

a) Phosphorus fertilization and herbage mass production

The result of the present study revealed that the three-years old mature stands of *F. macrophylla* had acquired higher fodder yield under 50 kg P with 30 kg N ha^{-1}. Since the legumes are highly responsive to the P fertilization (Geethakumari, 1981; Jain *et al*., 1986), the response further increased for the mature stands of the perennial fodder legumes. Phosphorus is a vital nutrient for N fixation, root proliferation and growth in legumes (Singh and Thrivedi, 1981; Rajasree and Pillai, 2001). The application of P stimulates early vegetative growth of plant by increasing the rapid cell division, root formation and other physiological roles. Moreover, the application of P might have increased the uptake of other minerals, especially N as reported by Khatri-Chhetri (1991). Simultaneously, lower fodder yield in the case of control and lower P fertilization treatment (0, 10 and 30 kg P ha^{-1}) might have been related to the situation mentioned by Haque and Jutzi (1984) that the P deficiency in the soil that affected especially to the N fixation through its effect on root infection, nodule development and nodule function and plant growth. In deed the soil under the continuous cultivation of perennial legumes becomes P deficit hence a certain soil P level is required for the plant establishment (Andersson *et al*., 2002) and optimum growth (~50 kg P ha^{-1}; present study). Hence, the findings of present study suggest the need of moderate level of P fertilization which could be perhaps varied in amount and dose as per the inherent variation in plant uptake, characteristics to the plant type and soil condition and structure (Rajasree and Pillai, 2001).

In the present study, chemical composition of the *F. macrophylla* was altered neither by the planting density nor by the levels of P application. Planting of *F. macrophylla* with very low planting density and application of 50 kg P ha^{-1} with 30 kg N ha^{-1} may increase the herbage mass without any deterioration in the quality of the fodder. In addition, higher CP content (approximately 16%) of *F. macrophylla* indicates the potential of good quality fodder from this leguminous shrub. These evidences support the fact that *F. macrophylla* could be considered as good quality fodder.

V. Conclusion

The results of the experiments conducted in the present study revealed that low density planting (15873 plants ha^{-1}) by providing the spacing of 0.9 × 0.7 m^2 $plant^{-1}$, defoliation at 0.75 m height from the ground level in an interval of 12 weeks are the appropriate practices for the cultivation of *F. macrophylla* fodder. The findings also revealed that yields of three-years old mature stands of *F. macrophylla* can be substantially increased by the application of 50 kg P with 30 kg N ha^{-1}. The information could be useful for the preparation of cultivation practices of *F. macrophylla* for the better fodder productivity. With the inclusion of these cultivation practices, it can be well expanded as a promising leguminous shrub, particularly to that of high humidity and dried areas of sub-tropical climate. It could contribute to mitigate the fodder deficit of farming communities as an alternative nutritious legume fodder for dry seasons with higher biomass yield.

