Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(4): 1265-1270
Received: 10-05-2019
Accepted: 12-06-2019

HP Sankhyan
Principal Scientist /Professor (Forestry), Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. Y.S Parmar University of Horticulture and Forestry, Nauni-Solan, Himachal Pradesh, India

Shikha Bhagta
Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. Y.S Parmar University of Horticulture and Forestry, Nauni-Solan, Himachal Pradesh, India

Sanjeev Thakur
Professor, Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. Y.S Parmar University of Horticulture and Forestry, Nauni-Solan, Himachal Pradesh, India

Correspondence
HP Sankhyan
Principal Scientist /Professor (Forestry), Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. Y.S Parmar University of Horticulture and Forestry, Nauni-Solan, Himachal Pradesh, India

Evaluation of the half sib progenies to identify prepotency of the mother clones of *Grewia optiva* Drummond

HP Sankhyan, Shikha Bhagta and Sanjeev Thakur

Abstract
Forty half sib progenies of *Grewia optiva* Drummond were evaluated for morphometric and fodder quality traits. The analysis of variance indicated highly significant differences among the various half sib families for all the traits. The experimental results revealed that out of 40 families, ten families viz., SI-15, SO-3,HA-2,HA-3,HA-4,SO-7,SH-7,SO-4,SI-6 and SI-14 were found superior on the basis of overall mean performance for all quantitative and qualitative traits under study. Hence, these half sib families can be used in further breeding programme.

Keywords: Half sib families, *Grewia optiva*, morphometric, fodder quality traits

Introduction
Livestock plays an important role in mountain farming systems and Himachal Pradesh is one of the important livestock rearing states in India. In this state, mixed agricultural production system is practiced by the farmers with both crop and livestock husbandry as the important components. Availability of nutritious fodder is the biggest constraint in animal husbandry in this state. Except for rainy season (July to September), there is scarcity of fodder throughout the year. In hilly and mountain regions, the demand of feeds and fodder for livestock is much higher than their availability (Singh and Bimal, 2004) [13]. *Grewia optiva* is one of the most important tree species used as fodder in Himachal Pradesh (Singh, 2005) [12]. It belongs to family Tiliaceae and naturally distributed in India, Bhutan, Nepal and Pakistan. In India it is distributed in areas of Himachal Pradesh, Jammu and Kashmir, Punjab, Sikkim and Uttar Pradesh (Hooker, 1875) [7]. Several species of *Grewia* are used as a very important multipurpose or agro forestry tree of which *Grewia optiva*, commonly known as 'Beul' and very popular agroforestry tree which is grown in low and mid-hills regions in the western and central Himalaya on account of its utility as fodder, fuel and fiber (Coleman, 1982) [4]. This variation, can be utilized for breeding purposes for some useful traits like fodder value, growth rate and for conservation of species. With the increase in demand for fodder, there is a need to develop clones of genetically superior trees. Therefore, it is essential to understand the genetic architecture of *Grewia optiva*, which provides useful guidelines to determine the source population and from which it is possible to derive appropriate genotypes with desired characters. Therefore, evaluating locally adopted beul families for commercial cultivation is priority area of research in improving the fodder quality.

Materials and Methods
The present investigation has been carried out in the Experimental Research Farm and Laboratory of the Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. YS Parmar University of Horticulture and Forestry, Nauni-Solan (Himachal Pradesh). A seedling seed orchard of *Grewia optiva* Drummond has been established in July 2000, which consists of 60 families each under three replications at spacing of 2mx2m. These different families have been sourced from various districts of Himachal Pradesh which include Sirmour, Solan, Chamba, Bilaspur, Mandi, Hamirpur and Kangra (Table- 1). For the present study, only 40 families are selected and were evaluated for various morphometric and fodder quality parameters and recorded observations on various morphometric parameters viz., plant height (m), plant diameter (cm), number of leaves, leaf area (cm2), leaf fresh weight (g), leaf dry weight (g), leaf dry matter content(%), fodder yield (kg), total fresh leaf biomass (g) and fodder quality parameters of families viz., ether extract (%), crude fibre (%), crude protein (%), total ash (%) and nitrogen free extract (%). Data has been analyzed statistically as per the

method suggested by (Panse and Sukhatme, 1967) [9]. The table for analysis of variance (ANOVA) was set as explained (Gomez, 1984) [6].

