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Correlation and path coefficient analysis in *Grewia optiva* Drummond

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Abstract
The genotypic and phenotypic correlation and path analysis was studied in forty *Grewia optiva* families for morphometric and fodder quality parameters. In general, the magnitude of genotypic correlations was higher than phenotypic correlations. The genotypic correlation coefficients among different characters revealed that total fresh leaf biomass had significant positive association with plant height (0.263), estimated number of leaves (0.937), leaf area (0.783), fresh weight of 100 leaves (0.896), dry weight of 100 leaves (0.819), fodder yield (0.903) and ether extract (0.3501). The highest positive direct effect on total fresh leaf biomass was imposed by dry weight of leaves (0.627) followed by estimated number of leaves (0.537), leaf dry matter content (0.195), nitrogen free extract (0.095), crude fibre (0.075), leaf area (0.063), fodder yield (0.049), plant height (0.044), fresh weight of 100 leaves (0.037), crude protein (0.035), and total ash (0.027). Diameter had negative direct effect on total fresh leaf biomass (-0.029). On the basis of this study, a higher leaf biomass would be achieved through direct selection based on fresh weight of leaves, leaf area, plant height and diameter. On the basis of fodder quality traits, a higher leaf biomass would be achieved through direct selection based on ether extract, crude protein. Therefore, the current study is important in selection of traits of economic importance based on other characters, whose direct effect is not visible.

Keywords: *Grewia optiva*, leaf biomass, genotypic and phenotypic correlation, path coefficient

Introduction
Grewia optiva, locally called as 'Beul' is an important agroforestry tree species of the low and mid-hill regions in the western and central Himalaya's which constitutes 44 genera and 400 species distributed globally throughout the tropical, subtropical and temperate regions of the world. In Indian subcontinent it is naturally distributed in Bhutan, Nepal, Pakistan and in India it is distributed in areas of Himachal Pradesh, Jammu and Kashmir, Punjab, Sikkim and Uttarakhand. There are about 150 species in the world, 42 in India and 5 in Himachal Pradesh (Hooker, 1875) [4]. The major sources of tree leaf fodder are trees growing on forests and common lands. However, with high timber value plantations coming up on scrub forests, this resource is getting depleted from near habitations. Another source of tree leaf fodder is trees growing on farm lands.
Grewia optiva is one of the most important tree species used as fodder in Himachal Pradesh (Singh, 2005) [7]. Effective tree breeding depends on an understanding of tree variation in nature and preserving such variation for future use. Knowledge of inter- character relationship is very important in plant breeding for indirect selection for characters that are not easily measured. However, under complex situation, correlation alone becomes insufficient to explain relationships among characters and thus path analysis of economically important components is important. Study of inter-character relationship and path analysis in *Grewia optiva* for fodder yield and quality parameters is meager. Therefore, field and laboratory investigations were carried out with a view to study the character association and direct and indirect effect of independent characters on dependent green fodder yield by assessing the germplasm stock maintained as seedling seed orchard at experimental farm field of the Department of Tree improvement and Genetic Resources, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during 2016-2018.

Materials and Methods
The present investigation was carried out in the research farm field and laboratory of the Department of Tree Improvement and Genetic Resources, College of Forestry, Dr Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh) to evaluate

various morphometric and fodder quality parameters in forty families of open pollinated seedling seed orchard of *Grewia optiva* Drummond established in July 2000.The orchard was raised in randomized block design involving 60 families with three replications at a spacing of 2m x 2m. These different families have been sourced from various districts of Himachal Pradesh which include Sirmour (SI), Solan (SO), Chamba (CH), Bilaspur (BI), Mandi (MA), Hamirpur (HA) and Kangra (KA). At present, only 40 families are complete in all respect with complete genotypes and were evaluated for morphometric and fodder quality parameters. Observations on plant height, stem diameter, number of leaves, stem and root dry biomass were recorded. Fresh samples for different components of plant were oven dried to constant weight. Using fresh: dry weight factor, the dry weight of the plant was calculated. The correlation coefficients between different pairs of traits, were determined at phenotypic and genotypic levels as suggested by Robinson *et al.* (1951) [6] and Al-Jibouri *et al.* (1958) [1]. It measures the mutual relationship between plant characters and determines the characters on which selection can be made for genetic improvement. Path coefficient analysis was performed as suggested by Deway and Lu (1959) [3]. The path coefficient analysis is simply a standardized partial regression coefficient which divides the correlation coefficient into the measures of direct and indirect contribution of independent variables on dependent variable.

Results and Discussion

Correlation among characters

The correlation coefficients among the different characters have been presented in Table 1.

Phenotypic Correlation: The phenotypic correlation coefficients among different characters showed that total leaf biomass had significant and positive correlation with estimated number of leaves (0.702), leaf area (0.647), fresh weight of 100 leaves (0.680), dry weight of 100 leaves (0.721), fodder yield (0.559) and ether extract (0.192). However, it showed significant negative correlation with leaf dry matter content (-0.340).

