

Evaluation of *Grewia optiva* Drummond Clonal seed orchard for morphometric and fodder quality parameters

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Short Report

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Abstract

Grewia optiva is an important agroforestry species and is grown in lower and mid hills of Western Himalayas by the farmers. It is a multi-purpose tree that provides leaf fodder, fibre and fuelwood. The leaves have high digestibility, nutritive value and is preferred by the livestock. With the increasing demand for fodder, there is a need to develop clones of genetically superior trees. Production of good quality seeds in sufficient large quantity ensures increased productivity of forest plantations by stable supply of genetically desirable and well adapted planting stock. Clonal seed orchard of *Grewia optiva* consisting of 21 clones was established in the year 2013 in three replicates in RBD design by planting of clonally propagated best families of seedling seed orchard. The clones were evaluated for variability in plant growth parameters, fruit and seed parameters, leaf parameters and fodder quality parameters. The data was subject to principle component analysis and cluster analysis to select best clones for various traits.

Introduction

Fodder trees form an important feed source for the livestock. In hilly and mountain regions, the demand for fodder is much higher than their availability (Singh and Bimal 2004). During lean periods, when grasses are either unavailable and have low nutritional value, fodder trees have the potential to supply feed (Gachuri et al. 2017). The leaf fodder is considered as nutritious as the leguminous fodder crops as it contains high crude protein, minerals and exhibit high levels of digestibility in livestock. The trees continue to produce well even during the dry season due to their deep root system (Paterson et al. 1998). Fodder trees are more resistant to variations in temperature and variable weather conditions and can draw water from deep soil layers. Therefore, they can provide fodder for longer time than shallow-rooted plants during dry periods. For this purpose, naturally regenerating tree species are raised on the terraces of farming fields under traditional agroforestry system (Rodger, 1992). In India, *Acacia nilotica*, *Albizia lebbek*, *Azadirachta indica*, *Dalbergia sissoo*, *Prosopis cineraria*, *Grewia optiva*, etc., are important indigenous fodder tree species having a large number of unique characteristics (Rai et al. 2007).

Grewia optiva Drummond (Beul) is an important agro-forestry species and is grown in lower and mid-hills of western Himalayas by the farmers (Verma, 2015). It belongs to family Malvaceae. It is naturally distributed in Indian subcontinent ranging from Bhutan, Nepal, Pakistan and India. In India, it is found in areas of Jammu and Kashmir, Himachal Pradesh, Punjab, Sikkim and Uttar Pradesh (Hooker, 1875). It is mostly found at an elevation of 500–2100 m, where the temperature ranges between 2° to 38°C and rainfall falls between 1200–2500 mm in a year (Joshie and Narain, 1992). It is a multi-purpose tree that provides leaf fodder, fibre, and fuelwood (Khosla et al. 1995). In its native range, Beul is one of the most preferred species by the farmers to feed their cattle. It has a high digestibility, nutritive value and is preferred by livestock (Khosla et al. 1980).

It is a medium-sized tree that reaches a height of about 5–12 m. The bole can reach upto 3–4 m and has diameter of around 1 m (Sankhyan et al. 2020). The leaves are petiolated with blades tomentose on both sides, rough, ovate to broadly ovate, 3.5–10 cm long and 2-6.5 cm broad. The inflorescence is a cyme

bearing yellowish-red flowers (Orwa et al. 2009). Flowers are monoecious and lemon-yellow in colour. The fruit is an edible drupe which is 1–4 lobed, olive-green in colour when immature, then becomes black on ripening (Troup, 1921). Old leaves are shed in March and April and new ones appear in the month of April to May. The fruit usually attains full size by September and ripens between October and December (Sankhyan et al. 2020).

With the increasing demand for fodder, there is a need to develop clones of genetically superior trees (Bhagta et al. 2015). Production of good quality seeds in sufficient large quantity ensures increased productivity of forest plantations by stable supply of genetically desirable and well adapted planting stock. Fodder quality is determined by the chemical composition of leaves which comprises of ether extract, crude fibre, crude protein, total ash content, organic matter, carbohydrates, minerals and nutrients.

Seed orchard is an orchard of genetically superior trees, isolated to reduce pollination from genetically inferior outside sources and intensively managed to produce frequent abundant and easily harvested seed crops (Zobel, 1958). It is established by setting out clones as cuttings or seedling progeny of trees selected for desired characteristics. Clonal seed orchard is an orchard raised from selected clones propagated by grafting, cutting, air-layering or tissue culture, whereas Seedling seed orchard is an orchard raised from seedlings produced from selected parents through natural or controlled pollination (Bhagta et al. 2016).

A seedling seed orchard comprising of 60 families in three replicates at 2×2-meter distance was established in UHF in the year 2000 (Bhat et al. 2015). The morphological and fodder quality parameters and the genetic divergence was studied on the basis of seed and seedling characters of progeny of the families (Sharma et al. 2021). The families were evaluated for variability in biomass, fodder and seedling growth characters (Bhagta et al. 2019b) using correlation and principal component analysis (Bhagta et al. 2019a). Based on scoring index best families were selected and their clones were planted in the clonal seed orchard. A quantum of work has been done on this species, but no systematic work has yet been reported particularly on clonal seed orchard of *Grewia optiva*. In clonal seed orchard we expect crude protein to be more than 20 per cent, which is the main component of the fodder.

Materials And Methods

Study site

Clonal seed orchard of *Grewia optiva* consisting of 21 clones was established in the year 2013 in three replicates in RBD design by planting of clonally propagated best families of Seedling seed orchard. The seedling seed orchard was raised from seeds collected from various districts of Himachal Pradesh namely Sirmour, Solan, Chamba, Bilaspur, Mandi, Hamirpur, Kangra, Shimla (Table 1). The clonal seed orchard was evaluated at an age of eight years for various morphometric, fruit, seed, leaf and fodder quality parameters.

Table 1
Origin of plant material of *Grewia optiva* Drummond (Beul) in clonal seed orchard

Sr. No.	Clonal identity	Location	District	Latitude (°N)	Longitude(°E)
1.	BI-3	Auhar	Bilaspur	31.3872	76.7269
2.	BI-4	Kuthira	Bilaspur	31.6353	76.4371
3.	CH-1	Chanad	Chamba	32.5534	76.1258
4.	CH-3	Balu	Chamba	32.3243	76.1001
5.	CH-6	Saru	Chamba	32.7945	76.2002
6.	HA-2	Patta Balakhar	Hamirpur	31.643	76.6427
7.	HA-3	Bassi	Hamirpur	31.6973	76.5163
8.	HA-4	Kanal	Hamirpur	31.6908	76.5177
9.	MA-2	Bachhwan	Mandi	31.6867	76.9697
10.	SH-3	Jeury	Shimla	31.1046	77.1734
11.	SH-7	Taradevi	Shimla	31.0597	77.1452
12.	SI-7	Nandel	Sirmour	30.5467	77.7647
13.	SI-10	Seenaghat	Sirmour	30.5906	77.6718
14.	SI-14	Saraha Chakli	Sirmour	30.7987	77.1216
15.	SI-15	Madhobag	Sirmour	30.5	77.2
16.	SI-16	Nainatikker	Sirmour	30.8044	77.119
17.	SO-1	Gaura	Solan	30.904	77.0969
18.	SO-3	Dharja	Solan	30.9084	77.0984
19.	SO-4	Deog	Solan	30.9045	77.0967
20.	SO-7	Oyali	Solan	30.9103	77.0992
21	SO-10	Jaunaji	Solan	30.9105	77.1102