Results and Discussion

The analysis of variance indicated highly significant differences among the families for all the morphometric traits and fodder quality traits studied, which revealed the existence of good deal of variability in the seedling seed orchard of *Grewia optiva*. The mean performance of all the families (Table- 2–3), general mean value, range and coefficient of variance (Table-4 - 5) for various traits under study is described below:

Morphometric parameters

Significant variations were obtained among all the families for plant height (Table-2). Plant height ranged from 4.67-9.20 m (Table -4). General mean for the character was 7.04m. Family SO-I show highest plant height and it was found statistically at par with seven other families viz., BI-3, HA-2, SH-2, SI-7, SI-10, SO-I, SO-7 and SO-12. Plant diameter ranged from 9.94-16.19 cm with general mean value of 12.16 cm. Family HA-4 recorded maximum diameter and found statically at par with nine families viz., BI-4, CH-4, HA-2, HA-4, SH-2, SI-7, SI-10, SO-1 and SO-12. Family SI-4 showed minimum value for diameter. Number of leaves is a major yield contributing trait in *Grewia optiva*. All the families studies revealed significant variations for this character. It ranged from 3634.3 -1687.6. Family with mean value of 2718.95. Maximum number of leaves per plant was observed in family SH-3 and it was statistically at par with 12 other families viz., CH-4, CH-6, HA-2, KA-3, SH-3, SH-7, SI-4, SI-6, SI-10, SI-15 and SO-7. Minimum number of leaves per plant was observed in BI-I. A perusal of data (Table -2) revealed that the differences in leaf area were significant among the different families. It ranged from 77.22-40.84. General mean for the character was 58.25 (Table -4). Family SH-7 recorded the maximum leaf area of while the minimum leaf area was recorded in BI-1. Families CH-I, HA-3, HA-4, MA-2, SH-7, SI-10, SI-15, SO-3, SO-4 and SO-7 were at par with the maximum. Fresh weight of 100 leaves (g) ranged from 48.16-87.00 in families SO-4 and BI-3 respectively. General mean for the character was 64.57. Families CH-I, HA-3, HA-4, MA-2, SH-7, SI-10, SI-15, SO-3, SO-4 and SO-7 were statistically at par with the maximum. Dry weight of 100 leaves (g) ranged from 25.16-50.33 (g). General mean of 33.71 was recorded for this character. Maximum dry weight of 100 leaves was recorded in HA-3 and it was found statistically at par with CH-I, HA-3, HA-4, MA-2, SH-7, SI-10,SI-15, SO-3, SO-4 and SO-7. Minimum dry weight of 100 leaves is recorded for family BI-3. Appraisal of the data Table 2 elucidated that SO-8 attained the maximum (55.56%) leaf dry matter content. HA-3 showed the lowest leaf dry matter content (41.22%). General mean for the character was 48.22%. General mean for the character was 48.19 per cent (Table- 4). Appraisal of the data presented in (Table- 2) elucidated that HA-3 attained the maximum fodder yield (13.81 kg) followed by SO-3, SO-9, SO-4 and SO-7 and SI-15 respectively. Minimum (8.84) was observed for family BI-1. As clearly indicated in (Table -2), total fresh leaf biomass (g) exhibited significant differences among families. Maximum total fresh leaf biomass was observed in family SH-7 (3024.97 g), whereas the minimum was recorded in family BI-1 (893.36g). Family SI-15 and SO-7 found statically at par with maximum. General mean was 1770.81 g for the character. Wide range of variation for different morphometric traits recorded by (Sehgal and Jaswal, 1996) [14] (Rathore, 1997) [11] in *Grewia optiva* (Bhat, 1999) [1] in *Albizia lebbek* and (Choudhary, 2000) [3] in *Toona ciliata*, (Pant *et al*., 2003) [8] in *Grewia optiva*; (Wani *et al*., 2009) [17] in *Bauhinia variegata*, (Sankhyan *et al*., 2009) [15] in *Grewia laevigata*. Similar variations were reported with respect to leaf dimensions and leaf area by (Wani *et al*., 2009) [17] in *Bauhinia variegata*, (Sankhyan *et al.,* 2009) [15] in *Grewia laevigata*, (Bhagta, 2015) [2] in *Grewia optiva* and (Sankhyan, *et al.,* 2016) [16] in *Grewia optiva* lend support to the present findings.

