

Quantitative Characteristics Analysis of *Hippophae salicifolia* D. Don (Seabuckthorn) Populations in Himachal Pradesh

Sumit Nangla^{1*} and H.P. Sankhyan²

¹Ph.D. Scholar, Department of Tree Improvement and Genetic Resources, Dr Y S Parmar University of Horticulture and Forestry Nauni, Solan (Himachal Pradesh), India.

²Professor & Head, Department of Tree Improvement and Genetic Resources, Dr Y S Parmar University of Horticulture and Forestry Nauni, Solan (Himachal Pradesh), India.

(Corresponding author: Sumit Nangla*)

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ABSTRACT: The present study was conducted to determine the variation among different populations and growing genotypes for quantitative characteristics of plant, leaves, thorns, fruits and seeds. Five female genotypes of *Hippophae salicifolia* at each site were selected at the time of fruit set i.e., during August-September, when male and female could be differentiated. The analysis of variance of quantitative characteristics showed significant variation among and between different populations. Based on quantitative characters, the population of Chitkul site was found promising for genotype height (3.34m), leaf area (4.00cm²), leaf density (24.20 per 10cm on branch), seed length (6.50mm), and Kupa site was found promising for branch length (122.67cm), leaf length (7.07cm), leaf width (1.01cm) and seed weight (7.07g). Maximum fruit weight (17.09g) was recorded in Sheigo. Highest heritability was recorded in seed weight (99.98%). Due to significant variability, the population can be used for future breeding programmes and for preparation of DUS guidelines of this species.

Keywords: *Hippophae salicifolia*, Quantitative characteristics, Genetic variation, Heritability, Genetic advance.

INTRODUCTION

Seabuckthorn (*Genus Hippophae*) is a berry-bearing, hardy shrub of the family Elaeagnaceae, naturally distributed in Asia and Europe and also introduced in North and South America. It includes 4 species (*Hippophae rhamnoides*, *Hippophae salicifolia*, *Hippophae tibetana* and *Hippophae neurocarpa*) and further 9 subspecies of *Hippophae rhamnoides* are reported so far from many parts of world out of which three species of seabuckthorn (*Hippophae rhamnoides* L. subsp. *turkestanica* Rousi, *Hippophae salicifolia* D. Don and *Hippophae tibetana* Sch.) are found in Spiti, Himachal Pradesh (Singh *et al.*, 2012). It is a unique and valuable genotype resource currently cultivated in various parts of the world. The natural habitat of Seabuckthorn extends widely in China, Mongolia, Russia, and most parts of North Europe. It can withstand extreme temperatures from -43°C to 40°C (Lu 1992) and is considered to be drought resistant. The cold deserts in Himachal Pradesh are found in the districts of Lahaul and Spiti, parts of Kinnaur and Pir Panjal region of Chamba. These areas are characterized by high ridges, difficult terrains with ice field, perpetual snow covered peaks and hostile climate. Among

various indigenous and under exploited genotype resources of high mountain area, Seabuckthorn (*Hippophae salicifolia* D. Don) is one of the best solution and can certainly metamorphose the ecology of cold desert by reclaiming these bare fragile mountains. Willow leaved Seabuckthorn and indigenous source locally Sutz/Sarla offers an opportunity to maintain more sustainable livelihood qualities as well as unique option for the simultaneous management of several problems such as capability to grow and survive under adverse climatic conditions, extensive root system with soil binding ability/ soil stabilization/control of river bank/ water retention, This *Frankia* association accounts for atmospheric nitrogen fixation, hence adding to the soil-fertility (Lu 1992; Singh, 2001), nitrogen fixing upto 60-180kg/ha/year (Mathew *et al.*, 2007), higher vitamin-C content and economic value of fruit and seed oil, excellent fodder and fuel wood qualities (Roomi *et al.*, 2015), wider application in food, cosmetics, therapeutic, pharmaceutical, and cosmetic properties and other pharmaceutical products (Kaushal *et al.*, 2013), excellent fencing hedge and social fencing. Though seabuckthorn is widely found under agroforestry system as well as hazard zones, yet no any systematic study has been carried out so far to