References Références Referencias

1. ANDERSSON M.S., SCHULTZE-KRAFT R., and PETERS M. (2002) *Flemingia macrophylla* (Willd.) Merrill. FAO Grassland Index, Rome, Italy (retrieved 22 August 2005 from http://www.fao.org/ag/ AGP/ AGPC/doc/GBASE/ data/pf000154.html.
2. AOAC (1990) Association of Official Analytical Chemists, Official method of analysis. (15th ed), Washington D.C., USA.
3. ASARE E.O. (1985) Effect of frequency and height of defoliation of forage yield and crude protein content of *Flemingia macrophylla*. In: xxx and xxx (eds) *Proceedings of the XV International Grassland Congress,* pp 24-31. Japan: Kyoto.
4. BUDELMAN A. and SIREGAR M.E. (1997) *Flemingia macrophylla*. In: xxx and xxx (eds) *Plant Resources of South-East Asia (PROSEA)* No. 11 Auxiliary plants, pp 144–147. Leiden, The Netherlands.
5. CHAUDHARI, N.P. (2007) *Flemingia macrophylla*. pp. 1-6. National Fodder Pasture and Animal Nutrition Center, Animal Production Directorate, Lalitpur, Nepal.
6. DUGUMA, B. (1982) Early response of four woody fallow species grown in acid Utisols to liming and phosphorus application. 49p. *Thesis, M.Sc*., University of Ibadan.
7. DZOWELA B.H. HOVE L., TOPPS J.H. and MAFONGOYA, P.L. (1995) Nutritional and anti-nutritional characters and rumen degradability of dry matter and nitrogen for some multipurpose tree species with potential for agroforestry in Zimbabwe. *Animal Feed Science and Technology*, **55**, 207–214.
8. ELLA, A., BLAIR, G.J. and STUR, W.W. (1989) Effect of age of forage tree legumes at the first cutting on subsequent production. *Tropical Grasslands*, **25**, 275-280.
9. FFTC. (2004) Food and Fertilizer Technology Center. 5F. 14 Wenchow St., Taipei 10616 Taiwan. (retrieved 26 April 2006 from http://www.agnet.org/ library/article/ pt2004007.html).
10. GEETHAKUMARI, V.L. (1981) Phosphorus nutrition of cowpea (Vigno sinensis). *Thesis, M. Sc. (Ag)*. India: Kerala Agricultural University, Thrissur.
11. GenStat Discovery Edition 4. (2011). *GenStat Release 10.3 DE.* VSN International Limited, UK.
12. GUEVARRA, A.B., WHITNEY, A.S. and THOMPSON, J.R. (1978) Influence of in-row spacing and cutting regimes on the growth and yield of *Leucaena*. *Agronomy Journal,* 70, 1033-1037.
13. HAGGAR, J.P., WARREN, G.P., BEER, J.W. and KASS, D. (1991) Phosphorus availability under alley cropping and mulched and unmulched sole cropping system in Costa Rica. *Plant and Soil*, 137, 275-283.
14. HAQUE, I and JUTZI, S. (1984) Nitrogen fixation by forage legumes in sub-Saharan Africa: potentials and limitations. *ILCA Bulletin,* 20, 2-13.
15. IBRAHIM, M., RAFIQ, M., SULTAN, A., AKRAM, M. and GOHEER, M.A. (2006) Green fodder yield and Quality evaluation of maize and cowpea sown alone and in combination. Journal of Agricultural Research, 44 (1), 15-21.
16. ISARASENEE, A., SHELTON, H.M., JONES, R.M. and BUNCH, G.A. (1984) Accumulation of edible forage of *Leucaena leucocephala* cv. Peru over late summer and autumn for use as dry season feed. *Leucaena Research Reports*, 5, 34.
17. JAIN, V.K., CHAUHAN, Y.S. AND JAIN, P.C. (1996) Effect of different doses of phosphorus on growth, yield and quality of cowpea (*Vigna unguilata* L. Walp). *Madras Agricultural Journal*, 73, 199-202.
18. KHAREL, R., AMATYA, S.M. and BASUKALA, R. (2000) Survival and growth of selected fodder species in Dhading, Kabhre, and Sindhupalchowk districts. *In: Proceedings of the National Workshop on improved strategies for identifying and address fodder deficit in Mid-hills of Nepal, 5-6 September, 2006*. Kathmandu, Nepal: Department of Forest Research and Survey, Ministry of Forest and Soil Conservation.
19. KHATRI-CHHETRI T.B. (1991) Introduction to soils and soil fertility. Rampur, Chitwan, Nepal: Institute of Agriculture and Animal Sciences, pp 28-42.
20. KRISHNA MURTHY, K. and MUNEGOWDA, M.K. (1982) Effect of cutting frequency regimes on the herbage yield of *Leucaena*. *Leucaena Research Reports,* 3, 31-32.
21. Pariyar, D., K.K. Shrestha and R. Pudyal (2013). Package of practice for year round forage production for commercial goat farming in different agro-regions. Proceedings of the National Workshop on Research and Development Strategies for Goat Enterprises in Nepal, 27-28 September, Kathmandu, Nepal (eds. T.B. Gurung, B.R. Joshi, U.M. Singh, K.P. Poudel, B.S. Shrestha, K.P. Rijal and D.R. Khanal). NARC, DLS, HEIFER International, PACT, HIMALI, HVAP, CLDP. Pp. 42-55.
22. RAJASREE, G and PILLAI, G.R. (2001) Performance of fodder legumes under lime and phosphorus

nutrition in summer rice fallows. *Journal of Tropical Agriculture*, 39, 67-70.

23. SHARMA, K. P. (2006) Positive impacts of forage development in milk production. *Forage Development in Nepal: Why and How?,* Pokhara, Kaski, Nepal: Shanti Publication, pp.122-123.
24. SINGH S.B. (2000) Leasehold Forestry and forage development project: innovative livestock and forage training and extension strategies. *In: Proceedings of the Third National Animal Science Convention, Kathmandu, Nepal, August 27-28, 1997*, pp 30-41.
25. SINGH, V. AND TRIVEDI, C.P. (1981) Influence of levels and sources of phosphorus in fodder production. *Madras Agricultural Journal,* 68, 138-140.
26. STUR, W. W., SHELTON, H.M. and GUTTERIDGE, R.C. (1998) Defoliation management of forage tree legumes. Forage Tree Legumes in Tropical Agriculture. In: Gutterdge, R.C. and Shelton, H.M. (eds). *Tropical Grassland Society of Australia Inc.* (Retrieved 10 September, 2009 from http://www.fao.org/ag/AGP/AGPC/doc/publicat/gutt-shel/x5556e0h.htm)
27. Upreti, C.R. and B.K. Shrestha (2006). Feed stuffs and animal production in Nepal. Nutrient Contents of Feeds and Fodder in Nepal. Animal Nutrition Division, Khumaltar, Lalitpur, Nepal, pp 1-5.
28. VAN SOEST, P.J. and ROBERTSON, D.J. and Lewis, B.A. (1991). Methods for dietary fiber, neutral detergent fiber and non-starch polysachharides in relation to animal nutrition. Journal of Dairy Science. 74:3583-3597.
29. Yadav, J.L. and N.R. Devkota. 2005. Feeds and feeding situation of livestock in the Terai region of Nepal. Proceeding of Fourth Meeting of Temperate Asia Pasture and Fodder Network (TAPAFON), Nepal.
30. Younas, M. and M. Yahoob (2005). Feed resources of Livestock in the Panjab, Pakistan. Livestock Research for Rural Development. 17 (2). http://www.lrrd.org/lrrd17/ 2/youn17018.htm