Fodder quality parameters

Crude protein is one of the most important constituents of fodder quality particularly for the growing demand of meat producing animals, as it contains the muscle building fraction of the diet. It is generally used as an index of nutritive value. Among 40 families crude protein ranged from 18.09-22.11 per cent (Table -5). The maximum of crude protein (22.10%) was observed in family HA-2 and the minimum in family MA-2 Table 3. Followed by family CH-3, HA-2, SI-11, SI-14, SI-16, SO-3, SO-8, SO-9 and So- 10. The crude fibre was observed in family HA-2 (21.84%) whereas the minimum was recorded in family SI-11 (18.58%). Thirteen families viz., CH-I, CH-3, HA-2, HA-4, SH-7, SI-3, SI-7, SI-14, SI-15, SO-I, SO-4, SO-7 and So-10 found statically at par with maximum. General mean was 20.52 for crude fibre in (Table -5) and Fig 1 and Fig2. Highest value of ether extract content was recorded for family MA-3(5.88%) which was closely followed by CH-I, CH-3, CH-6, HA-3, KA-3, MA-3,SI-15, SI-16, SO_1, SO-2, SO-3 and SO-7. However, lowest value was recorded for family SH-3 (8,80%). General mean was 5.34 for the character. Total ash ranged from 13.13-10.7 per cent. General mean for this trait was 11.96. Eighteen families recorded higher total ash content than population mean. Maximum (13.13 %) total ash content was recorded in family SO-12 and was statistically at par with families CH-I, HA-2, SI-11, SI-14, SI-16 and SO-12. Significant differences were observed with respect to nitrogen free extract (%) in all the families studied. It ranged from 38.37-44.25 per cent. General mean for the character was 41.18. maximum nitrogen free extract (44.25 %) was observed in family HA-3 whereas minimum (28.37 %) was noticed in family SH-7. Presence of tremendous genetic variation was also reported by (Kaushal, 1978) [10] in proximate principles and mineral nutrients in *Grewia optiva*; (Gera *et al.,* 2002) [5] in *Dalbergia sissoo*; (Wani *et al.,* 2009) [17] in *Bauhinia variegata* and (Sankhyan *et al.,* 2009) [15] in *Grewia laevigata*, (Bhagta, 2015) [15] and (Sankhyan *et al.,* 2016) [16] in *Grewia optiva* lend support to the present findings.

Table 1: Families under study established open pollinated seedling seed orchard of *Grewia optiva*.