understand its potential under agroforestry/forestry perspectives. So it help to be a valuable tool for land restoration and conservation in the cold desert of the Lahaul valley (Sankhyan *et al.*, 2018). The first prerequisite step to undertake breeding programme and to obtain improved genetic gain is selection of best population and best individuals within the population. Knowledge of the distribution of genetic diversity provides a guide to the proper management of the genetic resources of species in effective genetic conservation programs (Barrett and Kohn, 1991). Hence present study was undertaken to study variation in quantitative characteristics among and between different populations to select plus trees of *Hippophae salicifolia* D. Don.

MATERIAL AND METHODS

The present study was carried out in the fields of Baspa valley of District Kinnaur and Spiti valley of District Lahaul and Spiti as well as in the laboratories of the Department of Tree Improvement and Genetic Resources of Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India during the period 2018- 2020. After surveyed and proper identification of genotypes and population with selecting three natural populations in each valley and from each population five female genotypes were selected at the time of fruit set, i.e., during August-September, marked and taken for further investigation and recording quantitative characteristics. Leaves and berries were taken and carried from experimental sites to laboratory for further study. Altitude of populations ranged from 2590m amsl to 3538m amsl in the study area at different sites of Himachal Pradesh.

Observations on the following morphological characteristics were recorded. Genotype height (m), Branch length (cm), Leaf length (cm), Leaf width (cm), Leaf area (cm²), Leaf density, Number of thorns (average per branch), Fresh fruits weight (g -100 Fruits), Fruit length (mm), Fruit diameter (mm), Seeds weight (g -1000 Seeds), Seed length (mm), Seed width (mm).

ANOVA (Analysis of Variance) was carried out for quantitative characteristics as described by Panse and Sukhatme (1967); Chandel (1984). Design RBD(Factorial) with 6 treatments, 5 genotypes, 3 replication was used. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were estimated as per suggested by Burton and Devane(1953), heritability was estimated as per suggested by Burton and Devane (1953); Johnson *et al.* (1955), genetic advance as per procedure of Allard (1960) and genetic gain as per procedure of Johnson *et al.* (1955).

RESULT AND DISCUSSION

A. Quantitative Characters

Genotype height (m). It is evident from data presented in Table 1 that maximum genotype height was recorded in Chitkul (3.34 m) followed by Kupa (2.74 m), while minimum genotype height was observed in Shiego (1.20 m) followed by Giu (1.60 m). Between the genotype of different sites the maximum (4.3 m) genotype height was obtained from genotype number 5 of Chitkul (CG5), whereas the minimum genotype height (0.9 m) was noticed in Sheigo genotype 1 (SG1), respectively. The interaction between the population and among population was statistically significant. Similar genotype height up to 6 m was recorded by Yadav *et al.* (2006).

Table 1: Variation in genotype height (m) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Genotype Height (m)					Mean
		Genotype 1	Genotype 2	Genotype 3	Genotype 4	Genotype 5	
S1	Kupa	3.2	3.0	2.0	2.3	3.2	2.74
S2	Badseri	2.1	2.5	3.1	2.5	2.3	2.50
S3	Chitkul	2.3	3.1	3.0	4.0	4.3	3.34
S4	Giu	2.0	1.4	1.9	1.5	1.2	1.60
S5	Mane	1.5	2.9	2.15	2.4	3.0	2.39
S6	Shiego	0.9	1.5	1.1	1.2	1.3	1.20
	CD	0.05					
	AP	0.04					
	BP	0.03					
	AP × BP	0.09					

Branch length (cm). The maximum branch length was recorded in Kupa (122.67 cm) followed by Chitkul (111 cm) whereas minimum was observed in Shiego (58.27 cm) (Table 2). The highest value (180.00 cm) for branch length was recorded in genotype number 4 in Kupa (KG4), whereas minimum (46.67 cm) was observed in genotype 3 in Giu (GG3). The interaction

among and between population was statistically significant.

