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**Sumit Nangla**
MSc (Forestry) Forest Genetic Resources, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

**HP Sankhyan**
Principal Scientist/ Professor (Forestry), Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

**Sanjeev Thakur**
Professor and Head, Dr. Y S Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

**Bhupender Dutt**
Professor, Dr. Y S Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

**Neerja Rana**
Assistant Professor, (Biochemistry), Dr. Y S Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

**Corresponding Author:**
**Sumit Nangla**
MSc (Forestry) Forest Genetic Resources, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

# Qualitative characteristics analysis of *Hippophae salicifolia* D. Don (Seabuckthorn) populations in Himachal Pradesh

**Sumit Nangla, HP Sankhyan, Sanjeev Thakur, Bhupender Dutt and Neerja Rana**

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**Abstract**
To determine the variation among different populations and growing plants for qualitative characteristics of plant, leaves, thorns, fruits (berries) and seeds, five female plants of *Hippophae salicifolia* D. Don at each site were selected at the time of fruit set i.e., during August-September, when male and female could be differentiated. The selected plants were used for the assessment the qualitative variation of *Hippophae salicifolia* D. Don in Spiti valley and Baspa valley. Variation in qualitative traits of different sites of *Hippophae salicifolia* D. Don within and between different populations were studied. All the qualitative characters showed significant variation among and between different populations. Based on qualitative characters of different population of different sites, the population of Badseri and Kupa sites were found more promising for growth habit, plant vigour, density of shoot, number of thorns and length of thorns. Due to tremendous variability in population, the population can be used for future variability approaches and breeding programmes and for preparation of DUS guidelines of this species. It is suggested that for further propagation programmes, genepools from Sangla should be used and it can be planted on wastelands to develop grazing areas for sheep and goats and harvesting of fruits for Seabuckthorn value addition chain.

**Keywords:** *Hippophae salicifolia* D. Don, willow leaved seabuckthorn, qualitative characteristics, variation, plant vigour, DUS guidelines, genepools, population

## 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. It is a unique and valuable plant 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 -43ºC to 40ºC 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 plant 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. Seabuckthorn has outstanding qualities 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, nitrogen fixing (60-100 kg / ha / year), higher vitamin-C content and economic value of fruit and seed oil , excellent fodder and fuel wood qualities, wider application in food, cosmetics, beverages, medicines and other pharmaceutical products, 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) [5]. The first pre-requisite step to undertake breeding programme and to obtain improved genetic gain is selection of best population and best individuals within the population. Hence present study was undertaken to study variation in qualitative characteristics among and between different populations to select plus trees of *Hippophae salicifolia* D. Don. Nursery raising, plantation technology, fruit harvesting methodology and other biochemical aspects have been already worked out for *Hippophae rhamnoides* L. but this species is still lacking information, being its restricted and scattered distribution in patches. With this concept and idea in mind, this species has been preferred to work on qualitative parameters so that complete package and practice of this particular species is developed and this study may help in identification of discriminating morphological descriptors to know the extent of variation and variability among populations and within individuals of the populations, The present study was focused in only two valleys namely Sangla valley of district Kinnaur and Spiti valley of district Lahaul and Spiti, because major gene pool area of this species occur only in these two valleys and considered heart of cold desert of Himachal Pradesh , where choice of species is limited and Seabuckthorn is only suitable option and Lahaul valley is rich in genetic resources as concerned and Seabuckthorn is last option and choice for them. Finally, development of morphological descriptors of this species may certainly help in the preparation of DUS Guidelines at later stage. Hence present study was contemplated.

## Material and Methods

The present investigation 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, Department of Basic Sciences, Department of Environmental Science and Department of Silviculture and Agroforestry, College of Forestry at the Main Campus, Nauni, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India during the period, years 2018- 2020. Baspa valley of Kinnaur and Spiti valley of Lahaul and Spiti districts of Himachal Pradesh were surveyed for the occurrence of *Hippophae salicifolia* D. Don plant species, after proper identification of plants and population with selecting three natural populations in each valley and from each population five plants were selected, marked and taken for further investigation and recording qualitative characteristics. Experimental sites/populations were taken viz., Kuppa, Badseri, Chitkul of Baspa valley in the District Kinnaur and Mane, Shiego and Giu in Spiti valley in District Lahual and Spiti, Himachal Pradesh. Five female plants of *Hippophae salicifolia* D. Don at each site, i.e., population were selected at the time of fruit set, i.e., during August-September, when male and female could be differentiated. The selected plants were used for the assessment the qualitative variation of *Hippophae salicifolia* D. Don in Baspa valley of Kinnaur and Spiti Valley of Lahaul and Spiti. Leaves and berries were taken and carried from experimental sites to laboratory of Department of Tree improvement and Genetic Resources, College of Forestry, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh for further study of qualitative variation and preparation of morphological descriptors and fodder quality analysis in laboratories and the departments. 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 from naturally occurring populations and individuals, i.e., within population (Five individuals from each population)

- Plant: Sex.
- Plant: Growth type.
- Plant: Vigour
- Plant: Density of shoot.
- Plant: Position of inflorescence.
- Plant : One year old shoot thickness.
- Plant : Number of thorns per shoot.
- Plant : Length of thorn on shoot.

**Leaf characters**

- Leaf blade: Shape.
- Leaf blade: Size
- Leaf blade: Margin, i.e., undulation of margin.
- Leaf blade: Green colour and intensity of green colour of upper side.
- Leaf blade: Pubescence of lower side.

**Flower and fruit characteristics**

- Time of beginning of flowering.
- Time of beginning fruit ripening.
- Fruit : Colour of skin.
- Fruit: Shape.
- Fruit: Pubescence.
- Fruit: Length of stalk.
- Fruit: Size (width).