sr. No.	District	Location	Unique identifier for accession	sr. No.	District	Location	Unique identifier for accession
1.	Bilaspur	Bilaspur	UHF-TIGR- BI-1	21.	Sirmour	Dilman	UHF - TIGR- SI-4
2.	Bilaspur	Auhar	UHF - TIGR- BI-3	22.	Sirmour	Deyoltikkeri	UHF - TIGR- SI-5
3.	Bilaspur	Kuthira	UHF - TIGR- BI-4	23.	Sirmour	Kalaghat	UHF - TIGR- SI-6
4.	Chamba	Chanad	UHF - TIGR- CH-1	24.	Sirmour	Nandel	UHF - TIGR- SI-7
5.	Chamba	Balu	UHF - TIGR- CH-3	25.	Sirmour	Seenaghat	UHF - TIGR- SI-10
6.	Chamba	Audhpur	UHF - TIGR- CH-4	26.	Sirmour	Adgu	UHF - TIGR- SI--11
7.	Chamba	Saru	UHF - TIGR- CH-6	27.	Sirmour	Sarpadol	UHF - TIGR- SI-13
8.	Hamirpur	Patta Balakhar	UHF - TIGR- HA-2	28.	Sirmour	Saraha Chakli	UHF TIGR- SI-14
9.	Hamirpur	Bassi	UHF - TIGR- HA-3	29.	Sirmour	Madhobag	UHF - TIGR- SI-15
10.	Hamirpur	Hamirpur Kanal	UHF - TIGR- HA-4	30.	Sirmour	Nainatikker	UHF - TIGR- SI-16
11.	Hamirpur	Ghahar	UHF - TIGR- HA-5	31.	Solan	Gaura	UHF - TIGR- SO-1
12.	Kangra	Dharamshala	UHF - TIGR- KA-1	32.	Solan	Nauni	UHF - TIGR- SO-2
13.	Kangra	Bhalun	UHF - TIGR- KA-2	33.	Solan	Dharja	UHF - TIGR- SO-3
14.	Kangra	Varal	UHF - TIGR- KA-3	34.	Solan	Deog	UHF - TIGR- SO-4
15.	Mandi	Bachhwan	UHF - TIGR- MA-2	35.	Solan	Badhlech	UHF - TIGR- SO-5
16.	Mandi	Bambla	UHF - TIGR- MA-3	36.	Solan	Oyali	UHF - TIGR- SO-7
17.	Shimla	Ninmun	UHF - TIGR- SH-2	37.	Solan	Kailar	UHF - TIGR- SO-8
18.	Shimla	Jeury	UHF - TIGR- SH-3	38.	Solan	Deothi	UHF - TIGR- SO-9
19.	Shimla	Taradevi	UHF - TIGR- SH-7	39.	Solan	Jaunaji	UHF - TIGR- SO-10
20.	Sirmour	Deothal	UHF - TIGR- SI-3	40.	Solan	Kasholi	UHF - TIGR- SO-12

Table 2: Evaluation of Half sib Progenies of *Grewia optiva* for Morphometric traits

Sr. No.	Family	Height (m)	Diameter (cm)	Leaf area (cm^2)	Estimated number of leaves	Fresh weight of 100 leaves (g)	Dry weight of 100 leaves (g)	Leaf dry matter content (%)	Fodder yield (Kg)	Total fresh leaf biomass (g)
1	BI -1	7.00	11.57	40.84	1687.7	52.90	27.33	48.38	8.84	893.36
2	BI-3	8.00	11.38	52.44	2231.0	48.17	25.16	47.10	10.29	1074.60
3	BI-4	6.33	13.90	48.43	1989.3	49.07	25.33	48.24	10.33	976.10
4	CH-1	5.67	11.31	68.85	2267.7	76.50	43.83	42.69	10.49	1734.77
5	CH-3	7.47	12.01	56.92	2660.7	65.33	36.67	43.83	11.85	1738.30
6	CH-4	7.17	14.28	45.29	3351.7	52.84	27.67	47.61	9.58	1771.02
7	CH-6	6.33	10.22	63.57	3016.3	59.02	28.67	51.37	9.61	1780.24
8	HA-2	9.10	14.39	65.89	3050.7	73.47	27.50	50.68	9.98	1698.20
9	HA-3	7.00	11.47	75.30	2738.3	86.17	50.33	41.46	13.81	2359.53
10	HA-4	7.50	16.19	73.85	3123.0	77.17	43.17	43.88	12.42	2409.92
11	HA-5	6.50	10.32	48.57	2332.0	53.17	27.17	48.60	8.99	1239.85
12	KA-1	6.67	11.00	53.51	2559.3	62.43	32.17	47.90	10.27	1597.88
13	KA-2	6.83	11.34	57.93	2514.7	64.33	31.67	50.71	10.27	1617.77
14	KA-3	6.67	11.85	56.33	3187.7	61.33	30.83	49.60	9.94	1955.10
15	MA-2	6.67	11.82	66.20	2721.7	72.17	38.83	46.98	11.40	1964.14
16	MA-3	6.00	10.51	55.54	2807.3	62.50	33.83	46.76	10.81	1754.58
17	SH-2	7.53	14.79	59.12	2423.3	56.33	27.17	51.44	9.69	1365.14
18	SH-3	7.50	11.50	55.61	3634.3	70.00	39.83	42.86	11.66	2544.03
19	SH-7	7.50	11.53	77.22	3521.0	86.17	48.50	43.84	13.10	3024.97
20	SI-3	7.17	10.91	48.93	2366.0	54.50	26.83	50.83	10.05	1289.47
21	SI-4	5.84	9.94	51.97	2920.7	61.17	30.17	50.31	10.75	1786.47
22	SI-5	4.67	10.60	60.89	2760.0	61.50	28.83	53.19	10.36	
23	SI-6	7.17	11.45	58.95	3320.3	70.83	32.83	53.71	11.39	
24	SI-7	8.67	13.78	62.87	2793.0	71.50	39.00	46.02	12.35	1997.00
25	SI-10	8.63	13.87	65.29	2902.0	78.17	42.67	45.81	13.32	2268.40
26	SI-11	7.00	11.61	53.93	2470.3	59.33	32.50	45.00	10.87	1465.73
27	SI-13	7.50	12.24	59.88	2092.7	65.83	34.83	47.08	11.60	1377.67
28	SI-14	7.50	12.95	62.96	2509.7	68.33	34.67	49.17	12.46	1714.94
29	SI-15	7.17	12.40	66.00	3623.7	73.77	39.67	46.38	13.39	2673.06
30	SI-16	6.83	11.80	47.19	2810.3	49.00	25.50	47.76	9.41	1377.06
31	SO-1	9.20	13.45	49.51	3094.0	54.40	28.67	46.88	11.19	1683.14
32	SO-2	7.17	11.66	48.55	2535.3	64.10	31.67	50.60	11.11	1625.15
33	SO-3	6.17	12.49	66.35	2426.7	77.33	41.33	47.01	13.74	1876.62
34	SO-4	6.67	11.31	75.93	2392.0	87.00	46.00	47.46	13.45	2081.04
35	SO-5	6.00	10.35	50.22	2808.3	56.53	26.17	53.73	13.74	1587.64
36	SO-7	7.83	12.80	69.23	3402.3	77.43	41.83	46.50	13.45	2634.54
37	SO-8	6.50	12.87	53.79	2728.0	57.52	25.83	55.56	10.02	1569.15
38	SO-9	6.50	12.17	56.41	2254.0	66.05	34.83	47.60	13.50	1488.84
39	SO-10	6.00	10.72	56.34	2309.0	62.33	31.50	50.06	9.56	1439.28
40	SO-12	8.17	15.75	53.78	2422.0	55.00	27.47	50.07	10.94	1332.10
C.D.(0.05)		1.67	3.10	12.14	743.98	15.30	10.27	4.95	2.40	373.46

