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Variation studies in leaf fodder qualities in different clones of *Morus alba*

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Abstract
Variation among mineral nutrient and proximate composition were studied among fifteen selected clones of *Morus alba.* These fifteen clones were selected out of the originally twenty seven clones based on their growth performance over the years in a clonal evaluation trial. The significant differences were found among clones with respect to mineral nutrients like nitrogen (%), phosphorus (%), potassium (%) and proximate composition like dry matter (%), crude protein (%) crude fibre (%), ether extract (%), total ash (%) and nitrogen free extract (%) Tr10, S36, S799 and Mandaley showed higher values. Hence, these clones can be further used for site interaction trials etc and therefore recommending the end users in a particular area.

Keywords: variation, leaf fodder, clones, *Morus alba*

Introduction
The main source of fodder for livestock in India are the residues of agricultural crops, cultivated fodder, weeds, grasses, leaf fodder from trees and shrubs. The leaf fodder available from trees and shrubs roughly constitutes 10 per cent of the total green fodder available in the country (Dwivedi, 1999) [3]. Trees can produce as much green fodder per unit area as agricultural forage crops. Trees do not need such heavy inputs in the form of fertilizers, pesticides, fungicides, labour, etc. as are needed for growing fodder crops. So there is an urgent need to augment the leaf fodder production by planting superior multipurpose fodder trees and one of them is *Morus* species.

The leaves of the multipurpose perennial shrub, mulberry (*Morus* sp), traditionally used for silkworm rearing, is known for its high protein content with good amino acid profile, high digestibility, high mineral content, low fibre content and very good palatability. The high biomass yield of the plant together with its low tannin content (Singh and Makkar, 2000) [19] make it an attractive fodder resource for ruminants particularly, as a supplement to low quality basal diets. There is evidence that mulberry foliage compares favorably to commercial concentrates (Patra *et al*., 2002) [13], whilst maintaining optimum animal performance

White mulberry (*Morus alba*) is a fast-growing, small to medium sized tree which grows 10–20 m tall. It belongs to family Moraceae. It is cultivated in northern India from Jammu and Kashmir to Assam. Mulberry grows on a variety of soils ranging from sandy loam to clay loam but alluvial, deep loamy soil with sufficient moisture supply supports its best growth. Soil texture and depth are the important factors affecting growth.

In order to establish priorities for the conservation and improvement of tree genetic resources understanding of the degree of diversity among and between trees is required. Variations are essential for adaptation and improvement and the amount of variation determines the potential for improving species through breeding programmes. The species (*Morus alba*) offers an opportunity for studying variation among clones and to select superior individuals for further use in clone × site interaction trials etc. Therefore, the study was conducted to determine variation in fodder qualities of *Morus alba* clones.

Materials and Methods
The present studies were carried out in the Department of Tree Improvement and Genetic Resources, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) to evaluate different clones for various leaf mineral nutrients and proximate composition. In total fifteen clones were selected out of the originally twenty seven clones raised in a clonal evaluation trial in the field based on their growth performance over the years (Table 1).

For the estimation of leaf fodder quality; mineral nutrients i.e. nitrogen, phosphorus and potassium and proximate composition viz dry matter, crude protein, crude fibre, ether extract, total ash and nitrogen free extract were estimated. The analysis of leaf mineral nutrient and proximate composition was carried out as per the method recommended by AOAC (1995) [1]. The whole data was analysed statistically as per the method suggested by Panse and Sukhatme, 1967 [12].

Results and Discussion

Variation in fodder quality w.r.t nitrogen (%), phosphorus (%), potassium (%), dry matter (%), crude protein (%), crude fibre (%), ether extract (%), total ash (%) and nitrogen free extract (%) was studied. Analysis of variance revealed significant differences among clones for mineral nutrients i.e. nitrogen, phosphorus and potassium.