Plant Growth Parameters

Observations on plant growth parameters were made in the month of October. Observations on shoot were made during active growth period from March to September. Leaf observations were made on mature leaves from July to September. Leaf collection for the fodder quality estimation was done during first week of November. Observations on fruit were made at the time of fruit maturity, i.e., October to December. Fruit collection was done during first week of November. Seed were collected by depulping and

drying of fruit pods which were then packed, labeled and stored. The plant height was recorded as the length from ground level to topmost portion in canopy. It was measured using a scale/tape for small trees and with Ravi Multimeter for large trees (Bhagta et al. 2019). Similarly, basal diameter of each plant was measured with the help of vernier caliper at height of approximately 25 cm from the base. Internodal distance was taken with a measuring scale as the distance between the consecutive leaves on the main axis. Number of primary branches that were emerging out of main stem was recorded and number of leaves was counted per 30 cm on secondary and tertiary branches.

Fruit And Seed Parameters

The weight of hundred fresh fruits was measured with the help of Digital Balance. Fresh fruits were dried under the sun till their weight became constant and then weight of 100 dried fruits were weighed. The dried fruits were depulped to obtain the seeds and then hundred seed weight was taken. Seed length, seed width and seed thickness was measured in mm using digital vernier caliper.

Leaf Parameters

Leaf samples were collected, properly labeled in paper bags and brought to the laboratory for measurement of leaf parameters. Leaf length and leaf width were recorded using a measuring scale and leaf area was taken using digital leaf area meter. A composite sample of 100 fresh leaves was taken and fresh weight was recorded. Thereafter, leaf samples were thoroughly washed in tap water, thereafter with 0.1N HCl followed by distilled water. The washed samples were air dried for some time and thereafter in an oven at 60°C till the samples attained a constant weight. Subsequently, the dry weight of 100 leaves was taken using digital top pan for estimation of leaf dry matter content that is the differences in leaf weight due to loss of moisture content before and after drying. The dry matter was expressed in percentage using the formula:

$$\text{Leaf dry matter content (\%)} = \frac{\text{Weight of dried leaf samples}}{\text{Weight of fresh leaf samples}} \times 100$$

Fodder Quality Parameters

The dried leaf samples were grounded thoroughly and stored in plastic bags and used for analysis of the fodder quality parameters. Analyses of ether extract crude protein and crude fiber was determined (AOAC, 1995) (Sankaram, 1966). Ether extract was intended by extracting it, from sample, with diethyl ether at 60°C in soxlet apparatus. Crude fiber was estimated by refluxing the sample with 1.25% H₂SO₄ and subsequently with 1.25% NaOH for 30 minutes each. This dissolved acid and basic soluble component, the dregs containing the crude fiber was dried upto a constant weight and then it was ignited in a muffle furnace. On ignition the weight loss by the remains was known for crude fiber. Crude protein content was known by micro kjeldhal method. Samples were oven dried and were then allowed to digest

in H₂SO₄ with a catalyst mixture that contained K₂SO₄ and CuSO₄ (Hashmi and Waqar, 2014). A known portion of the diluted sample was purified in the occurrence of 10 ml boric acid solution of 2% concentration and then titrated against standard 0.1 N H₂SO₄. Crude protein was estimated by calculating percent of nitrogen. Ash was determined by burning the sample in muffle furnace at 550°C, this burns the organic matter and the remainder was ash left. Nitrogen free extract was found by the difference of crude protein, crude fiber, ash contents and ether extract (Azim et al. 2002).

$$1. \text{ Ether extract (\%)} = \frac{\text{Weight of fat}}{\text{Original weight of sample}} \times 100$$

$$2. \text{ Crude fibre (\%)} = \frac{\text{Weight of crude fibre}}{\text{Original weight of sample}} \times 100$$

$$3. \text{ Crude protein (\%)} = \frac{100 \times Y \times 0.0014 \times 6.25}{X \times W} \times 100$$

Where,

Y = Aliquot volume made of digested sample (100ml)

T = Titre value (ml)

X = Volume taken for distillation (5ml)

W = Weight of sample taken for digestion (1g)

$$4. \text{ Total ash (\%)} = \frac{\text{Weight of ash}}{\text{Original weight of sample}} \times 100$$

$$5. \text{ NFE (\%)} = 100 - (\text{CP\%} + \text{CF\%} + \text{EE\%} + \text{Total ash \%})$$

The data was subjected to the principal component analysis (PCA) using SPSS Software (version 16.0) with a purpose to view data more realistically. Through this analysis the numbers of variables are reduced to a few linear variable combinations that account for variation in the original variables and which can be interpreted easily (Singh *et al*, 2012). Cluster analysis is performed in order to see the possibility of existence of groups or subsets of closely associated individuals based on similarities in the recorded observations of sample objects. Karl Pearson's correlation coefficient was worked out for morphometric and fodder quality parameters among different clones of *Grewia optiva* Drummond. The data were compiled and subjected to statistical analysis and analysis of variance was done as per Panse and Sukhatme (1985) and as explained by (Gomez 1984).

Results And Discussion

Plant height (Table 2) was recorded maximum in clone SI-10 (5.97 m) which was statistically at par with clones SO-1 (5.80 m), HA-4 (5.62 m), BI-3 (5.53 m), SI-7 (5.52 m), SO-3 (5.50 m) and SI-15 (4.83 m). The maximum basal diameter was recorded in clone BI-3 (16.75 cm), which was statistically at par with clones SO-1 (16.20 cm), SI-7 (15.93 cm), SO-3 (15.13 cm), SI-15 (14.40 cm), SI-10 (14.23 cm), SI-16 (12.57

cm) and SO-7 (12.47 cm). The maximum value of internodal length was observed in clone SH-3 (4.72 cm), was statistically at par with clones CH-1 (4.39 cm), SH-7 (4.39 cm), BI-4 (4.31 cm), CH-6 (4.09 cm), MA-2 (3.61 cm), CH-3 (3.44 cm), HA-4 (3.44 cm) and SO-10 (3.28 cm). The maximum number of primary branches was recorded in clone SI-10 (5.97 m) which was statistically at par with clones HA-4 (7.67), SO-1 (7.67), SI-7 (7.33), SI-10 (7), SI-15 (7), SI-16 (7), SO-10 (7) and HA-2 (6.67), SO-7 (6.67). The above findings on variation of morphological parameters are in accordance with findings of Sankhyan et al. (2020) who concluded that various populations of *Grewia optiva* had the plant height in the range (8.57–3.73 mm), diameter (29.63-12.01cm) and the maximum number of primary branches in the range (6.67–2.67). Bhagta (2015) reported that in the seedling seed orchard maximum plant height, collar diameter and internodal length recorded were 54.49 cm, 0.52 cm and 4.15 respectively.