**Seed characteristics**

- Seed: colour.
- Seed: Shape of seed tip.

Recording observation on qualitative characteristics and their expression with code/ notes

| Sr. No. | Qualitative Characteristics | States | Code/ Notes |
|---|---|---|---|
| 1. | Plant Sex | Female | 1 |
| | | Male | 2 |
| 2. | Plant Growth type | Tree | 1 |
| | | Small Tree | 2 |
| | | Shrub | 3 |
| 3. | Plant Vigour | Weak | 1 |
| | | Medium | 2 |
| | | Strong | 3 |
| 4. | Density of Shoot | Sparse (1-7) | 1 |
| | | Medium (7-14) | 2 |

| | | | |
|---|---|---|---|
| | | Dense (>14) | 3 |
| 5. | Position of Inflorescence | On one year shoots | 1 |
| | | Both on one year shoots and older shoots | 2 |
| 6. | One Year Old Shoot Thickness | Thin (1-2mm) | 1 |
| | | Medium(2.1-4mm) | 3 |
| | | Thick(>4mm) | 5 |
| 7. | Thorniness | Absent (0) | 0 |
| | | Sparse/Few (1-2) | 3 |
| | | Medium (2-5) | 5 |
| | | Abundant/Dense (>5) | 7 |
| 8. | Length of Thorn | Short (1-8mm) | 1 |
| | | Medium (8-16mm) | 3 |
| | | Long (>16mm) | 5 |
| 9. | Leaf Blade Shape | Linear | 1 |
| | | Lanceolate | 2 |
| | | Ovate | 3 |
| 10. | Leaf Blade Size | Small (1-3.82cm²) | 1 |
| | | Medium (3.83-5.85cm²) | 3 |
| | | Large (>5.85cm²) | 5 |
| 11. | Undulation of Leaf Margin | Absent | 1 |
| | | Present | 2 |
| 12. | Intensity and Green Colour of upper side | Light Green | 1 |
| | | Medium Green | 2 |
| | | Dark Green | 3 |
| | | Other (specify) | 99 |
| 13. | Pubescence of Lower Side | Weak | 1 |
| | | Medium | 2 |
| | | Strong | 3 |
| 14. | Fruit Size | Small (5.29-6.07mm) | 1 |
| | | Medium(6.07-6.85mm) | 3 |
| | | Large(6.85-7.63mm) | 5 |
| 15. | Fruit Colour | Yellow | 1 |
| | | Orange | 3 |
| | | Red | 5 |
| | | Deep red | 7 |
| | | Purple | 9 |
| | | Other (specify) | 99 |
| 16. | Fruit Shape | Round | 3 |
| | | Oval | 5 |
| | | Long | 7 |
| | | Other (specify) | 99 |
| 17. | Fruit Pubescence | Weak | 1 |
| | | Medium | 3 |
| | | Strong | 5 |
| 18. | Fruit Length of Stalk | Short (upto 4mm ) | 1 |
| | | Medium (4-6m) | 3 |
| | | Long (>6mm) | 5 |
| 19. | Time of Beginning of Flowering | March | 1 |
| | | April | 3 |
| | | May | 5 |
| | | Other (Specify) | 7 |
| 20. | Time of Beginning of Fruit Ripening | August | 1 |
| | | September | 3 |
| | | October | 5 |
| | | Other (Specify) | 7 |
| 21. | Seed Colour | Light Brown | 1 |
| | | Brown | 3 |
| | | Dark Brown | 5 |
| 22. | Seed Tip Shape | Pointed | 1 |
| | | Round | 3 |
| | | Depressed | 5 |

## Result and Discussion

### Qualitative Characters

### Growth habit and plant vigour

The growth habit among the population studied was either found to vary from small tree and shrub (Table 1). The KP3, SP1, SP2, SP3, SP4 and SP5 were shrub types, whereas the other genotypes of between population were small tree type. The plant vigour was found to vary from weak, medium and strong (Table 1). KP3, CP3 and MP1 were weak plant vigour, whereas KP1, KP2, KP4, KP5, BP1, CP4, GP2, GP4, GP5, MP2, MP3, MP4, SP1, SP2, SP3, SP4 and SP5 were Medium type. On the other hand, BP2, BP3, BP4, BP5, CP1, CP2,

CP5, GP1, GP3 and MP5 had strong plant vigour. From inclusive study, 60 per cent of population was found to be small tree type and rest 40 per cent was shrub type, however 56.6 per cent population had medium vigour, 33.3 per cent strong and only 10 per cent population showed weak shoot vigour (Fig- 1, 2).

**Density of shoot**

The character density of shoot showed a wide variation between as well as among population, which varied from sparse, medium and dense (Table 1). The population KP1, BP4,

**Table 1:** Variation in morphological descriptors in plant sex, growth habit, plant vigour, density of shoot and position of inflorescence among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh

| Populations | Plant Sex | Growth Habit | Plant Vigour | Density of Shoot | Position of Inflorescence |
|---|---|---|---|---|---|
| KP1 | Female | Small Tree | Medium | Sparse | On one year old shoot |
| KP2 | Female | Small Tree | Medium | Medium | On one year old shoot |
| KP3 | Female | Shrub | Weak | Medium | On one year old shoot |
| KP4 | Female | Small Tree | Medium | Medium | On one year old shoot |
| KP5 | Female | Small Tree | Medium | Dense | On one year old shoot |
| BP1 | Female | Small Tree | Medium | Dense | On one year old shoot |
| BP2 | Female | Small Tree | Strong | Medium | On one year old shoot |
| BP3 | Female | Small Tree | Strong | Medium | On one year old shoot |
| BP4 | Female | Small Tree | Strong | Sparse | On one year old shoot |
| BP5 | Female | Small Tree | Strong | Dense | On one year old shoot |
| CP1 | Female | Small Tree | Strong | Sparse | On one year old shoot |
| CP2 | Female | Small Tree | Strong | Medium | On one year old shoot |
| CP3 | Female | Small Tree | Weak | Medium | On one year old shoot |
| CP4 | Female | Small Tree | Medium | Sparse | On one year old shoot |
| CP5 | Female | Small Tree | Strong | Medium | On one year old shoot |
| GP1 | Female | Small Tree | Strong | Sparse | On one year old shoot |
| GP2 | Female | Small Tree | Medium | Sparse | On one year old shoot |
| GP3 | Female | Small Tree | Strong | Medium | On one year old shoot |
| GP4 | Female | Small Tree | Medium | Sparse | On one year old shoot |
| GP5 | Female | Small Tree | Medium | Sparse | On one year old shoot |
| MP1 | Female | Small Tree | Weak | Sparse | On one year old shoot |
| MP2 | Female | Small Tree | Medium | Sparse | On one year old shoot |
| MP3 | Female | Small Tree | Medium | Sparse | On one year old shoot |
| MP4 | Female | Small Tree | Medium | Sparse | On one year old shoot |
| MP5 | Female | Small Tree | Strong | Sparse | On one year old shoot |
| SP1 | Female | Shrub | Medium | Sparse | On one year old shoot |
| SP2 | Female | Shrub | Medium | Sparse | On one year old shoot |
| SP3 | Female | Shrub | Medium | Sparse | On one year old shoot |
| SP4 | Female | Shrub | Medium | Sparse | On one year old shoot |
| SP5 | Female | Shrub | Medium | Sparse | On one year old shoot |

K- Kupa, B-Badseri, C- Chitkul, G- Giu, M- Mane, S- Shiego, P- Plant

CP1, CP4, GP1, GP2, GP4, MP1, MP2, MP3, MP4, MP5, SP1, SP2, SP3, SP4 and SP5 showed sparse shoot density whereas, KP1, KP2, KP3, BP2, BP3, CP2, CP3, CP5, GP3 had medium shoot density. On the other hand, the population KP5, BP1and BP5 showed dense shoot density. From the Table 2, it is clear that, 60 per cent of population showed sparse shoot density, 30 per cent were medium and 10 per cent of population showed dense shoot density (Fig 3).

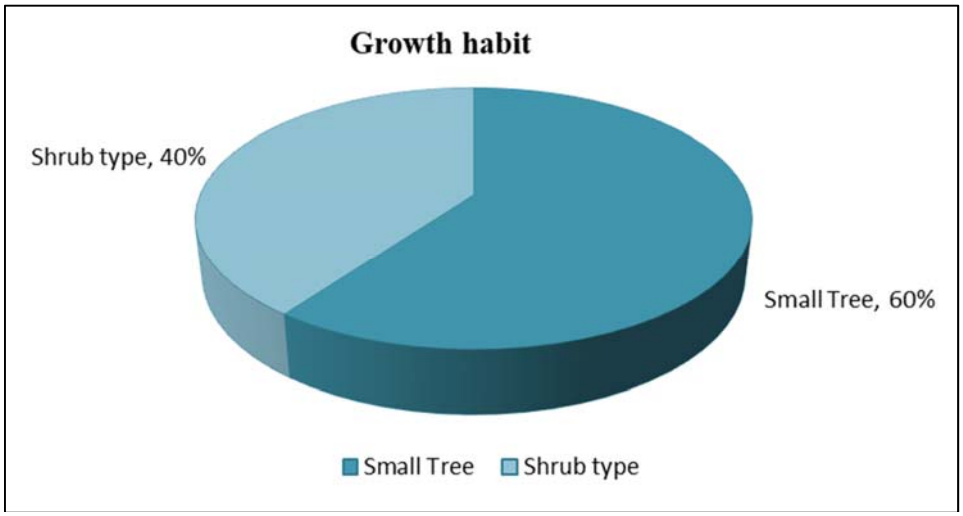


**Fig 1:** Morphological descriptor of growth habit among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

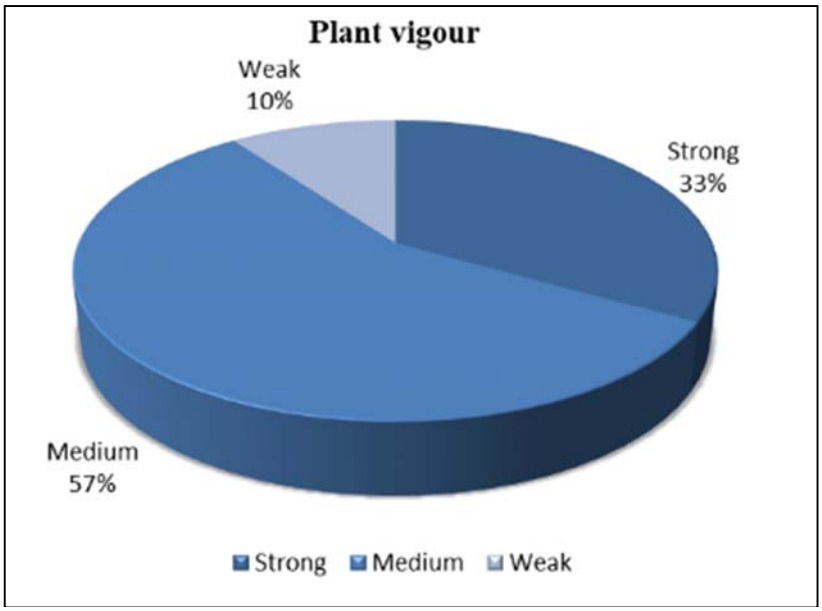


**Fig 2:** Morphological descriptor of plant vigour among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

**Plant sex and position of inflorescence**

All the 100 per cent studied population had female type of plant sex (Table 1). On the other hand, the position of inflorescence in 100 per cent population on one-year old shoot was recorded.