Leaf length (cm). The mean leaf length ranged from 7.07 to 3.92 cm presented in Table 3. Maximum value was recorded for Kupa (7.07 cm) and the minimum value was noticed in Shiego (3.92 cm). From the studied genotypes, the maximum leaf length (8.10 cm)

was observed in genotype 4 for Kupa (KG4), while the minimum (3.34 cm) was recorded in Sheigo genotype 3 (SG3). The interaction among and between population was observed to be significant whereas it was non-significant between population. On the other hand, the variation among population was also shown to be significant. Similar leaf length was recorded by Yadav *et al.* (2016) which was ranged from 8.46-4.83 cm.

Leaf width (cm). Content of the data presented in Table 4 showed that the variation among the population as well as the interaction between among and between population showed significant variation on leaf width. Maximum leaf width was recorded in Kupa (1.01 cm) followed by Chitkul (0.88 cm) and minimum was recorded in Shiego (0.48 cm) followed by Giu (0.55

cm). However, among population, the maximum leaf width (1.34 cm) was recorded in genotype 3 for Kupa (KG3) whereas, minimum was recorded in genotype 3 (0.37 cm) for Sheigo (SG3). The variation among population as well as between population was also found to be significant. Similar leaf width was recorded by Yadav *et al.* (2016) which was ranged from 1.4-0.37 cm.

Leaf area (cm²). The mean data in Table 5 revealed that the maximum leaf area was recorded in Chitkul (4.00 cm²) followed by Kupa (3.83 cm²) and minimum was recorded in Shiego (2.21 cm²) followed by Giu (2.32 cm²). A significant variation was found between population and the interaction between population and among population was also found to be significant.

Table 2: Variation in branch length (cm) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Branch Length (cm)					Mean
		Genotype 1	Genotype 2	Genotype 3	Genotype 4	Genotype 5	
S1	Kupa	73.33	136.67	86.67	180.00	136.67	122.67
S2	Badseri	130.00	83.33	130.00	70.00	83.33	99.33
S3	Chitkul	106.67	130.00	110.00	116.67	91.67	111.00
S4	Giu	70.00	70.00	46.67	70.00	83.33	68.00
S5	Mane	63.33	69.00	90.00	75.00	70.00	73.47
S6	Shiego	53.33	60.00	65.00	55.00	58.00	58.27
CD		0.05					
AP		20.93					AP: Among population
BP		NS					BP: Between population
AP × BP		46.82					

Table 3: Variation in leaf length (cm) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Leaf Length (cm)					Mean
		Genotype 1	Genotype 2	Genotype 3	Genotype 4	Genotype 5	
S1	Kupa	7.32	5.78	7.24	8.10	6.90	7.07
S2	Badseri	4.38	6.04	5.90	6.75	5.41	5.70
S3	Chitkul	7.12	5.90	4.64	5.68	6.36	5.94
S4	Giu	4.14	4.06	4.39	3.53	3.74	3.97
S5	Mane	5.15	5.59	6.31	3.86	3.50	4.88
S6	Shiego	3.60	4.73	3.34	3.56	4.37	3.92
CD		0.05					
AP		0.31					AP: Among population
BP		NS					BP: Between population
AP × BP		0.68					

Table 4: Variation in leaf width (cm) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Leaf Width (cm)					Mean
		Genotype 1	Genotype 2	Genotype 3	Genotype 4	Genotype 5	
S1	Kupa	0.90	0.90	1.34	1.04	0.88	1.01
S2	Badseri	0.80	0.88	0.60	1.08	0.94	0.86
S3	Chitkul	1.24	0.86	0.74	0.80	0.74	0.88
S4	Giu	0.55	0.53	0.63	0.51	0.55	0.55
S5	Mane	0.57	0.91	1.01	0.55	0.51	0.71
S6	Shiego	0.42	0.58	0.37	0.48	0.52	0.48
CD		0.05					
AP		0.059					AP: Among population
BP		0.054					BP: Between population
AP × BP		0.133					

Between population, the maximum (7.88 cm²) leaf area was recorded in Chitkul genotype 1 (CG1) where minimum (1.79 cm²) in genotype 3 for Sheigo (SG3). Yadav *et al.* (2006) also reported similar leaf area ranged from 2.28 to 9.35 cm².