Table 2
Variation in Plant growth parameters among *Grewia optiva* clones

Clonal Identity	Plant height (m)	Basal diameter (cm)	Internodal distance (cm)	No. of primary branches
BI-3	5.53	16.75	4.13	8.33
BI-4	1.85	5.28	4.31	5.00
CH-1	3.13	7.02	4.39	4.67
CH-3	2.60	8.28	3.44	5.00
CH-6	3.92	11.62	4.09	5.33
HA-2	3.82	11.80	2.85	6.67
HA-3	2.92	10.28	3.11	6.00
HA-4	5.62	15.85	3.44	7.67
MA-2	2.78	8.80	3.61	4.33
SH-3	2.82	8.10	4.72	4.67
SH-7	2.88	7.43	4.39	6.00
SI-7	5.52	15.93	3.06	7.33
SI-10	5.97	14.23	2.83	7.00
SI-14	3.43	8.90	2.78	4.33
SI-15	4.83	14.40	2.61	7.00
SI-16	4.52	12.57	2.55	7.00
SO-1	5.80	16.20	2.67	7.67
SO-3	5.50	15.13	2.61	6.00
SO-4	4.35	10.83	2.56	5.67
SO-7	4.60	12.47	2.78	6.67
SO-10	4.10	10.77	3.28	7.00
Mean	4.12	11.55	3.34	6.16
C.D. _(0.05)	1.25	4.83	1.44	1.97
C.V.	18.28	25.21	26.05	19.29

The maximum number of leaves per 30 cm on secondary branches were recorded for clones SI-10 (7.67 per 30 cm) which was statistically at par with clones SI-15 (7.22), HA-3 (6.78), CH-3 (6.67) and SI-14 (6.56) (Table 3). The maximum fresh weight of 100 leaves was recorded for the clone SI-7 (128.24g) which was statistically at par with clones HA-4 (122.15 g) and SH-7 (110.13 g) and the maximum value for dry weight of 100 leaves was recorded in the clone SI-7 (62.35g) which was statistically at par with clones SO-10 (61.94 g), HA-4 (60.03 g), SI-15 (55.23 g) and SH-7 (53.69 g). The leaf dry matter content was maximum (60.29%) in the clone SO-10 which was statistically at par with clones SO-4 (59.33%), SI-14 (57.61%), MA-2 (56.62%), HA-3 (55.27%), SI-15 (55.87%), SH-7 (53.96%) and SO-3 (52.67%). The maximum leaf length was recorded in clone HA-4 (17.38 cm) which was significantly at par with clones SO-1 (16.13 cm), SI-7 (16.10 cm) and SI-15 (15.70 cm). The maximum leaf width was recorded in the clone HA-4 (11.6 cm) which was significantly at par with clone SI-7 (10.81) and the maximum leaf area was recorded in the clone HA-4 (129.89 cm²), which was significantly at par with the clone SI-7 (128.93 cm²). Sankhyan et al. (2020) found that fresh weight as well as the maximum dry weight of 100 leaves of *Grewia optiva* leaves ranged between (23.20-20.35g) and (15.70-12.14g), respectively. In the seedling seed orchard of *Grewia optiva* the maximum leaf area was recorded in HA-2 (51.04 cm²) (Bhagta, 2016).

Table 3
Leaf parameters of *Grewia optiva* Drummond clones in clonal seed orchard

Clonal Identity	Number of leaves (per 30 cm)	Fresh weight of 100 Leaves (g)	Dry weight of 100 leaves (g)	Leaf dry matter content (%)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm ²)
BI-3	5.89	80.13	36.43	46.85	12.38	8.51	79.94
BI-4	5.67	69.82	33.75	42.02	13.13	8.20	80.37
CH-1	5.44	70.42	33.18	46.70	11.81	7.02	61.72
CH-3	6.67	94.01	43.37	46.82	12.94	7.98	79.53
CH-6	6.00	92.83	47.05	50.30	13.20	8.87	78.52
HA-2	7.11	97.99	44.60	46.42	13.41	8.73	80.18
HA-3	6.78	82.61	45.50	55.27	12.39	7.22	70.37
HA-4	5.78	122.15	60.03	49.81	17.38	11.60	129.89
MA-2	4.00	83.42	44.53	56.62	15.11	8.89	98.69
SH-3	5.67	99.93	44.38	44.19	13.83	8.64	85.78
SH-7	4.56	110.13	53.69	53.96	15.36	9.69	110.96
SI-7	5.67	128.24	62.35	49.04	16.10	10.81	128.93
SI-10	7.67	80.07	40.13	52.19	12.92	7.72	69.87
SI-14	6.56	95.28	50.90	57.61	12.19	8.06	71.50
SI-15	7.22	99.86	55.23	55.87	15.70	9.08	96.07
SI-16	5.33	84.95	42.21	52.21	13.87	8.67	90.03
SO-1	5.56	99.66	47.16	48.28	16.13	9.69	103.67
SO-3	6.11	91.57	47.00	52.67	13.54	8.42	83.90
SO-4	6.11	81.87	45.37	59.33	12.97	9.81	93.98
SO-7	6.11	108.52	50.33	47.51	15.23	9.69	103.72
SO-10	5.11	104.02	61.94	60.29	12.27	8.00	72.70
Mean	5.95	94.17	47.10	51.14	13.90	8.82	89.06
C.D. _(0.05)	1.44	19.22	10.76	7.66	1.88	1.22	19.98
C.V.	14.58	12.32	13.79	9.04	8.18	8.31	13.54

The maximum fresh fruit weight for 100 fruits (Table 4) was recorded in the clone SI-7 (22.17g) which was significantly at par with clones HA-4 (21.75 g), SO-1 (21.44 g), HA-2 (21.40 g), CH-6 (21.36 g), SI-10 (21.31 g), SH-3 (21.05 g), SI-15 (20.82 g), CH-3 (20.52 g), SO-7 (20.48 g), SI-16 (20.41 g) and BI-3 (20.25 g). The maximum dry fruit weight was recorded in the clone CH-3 (15.56 g) which was statistically at par with clones CH-1 (15.42 g), CH-6 (14.49 g), BI-3 (14.48 g) and HA-3 (14.71 g). The maximum weight of 100 seeds was recorded in clone CH-1 (9.54 g), which was statistically at par with clone CH-3 (9.42 g). The maximum seed length was recorded for the clone BI-3 (6.53 mm) which was statistically at par with clones SH-7 (6.50 mm), SO-7 (6.44 mm), SH-3 (6.30 mm), SI-10 (6.29 mm), MA-2 (6.28 mm), HA-4 (6.26 mm), CH-1 (6.20 mm) and HA-3 (6.19 mm). Clone SH-3 recorded the maximum value for seed width (5.38 mm) which was statistically at par with clones SH-3 (5.38 mm), BI-3 (5.21 mm), SI-10 (5.12 mm), SI-15 (5.10 mm), HA-4 (5.09 mm) and CH-3 (5.08 mm). Maximum seed thickness was recorded in the clone MA-2 (5.04 mm) which was statistically at par with clones CH-3 (5.01 mm), SO-4 (4.91 mm), SO-7 (4.85 mm), HA-4 (4.79 mm), SH-7 (4.77 mm), BI-4 (4.73 mm), SI-14 (4.71 mm), SH-3 (4.70 mm), HA-3 (4.69 mm), CH-1 (4.69 mm), CH-6 (4.66 mm), SO-10 (4.59 mm) and HA-2 (4.48 mm).