**One-year old shoot thickness**

The pertinent data is presented in Table 2. For the said parameter, the thickness was varied from thin, thick and medium among and between population. Among all the investigated population, 30 per cent were thick one- year old shoot, 56.6 per cent had medium thickness and 13.3 per cent showed thin one year old shoot thickness. The shoot thickness of population KP1, MP4, SP4 and SP5 was thin whereas it was medium in KP2, KP2, KP3, KP4, KP5, BP2, BP3, BP4, BP5, CP3, CP4, CP5, GP1, GP4, GP5, MP1, MP3 and MP5. On the other hand, the thick shoot was found in BP1, CP1, CP2, GP2, GP3, MP2, SP1, SP2 and SP3 (Fig 4).

**Number of thorns**

The range of the number of thorns varied from absent, few, medium and dense (Table 2). From the recorded data, 16.6 per cent of population showed absence of thorns whereas, 56.6 per cent population had medium number of thorns and only few thorns were present in 20 per cent of population. The said character was absent in BP2, BP4, BP5, CP2 and CP5 population whereas KP1, KP2, KP3, KP4, KP5 and GP4 had few number of thorns. On the other hand, BP1, BP3, CP1, CP3, CP4, GP2, GP5, MP1, MP2, MP3, MP4, MP5, SP1, SP2, SP3, SP4, and SP5 population showed medium number of thorns, whereas it was dense in GP1 and GP3 (Fig 5).

**Length of thorn**

Length of thorn (Table 2) ranged from short, medium, long and absent. The said character was absent in BP2, BP4, BP5, CP2 and CP5 population and it was short in KP1, KP2, KP3, KP4, KP5, BP1, BP3, Sp1, SP2, SP3, SP4 and SP5. On the other hand, the length of thorn was medium in CP3, CP4, GP1, GP2, GP3, GP4 and GP5 whereas it was long in CP1, MP1, MP2, MP3, MP4 and MP5 respectively. From the mentioned data, 40 per cent population had short length of thorn whereas, 20 per cent of population with long length of thorn was found (Fig 6).

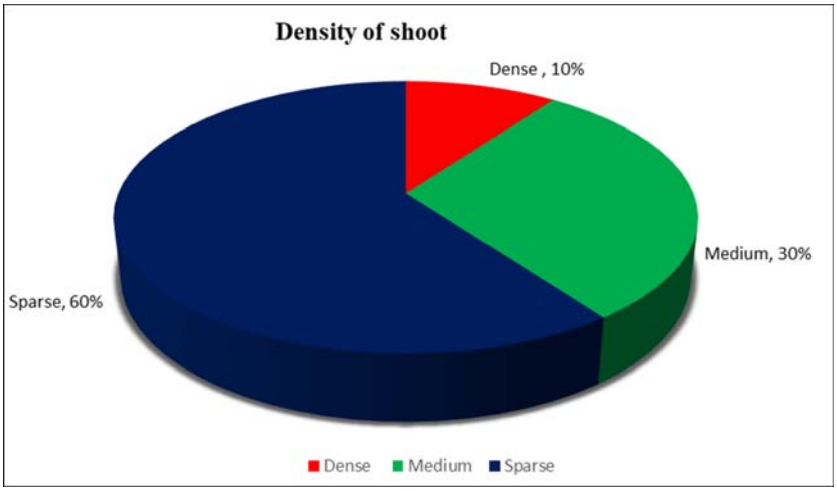


**Fig 3:** Morphological descriptor of density of shoot among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

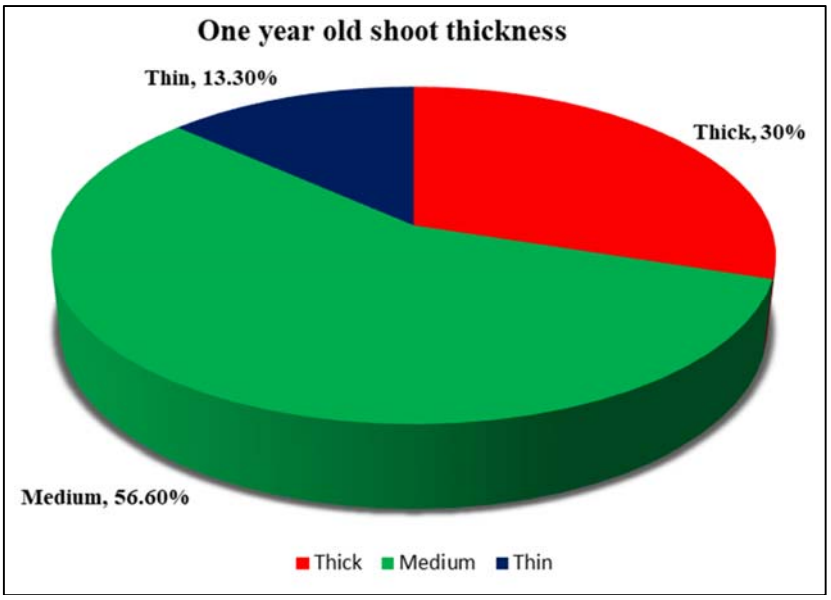


**Fig 4:** Morphological descriptor of one-year old shoot thickness among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