Leaf density (10 cm of branch). The data presented in Table 6 revealed that the maximum leaf density was recorded in Chitkul (24.20 per 10 cm) and minimum was observed in Sheigo (14.67 per 10 cm). Between

population, the highest (27.00 per 10 cm) leaf density per 10 cm was recorded in Chitkul genotype 5 (CG5), whereas the minimum was in Kupa genotype 5 (13.00 per 10 cm). The interaction among population and between population was found to be significant but it was non-significant between the population. Similar leaf density was recorded by Yadav *et al.* (2006) that ranged from. 29.83 leaves per 10 cm.

Table 5: Variation in leaf area (cm²) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Leaf Area (cm ²)					Mean
		Genotype 1	Genotype 2	Genotype 3	Genotype 4	Genotype 5	
S1	Kupa	4.60	3.80	3.90	4.16	2.68	3.83
S2	Badseri	3.11	4.14	2.48	2.87	1.84	2.89
S3	Chitkul	7.88	4.18	2.08	2.98	2.89	4.00
S4	Giu	2.33	2.23	2.85	1.90	2.31	2.32
S5	Mane	3.10	5.39	6.20	2.25	1.89	3.77
S6	Sheigo	1.99	2.89	1.79	1.85	2.52	2.21
CD		0.05					
AP		0.337					AP: Among population
BP		0.307					BP: Between population
AP × BP		0.753					

Table 6: Variation in leaf density (per 10 cm) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Leaf Density (per 10 cm)					Mean
		Genotype 1	Genotype 2	Genotype 3	Genotype 4	Genotype 5	
S1	Kupa	14.67	23.00	19.00	14.00	13.00	16.73
S2	Badseri	20.00	17.00	18.00	20.00	25.00	20.00
S3	Chitkul	23.00	21.00	25.67	24.33	27.00	24.20
S4	Giu	20.00	19.33	21.33	18.00	14.00	18.53
S5	Mane	19.00	20.00	14.67	20.67	14.00	17.67
S6	Sheigo	13.33	13.67	16.00	14.67	15.67	14.67
CD		0.05					
AP		1.74					AP: Among population
BP		NS					BP: Between population
AP × BP		3.893					

Number of thorn (per 10 cm of shoot). The data on number of thorns is detailed in Table 7. The maximum number of thorn was recorded in (4.53 per 10 cm) and the minimum was recorded in Kupa (1.47 per 10 cm), respectively. Between the population of all the sites, the maximum number of thorns per 10 cm was recorded in genotype 5 (5.33 per 10 cm) of Giu (GG5) and minimum number was recorded in Mane genotype 5 (MG5) (0.67 per 10 cm). The interaction was also significant between population and among populations. Similar number of thorn was recorded by Singh V (2006) that ranged from 4.3-6.9 per 10 cm.

Fresh fruit weight (g -100 fruits). The fruit weight showed significant variation among population, which varied from 17.09 to 11.14 g in Table 8. The maximum fruit weight was noticed in Sheigo (17.09 g) followed by Mane (16.45 g) and minimum was recorded in Badseri (11.14 g) which was differed statistically. Between the population, the maximum fruit weight (20.11 g) was recorded in Mane genotype 4 (MG4) and

minimum was in (MG1) Mane genotype 1 (8.84 g). The variation between population was noticed to be significant and the interaction was also statistically significant for among population and between population. Nawaz *et al.* (2018) also found the maximum and minimum fruit weight value of 20 berries ranged from 6.28 to 1.08 g.