Bhagta (2015) reported that in the seedling seed orchard of *Grewia optiva*, the variations among genotypes in the seedling seed orchard were in the range: 100 fresh fruit weight (17.96–28.48 g), 100 dry fruit weight (10.82–17.48 g), seed length (4.78–6.99 mm), seed width (3.69–5.82 mm), seed thickness (3.18–5.92 mm) and 100 seed weight (7.25–13.41 g). Similarly, Sankhyan et al. (2020) while studying populations of *Grewia optiva* observed that maximum seed length (6.26 mm), width (5.12 mm) and thickness (5.20 mm) were found in population site HM3, MN2, HM4, respectively.

Table 4
Fruit and seed parameters among different clones of *Grewia optiva* Drummond

Clonal Identity	Fresh weight of 100 fruits (g)	Dry weight of 100 fruits (g)	100 seed weight (g)	Seed length (mm)	Seed width (mm)	Seed thickness (mm)
BI-3	20.25	14.48	8.90	6.53	5.21	5.01
BI-4	18.28	14.27	8.80	6.01	4.84	4.73
CH-1	18.47	15.42	9.54	6.20	4.99	4.69
CH-3	20.52	15.56	9.42	5.98	5.08	5.01
CH-6	21.36	14.49	8.87	6.18	4.98	4.66
HA-2	21.40	13.83	9.01	6.12	4.58	4.48
HA-3	19.94	14.71	9.06	6.19	4.98	4.69
HA-4	21.75	14.29	9.12	6.26	5.09	4.79
MA-2	19.15	13.95	9.07	6.28	4.95	5.04
SH-3	21.05	14.17	8.91	6.30	5.38	4.70
SH-7	19.93	13.68	8.62	6.50	4.93	4.77
SI-7	22.17	13.69	8.59	5.70	4.89	4.34
SI-10	21.31	13.71	9.01	6.29	5.12	4.40
SI-14	19.37	12.95	8.65	5.80	4.88	4.71
SI-15	20.82	13.26	8.81	6.09	5.10	4.24
SI-16	20.41	13.11	8.26	5.77	4.70	4.44
SO-1	21.44	13.98	8.89	5.86	4.72	4.05
SO-3	20.52	13.79	8.68	6.05	4.90	4.12
SO-4	19.86	12.99	8.76	6.16	4.97	4.91
SO-7	20.48	13.71	8.94	6.44	4.89	4.85
SO-10	19.81	13.29	8.36	5.84	4.93	4.59
Mean	20.39	13.97	8.87	6.12	4.96	4.63
C.D. _(0.05)	2.13	1.13	0.39	0.34	0.37	0.56
C.V.	6.31	4.88	2.67	3.39	4.53	7.27

Ether Extract (Table 5) was recorded maximum for the clone SI-16 (5.8%) which was statistically at par with the clones SO-7 (5.76%), HA-3 (5.73%), SO-3 (5.72%), CH-6 (5.71%), CH-3 (5.69%), SI-15 (5.69%) and SO-1 (5.69%). For crude fibre it was found that the maximum value was recorded in the clone CH-1 (21.78%) which was statistically at par with clones HA-2 (21.77%), SO-4 (21.65%), HA-4 (21.64%), SI-16 (21.63%), SI-15 (21.61%), CH-3 (21.60%), SH-7 (21.49%), SI-7 (21.42%), SO-7 (21.40%), SO-10 (21.37%) and SI-14 (21.33%). The maximum value of crude protein was manifested in the clone HA-3 (23.51%) which was statistically at par with the clones SO-10 (23.01%) and CH-3 (22.30%). The maximum value of total ash content was recorded for the clone HA-2 (13.83%) which was statistically at par with the clones SO-3 (13.79%), SO-7 (13.71%), SO-10 (13.29%), SH-3 (13.05%), SI-14 (12.95%), BI-3 (12.84%) and HA-4 (12.62%). The maximum value of Nitrogen Free Extract was observed in clone MA-2 (42.04%) which was statistically at par with the clones SH-3 (41.84%), SI-14 (41.37%), BI-4 (41.23%), CH-6 (41.09%), SH-7 (40.96%) and SI-10 (40.92%).

Ether extract or the crude fat content of leaves is composed of waxes, fats, oils and pigments, lipids and fat soluble vitamins as A, D, E and K and fatty acid esters (Sharma et al. 2021). The main role of crude fat in leaves is determination of palatability plays role in providing sustenance energy to the animals, helps in milk production in lactating cows and is a source of energy for metabolism. Bhagta et al (2016) reported that ether extract among families in the seedling seed orchard ranged from 5.49–4.62 per cent. Ether extract increases as the leaves mature (Kant et al. 2017), (Singh and Todaria 2012). Crude fiber comprises of comparatively insoluble fractions of carbohydrates, cellulose and hemicellulose but they act as energy source to the ruminants. The main role of crude fiber is to help in fodder digestion and sustain ruminal function. Lactating cattles have more demand for fiber. As per the study conducted by the minimum percentage of crude fiber required in dairy cows is 17 per cent (Moran, 2005). Crude protein is one of preferred criteria for assessment of fodder quality (Saddul et al. 2005). It was found that values of crude protein ranged between (19.35 to 23.51%). The crude protein content is maximum in young leaves and decreases with maturity (Kamalak et al. 2005). Reason for this could be associated with translocation of nitrogen in leaves back into branches before leaf fall as well as dilution components are linked with development and maturity of leaves (Khosla et al. 1992). During dry season as a result of water stress, lignocellulosic substances form which dilute nitrogen in leaves (Anele et al. 2009). Total ash is basically the inorganic residue remaining after removal of organic matter from the leaves. It is the measure of minerals in the feed that provide energy for growth and biological processes in animals. Mature leaves have more ash content since they accumulate more minerals (Jadhav et al. 2020). Nitrogen free extract constitutes the soluble carbohydrates, sugars, starches which are used by animals to generate heat, energy and fats. Nitrogen free extract was found comparatively less in mature leaves (Hashmi and Waqar, 2014).