**Table 2:** Variation in morphological descriptors of one-year old shoot thickness, number of thorn and length of thorn among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh

| Populations | One- Year Old Shoot Thickness | Number of Thorn | Length of Thorn |
|---|---|---|---|
| KP1 | Thin | Few | Short |
| KP2 | Medium | Few | Short |
| KP3 | Medium | Few | Short |
| KP4 | Medium | Few | Short |
| KP5 | Medium | Few | Short |
| BP1 | Thick | Medium | Short |
| BP2 | Medium | Absent | Absent |
| BP3 | Medium | Medium | Short |
| BP4 | Medium | Absent | Absent |
| BP5 | Medium | Absent | Absent |
| CP1 | Thick | Medium | Long |
| CP2 | Thick | Absent | Absent |
| CP3 | Medium | Medium | Medium |
| CP4 | Medium | Medium | Medium |
| CP5 | Medium | Absent | Absent |
| GP1 | Medium | Dense | Medium |
| GP2 | Thick | Medium | Medium |
| GP3 | Thick | Dense | Medium |
| GP4 | Medium | Few | Medium |
| GP5 | Medium | Medium | Medium |
| MP1 | Medium | Medium | Long |
| MP2 | Thick | Medium | Long |
| MP3 | Medium | Medium | Long |
| MP4 | Thin | Medium | Long |
| MP5 | Medium | Medium | Long |
| SP1 | Thick | Medium | Short |
| SP2 | Thick | Medium | Short |
| SP3 | Thick | Medium | Short |
| SP4 | Thin | Medium | Short |
| SP5 | Thin | Medium | Short |

**Leaf blade shape, leaf blade size and undulation of margin**

The data leaf blade shape, leaf blade size and undulation of margin is detailed in Table 3. All the 100 per cent studied population showed linear leaf blade shape. The leaf blade size ranged from small, medium and large. Population KP2, KP3, KP5, BP1, NP3, BP4, BP5, CP3, CP4, CP5, GP1, GP2, GP3, GP4, GP5, MP1, MP4, MP5, SP1, SP2, SP3, SP4 and SP5 showed small size of leaf blade whereas in KP1, KP4, BP2, CP2 and MP2 medium leaf blade size was recorded. On the other hand, large size leaf blade was noticed in CP1 and MP3. The data on leaf blade size showed that 16.6 per cent population was with small size blade, 76.7 per cent had medium size and only 6.6 per cent population showed large leaf blade size respectively. The undulation of margin was absent in all 100 per cent among and between studied population (Fig7).

**Green colour intensity and pubescence on the lower side**

The green colour intensity ranged from medium green, dark green and light-yellow green. Among studied population, 73.3 per cent showed medium green colour intensity whereas MP1 had dark green colour intensity and MP4, MP5, SP1, SP2, SP3, SP4 and SP5 showed light yellow green colour intensity which accounts for 23.3 per cent of total population. The character pubescence on lower side was present in 100 per cent of studied population (Table 3, Fig 8).

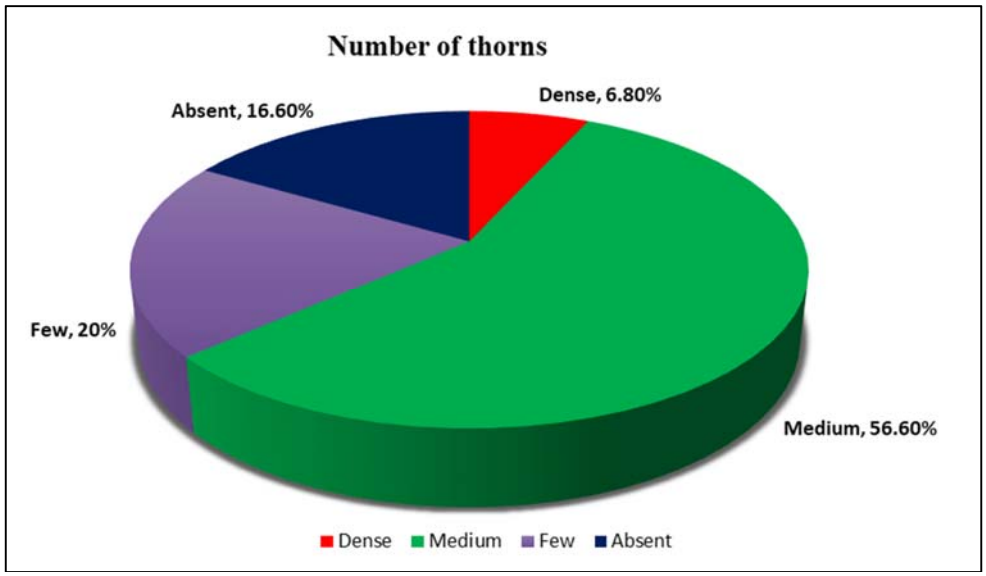


**Fig 5:** Morphological descriptor of number of thorns among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

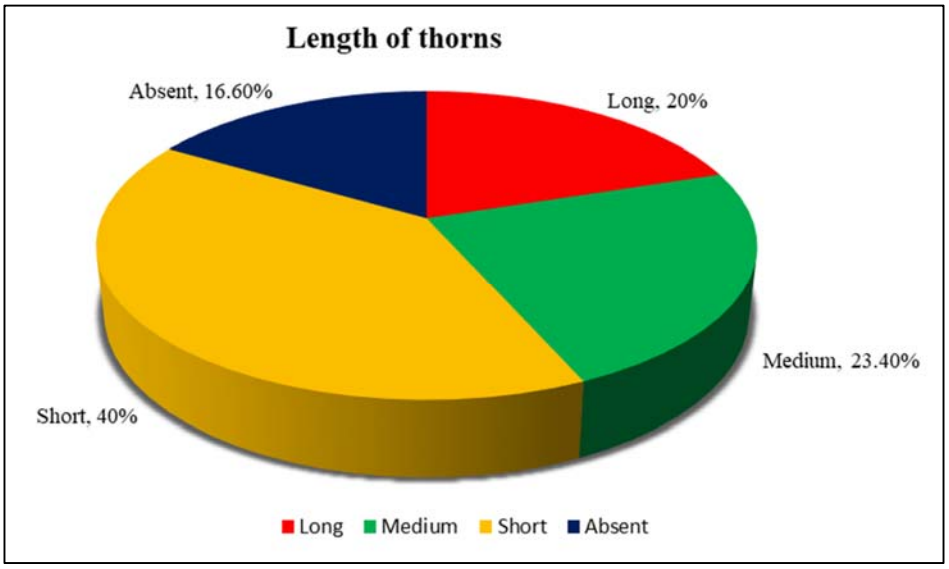


**Fig 6:** Morphological descriptor of length of thorns among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn).

**Table 3:** Variation in morphological descriptors in leaf blade shape, leaf blade size, undulation of margin, green colour intensity and pubescence on lower side among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