Contd…

Table 3: Evaluation of half sib progenies for fodder quality traits of *Grewia optiva*.

Sr. No.	Family code	Ether Extract (%)	Crude fibre (%)	Crude protein (%)	Total ash (%)	NFE (%)
1	BI -1	4.85	20.54	20.46	12.09	42.06
2	BI-3	5.56	20.18	20.60	12.31	41.35
3	BI-4	5.06	20.52	20.65	12.14	41.63
4	CH-1	5.62	21.81	20.56	13.09	38.92
5	CH-3	5.82	21.40	21.97	11.84	38.97
6	CH-4	4.83	20.86	19.85	11.92	42.54
7	CH-6	5.72	18.73	21.63	12.37	41.55
8	HA-2	4.87	21.84	22.11	11.34	39.84
9	HA-3	5.80	19.30	18.85	11.80	44.25
10	HA-4	5.55	21.68	21.03	12.85	38.89
11	HA-5	5.30	19.24	19.57	12.46	43.43
12	KA-1	4.96	20.92	19.53	12.17	42.42
13	KA-2	5.04	20.17	19.84	10.93	44.02
14	KA-3	5.71	19.68	20.31	12.55	41.75
15	MA-2	5.51	20.96	18.09	13.03	42.41
16	MA-3	5.88	19.73	19.93	12.66	41.80
17	SH-2	5.26	19.30	18.98	12.69	43.77
18	SH-3	4.65	19.29	20.03	12.95	43.08
19	SH-7	5.10	21.43	19.84	15.26	38.37
20	SI-3	5.20	21.33	19.98	12.66	40.83
21	SI-4	5.62	18.78	21.59	11.96	42.05
22	SI-5	5.35	21.00	21.47	11.38	40.80
23	SI-6	5.56	18.87	21.64	11.83	42.10
24	SI-7	5.10	21.32	20.66	11.85	41.07
25	SI-10	5.31	20.31	21.58	11.95	40.85
26	SI-11	5.54	18.59	21.73	11.90	42.24
27	SI-13	5.25	19.44	19.69	12.82	42.80
28	SI-14	4.97	21.44	21.67	10.74	41.18
29	SI-15	5.84	21.64	21.57	10.84	40.11
30	SI-16	5.86	21.07	21.64	11.49	39.94
31	SO-1	5.77	21.35	21.30	11.76	39.82
32	SO-2	5.71	19.77	20.57	10.82	43.13
33	SO-3	5.78	19.84	21.89	11.47	41.02
34	SO-4	5.08	21.65	21.07	10.90	41.30
35	SO-5	5.21	21.23	20.57	12.23	40.76
36	SO-7	5.81	21.34	21.46	11.43	39.96
37	SO-8	4.90	21.13	21.74	11.35	40.88
38	SO-9	4.82	20.72	21.71	11.25	41.50
39	SO-10	4.84	21.76	21.86	11.72	39.82
40	SO-12	5.25	20.86	20.68	13.13	40.08
$C.D_{(0.05)}$		0.46	0.58	0.28	0.41	0.82

