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Seasonal Productivity of Flemingia Macrophylla under Different Defoliation Frequencies

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Abstract- Flemingia macrophylla is introduced and established with the aim of helping to mitigate the dry season fodder deficit in many developing countries. A study was carried out to assess the effect of season and defoliation frequency on the fodder yield and the chemical constituents of F. macrophylla. The experiment was conducted using a Randomized Complete Block Design (RCBD) with 2 2 factorial arrangements of treatments for four-years-old mature stands of F. macrophylla. Dry and wet were the levels of season factor and three months and six months defoliation intervals were the levels of defoliation frequency. Each treatment was replicated for five times. The nutrient contents of fodders were determined using proximate analysis. The results showed that the plants harvested on wet season had higher ($p<0.01$) dried fodder yield than the plants harvested in dry seasons. The plants defoliated in three months interval had yielded higher ($p<0.001$) annual fodder biomass than the plants defoliated in six months interval. Likewise, the fodder harvested in the wet season had better nutrient composition compared to the fodder harvested in dry season. Similarly, the fodder harvested in three months defoliation interval had better nutrient composition than the fodders harvested in six months defoliation. The results revealed that the seasonal variation in dry and wet season yields of F. macrophylla was prominent, and harvesting of the fodder in three months defoliation interval could be the better practice in comparison to defoliation in six months interval in order to produce higher fodder yield with better nutrient composition.

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Abstract- Flemingia macrophylla is introduced and established with the aim of helping to mitigate the dry season fodder deficit in many developing countries. A study was carried out to assess the effect of season and defoliation frequency on the fodder yield and the chemical constituents of F. macrophylla. The experiment was conducted using a Randomized Complete Block Design (RCBD) with 2×2 factorial arrangements of treatments for four-years-old mature stands of F. macrophylla. Dry and wet were the levels of season factor and three months and six months defoliation intervals were the levels of defoliation frequency. Each treatment was replicated for five times. The nutrient contents of fodders were determined using proximate analysis. The results showed that the plants harvested on wet season had higher ($p<0.01$) dried fodder yield than the plants harvested in dry seasons. The plants defoliated in three months interval had yielded higher ($p<0.001$) annual fodder biomass than the plants defoliated in six months interval. Likewise, the fodder harvested in the wet season had better nutrient composition compared to the fodder harvested in dry season. Similarly, the fodder harvested in three months defoliation interval had better nutrient composition than the fodders harvested in six months defoliation. The results revealed that the seasonal variation in dry and wet season yields of F. macrophylla was prominent, and harvesting of the fodder in three months defoliation interval could be the better practice in comparison to defoliation in six months interval in order to produce higher fodder yield with better nutrient composition.

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I. Introduction

Fodder production is the integral part of the ruminant production system. The ruminant animals are more dependent on the forage based system, especially in the developing countries. In this context, cultivation of different species and cultivars of fodders to feed livestock is a common practice. But, fodder deficit, especially in the dry seasons, is one of the major problems in many of the Asian, African and Latin American countries (Egan, 1997; Upreti and Shrestha, 2006; Pariyar et al., 2013). In order to mitigate the fodder deficit situations, many fodder species are being introduced and established with the aim of year round fodder production. Most of the established species and cultivars are more productive in wet seasons but the fodder yield drastically reduced in winter. The yield of the perennial fodder legumes, like other non-leguminous species, is more often influenced substantially by the season and defoliation frequency (Smith, 1992).

Use of shrubs and tree fodders for the sustainability of the year round fodder production is one of the accepted methods of overcoming the problems of dry season fodder deficit (Raynolds, 1995). Flemingiamacrophylla is a multipurpose perennial fodder legume species, especially popular for dry season fodder (Budelman and Siregar, 1997) with excellent coppicing capacity and re-growth after defoliation (Anderson et al., 2002). It is high biomass yielding and higher crude protein containing species of fodder shrubs which improves the soil fertility (Dung et al., 2005). This species had yielded higher fodder biomass with the defoliation interval of three months while compared with two months interval in the previous experiment (Kayastha, 2004). This study was carried out to identify the appropriate defoliation frequency in different seasons for the fodder yield and chemical composition of F. macrophylla aiming to generate suitable defoliation practices.

II. Materials and Methods

The experiment was conducted at the Livestock Farm of Institute of Agriculture and Animal Science, Chitwan, Nepal from July 2008 to June 2009. Geographically, it is located at 27°40' N (latitude) and 84°19' E (longitude) with an altitude of 228 masl. The soil was sandy loam and fairly well drained. The mean soil pH, organic matter, nitrogen, phosphorus and potash contents were 6.17, 2.09 %, 0.14 %, 40.6 kg ha-1 and 146.0 kg ha-1, respectively. Average monthly maximum and minimum temperatures and monthly total rainfall of the experimental duration is presented in Figure (1).