Fruit length (mm). The data pertaining to the fruit length is presented in Table 9, which showed significant variations among studied population. Maximum fruit length (7.00 mm) was observed in Kupa which was statistically different from other population and minimum was recorded in Giu (5.73 mm) which was at par with Sheigo (5.88 mm) respectively. Between population, the maximum fruit length (7.23 mm) was also noticed in Kupa genotype 2 (KG2) which was followed by (CP2), (CP5), (KP3), (CP3) whereas, minimum was recorded in Giu Genotype 5 (GG5) (5.17 mm). The interaction among population and between population was found significant but it was non-

significant between population. Yadav *et al.* (2006) of fruit length varied from 5.78 to 7.92 mm. reported almost similar maximum and minimum range

Table 7: Variation in number of thorn (per 10 cm) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Number of Thorn (per 10 cm)					Mean
		Genotype 1	Genotype 2	Genotype3	Genotype4	Genotype5	
S1	Kupa	2.00	1.33	1.00	1.00	2.00	1.47
S2	Badseri	3.00	2.00	2.33	3.00	4.00	2.87
S3	Chitkul	3.00	2.00	4.00	3.00	1.00	2.60
S4	Giu	4.00	4.00	5.00	4.33	5.33	4.53
S5	Mane	3.00	2.00	1.00	2.33	0.67	1.80
S6	Shiego	4.00	3.00	4.33	1.00	3.00	3.07
CD		0.05					
AP		0.56	AP: Among population				
BP		0.51	BP: Between population				
AP × BP		1.26					

Table 8: Variation in 100 fresh fruit weight (g) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	100 Fresh Fruit Weight (g)					Mean
		Genotype 1	Genotype 2	Genotype3	Genotype4	Genotype5	
S1	Kupa	16.08	14.50	13.78	19.80	14.48	15.73
S2	Badseri	9.18	11.40	10.48	11.95	12.70	11.14
S3	Chitkul	12.35	14.80	12.80	10.14	13.79	12.78
S4	Giu	15.13	14.85	13.70	15.00	18.86	15.51
S5	Mane	8.84	15.36	18.45	20.11	19.47	16.45
S6	Shiego	16.15	15.64	18.36	18.07	17.21	17.09
CD		0.05					
AP		0.04	AP: Among population				
BP		0.04	BP: Between population				
AP × BP		0.09					

Table 9: Variation in fruit length (mm) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Fruit Length (mm)					Mean
		Genotype 1	Genotype 2	Genotype 3	Genotype 4	Genotype 5	
S1	Kupa	6.87	7.23	7.07	6.89	6.92	7.00
S2	Badseri	5.93	6.28	5.66	6.12	6.17	6.03
S3	Chitkul	6.02	7.21	7.06	6.34	7.18	6.76
S4	Giu	6.26	5.80	5.80	5.60	5.17	5.73
S5	Mane	6.30	6.00	6.53	6.17	6.30	6.26
S6	Shiego	5.61	5.41	6.17	5.94	6.27	5.88
CD		0.05					
AP		0.22	AP: Among population				
BP		NS	BP: Between population				
AP × BP		0.49					

Fruit diameter (mm). The data pertaining to fruit diameter are presented in Table 10 which revealed a significant variation among all the population. Mane showed the highest (7.17 mm) fruit diameter which was statistically different from all other population whereas, Badseri reported the minimum (5.88 mm) fruit diameter which was at par with Shiego (5.96) and Chitkul (5.98), respectively. Between population, the maximum (7.63 mm) fruit diameter was noticed in Mane genotype 4 (MG4) and minimum (5.29 mm) was recorded in Badseri genotype 3 (BG3). All the population showed a

significant variation between each other and the interaction among population and between population also found to be significant. Yadav *et al.* (2006) reported almost similar fruit diameter ranged from 5.51 to 7.24 mm.

Seed weight (g -1000 seeds). The population taken for study showed considerable variation among themselves (Table 11). The highest value (21.30 g) for seed weight was recorded in Sheigo was statistically different from other whereas, the minimum seed weight was recorded in Badseri (11.30 g). Between all population, the

maximum (24.00 g) seed weight was observed in Sheigo genotype1 and minimum (10.00 g) was recorded in Badseri genotype5 (BG5). The interaction between population and among population showed significant variation and the variation was also statistically significant for among population and between population. Similar seed weight was recorded by Tomar and Rattan (2012) which was ranged between 2.83-1.30 g.