Table 1: Details of fifteen selected top clones of *Morus alba*

Sr. No.	Name of clone	Place	State
1	Kanva 2	Panchkula	Haryana
2	S30	Sahaspur	Uttarakhand
3	Phillipino	Sahaspur	Uttarakhand
4	China White	Sahaspur	Uttarakhand
5	K2MS	Sahaspur	Uttarakhand
6	S146	Sahaspur	Uttarakhand
7	S1531	Sahaspur	Uttarakhand
8	S799	Sahaspur	Uttarakhand
9	Mandaley	Sahaspur	Uttarakhand
10	Berhampore	Jammu	Jammu & Kashmir
11	S36	Jammu	Jammu & Kashmir
12	S1307	Jammu	Jammu & Kashmir
13	ME-65	CSGRC, TN	Tamil Nadu
14	Tr10	Sahaspur	Uttarakhand
15	Nauni	Nauni	Himachal Pradesh

The results given in table 2 showed significant difference among the two seasons for nitrogen content. Nitrogen content in rainy season (2.85%) was significantly higher than autumn season (2.29%). With respect to clones, maximum nitrogen content (3.08%) was recorded in clones S36 and Tr10, which was significantly at par with clones S1531 (3.00%), S1307 (3.00%), S146 (2.80%), S30 (2.75%), S799 (2.73%), K2MS (2.67%), ME-65 (2.60%), Kanva 2 (2.57%), Phillipino (2.53%) and Berhampore (2.37%). However, minimum nitrogen content was recorded in the clone Nauni (1.33%).

Table 2: Seasonal variation in leaf nitrogen, phosphorus and potassium content among different clones of *Morus alba*

	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
Clone	Rainy season (July)	Autumn season (October)	Mean	Rainy season (July)	Autumn season (October)	Mean	Rainy season (July)	Autumn season (October)	Mean
Kanva 2	3.50	1.63	2.57	0.21	0.11	0.16	1.60	1.33	1.47
S30	2.87	2.63	2.75	0.22	0.20	0.21	1.66	1.39	1.52
Phillipino	3.00	2.07	2.53	0.23	0.21	0.22	1.61	1.33	1.47
China White	2.20	2.23	2.22	0.26	0.17	0.22	1.14	1.38	1.26
K2MS	2.53	2.80	2.67	0.40	0.14	0.27	1.60	1.45	1.52
S146	4.07	1.53	2.80	0.13	0.15	0.14	1.67	1.47	1.57
S1531	3.37	2.63	3.00	0.21	0.18	0.19	1.71	1.39	1.55
S799	3.13	2.33	2.73	0.22	0.12	0.17	1.64	1.80	1.72
Mandaley	1.97	1.73	1.85	0.23	0.19	0.21	1.66	1.48	1.57
Berhampore	2.80	1.94	2.37	0.24	0.16	0.20	1.64	1.45	1.54
S36	3.13	3.03	3.08	0.18	0.12	0.15	0.93	1.46	1.19
S1307	3.23	2.77	3.00	0.23	0.17	0.20	1.66	1.44	1.55
ME-65	2.33	2.87	2.60	0.22	0.18	0.20	1.72	1.42	1.57
Tr10	3.37	2.80	3.08	0.48	0.22	0.35	1.74	1.60	1.67
Nauni	1.27	1.40	1.33	0.30	0.16	0.23	1.89	0.80	1.34
MEAN	2.85	2.29		0.25	0.17		1.59	1.41	
$CD_{0.05}$	Seasons (S)	0.30			0.02			0.05	
$CD_{0.05}$	Clones (C)	0.83			0.05			0.15	
$CD_{0.05}$	(SXC)	1.17			0.06			0.21	

It is apparent from the result that with respect to interaction effect between seasons and clones, highest nitrogen content (4.07%) was recorded in clone S146 in rainy season which was statistically at par with clones Kanva 2 (3.50%), S1531 (3.37%), Tr10 (3.37%), S1307 (3.23%), S799 (3.13%), S36 (3.13%), Phillipino (3.00%) during July and clone S36 (3.03%) during October. Minimum nitrogen content was recorded in clone Nauni (1.27%) during rainy season.

Phosphorus content in rainy season (0.25%) was significantly higher than autumn season (0.17%).Among clones maximum phosphorus content (0.35%) was recorded in clone Tr10 which was statistically higher than all other clones. However, minimum phosphorus content (0.14%) was recorded in the clone S146 (table 2). With respect to interaction effect between seasons and clones maximum phosphorus content (0.48%) was recorded in clone Tr10 during rainy season which is significantly higher than all other interactions.