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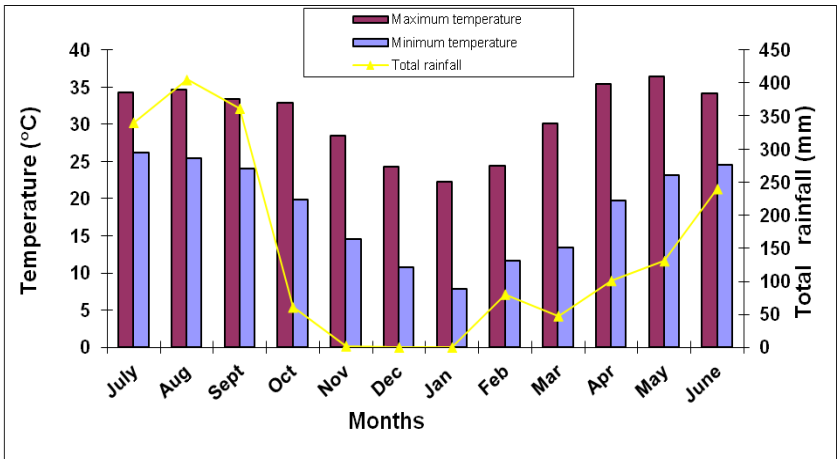

Figure 1 : Mean maximum and minimum temperature and monthly rainfall in different months at Chitwan, Nepal

The experiment was conducted using a Randomized Complete Block Design (RCBD) with 2×2 factorial arrangements. Four treatment combinations of two levels of season (dry and wet) and two levels of defoliation frequency (six months and three months interval) were employed. Each treatment was replicated five times. The experimental plants of four-years-old mature stands of F. macrophylla were used after maintaining the uniform defoliation height of 75 cm and uniform spacing of 90×70 cm. Each experimental plot was of 7.56 m^2 consisting of 12 plants $plot^{-1}$. The number of branches $plant^{-1}$ for different treatments at the beginning of the experiment were also similar (11.32±1.26).

Fresh and dry biomass assessment and sample collection were done at three and six months defoliation interval in both of the seasons. The harvestings were taken twice on wet (June 15 and September 15) and dry season (December 15 and April 15) for three months defoliation interval and once in wet season and once in dry season for six months defoliation interval. Harvesting of fodder was done by defoliating all the experimental plants (12 plants $plot^{-1}$) at 75 cm from the ground level. The leaves with their petioles were detached from the non-edible parts of branches and weighed separately, and the leaf and stem ratio was calculated. The numbers of branches were counted at the defoliation height in every harvesting.

a) Laboratory Analysis

Collected samples of fodders were dried at constant heat in hot air oven at 72°C for 24 hours and dry matter (DM) was estimated. Nitrogen content was determined by Micro Kjheldal method and crude protein (CP) content was calculated (AOAC, 1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined using the method developed by Van Soest et al. (1991).

b) Statistical analysis

The data were analysed by using Analysis of Variance (ANOVA) technique. The statistical analyses were carried out by using GenStat Discovery Edition (2011). Alpha level was set as 0.05

III. Results and Discussion

a) Fodder yield

The effect of season and defoliation frequency was significant on the annual fodder yield of F. macrophylla (Table 1). The number of branch $plant^{-1}$ was similar ($p>0.05$) for both the seasons, dry and wet. Likewise, the effect of defoliation frequency was similar to the number of branch $plant^{-1}$. Branch heights were also similar ($p>0.05$) for the dry and wet seasons. But, the plants defoliated in six months interval had attained taller branch height than the plants defoliated in three months interval. The leaf and stem ratio was better ($p<0.05$) in the wet season compared to dry season. The fodder dry matter yield in the wet season was higher ($p<0.01$) than the yield during dry season (5.93 t ha^{-1} Vs 4.31 t ha^{-1}). Likely, the plants defoliated in three months interval had yielded higher ($p<0.001$) fodder dry matter (6.39 t ha^{-1}) compared to the plants defoliated in six months interval (Table 1).