Seed length (mm). The genotypes taken for study showed considerable variation among themselves (Table 12). The highest value (5.83 mm) for seed length

was recorded in Chitkul which was significantly different from other population, whereas the minimum seed length was recorded in Mane (4.17 mm). Between population, the maximum seed length (6.50 mm) was noticed in Chitkul genotype 2 whereas, minimum (3.50 mm) was recorded in Mane genotype1 (MG1). The interaction between population and among population as well as between population showed statistically significant variation. The present investigations are in line with the findings of Mir *et al.*, (2018); for seed length ranged from 4-7 mm.

Table 10: Variation in fruit diameter (mm) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Fruit Diameter (mm)					Mean
		Genotype 1	Genotype 2	Genotype 3	Genotype4	Genotype5	
S1	Kupa	6.97	6.30	6.33	6.67	6.05	6.46
S2	Badseri	5.60	6.15	5.29	6.15	6.21	5.88
S3	Chitkul	5.61	5.82	6.26	6.04	6.18	5.98
S4	Giu	6.22	5.90	6.80	6.90	6.13	6.39
S5	Mane	7.23	6.77	7.43	7.63	6.80	7.17
S6	Shiego	6.13	6.00	5.87	5.54	6.27	5.96
CD		0.05					
AP		0.22					
BP		0.201					
AP × BP		0.492					

Table 11: Variation in 1000 seed weight (g) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	100 Seed Weight (g)					Mean
		Genotype1	Genotype2	Genotype3	Genotype4	Genotype5	
S1	Kupa	1.31	1.27	1.12	1.06	1.46	1.24
S2	Badseri	1.22	1.18	1.15	1.11	1.00	1.13
S3	Chitkul	1.42	1.25	1.66	1.33	1.36	1.40
S4	Giu	1.90	2.01	2.07	2.11	1.88	1.99
S5	Mnae	2.02	2.13	2.04	1.98	2.06	2.05
S6	Shiego	2.40	2.20	2.00	2.04	2.00	2.13
CD		0.05					
AP		0.004					
BP		0.004					
AP × BP		0.01					

Table 12: Variation in seed length (mm) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Seed Length (mm)					Mean
		Genotype 1	Genotype 2	Genotype 3	Genotype 4	Genotype 5	
S1	Kupa	5.00	5.00	6.00	4.00	4.00	4.80
S2	Badseri	5.50	5.13	5.00	4.33	4.70	4.93
S3	Chitkul	6.00	6.50	5.00	6.00	5.67	5.83
S4	Giu	5.00	5.67	4.17	4.67	4.50	4.80
S5	Mane	3.50	4.17	4.67	3.67	4.83	4.17
S6	Shiego	5.17	5.67	5.17	4.83	5.33	5.23
CD		0.05					
AP		0.23					
BP		0.21					
AP × BP		0.52					

Seed width (mm). The data pertaining to the seed width is presented in Table 13, which showed significant variations among studied population.

Badseri showed the highest (3.16 mm) seed width which was statistically different from other population and Kupa reported the minimum (2.18 mm) seed width.

Between population, the maximum seed width was noticed in Badseri genotype 4 (3.50 mm) and minimum (1.80 mm) was recorded in Kupa genotype 3. Between population showed non-significant variation among each other and the interaction between population and among population showed statistically significant. The present investigations are in line with the findings of Kaushal and Sharma (2012) for seed width varied from 2.5-3.5 mm.