Minimum phosphorus content (0.11%) was recorded in the clone Kanva 2 during autumn season.
There was significant difference between two seasons for potassium content. Potassium content in rainy season (1.59%) was significantly higher than autumn season (1.41%). Among clones maximum potassium content (1.72%) was recorded in clone S799, which was statistically at par with clone Tr10 (1.67%). While, minimum potassium content (1.19%) was recorded in the clone S36 (table 2). With respect to interaction effect between seasons and clones maximum potassium content (1.89%) was recorded in clone Nauni during rainy season, which was significantly at par with clone S799 (1.80%) during October, clones Tr10 (1.74%), ME-65 (1.72%) and S1531 (1.71%) during July. Minimum potassium content was recorded in clone S36 (0.80%) during autumn.
Mineral nutrient content i.e. nitrogen, phosphorus and potassium decreased with the progress of season. The results are in accordance with the finding of Bari and Quader (2000) [2] who reported better nutritional values of *Morus alba* during June than other seasons. Manga and Sen (2001) also reported nitrogen content 2.8 to 3.6 per cent, potassium content 0.646-1.573 per cent and phosphorus content from 0.260-0.346 per cent for a fodder tree species *Prosopis cineraria.* Jain *et al.* (2002) [5] reported that leaf nitrogen varied from 1.35-2.47 percent, phosphorus 0.08-0.15 per cent and potassium 0.17-0.69 per cent for another fodder species viz. *Azadirachta indica*. Satpal *et al.* (2004) [16] reported that with the increase in leaf age there was decrease in nitrogen, phosphorus and potassium content. Nooruldin *et al.* (2015b) [11] revealed that nitrogen, phosphorus and potassium contents in leaf decreased with the advancement of age. Murthy *et al.* (2013b) [9] and Kumar *et al.* (2018) [6] concluded that total proteins, total sugars and amino acids were high in tender leaves followed by medium and coarse leaves.

Proximate composition

Analysis of variance revealed significant differences for proximate composition viz; dry matter content, crude protein, crude fibre, ether extract, total ash and nitrogen free extract.
The results given in table 3 revealed significant difference for per cent dry matter content between both the seasons. Dry matter content in autumn i.e, October (78.18%) was significantly higher than rainy season (74.41%). With respect to clones, maximum dry matter content (80.72%) was recorded in the Tr10, which was significantly higher than all other clones. However, minimum dry matter content was recorded for the clone S30 (74.32%).It is apparent from the results that with respect to interaction effect between seasons and clones, maximum dry matter content were recorded for clone Tr10 during autumn (82.27%), which was significantly higher than all other interactions. Minimum dry matter content (70.43%) was recorded in the clone S799 during rainy season (table 3).

Table 3: Seasonal variation in leaf dry matter content among different clones of *Morus alba*

	Dry matter (%)			Crude protein (%)			Crude fibre (%)		
Clone	**Rainy Season (July)**	**Autumn Season (October)**	**Mean**	**Rainy Season (July)**	**Autumn Season (October)**	**Mean**	**Rainy Season (July)**	**Autumn Season (October)**	**Mean**
Kanva 2	73.87	78.83	76.35	21.88	10.21	16.05	9.17	14.37	11.77
S30	72.13	76.50	74.32	17.92	16.46	17.19	10.80	14.57	12.68
Phillipino	70.77	78.57	74.67	18.75	12.92	15.84	11.50	15.00	13.25
China White	74.27	75.37	74.82	13.75	13.96	13.86	10.77	14.80	12.78
K2MS	74.13	80.13	77.13	15.84	17.50	16.67	11.30	14.50	12.90
S146	77.97	79.27	78.62	25.42	9.59	17.50	11.27	14.90	13.08
S1531	73.60	78.07	75.83	21.04	16.46	18.75	10.77	14.60	12.68
S799	70.43	78.53	74.48	19.59	14.59	17.09	11.67	15.20	13.43
Mandaley	75.60	77.63	76.62	12.30	10.84	11.57	11.93	15.07	13.50
Berhampore	74.87	77.50	76.18	17.50	12.13	14.82	11.70	15.10	13.40
S36	73.70	79.07	76.38	19.59	18.96	19.27	9.33	15.17	12.25
S1307	74.87	74.13	74.50	20.21	17.30	18.76	11.67	15.00	13.33
ME-65	74.07	78.33	76.20	14.59	17.92	16.25	11.43	14.90	13.17
Tr10	79.17	82.27	80.72	21.04	17.50	19.27	11.63	15.37	13.50
Nauni	76.67	78.47	77.57	7.92	8.75	8.34	11.57	12.87	12.22
MEAN	74.41	78.18		17.82	14.34		11.10	14.66	
$CD_{0.05}$	Seasons (S)	0.45			1.89			0.33	
$CD_{0.05}$	Clones (C)	1.22			5.18			0.91	
$CD_{0.05}$	(SXC)	1.72			7.33			1.29	