Table 1: Effect of season and defoliation frequency on the fodder yield and yield attributing characters

Treatments	Number of branch plant^{-1}	Average branch height (cm)	Leaf: stem ratio	Fodder yield (DM, t ha^{-1})
Season				
Dry	13.74	134.3	1.55	4.31
Wet	14.87	141.7	1.91	5.93
SEM	0.86	3.70	0.13	0.43
F-Probability	NS	NS	<0.05	<0.01
Defoliation frequency				
3 months interval	13.75	130.6	2.33	6.39
6 months interval	14.86	145.3	1.19	3.86
SEM	0.86	3.70	0.22	0.43
F-probability	NS	<0.001	<0.001	<0.001

The interaction effects of the season and defoliation frequency on the annual fodder yield has been presented in Table 2. The number of branch was not affected ($p>0.05$) by the season and the defoliation interval, whereas the difference among the branch height was significant ($p<0.01$). The plants defoliated in six months interval had resulted taller branch height in both dry and wet seasons. Higher ($p<0.001$) leaf: stem ratio was obtained from the plants defoliated in wet season with three months interval. It was followed for the treatment of dry season defoliation with three months interval. Highest fodder dry matter yield (7.62 t ha^{-1}) was obtained from the plants defoliated in three months interval at wet season ($p<0.001$), and was followed by the treatment of three months defoliation interval in dry season (5.15 t ha^{-1}). The plants defoliated in the dry season and six months interval had shown lowest fodder yield.

Table 2 : Interaction effects on season and defoliation interval on the fodder yield and yield attributing characters

Treatments	Number of branch (plant^{-1})	Branch height (cm)	Leaf:stem ratio	Fodder yield (DM, t ha^{-1})
Dry season × 3 months interval	12.62	126.0	2.06	5.15
Dry season × 6 months interval	14.86	142.6	1.16	3.47
Wet season × 3 months interval	14.87	135.2	2.95	7.62
Wet season × 6 months interval	14.86	148.1	1.23	4.24
SEM	1.22	5.23	0.38	0.60
F-probability	NS	<0.01	<0.001	P<0.001

b) Nutrient composition

Nutrient compositions of the fodders for different treatments are presented in Table 3. The dry matter content and acid detergent lignin (ADL) content of the fodder were higher in the dry season than in the wet season. But, CP content and calcium (Ca) content were higher in the fodders harvested in the wet season in comparison to the fodders for dry season. Similarly, the effects of defoliation interval was significant ($p<0.05$) in the nutrient composition. The dry matter content was higher for the fodder defoliated in six months interval than in the three months. Likewise, the detergent fractions (NDF, ADF and Lignin) and Ca content were also higher ($p<0.05$) in the fodder defoliated in the six months than in the fodder defoliated in three months interval. But, the CP content was better ($p<0.05$) for the fodder defoliated in three months than in the fodder defoliated in the six months interval. Likewise, P content was also higher ($P<0.001$) in the fodder harvested in three months interval than six months interval.

Table 3 : Nutrient composition of the fodders defoliated in different seasons and intervals, %

Treatments	DM	CP	NDF	ADF	Lignin	Ca	P
Season							
Dry	30.89	16.60	56.46	45.37	32.31	1.38	0.27
Wet	28.61	17.75	54.49	46.75	30.14	1.16	0.28
SEM	0.33	0.21	0.85	0.86	0.65	0.04	0.01
F-Probability	<0.001	<0.001	NS	NS	<0.05	<0.001	NS
Defoliation frequency							
3 months interval	27.37	17.43	54.01	43.91	30.05	1.14	0.29
6 months interval	32.13	16.91	56.94	48.20	32.41	1.39	0.25
SEM	0.33	0.21	0.85	0.86	0.65	0.04	0.01
F-probability	<0.001	<0.05	<0.05	<0.001	<0.05	<0.001	<0.001

The interaction effects of the season and defoliation frequency on the nutrient content of the fodders are presented in Table 4. Dry matter content was similar ($p>0.05$) for all the treatments. Similarly, the detergent fractions, viz. NDF, ADF and Lignin were not also influenced by the treatments ($p>0.05$). The P content were also similar for different treatments ($p>0.05$). But, CP content and Ca content were influenced. The treatments of wet season harvests with three months defoliation interval, the dry season harvests with three months defoliation interval and wet season harvests with three months defoliation interval had yielded higher ($p<0.01$) proportion of CP than the treatment of dry season harvest with six months defoliation interval. Similarly, the fodder having the treatment of dry season harvest with six months defoliation interval had the higher content of Ca ($p<0.05$).

Table 4 : Interaction effect of the season and defoliation frequency on the major nutrient composition of the fodders, %

Treatments	DM	CP	NDF	ADF	Lignin	Ca	P
Dry season × 3 months interval	28.68	17.59	55.28	43.29	30.77	1.19	0.29
Dry season × 6 months interval	33.10	15.92	57.65	47.45	33.86	1.57	0.25
Wet season × 3 months interval	26.06	17.90	52.75	44.54	29.33	1.09	0.30
Wet season × 6 months interval	31.17	17.27	56.23	46.96	30.96	1.22	0.25
SEM	0.46	0.29	1.20	1.22	0.92	0.05	0.01
F-probability	NS	<0.01	NS	NS	NS	<0.05	NS