Table 5
Variation in fodder quality parameters among different clones

Clonal Identity	Ether extract (%)	Crude fibre (%)	Crude protein (%)	Total ash (%)	Nitrogen free extract (%)
BI-3	5.49 (2.55)	20.48 (4.64)	21.81 (4.78)	12.84 (3.72)	39.38 (38.85)
BI-4	5.15 (2.48)	21.05 (4.70)	20.16 (4.60)	12.41 (3.66)	41.23 (39.93)
CH-1	5.60 (2.57)	21.78 (4.77)	21.22 (4.71)	11.96 (3.60)	39.44 (38.89)
CH-3	5.69 (2.59)	21.60 (4.75)	22.30 (4.83)	11.88 (3.59)	38.53 (38.35)
CH-6	5.71 (2.59)	18.73 (4.44)	21.98 (4.79)	12.49 (3.67)	41.09 (39.85)
HA-2	4.88 (2.43)	21.77 (4.77)	21.40 (4.73)	13.83 (3.85)	38.12 (38.10)
HA-3	5.73 (2.59)	19.43 (4.52)	23.51 (4.95)	11.78 (3.58)	39.55 (38.95)
HA-4	5.58 (2.56)	21.64 (4.76)	21.50 (4.74)	12.62 (3.69)	38.66 (38.43)
MA-2	5.59 (2.57)	20.75 (4.66)	19.78 (4.56)	11.84 (3.58)	42.04 (40.40)
SH-3	4.71 (2.39)	19.35 (4.51)	21.05 (4.70)	13.05 (3.75)	41.84 (40.29)
SH-7	5.25 (2.50)	21.49 (4.74)	19.93 (4.57)	12.38 (3.66)	40.96 (39.78)
SI-7	5.19 (2.49)	21.42 (4.74)	22.17 (4.81)	12.36 (3.66)	38.87 (38.55)
SI-10	5.42 (2.53)	20.43 (4.63)	21.31 (4.72)	11.92 (3.60)	40.92 (39.75)

Clonal Identity	Ether extract (%)	Crude fibre (%)	Crude protein (%)	Total ash (%)	Nitrogen free extract (%)
SI-14	4.97 (2.44)	21.33 (4.73)	19.37 (4.51)	12.95 (3.74)	41.37 (40.02)
SI-15	5.69 (2.59)	21.61 (4.76)	20.82 (4.67)	12.37 (3.66)	39.52 (38.93)
SI-16	5.80 (2.61)	21.63 (4.76)	20.41 (4.63)	12.32 (3.65)	39.85 (39.13)
SO-1	5.69 (2.59)	21.24 (4.72)	21.44 (4.74)	11.76 (3.57)	39.86 (39.14)
SO-3	5.72 (2.59)	19.77 (4.56)	20.52 (4.64)	13.79 (3.85)	40.21 (39.34)
SO-4	5.24 (2.50)	21.65 (4.76)	20.37 (4.62)	12.99 (3.74)	39.75 (39.07)
SO-7	5.76 (2.60)	21.40 (4.73)	21.87 (4.78)	13.71 (3.84)	37.27 (37.61)
SO-10	4.84 (2.42)	21.37 (4.73)	23.01 (4.90)	13.29 (3.78)	37.50 (37.74)
Mean	5.41 (2.53)	20.95 (4.68)	21.23 (4.71)	12.60 (3.72)	39.81 (39.10)
C.D. _(0.05)	0.02	0.05	0.14	0.11	0.96
C.V.	0.50	0.67	1.77	1.73	2.48

(*note: Figures In Parenthesis Are Values After Transformation Of Per Cent Data)

Genetic Parameters

The Genetic estimates (Table 6) shows that the parameter which recorded the highest heritability among morphological parameters was plant height (70.46%) followed by leaf area (66.90). Among fodder quality parameters highest heritability was shown by ether extract (96.85%) followed by crude fiber (90.32%). The maximum genetic advance among morphological characters was observed in leaf area (28.89%) and maximum genetic advance among fodder quality parameters was recorded in nitrogen free extract (1.99%). The maximum value of genetic gain was recorded in plant height (48.79%) among morphological parameters and ether extract (5.44%) among fodder parameters. The characters having high heritability as well as genetic gain were plant height, basal diameter and leaf area. Therefore, selection can be carried out directly on basis for these two characters *viz.*, high heritability and genetic gain.

Table 6
Genetic estimates of *Grewia optiva* Drummond clones in clonal seed orchard

Sr.No.	Parameter	Heritability (%)	Genetic advance (%)	Genetic gain (%)
1.	Plant height (m)	70.46	2.01	48.79
2.	Basal diameter (cm)	50.98	4.37	37.82
3.	Internodal Length (cm)	25.81	0.54	16.08
4.	No. of primary branches	40.74	1.29	21.03
5.	Leaf density (per 30 cm)	40.06	0.93	15.54
6.	Fresh weight of 100 leaves (g)	58.29	21.57	22.91
7.	Dry weight of 100 leaves (g)	55.92	11.27	23.93
8.	Leaf Dry matter content (%)	46.48	6.05	11.83
9.	Leaf length (cm)	61.13	2.30	16.52
10.	Leaf width (cm)	66.21	1.72	19.51
11.	Leaf area (cm)	66.90	28.89	32.44
12.	Fresh weight of 100 Fruits (g)	23.73	0.72	3.53
13.	Dry weight of 100 Fruits (g)	42.62	0.79	5.65
14.	100 seed weight (g)	56.02	0.41	4.64
15.	Seed Length (mm)	49.41	0.30	4.85
16.	Seed Width (mm)	22.28	0.12	2.35
17.	Seed Thickness (mm)	27.25	0.22	4.78
18.	Ether Extract	96.85	0.14	5.44
19.	Crude Fibre	90.32	0.19	4.04
20.	Crude Protein	59.62	0.16	3.43
21.	Total ash content	62.50	0.13	3.60
22.	NFE	61.05	1.99	4.99

Bhagta (2015) reported that in the seedling seed orchard of *Grewia optiva*, high heritability with moderate genetic gain was recorded for seed length, seed thickness, seed weight which reveals that traits were under genetic control and wide range (1.54–21.9) was observed for genetic gain for different characters.

Kaushal (1978) also showed genetic variation in the proximate principles and mineral nutrients of *Grewia optiva*. Johnson et al. (1955) suggested that a high heritability estimated along with high genetic gain is usually more useful than the heritability values alone in predicting the resultant effect from selecting the best individual and therefore, a high heritability estimate does not necessarily mean an increased genetic advance. Verma (2014) conducted a study on *Grewia optiva* and reported that maximum heritability was observed in collar diameter and number of leaves, plant height had the maximum genetic advance (5.27) and genetic gain (32.67%). High heritability values for height (0.67–0.71) and diameter (0.50–0.59) with higher genetic gains were also obtained by Luna and Singh (2009) in *Eucalyptus* hybrids. Singh et al. 2012 while studying genetic estimates in *Salix* clones concluded that relatively high heritability and genetic gain for plant height and leaf area indicated that selection can be carried out directly on the phenotypic basis for these two characters.