| Populations | Leaf Blade shape | Leaf Blade Size | Undulation of Margin | Green Colour intensity | Pubescence on lower side |
|---|---|---|---|---|---|
| KP1 | Linear | Medium | Absent | Medium Green | Present |
| KP2 | Linear | Small | Absent | Medium Green | Present |
| KP3 | Linear | Small | Absent | Medium Green | Present |
| KP4 | Linear | Medium | Absent | Medium Green | Present |
| KP5 | Linear | Small | Absent | Medium Green | Present |
| BP1 | Linear | Small | Absent | Medium Green | Present |
| BP2 | Linear | Medium | Absent | Medium Green | Present |
| BP3 | Linear | Small | Absent | Medium Green | Present |
| BP4 | Linear | Small | Absent | Medium Green | Present |
| BP5 | Linear | Small | Absent | Medium Green | Present |
| CP1 | Linear | Large | Absent | Medium Green | Present |
| CP2 | Linear | Medium | Absent | Medium Green | Present |
| CP3 | Linear | Small | Absent | Medium Green | Present |

| | | | | | |
|---|---|---|---|---|---|
| CP4 | Linear | Small | Absent | Medium Green | Present |
| CP5 | Linear | Small | Absent | Medium Green | Present |
| GP1 | Linear | Small | Absent | Medium Green | Present |
| GP2 | Linear | Small | Absent | Medium Green | Present |
| GP3 | Linear | Small | Absent | Medium Green | Present |
| GP4 | Linear | Small | Absent | Medium Green | Present |
| GP5 | Linear | Small | Absent | Medium Green | Present |
| MP1 | Linear | Small | Absent | Dark Green | Present |
| MP2 | Linear | Medium | Absent | Medium Green | Present |
| MP3 | Linear | Large | Absent | Medium Green | Present |
| MP4 | Linear | Small | Absent | Light Yellow-Green | Present |
| MP5 | Linear | Small | Absent | Light Yellow-Green | Present |
| SP1 | Linear | Small | Absent | Light Yellow-Green | Present |
| SP2 | Linear | Small | Absent | Light Yellow-Green | Present |
| SP3 | Linear | Small | Absent | Light Yellow-Green | Present |
| SP4 | Linear | Small | Absent | Light Yellow-Green | Present |
| SP5 | Linear | Small | Absent | Light Yellow-Green | Present |

**Fruit size and fruit shape**

The character fruit size and fruit shape are detailed in Table 4. The fruit size showed wide variation ranged from small, medium and large. The fruit size was large, in population KP1, GP4, MP1, MP3 and MP4 whereas it was medium in KP2, KP3, KP4, BP2, BP4, BP5, CP3, CP5, GP1, GP3, GP5, MP2, MP5, SP1 and SP5. The small size fruit were also recorded in population KP5, BP1, BP3, CP1, CP2, CP4, GP2, SP2, SP3 and SP4 respectively. From the investigated data, a total of 36.6 per cent had small fruit size, 46.6 per cent had medium fruit size and only 16.6 per cent of population showed large size of fruits (Fig 9, 10).

The character fruit shape varied from round to oval. All the studied population had round fruit shape which accounts for 93.3 per cent of population except MP2 and MP3 which had oval fruit shape.

**Table 4:** Variation in morphological descriptors in fruit size, fruit shape, fruit colour, fruit pubescence and fruit length of stalk among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh

| Populations | Fruit Size | Fruit Shape | Fruit Colour | Fruit Pubescence | Fruit stalk length |
|---|---|---|---|---|---|
| KP1 | Large | Round | Yellow-Orange | Weak | Short |
| KP2 | Medium | Round | Yellow-Orange | Weak | Medium |
| KP3 | Medium | Round | Yellow-Orange | Weak | Medium |
| KP4 | Medium | Round | Yellow-Orange | Weak | Long |
| KP5 | Small | Round | Yellow-Orange | Weak | Medium |
| BP1 | Small | Round | Yellow-Orange | Weak | Medium |
| BP2 | Medium | Round | Yellow-Orange | Weak | Medium |
| BP3 | Small | Round | Yellow-Orange | Weak | Long |
| BP4 | Medium | Round | Yellow-Orange | Weak | Medium |
| BP5 | Medium | Round | Yellow-Orange | Weak | Medium |
| CP1 | Small | Round | Yellow-Orange | Weak | Medium |
| CP2 | Small | Round | Yellow-Orange | Weak | Medium |
| CP3 | Medium | Round | Yellow-Orange | Weak | Medium |
| CP4 | Small | Round | Yellow-Orange | Weak | Medium |
| CP5 | Medium | Round | Yellow-Orange | Weak | Medium |
| GP1 | Medium | Round | Orange-Red | Weak | Medium |
| GP2 | Small | Round | Orange-Red | Weak | Medium |
| GP3 | Medium | Round | Orange-Red | Weak | Medium |
| GP4 | Large | Round | Orange-Red | Weak | Medium |
| GP5 | Medium | Round | Orange-Red | Weak | Long |
| MP1 | Large | Round | Yellow-Orange | Weak | Long |
| MP2 | Medium | Oval | Orange-Red | Weak | Long |
| MP3 | Large | Oval | Orange-Red | Weak | Long |
| MP4 | Large | Round | Orange-Red | Weak | Long |
| MP5 | Medium | Round | Orange-Red | Weak | Long |
| SP1 | Medium | Round | Orange | Weak | Short |
| SP2 | Small | Round | Orange | Weak | Short |
| SP3 | Small | Round | Orange | Weak | Short |
| SP4 | Small | Round | Orange | Weak | Short |
| SP5 | Medium | Round | Orange | Weak | Short |