IV. Discussion

The number of branch was neither affected by the seasons nor by the defoliation frequency in the mature stands of F. macrophylla (Table 1). Branch height was not affected by the season, but influenced by the defoliation frequency. The plants with longer growing period of six months defoliation interval had attained the taller height of the branches. With the similar number of branches and branch heights, the leaf and stem ratio was higher ($p<0.05$) in the wet season. The similar results were obtained for the dried fodder yield. The fodder yield of F. macrophylla was significantly higher ($p<0.01$) in the wet season in comparison to dry season. Comparing the higher biomass yield in wet seasons with climate pattern (Figure 1), higher rainfall and higher temperature could have accelerated the foliage growth rate. These significant influences of the seasons caused the seasonal variations in the yield of F. macrophylla like in other leguminous fodder trees which was also reported by Ivory (1989). The results of this study was in the agreement with the results of another experiment that the monsoon harvest of F. macrophylla was higher than the winter harvest in the similar climatic condition of Nepal (Kayastha, 2004). The winter foliage production of F. macrophylla could be slow due to low temperature and due to decrease in the activity of root nodules bacteria in legumes (Barnes, 1998).

Defoliation frequency did not affect the number of branches, whereas branch height was taller ($p<0.001$) for the plants defoliated in six months interval. The plants defoliated in three months interval had yielded higher leaf and stem ratio which indicated the higher leaf biomass. The dried fodder yield was higher ($p<0.001$) from the plants defoliated in three months interval compared to the plants defoliated in six months interval (Table 1). The appropriate defoliation interval for F. macrophylla was observed to be 3 month. In a previous study, Kayastha (2004) obtained the better fodder yield from the plants defoliated in three months interval compared to the plants defoliated in two months interval in the similar field and climatic conditions.

The branch height, leaf and stem ratio and dried fodder yield was significantly influenced by the interaction effect of seasons and defoliation intervals (Table 2). Although, the branch height was taller for the

plants defoliated on wet season with six months interval and the plants defoliated on dry season with six months interval, the leaf and stem ratio and fodder dry matter yield were better for the plants defoliated on wet season with three months defoliation interval and the plants defoliated on dry season with three months defoliation interval. The results of this study agree with the findings of Asare (1985) that the defoliation interval depends upon the climatic conditions. In the experiment also, F. macrophylla responded better during wet than cool and dry season. The results from another study on Gliricidia and Leucaena had revealed that the foliage growth and retention appeared lower during the dry season, demonstrating the seasonal influence under frequent defoliation (Smith, 1992). The results of this study also support the findings in the case of F. macrophylla.

a) Nutrient composition

The fodder of F. macrophylla harvested in dry season had higher ($p<0.001$) DM and Ca content than in the fodders harvested in wet season, whereas crude protein content was better in wet season (Table 3). The detergent fractions, except lignin, were not affected by the season. The result was in agreement with Smith (1992) that the season of defoliation affects the nutrient composition of the tree and shrub fodders (Smith, 1992). The higher concentration of CP and mineral content is a main feature of the legume browse plants and the concentration of CP in those fodder trees and shrubs is obtained higher even in the dry season when it tends to decrease (Dicko and Sikena, 1992). The fodder of F. macrophylla could be considered a good quality fodder while it content higher CP and mineral even in dry season (16.60% CP, 1.38% Ca and 0.27% P).

Delayed maturity alters certain nutrients composition in the fodder (Kamalak et al., 2005). The dry matter and detergent fractions were increased and CP and P concentration were decreased with the longer defoliation interval (six months). Similar results were obtained in another study on Puerariaphaseoloides that increased detergent fractions and decreased CP due to increased cutting interval (Nguyen Van Hiep et al., 2008). Similarly, increasing the defoliation interval had decreased CP content of the fodder of Leucaenaleucocephala, Gliricidiasepium and Trichanthera gigantean in another experiment (Edwards et al., 2012). Calcium content was also increased in delayed harvests (Table 3). Significant increment of detergent fraction in the fodder defoliated in six months interval, especially lignin content is the indicator of reduced digestibility of the fodders to the animals. The fodder harvested in three months interval was considered better quality due to the significantly higher ($p<0.05$) content of CP and P and lower content of lignin.

V. Conclusion

The perennial leguminous fodder F. macrophylla had shown greater response of seasons and defoliation frequency on the fodder yield and quality. Yield was higher in the wet season and in the shorter defoliation interval of three months. The nutrient compositions were also obtained better for wet season and three months defoliation interval. It is clear that better fodder yield could be obtained in wet season from F. macrophylla three months defoliation interval, although, this perennial fodder legume had shown considerable fodder yield in dry season as well. This fodder species could contribute substantially if used in the year round fodder management packages.

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