Principal Component Analysis

Principal component analysis for morphometric traits revealed five components with Eigen value greater than one (Table 7). Principal component 1 had eigen value ($\lambda_1 = 6.424$) and comprised 37.787 per cent variation. Basal diameter had the maximum loading value (0.786), followed by leaf width (0.775), fresh weight of 100 leaves (0.774), plant height (0.763), fresh weight of 100 fruits (0.753), dry weight of 100 leaves (0.752), leaf area (0.746), leaf length (0.733) and number of primary branches (0.716). Principal component 2 ($\lambda_2 = 2.963$) recorded 17.4 per cent variations. Internodal length had the maximum loading value (0.635), followed by seed length (0.577) and dry weight of 100 fruits (0.501). Principal component 3 ($\lambda_3 = 2.438$) comprised of 14.3 per cent variation and leaf density had the maximum loading value (0.693) followed by plant height (0.481) and weight of 100 seeds (0.480). In Principal component 4 ($\lambda_4 = 1.357$) 8 per cent variation was recorded. Seed width had the maximum loading value (0.605), followed by leaf dry matter content (0.593), followed by seed length (0.497). Principal component 5 ($\lambda_5 = 1.042$) comprised of 6.128 per cent variation and leaf density had the maximum loading value (0.445).

Table 7. Principal component analysis for morphometric traits among different clones

Parameters	Principal components				
	PC1	PC2	PC3	PC4	PC5
Plant height (m)	0.763	-0.124	0.481	0.186	-0.235
Basal diameter (cm)	0.786	-0.055	0.504	0.14	-0.199
Internodal length (cm)	-0.569	0.635	-0.12	-0.02	-0.112
No of primary branches	0.716	-0.002	0.408	0.102	-0.356
Leaf density (per 30 cm)	0.058	-0.355	0.693	0.1	0.445
Fresh weight of 100 leaves (g)	0.774	0.363	-0.212	-0.048	0.363
Dry weight of 100 leaves (g)	0.752	0.08	-0.381	0.171	0.41
Leaf dry matter content (%)	0.213	-0.48	-0.442	0.593	0.144
Leaf length (cm)	0.733	0.499	-0.158	-0.192	-0.031
Leaf width (cm)	0.775	0.488	-0.215	-0.045	-0.073
Leaf area (cm ²)	0.746	0.53	-0.279	-0.116	-0.072
Fresh weight of 100 fruits (g)	0.753	0.186	0.414	-0.055	0.25
Dry weight of 100 fruits (g)	-0.539	0.501	0.424	-0.283	0.148
Weight of 100 seeds (g)	-0.473	0.46	0.480	-0.112	0.267
Seed length (mm)	-0.269	0.577	0.219	0.497	-0.272
Seed width (mm)	-0.222	0.476	0.252	0.605	0.217
Seed thickness (mm)	-0.525	0.471	-0.252	0.372	-0.013
Eigen values (λ)	6.424	2.963	2.438	1.357	1.042
Percentage of variance	37.787	17.43	14.339	7.981	6.128
Cumulative percentage of variance	37.787	55.216	69.556	77.536	83.665

The principal component analysis for fodder quality parameters (Table 8) showed that three components had Eigen value greater than one. Principal component 1 ($\lambda_1 = 1.754$) exhibited 35.1 per cent variation and crude protein had the maximum loading value (0.671). Principal component 2 ($\lambda_2 = 1.488$) comprised of 29.8 per cent variation in which ether extract had the maximum loading value (0.783) followed by crude protein (0.519). Principal component 3 ($\lambda_3 = 1.156$) recorded 23.1 per cent variation and crude fibre had the maximum loading value (0.835). Therefore, among morphometric parameters, the basal diameter had the maximum loading value (0.786) and among fodder parameters crude protein, recorded the maximum loading value (0.671). These parameters could be considered for selection including other parameters in PCA 1.

Mehta et al. (2022) conducted a study to evaluate *Grewia optiva* clones for fodder yield and other related traits among nine different clones in lower Shivalik North Western Himalayas and Principal component analysis revealed total variability of 77.8% among genotypes contributed by PC-1 (57.3%) and PC-2 (20.5%). Similarly, Isik Tophu (2004) considered growth trait in black poplar as most important on the basis of principal analysis. Factor analysis was applied for 13 components and 71.46 per cent of total variance was explained in first five components while studying morphological characters of *Populus deltoides* hybrid clones in nursery by Ozel et al. (2010).

Table 8. Principal component analysis for fodder quality parameters among different clones

Parameters (%)	Principal components		
	PC1	PC2	PC3
Ether extract	0.034	0.783	0.318
Crude fiber	0.409	-0.338	0.835
Crude protein	0.671	0.519	-0.453
Total ash	0.387	-0.701	-0.378
Nitrogen free extract	-0.993	-0.035	-0.099
Eigen values (λ)	1.754	1.488	1.156
Percentage of variance	35.1	29.8	23.1
Cumulative percentage of variance	35.1	64.8	88.0

Cluster Analysis

Based on the evaluation for morphological parameters, the 21 clones of *Grewia optiva* Drummond were grouped into 3 clusters (Table 9). Cluster 1 recorded the highest mean for most of the morphological parameters (Table 10). Mean was maximum in cluster 1 for plant height, basal diameter, number of primary branches, weight of 100 fresh leaves, weight of 100 dry leaves, leaf length, leaf width, leaf area, weight of 100 fresh fruits and weight of 100 dry fruits. In cluster 2 the maximum mean was recorded for leaf dry matter content. Mean was maximum in cluster 3 for internodal length followed by leaf density, 100 seed weight, seed length, seed width and seed thickness.

Table 9
Clustering for morphological and fodder parameters among different clones

PARAMETERS	Cluster No.	No. of clones	Clones
MORPHOLOGICAL	1	4	HA-4, SH-7, SI-7, SO-7
	2	12	CH-3, CH-6, HA-2, MA-2, SH-3, SI-14, SI-15, SI-16, SO-1, SO-3, SO-4, SO-10
	3	5	BI-3, BI-4, CH-1, HA-3, SI-10
FODDER QUALITY	1	6	CH-3, HA-2, HA-4, SI-7, SO-7, SO-10
	2	7	BI-4, CH-6, MA-2, SH-3, SH-7, SI-10, SI-14
	3	8	BI-3, CH-1, HA-3, SI-15, SI-16, SO-1, SO-3, SO-4

Table 10
Means of morphological and fodder parameters for different clones of *Grewia optiva* included in cluster