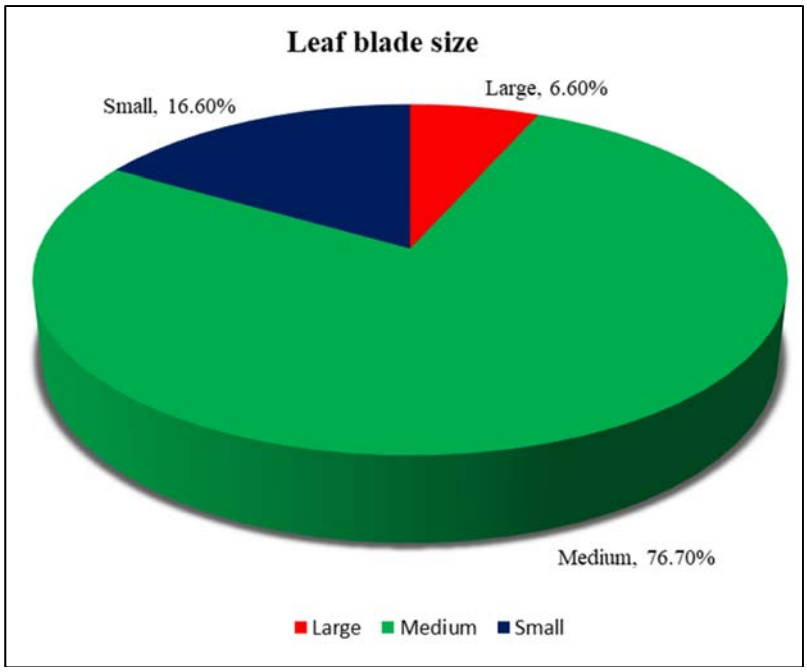


**Fig 7:** Morphological descriptor of leaf blade size among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

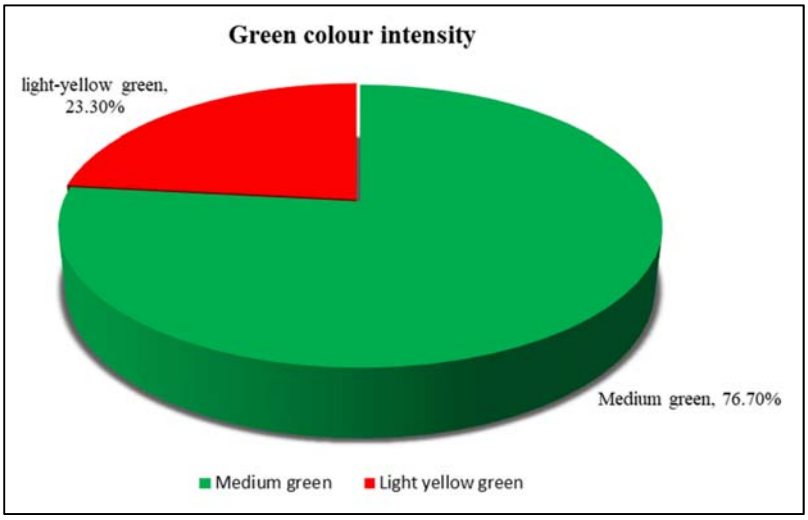


**Fig 8:** Morphological descriptor of green colour intensity among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

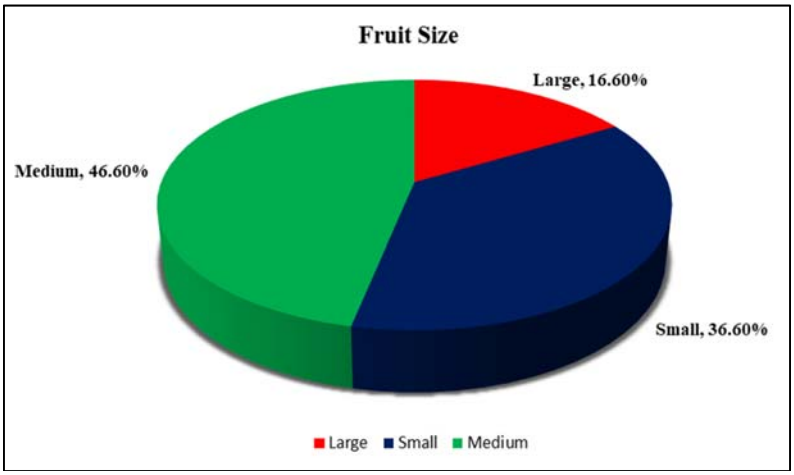


**Fig 9:** Morphological descriptor of fruit size among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

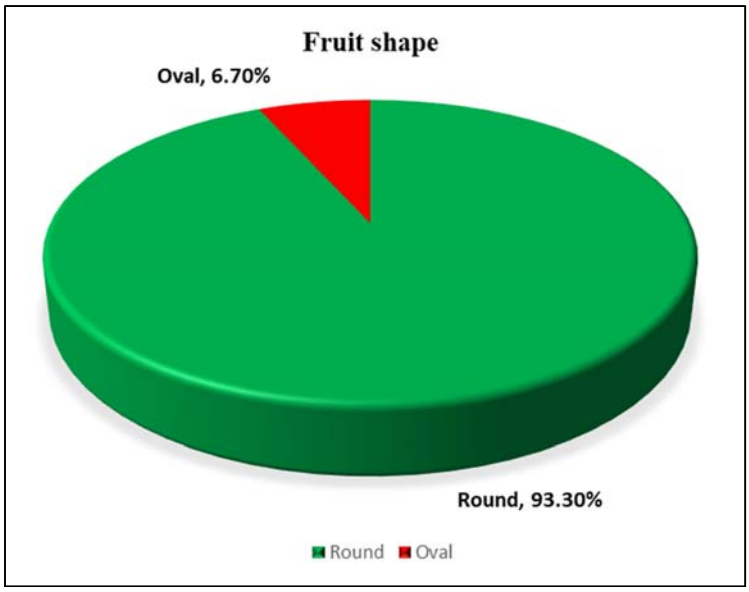


**Fig 10:** Morphological descriptor of fruit shape among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

**Fruit colour, fruit pubescence and fruit stalk length**

The plants taken for study showed considerable variation among themselves (Table 4). The fruit colour ranges from yellow orange, orange red and orange. The population KP1, KP2, KP3, KP4, KP5, BP1, BP2, BP3, BP4, BP5, CP1, CP2, CP3, CP4 and CP5 showed yellow orange fruit colour whereas in GP1, GP2, GP3, GP4, GP5, MP2, MP3, MP4 and MP5 recorded orange red colour. The orange colour of population SP1, SP2, SP3, SP4 and SP5 was also observed. From the mentioned record, 53.3 per cent population was with yellow orange colour, 30 per cent was with orange red and rest 16.6 per cent showed orange colour of fruits (Fig 11).

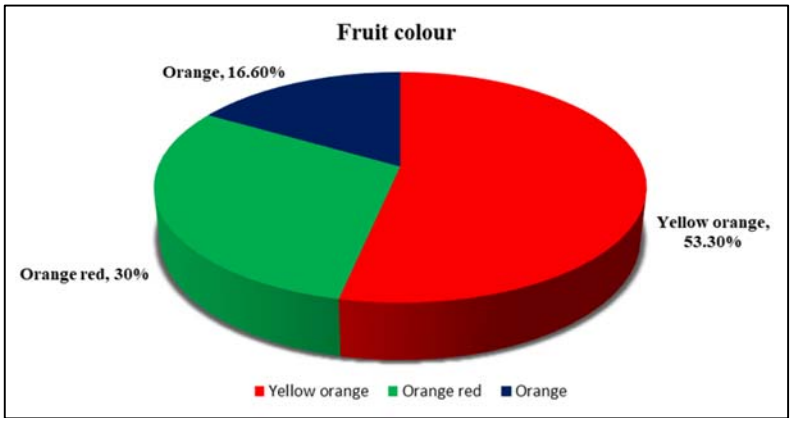


**Fig 11:** Morphological descriptor of fruit colour among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

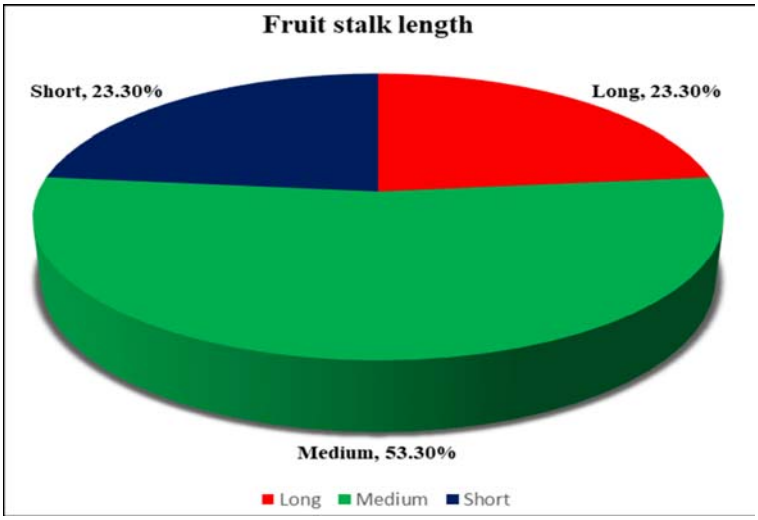