Table 4: General mean, range and coefficient of variance (C.V.) of morphometric and leaf parameters among different families of *Grewia optiva.*

Sr. No.	Parameter	Mean	Range	C.V.
1.	Height (m)	7.04	4.67-9.20	14.62
2.	Diameter (cm)	12.16	9.94-16.19	12.16
3.	Leaf area (cm^2)	58.25	40.84-77.22	58.25
4.	Estimated number of leaves	2718.95	1687.66-3634.33	16.83
5.	Fresh weight of 100 leaves (g)	64.57	48.16-87.00	.64.57
6.	Dry weight of 100 leaves (g)	33.71	25.16-50.33	33.71
7.	Leaf dry matter content(%)	48.19	41.22-55.56	48.19
8.	Fodder yield (kg)	11.10	8.84-13.81	13.29
9.	Total fresh green leaf biomass (g)	1770.81	893.36-3024.97	12.97

Table 5: General mean, range, standard deviation (S.D.) and coefficient of variance (C.V) of Proximate fodder analysis among different families of *Grewia optiva*.

Sr. No.	Parameter	Mean	Range	C.V.
1.	Crude protein (%)	20.74	18.09-22.11	1.36
2.	Crude fibre (%)	20.52	18.58-21.83	1.74
3.	Ether extract (%)	5.34	4.65-5.88	3.22
4.	Total ash (%)	11.97	10.74-13.13	2.05
5.	NFE (%)	41.18	38.37- 44.25	1.19