Morphometric Parameters	Cluster 1	Cluster 2	Cluster 3
Plant Height (m)	4.66	4.04	3.88
Basal Diameter (cm)	12.92	11.45	10.71
Internodal Length (cm)	3.42	3.15	3.75
No of primary branches	6.92	5.89	6.20
Leaf Density (per 30 cm)	5.53	5.95	6.29
Fresh Weight of 100 leaves (g)	117.26	93.78	76.61
Dry Weight of 100 leaves (g)	56.60	47.81	37.80
Leaf Dry Matter Content (%)	50.08	52.55	48.61
Leaf Length (cm)	16.02	13.76	12.53
Leaf Width (cm)	10.45	8.74	7.73
Leaf Area (cm ²)	118.38	86.21	72.45
Fresh weight of 100 Fruits (g)	21.08	20.48	19.65
Dry weight of 100 Fruits (g)	13.84	13.78	14.52
Weight of 100 seeds (g)	8.82	8.81	9.06
Seed length (mm)	6.23	6.04	6.24
Seed Width (mm)	4.95	4.93	5.03
Seed Thickness (mm)	4.69	4.58	4.70
Fodder Parameters			
Ether extract (%)	2.52	2.50	2.57
Crude Fiber (%)	4.75	4.63	4.69
Crude protein (%)	4.80	4.64	4.72
Total ash (%)	3.74	3.67	3.67
Nitrogen free extract (%)	38.16	41.35	39.70

Based on cluster analysis for fodder parameters, 21 clones of *Grewia optiva* Drummond were grouped into 3 clusters (Table 9). Clones in cluster 1 recorded the maximum mean values for the two most important fodder quality parameters *viz.* crude fiber and crude protein as well as for total ash (Table 10).

Therefore, based on cluster analysis it can be concluded that clones classified for morphological parameters were HA-4, SH-7, SI-7 and SO-7 and the clones for fodder quality parameters were CH-3, HA-2, HA-4, SI-7, SO-7, SO-10. Mehta et al. (2022) based on their study concluded that the Cluster I contained the highest number of genotypes followed by Cluster II, III, IV and Cluster V. The highest inter cluster values were recorded between cluster II and IV exhibiting wide genetic diversity and crossing between genotypes of these clusters and *Grewia optiva* clones with (C₈, C₁, and C₄) higher fresh fodder and fuel wood productivity were identified.

Dendrogram

Based on the data, 21 clones were clustered into major clusters using SPSS 16 SOFTWARE.

Correlation Studies

Plant height showed a positive and highly significant correlation with basal diameter (0.951), number of primary branches (0.799), fresh fruit weight (0.657). Basal diameter recorded highly significant correlation with number of primary branches (0.839) and fresh fruit weight (0.723). Internodal distance was negatively correlated with leaf density (-0.440) and leaf dry matter content (-0.465). Number of primary branches showed highly significant correlation with fresh fruit weight (0.586) and significant correlation with leaf width (0.435). Fresh weight of 100 leaves recorded highly significant correlation with leaf dry weight (0.885), leaf area (0.757) and fresh fruit weight (0.668). Leaf dry weight exhibited highly significant correlation with leaf area (0.61) and significant correlation with leaf dry matter content (0.462). Leaf dry matter content showed highly significant negative correlation with Dry fruit weight (-0.58). Fresh fruit weight had highly significant correlation with number of primary branches (0.586), leaf fresh weight (0.668), and leaf width (0.560) and significant relation with leaf dry weight (0.488) and leaf area (0.493). Dry fruit weight had highly significant correlation with seed weight (0.803). Among fodder quality parameters, correlation was highly significant and negative among nitrogen free extract and crude fiber (-0.469) and between nitrogen free extract and crude protein (-0.63). Significant negative correlation was found between nitrogen free extract and number of primary branches (-0.549) (Table 11).

Table 11. Correlation for morphometric and fodder quality parameters among different clones of *Grewia optiva* Drummond (Beul)

Parameters	Plant height (m)	Basal diameter (cm)	Internodal distance (cm)	No. of primary branch	Leaf density/ 30 cm	Leaf fresh weight (g)	Leaf dry weight (g)	Leaf dry matter (%)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm ²)	Fresh fruit weight (g)	Dry fruit weight (g)	Seed weight (g)	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	Ether extract (%)	Crude fiber (%)	Crude protein (%)	Total ash (%)
Plant Height (m)	1																				
Basal Diameter (cm)	0.951 ^{***}	1																			
Internodal dist (cm)	-0.542 ^{***}	-0.527 ^{***}	1																		
Primary branches	0.799 ^{***}	0.839 ^{***}	-0.368	1																	
Leaf density / 30 cm	0.268	0.273	-0.440 [*]	0.178	1																
Leaf fresh weight (g)	0.348	0.397	-0.164	0.389	-0.090	1															
Leaf dry weight (g)	0.324	0.354	-0.315	0.337	-0.097	0.885 ^{***}	1														
Leaf dry matter (%)	0.112	0.061	-0.465 ^{***}	-0.024	-0.074	0.057	0.462 ^{***}	1													
Leaf length (cm)	0.373	0.429	-0.162	0.394	-0.245	0.707 ^{***}	0.56 ^{***}	-0.077	1												
Leaf width (cm)	0.441 ^{***}	0.471 ^{***}	-0.160	0.435 ^{***}	-0.238	0.748 ^{***}	0.61 ^{***}	-0.018	0.856 ^{***}	1											
Leaf area (cm ²)	0.359	0.408	-0.127	0.401	-0.335	0.757 ^{***}	0.61 ^{***}	-0.031	0.926 ^{***}	0.950 ^{***}	1										
Fresh fruit weight (g)	0.657 ^{***}	0.723 ^{***}	-0.318	0.586 ^{***}	0.345	0.668 ^{***}	0.488 ^{***}	-0.136	0.528 ^{***}	0.560 ^{***}	0.493 [*]	1									
Dry fruit weight (g)	-0.327	-0.243	0.562 ^{***}	-0.223	0.007	-0.251	-0.45 ^{***}	-0.58 ^{***}	-0.200	-0.315	-0.247	-0.114	1								
100 Seed weight (g)	-0.225	-0.201	0.307	-0.291	0.223	-0.259	-0.427	-0.417	-0.091	-0.220	-0.201	-0.098	0.803 ^{***}	1							
Seed length (mm)	-0.072	-0.071	0.458 [*]	0.006	-0.052	-0.145	-0.276	-0.168	0.028	0.023	0.006	-0.088	0.275	0.410	1						
Seed width (mm)	-0.016	-0.020	0.474 [*]	-0.105	0.089	-0.027	-0.049	-0.065	-0.079	-0.073	-0.071	0.052	0.304	0.313	0.48 ^{***}	1					
Seed thickness (mm)	-0.524 [*]	-0.488 [*]	0.482 [*]	-0.380	-0.276	-0.201	-0.230	-0.026	-0.246	-0.058	-0.081	-0.436 [*]	0.323	0.349	0.50 [*]	0.362	1				
Ether extract (%)	0.272	0.333	-0.259	0.197	0.032	-0.166	-0.171	-0.006	0.227	0.030	0.113	0.058	0.306	0.271	0.118	-0.070	-0.085	1			
Crude fiber (%)	0.081	-0.002	-0.311	0.222	-0.074	0.205	0.193	0.078	0.255	0.287	0.312	-0.133	-0.242	-0.039	-0.26	-0.398	0.019	-0.064	1		
Crude protein (%)	0.175	0.286	-0.013	0.405	0.259	0.202	0.200	-0.122	-0.115	-0.109	-0.105	0.367	0.432	0.202	-0.02	0.153	-0.028	0.138	-0.239	1	
Total ash (%)	0.164	0.145	-0.187	0.112	0.136	0.265	0.232	0.007	-0.090	0.155	0.004	0.123	-0.407	-0.343	0.085	-0.137	-0.053	-0.407	0.011	-0.061	1
NFE (%)	-0.321	-0.356	0.366	-0.549 [*]	-0.222	-0.381	-0.356	0.034	-0.090	-0.187	-0.151	-0.263	-0.064	-0.049	0.116	0.239	0.040	-0.117	-0.469 [*]	-0.63 ^{***}	-0.34