Genotypic Correlation: The genotypic correlation coefficients among different characters revealed that total fresh leaf biomass had significant positive association (Table 1) with plant height (0.263), estimated number of leaves (0.937), leaf area (0.783), fresh weight of 100 leaves (0.896), dry weight of 100 leaves (0.819), fodder yield (0.903), and ether extract (0.228) respectively while, significant negative correlations were observed with leaf dry matter content (-0.437). Nitrogen free extract showed significant positive correlation with leaf dry matter content while significant negative correlation was observed with diameter (-0.276), leaf area (-0.182), ether extract (-0.128), crude fibre (-0.589) and crude protein (-0.583). Total ash exhibited significant negative correlation with fresh weight of 100 leaves (-0.254), leaf dry matter content (-0.253), fodder yield (-0.384), crude fibre (-0.230) and crude protein (-0.536). Crude protein showed significant positive correlation with leaf dry matter content (0.243), fodder yield (0.196) and crude fibre (0.207). Crude fibre showed significant positive correlation with plant height (0.214), diameter (0.430), leaf area (0.292), fresh weight of 100 leaves (0.259), dry weight of 100 leaves (0.227) and fodder yield (0.239) while significant negative correlation was observed with ether extract (-0.239), respectively. Ether extract had significant positive correlation with estimated number of leaves (0.272), leaf area (0.222), fodder yield (0.350)and dry weight of 100 leaves (0.220) while significant negative correlations with diameter (-0.241), leaf dry matter content (-0.275). Fodder yield had significant positive correlation with plant height (0.373), diameter (0.282), estimated number of leaves (0.467), leaf area (0.932), fresh weight of 100 leaves (0.991), dry weight of 100 leaves (0.994) respectively, while significant negative correlation with leaf dry matter content (0.639). Leaf dry matter content exhibited significant negative correlation with plant height (-0.432), diameter (-0.230), leaf area (-0.426), fresh weight of 100 leaves (-0.541) and dry weight of 100 leaves (-0.731), respectively. Dry weight of 100 leaves showed significant positive correlation with plant height (0.200), estimated number of leaves (0.391) and leaf area (0.922) and fresh weight of 100 leaves (0.962). Fresh weight of 100 leaves had significant positive correlation with estimated number of leaves (0.455) and leaf area (0.982). Leaf area showed significant positive correlation with estimated number of leaves (0.413). Estimated number of leaves had significant positive correlation with plant height (0.357) and diameter (0.217) and diameter showed significant positive correlation with plant height (0.752). Similar kind of results were reported by Neelannavar *et al.* (2009) [5] in *Albizia lebbek* and Bhagta (2015) [2] in *Grewia optiva.*

Table 1: Genotypic (above diagonal) and phenotypic (below diagonal) coefficient of correlation for morphometric and fodder quality parameters among different families of *Grewia optiva*

Parameters	Plant Height (m)	Diameter (cm)	Estimated Number of Leaves	Leaf Area (cm^2)	Fresh Weight of 100 Leaves (g)	Dry Weight of 100 Leaves (g)	Leaf Dry Matter Content (%)	Fodder Yield (kg)	Ether Extract (%)	Curde Fibre (%)	Crude Protein (%)	Total Ash (%)	Nitogen Free Extract (%)	Total Fresh Leaf Biomass (g)
Plant Height (m)	1.000	0.752**	0.357**	0.133**	0.210*	0.200*	-0.432**	0.373**	-0.071	0.214*	0.041	-0.041	-0.124	0.263**
Diameter (cm)	0.546**	1.000	0.217*	0.191*	0.116	0.068	-0.230*	0.282**	-0.241**	0.430**	0.099	0.083	-0.276**	0.127
Estimated Number of Leaves	0.149	0.034	1.000	0.413**	0.455**	0.391**	-0.171	0.467**	0.272**	0.070	0.138	-0.150	-0.104	0.937**
Leaf Area (cm^2)	0.050	0.119	0.244**	1.000	0.982**	0.922**	-0.426**	0.932**	0.222*	0.292**	0.009	-0.096	-0.182*	0.783**
Fresh Weight of 100 Leaves (g)	0.038	0.028	0.264**	0.754**	1.000	0.96288	-0.541**	0.991**	0.138	0.259**	0.045	-0.254**	-0.059	0.896**
Dry Weight of 100 Leaves (g)	-0.010	0.019	0.212*	0.741**	0.788**	1.000	-0.731**	0.994**	0.220*	0.227*	-0.136	-0.070	-0.047	0.819**
Leaf Dry Matter Content (%)	-0.106	-0.064	-0.080	-0.381**	-0.408**	-0.684**	1.000	-0.639**	-0.275**	-0.165	0.243**	-0.253**	0.164	-0.437**