Appraisal of the results presented in Table 3 elucidated significant difference in per cent crude protein content between two seasons. Crude protein content in rainy season (17.82%) was found significantly higher than autumn (14.34%). Among clones maximum crude protein content (19.27%) was recorded in the clones S36 and Tr10, which was statistically at par with clones S1307 (18.76%), S1531 (18.75%), S146 (17.50%), S30 (17.19%), S799 (17.09%), K2MS (16.67%), ME-65 (16.25%), Kanva 2 (16.05%), Phillipino (15.84%) and Berhampore (14.82%), however minimum nitrogen was recorded in the clone Nauni (8.34%).It is apparent from the result that with respect to interaction effect between seasons and clones, highest nitrogen content (25.42%) was recorded in clone S146 in rainy season which was statistically at par with clones Kanva 2 (21.88%), S1531 (21.04%), Tr10 (21.04%), S1307 (20.21%), S799 (19.59%), S36 (19.59%), Phillipino (18.75%) during July and clone S36 (18.96%) during October. Minimum crude protein content was recorded in clone Nauni (7.92%) during rainy season (table 3).
Results showed significant difference among the two seasons for crude fibre content. Crude fibre content in autumn season (14.66%) was significantly higher than rainy season (11.10%). With respect to clones, maximum crude fibre content (13.50%) was recorded in clones Mandaley and Tr10 which was significantly at par with S799 (13.43%), Berhampore (13.40%), S1307 (13.33%), Phillipino (13.25%), ME-65 (13.17%), S146 (13.08%), K2MS (12.90%), China

White (12.78%), S30 (12.68%) and S1531 (12.68%). Minimum crude fibre content was recorded in the clone Kanva 2 (11.77%).

It is apparent from the results that with respect to interaction effect between seasons and clones highest crude fibre content (15.37%) was recorded in clone Tr10 during autumn season which was statistically at par with clones S799 (15.20%), S36 (15.17%), Berhampore (15.10%), Madaley (15.07%), Phillipino (15.00%), S1307 (15.00%), S146 (14.90%), ME-65 (14.90%), China White (14.80%), S1531 (14.60%), S30 (14.57%), K2MS (14.50%) and Kanva 2 (14.37%) during autumn season. Minimum crude fibre content was recorded in clone Kanva 2 (9.17) during rainy season (table 3).

The results pertaining to per cent ether extract content has been depicted in Table 4 An examination of the result revealed that ether extract content in autumn season (9.83%) was significantly higher than rainy season (6.90%). Among clones, maximum ether extract content (9.60%) was recorded in clone Tr10 which was statistically at par with the clones Mandaley (9.02%), ME-65 (8.68%) and Nauni (8.92%). However, minimum ether extract content (6.47%) was recorded in the clone Kanva 2. With respect to interaction effect between seasons and clones, maximum ether extract content (12.10%) was recorded in clone Tr10 during autumn which was significantly at par with clones Mandaley (10.77%) and Nauni (10.60%) during autumn. Minimum ether extract content (5.47%) was recorded in the clone S36 during rainy season.

The results given in table 4 revealed significant difference for per cent total ash content between both the seasons. Total ash content in autumn (15.71%) was significantly higher than rainy season (12.75%). With respect to clones maximum total ash content (15.45%) was recorded in the clone Nauni which was significantly higher than all other clones. However, minimum total ash content was recorded for the clone Kanva 2 (11.73%).It is apparent from the results that with respect to interaction effect between seasons and clones maximum total ash content were recorded for clone Tr10 during autumn (16.77%), which was significantly higher than all other interactions. However, minimum total ash content (9.73%) was recorded in the clone S146 during rainy season.

The results given in table 4 revealed that there were significant differences among both the seasons for nitrogen free extract. Nitrogen free extract in rainy season (51.44%) was significantly higher than autumn season (45.37%).With respect to clones maximum nitrogen free extract was recorded in clone Nauni (55.09%) which was statistically at par with the clones Kanva 2 (54.00%), Mandaley (51.76%) and China white (50.52%). Minimum nitrogen free extract (42.83%) was observed in Tr10. It is apparent from the results that with respect to interaction effect between seasons and clones maximum nitrogen free extract was recorded in the clone Nauni (58.52%) during rainy season which was statistically at par with the clones Kanva 2 (56.36%) during October, Mandaley (55.68%), China white (55.35%), ME-65 (54.25%), K2MS (53.77%), S36 (51.92%), Kanva 2 (51.63%), and S30 (51.35%) during July. However, minimum nitrogen free extract (38.27%) was observed in the clone Tr10 during autumn season.