*, Correlation is significant at 5% level of significance

**, Correlation is significant at the 1% level of significance

The main objective of Tree Improvement is to produce best genotypes that bring economic returns. In this regard, practical and efficient means of screening is important. It is important to recognize how various characters relate to one another (Luna and Singh, 2009). With regard to early selection, in any tree improvement programme, the criterias taken are highly correlated genetically (Singh et al. 2012). These correlations indicate that improvement of one character will result in the improvement of another. Bhagta (2016) reported that 100 dry fruit weight was highly correlated with 100 seed weight at genotypic and phenotypic level, (0.22 and 0.17 respectively) in the seedling seed orchard. Khurana et al. (1992) also reported high correlation between plant height and collar diameter in poplar clones. Mehta et al (2022). conducted a study to evaluate *Grewia optiva* clones for fodder yield and other related traits among nine different clones in lower Shivalik North Western Himalayas and the results demonstrated positive correlations between collar diameter and fresh fodder weight. Similarly, diameter at breast height was also strongly correlated with collar diameter, fresh fodder weight and fuel wood weight.

Conclusions

In autumns and during winter season *Grewia optiva* is considered as the best fodder species having high nutritive value and palatability. Keeping this in view there is a need for production of better quality planting material of *Grewia optiva* as source of fodder. On the basis of results obtained for fodder quality parameters as well as based on the results of cluster analysis, it can be concluded that the best clones in terms of morphometric parameters were HA-4, SH-7, SI-7, SO-7 and CH-1 and fodder quality parameters were CH-3, HA-2, HA-4, SI-7, SO-7 and SO-10. Further it was found that the best clones for plant growth parameters were BI-3, HA-4, SI-7, SI-10, SI-15, SO-1 and SO-3, for leaf parameters were HA-4, SH-7, SI-7 and SO-7 and best clones for fruit and seed parameters were BI-3, BI-4, CH-1, CH-3, HA-3 and MA-2. In order to

obtain better quality planting material Juvenile Mature correlation may be used for the selection of clones and further detailed work may be conducted in order to obtain the planting material with desired results. Some of the traits possessing high heritability and genetic gain can be further studied and exploited through various breeding programmes for developing advanced generations through selection. In the present study, the result obtained for different parameters of variability estimation among clones have wide range which depicts presence of good amount of variation among selected clones. Therefore, the clones having wide range of variability offer scope for further screening for desired traits.

Declarations

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Figures

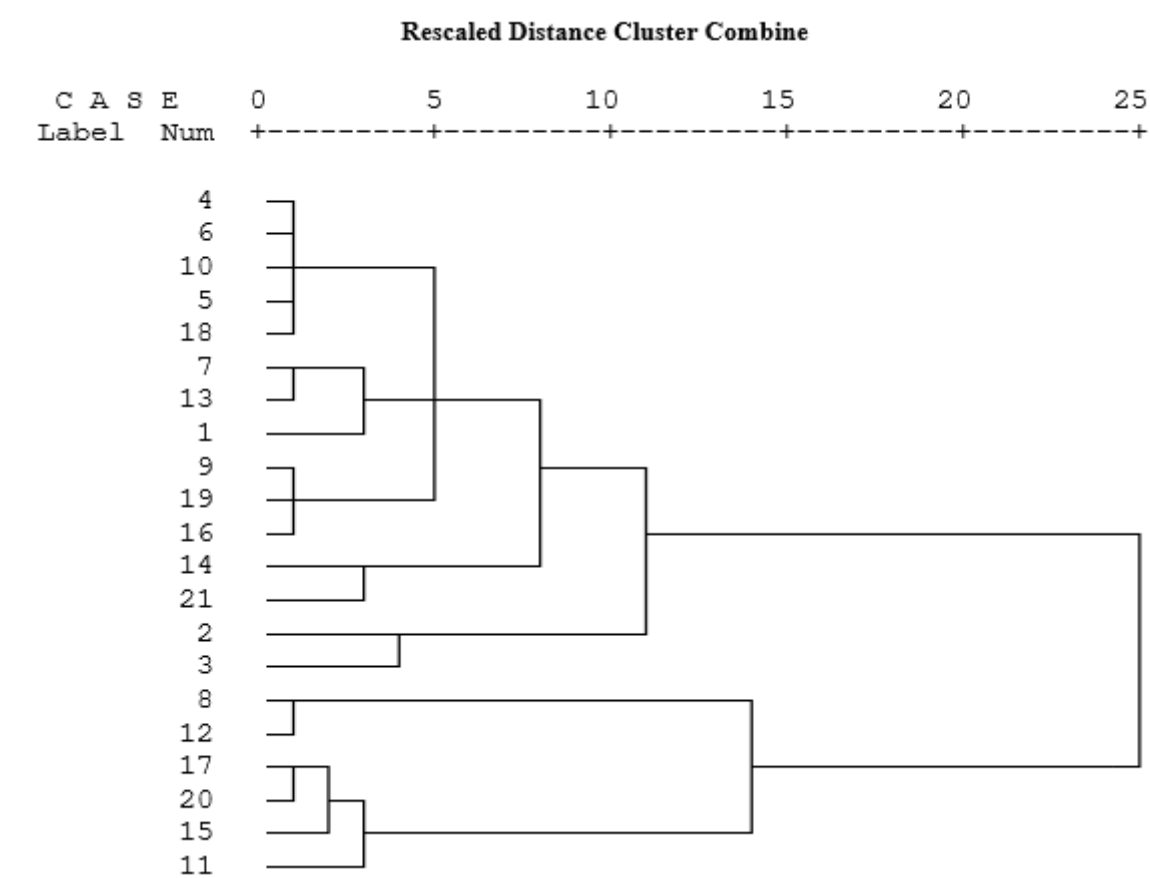


Figure 1

Dendrogram based on morphometric and fodder quality parameters among different clones of *Grewia optiva* Drummond