Variability Estimate and genetic parameters for quantitative characters. Noteworthy distinction was observed during the investigation of coefficient of variation, heritability, genetic advance and genetic gain for various parameters of between different population of Himachal Pradesh. The characters evaluated for variability and genetic parameters included quantitative (plant height, branch length, leaf characters, fruit characters and seed characters). The consequences found for variability and genetic parameters are accessible in the certifying tables and unfolding as follows:

The total variance panel into different mechanisms as described in Table 14 showed that the highest genotypic

and phenotypic coefficient of variability among quantitative traits was observed in number of thorns (45.3; 53.36) followed by leaf area (43.87; 46.21) and minimum value in fruit diameter (8.44; 9.69). Maximum heritability was shown by 100 seeds weight (99.98%) followed by fruit weight (99.97%), plant height (99.54%), leaf length (91.25%), leaf area (90.16%) and minimum value was shown by seed width (47.11 %). Genetic advance was maximum in branch length (38.70) and minimum in leaf width (0.47). Genetic gain was maximum for leaf area (85.82 %) and minimum was for fruit diameter (15.15 %).

These results support the findings of Mohapatra (1996) in *Acacia catechu*, Manga and Sen (1998) in *Prosopis cineraria*, Gera *et al.* (2002) in *Dalbergia sissoo*, Khosla *et al.* (1982) in *Santalum album*, (Kaushal 1978; Khosla *et al.*, 1980; Gupta 1993; Sehgal and Jaswal 1996; Rathore 1997; Bhat 2010) in *Grewia optiva*. This suggests the selection of the required traits, so as to exploit the potentialities and huge variation existing in the valuable species, which is of great agroforestry importance in cold desert of Spiti Valley and Baspa Valley of Kinnaur.

Table 13: Variation in seed width (mm) among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Between Among	Populations	Seed Width (mm)					Mean
		Genotype 1	Genotype 2	Genotype 3	Genotype 4	Genotype 5	
S1	Kupa	1.97	1.80	2.83	2.17	2.13	2.18
S2	Badseri	2.67	3.00	3.33	3.50	3.30	3.16
S3	Chitkul	2.00	2.50	2.30	2.53	2.17	2.30
S4	Giu	2.83	2.83	2.17	2.33	2.27	2.49
S5	Mane	2.27	2.33	2.17	2.17	2.00	2.19
S6	Shiego	2.17	2.50	3.17	2.17	2.50	2.50
CD		0.05					
AP		0.29					
BP		NS					
AP × BP		0.66					

Table 14: Variability and genetic parameters for quantitative parameters of Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

Traits	Coefficient of Variability		Heritability (broad sense)	Genetic Advance	Genetic Gain (%)
	Genotypic	Phenotypic			
Plant height	36.808	36.892	99.546	1.73	75.65
Branch length	30.67	44.455	47.60	38.70	43.59
Leaf length	25.67	26.87	91.25	2.65	50.51
Leaf width	32.48	34.239	89.99	0.47	63.47
Leaf area	43.87	46.21	90.16	2.72	85.82
Leaf density	20.34	24.007	71.79	6.62	35.51
No. of thorns	45.3	53.36	72.07	2.16	79.22
Fruit weight	21.16	21.16	99.97	6.44	43.58
Fruit length	8.53	9.81	75.66	0.96	15.28
Fruit diameter	8.44	9.69	75.88	0.95	15.15
100 seeds weight	25.99	25.99	99.98	0.88	53.53
Seed length	14.24	15.62	83.15	1.33	26.75
Seed width	15.39	22.42	47.11	0.54	21.76

CONCLUSION

— On the basis of quantitative characters, the population of Chitkul was found more promising for higher genotype height, leaf area, leaf density, seed length whereas, Badseri population was found more effective for seed width and Kupa population was more effective for the characters such as branch length, leaf length, leaf width, number of thorns and fruit length. The population of Shiego found more effective for fruit weight and seed weight. The population of Mane for fruit diameter. It is also suggested that for further propagation programmes, genepool from Sangla Valley should be used.

— Phenotypic coefficient of variability is higher than genotypic coefficient of variability for all traits, it means that the characters have influenced with the environment to some degree. All traits were more over genetically controlled as revealed by high heritabilities. Conclusively on the basis of phenotypic performance based, some quantitative of wanted characters can be used for the future improvement forthcoming and so there is more scope for improvement of these characteristics.

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Conflict of Interest. None.

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