Table 4: Seasonal variation in leaf ether extract, total ash and nitrogen free extract among different clones of *Morus alba*

	Ether extract (%)			**Total ash (%)**			**Nitrogen free extract (%)**		
clone	**Rainy season (July)**	**Autumn season (October)**	**Mean**	**Rainy season (July)**	**Autumn season (October)**	**Mean**	**Rainy season (July)**	**Autumn season (October)**	**Mean**
Kanva 2	6.60	6.33	6.47	10.73	12.73	11.73	51.63	56.36	54.00
S30	7.40	9.50	8.45	12.53	15.50	14.02	51.35	43.98	47.32
Phillipino	7.47	9.47	8.47	12.73	15.53	14.13	49.55	47.09	48.32
China White	6.83	9.50	8.17	13.30	16.07	14.68	55.35	45.68	50.52
K2MS	6.63	9.87	8.25	12.47	15.73	14.10	53.77	42.40	48.09
S146	6.97	9.77	8.37	9.73	15.97	12.85	46.62	49.79	48.20
S1531	6.77	9.27	8.02	12.97	15.90	14.43	48.46	43.78	46.12
S799	7.13	9.73	8.43	13.10	15.63	14.37	48.52	44.85	46.69
Mandaley	7.27	10.77	9.02	12.83	15.50	14.17	55.68	47.84	51.76
Berhampore	6.87	10.27	8.57	13.33	15.83	14.58	50.60	46.68	48.64
S36	5.47	10.30	7.88	13.70	15.83	14.67	51.92	39.75	45.83
S1307	6.77	9.60	8.18	13.40	16.03	14.62	47.96	42.08	45.02
ME-65	6.93	10.43	8.68	12.80	16.43	14.62	54.25	40.32	47.29
Tr10	7.10	12.10	9.60	12.83	16.77	14.80	47.39	38.27	42.83
Nauni	7.23	10.60	8.92	14.67	16.13	15.45	58.52	51.65	55.09
MEAN	6.90	9.83		12.75	15.71		51.44	45.37	
$CD_{0.05}$	Seasons (S)	0.37			0.26			1.84	
$CD_{0.05}$	Clones (C)	1.01			0.72			5.05	
$CD_{0.05}$	(SXC)	1.43			1.02			7.14	

Proximate composition increased with the progress of season except crude protein and nitrogen free extract content. The results of the present investigation are supported by similar findings reported by Manga and Sen (2000) [7] for crude protein content 18.02-22.17 for fodder species *Prosopis cineraria.* Elseed *et al.* (2002) [4] reported significant reduction in crude protein in dry season. Sharma and Sharma (2006) [17] recorded range of crude protein content and ash content as 10.4-18.4 per cent and 6.5-18.8 per cent, respectively in leaf samples of fifteen fodder trees including *Morus alba*. Singh and Todaria (2012) [20] reported that dry matter and total ash content significantly decreased in July as compared to other months. Also crude protein and phosphorus contents significantly increased in July and finally declined in late maturation of October. Ether extract decreased after growing season (July) but increased in late maturity (October). Murthy *et al.* (2013b) [9] and Kumar *et al.* (2018) [6] revealed that total proteins, total sugars and amino acids were high in tender leaves followed by medium and coarse leaves. Mayouf and Arbouche (2015) [8] reported that crude protein content differed significantly among the seasons and was higher in the wet season compared to dry season. Rather *et al.*

(2017) [14] concluded that there is a decrease in crude protein, nitrogen free extract and total organic matters with the maturity of leaves whereas, a reverse trend was found for dry matter, crude fibre, ether extract and total ash during a fodder analysis. Nabi *et al.* (2018) [10] reported that the crude protein content decreased, while crude fibre, ether extract and ash content increased with successive seasons among different fodder species. Saddul *et al*. 2004 [15] also reported that the optimum stage to harvest the whole plant is 5 weeks, which is a compromise between yield, nutrient composition (CP and fibre components), and the annual number of cuts, with good crop persistence to repeated harvests. Fresh mulberry whole plant can provide a valuable supplemental source of nutrients to poor quality basal diets.

Conclusion

Based on leaf mineral nutrient and proximate composition values clones Tr10, S36, S799 and Mandaley were found to be better as compared to other clones. Therefore, these clones can be further used in site × clone interaction trials as different locations.

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