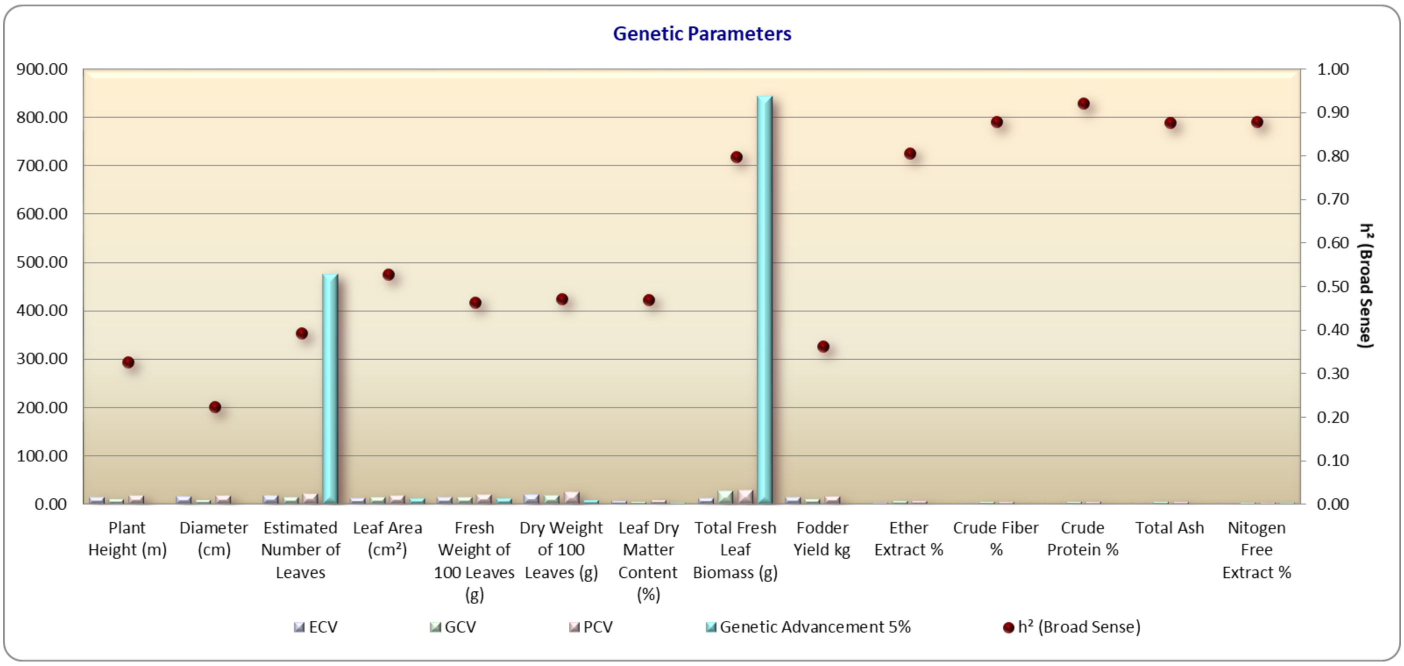

Fig 1: Estimates of variation and genetic parameters of different characters in *Grewia optiva*