Fodder yield (kg)	0.126	0.060	0.210*	0.582**	0.692**	0.653**	-0.448**	1.000	0.350**	0.230*	0.196*	-0.384**	-0.109	0.903**
Ether Extract %	-0.070	-0.073	0.150	0.131	0.052	0.145	-0.138	0.142	1.000	-0.239**	0.101	0.046	-0.218*	0.228*
Curde Fibre %	0.124	0.220*	0.008	0.119	0.111	0.041	0.020	0.113	-0.199	1.000	0.207**	-0.230*	-0.589**	0.120
Crude Protein %	0.044	0.058	0.088	0.005	-0.026	-0.066	0.148	0.076	0.097	0.190*	1.000	-0.536**	-0.583**	0.011
Total Ash	0.014	0.080	-0.016	-0.100	-0.143	-0.054	-0.167	-0.220*	0.043	-0.219*	-0.474**	1.000	-0.112	-0.150
Nitrogen Free Extract %	-0.133	-0.175	-0.064	-0.070	-0.018	-0.011	0.066	-0.056	-0.204*	-0.549**	-0.544**	-0.109	1.000	-0.033
Total Fresh Leaf Biomass	0.085	0.024	0.702**	0.647**	0.680	0.721**	-0.340**	0.559	0.192	0.062	0.029	-0.113	-0.017	1.000

*Significant at 5% level of significance
* *Significant at 1% level of significance

Path Coefficient Analysis

Path coefficient analysis depicts the effects of independent characters individually and in combination with other characters on the expression of yield and other characters. Path coefficient analysis devised by Dewey and Lu (1959) [3] provides a realistic basis for allocation of appropriate weightage to various attributes while designing a pragmatic programme for the improvement of leaf biomass. The data on path coefficient analysis at genotypic level showing the direct and indirect effects of significant characters over total fresh leaf biomass have been represented in Table 2. A perusal of genotypic path coefficient analysis indicated that maximum direct positive effect on total fresh leaf biomass was imposed by dry weight of 100 leaves (0.627) followed by estimated number of leaves (0.537), leaf dry matter content (0.195), nitrogen free extract (0.095), crude fibre (0.075), leaf area (0.063), fodder yield (0.049), plant height (0.044), fresh weight of 100 leaves (0.037), crude protein (0.035), and total ash (0.027). Diameter had negative direct effect on total fresh leaf biomass (-0.029). Similar kinds of results were found by Thakur (2014) [8] in *Melia azedacach.*

Table 2: Path analysis (Estimation of direct and indirect effect of different traits in *Grewia optiva*)

Parameters	Plant Height (m)	Diameter (cm)	Estimated Number of Leaves	Leaf Area (cm^2)	Fresh Weight of 100 Leaves (g)	Dry Weight of 100 Leaves (g)	Leaf Dry Matter Content (%)	Fodder Yield (kg)	Ether Extract (%)	Curde Fibre (%)	Crude Protein (%)	Total Ash (%)	Nitogen Free Extract (%)	Total Fresh Leaf Biomass (g)
Plant Height (m)	0.044	0.024	0.007	0.002	0.002	0.000	-0.005	0.006	-0.003	0.005	0.002	0.001	-0.006	0.085
Diameter (cm)	-0.016	-0.029	-0.001	-0.003	-0.001	-0.001	0.002	-0.002	0.002	-0.006	-0.002	-0.002	0.005	0.024
Estimated Number of Leaves	0.080	0.018	0.537	0.131	0.142	0.114	-0.043	0.113	0.080	0.004	0.047	-0.008	-0.034	0.702
Leaf Area (cm^2)	0.003	0.007	0.015	0.063	0.047	0.047	-0.024	0.037	0.008	0.008	0.000	-0.006	-0.004	0.647
Fresh Weight of 100 Leaves (g)	0.001	0.001	0.010	0.028	0.037	0.029	-0.015	0.026	0.002	0.004	-0.001	-0.005	-0.001	0.680
Dry Weight of 100 Leaves (g)	-0.006	0.012	0.133	0.464	0.494	0.627	-0.429	0.409	0.091	0.026	-0.042	-0.034	-0.007	0.721
Leaf Dry Matter Content (%)	-0.021	-0.012	-0.016	-0.074	-0.080	-0.134	0.195	-0.088	-0.027	0.004	0.029	-0.033	0.013	-0.340
Fodder yield (kg)	0.006	0.003	0.010	0.029	0.034	0.032	-0.022	0.049	0.007	0.006	0.004	-0.011	-0.003	0.559
Ether Extract %	-0.004	-0.004	0.009	0.008	0.003	0.009	-0.008	0.009	0.061	-0.012	0.006	0.003	-0.012	0.192
Curde Fibre %	0.009	0.017	0.001	0.009	0.008	0.003	0.001	0.008	-0.015	0.075	0.014	-0.017	-0.041	0.062
Crude Protein %	0.002	0.002	0.003	0.000	-0.001	-0.002	0.005	0.003	0.003	0.007	0.035	-0.017	-0.019	0.029
Total Ash	0.000	0.002	0.000	-0.003	-0.004	-0.001	-0.004	-0.006	0.001	-0.006	-0.013	0.027	-0.003	-0.113
Nitogen Free Extract %	-0.013	-0.017	-0.006	-0.007	-0.002	-0.001	0.006	-0.005	-0.019	-0.052	-0.052	-0.010	0.096	-0.017

Residual effect= 1.2225
Diagonal figure represent the direct effect

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