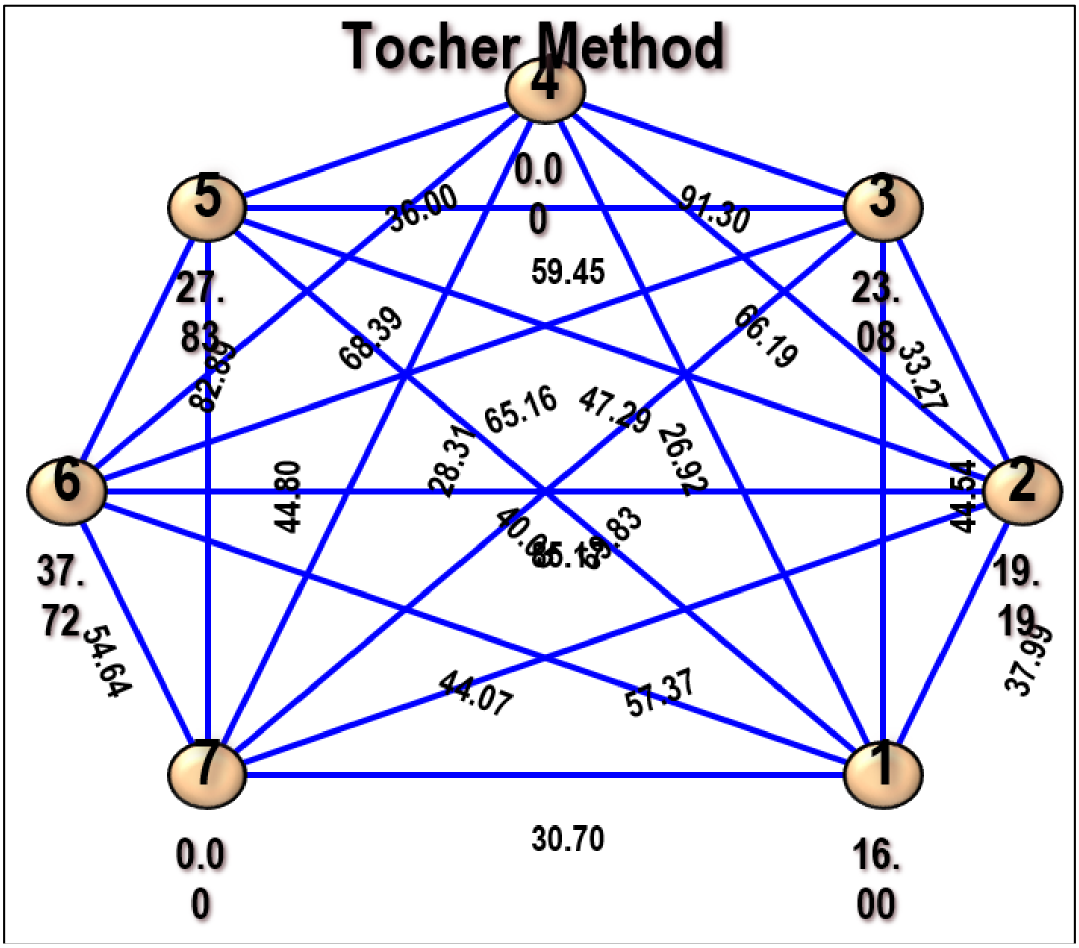

Fig 2: A statistical distance ($\sqrt{D^2}$) among forty families of *Grewia optiva*

References

1. Bhat GS. Provenances variation in seed and seedling traits of *Albizia lebbek* Benth. M.Sc. Thesis. Dr. Y.S Parmer University of Horticulture and Forestry, Nauni-Solan (H.P), 1999, 88.
2. Bhagta S. Progeny evaluation of open pollinated seedling seed orchard of *Grewia optiva* Drummond. Department of Tree Improvement and Genetic Resources, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, 2015, 108.
3. Choudhary P. Studied on genetic variations in open pollinated families of *Toona ciliata*. M.Sc. Thesis. Dr. Y.S. Parmer University of Horticulture and Forestry, Nauni, Solan, 2000, 73.

4. Coleman. Chromosome numbers of angiosperms collected in the state of Sao Paulo. Brazilian Journal of Genetics. 1982; 5(3):533-549.
5. Gera M, Gera N, Aggarwal R, Gupta BN. Genetic variation in biochemical contents in foliage of twenty seed sources of *Dalbergia sissoo.* Indian Forestry. 2002; 128(7):726-737.
6. Gomez KA, Gomez AA. Stastical procedures for agricultural research. A Wiley - Intersiences Publication, New York. 1984, 2 ed., 680.
7. Hooker JD. Flora of British India L. Revve & Co., London, 1875.
8. Pant KS, Prabhaker M, Panwar P. Floral biology of *Grewia optiva* Drummond. Annals of Plant and Soil Research. 2003; 5(10):61-69.
9. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. ICAR, New Delhi, 1967, 610.
10. Kaushal PS. Screening of beul trees (*Grewia optiva*) for superior nutritative stains M.Sc. Thesis Himachal Pradesh University, 1978, 64.
11. Rathore Amandeep. Evaluation of selected genotypes of *Grewia optiva.* M.Sc. Thesis Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan (H.P.), 1997, 55.
12. Singh R. Survey of socio-economic profile of farmers and animal feed resources in the mountains of Himachal Pradesh. Himalayan Ecology. 2005; 13(2):12-15.
13. Singh R, Bimal M. Traditional animal rearing practices in mountains of Himachal Pradesh. Himalayan Ecology. 2004; 12(1):6-9.
14. Sehgal RN, Jaswal S. Seed source variation on *Grewia optiva.* In: Proc. QFRI-IURFO Conference on Tree Improvement for Sustainable Tropical Forestry Caloundra, Australia, 27 October to November, 1996.
15. Sankhyan HP, Bawa R, Mariappan N. Fodder quality evaluation of *Grewia laevigata* Vahl: a lesser known tree species of Shiwaliks. Indian Forester. 2009; 135(3):347-360.
16. Sankhyan HP, Bhagta Shikha. Fodder quality analysis of open pollinated seedling seed orchard of Grewia optiva Drummond. The Bioscan. 2016; 11(2):709-713.
17. Wani AM, Raj AJ, Chauhan. Association analysis for morphological and biomass traits in *Bauhinia variegata* seedlings. Ind. J Trop. Biodiv. 2009; 16(1):61-70.