**Fig 12:** Morphological descriptor of fruit stalk length among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

The fruit pubescence was recorded weak in all 100 per cent individuals of investigated population. The fruit length of stalk ranged from short, medium and long. The short fruit stalk length was observed in population KP1, SP1, SP2, SP3, SP4 and SP5 whereas in KP2, KP3, KP5, BP1, BP2, BP4, BP5, CP1, CP2, CP3, CP4, CP5, GP1, GP2, GP3 and GP4 recorded medium fruit stalk length. The remaining population KP4, BP3, GP5, MP1, MP2, MP3, MP4 and MP5 long fruit stalk length was observed. On an average, 23.3 per cent of population had short fruit stalk, 53.3 per cent had medium stalk length and 23.3 per cent population was with long fruit stalk length (Fig 12).

**Time of beginning of flowering and time of beginning of fruit ripening**

The characters time of beginning of flowering and time of beginning of fruit ripening showed no variations (Table 5) as the flowering began in the month of April-May in 100 per cent of population and the fruit ripening began in the month of September in all the studied among and between population except MP1 and SP1, where the fruit ripening was started in month of October (Fig 13).

**Table 5:** Variation in morphological descriptors in time of beginning of flowering and time of beginning of fruit ripening among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh

| Populations | Time of Beginning of Flowering | Time of Beginning of Fruit ripening |
|---|---|---|
| KP1 | April-May | September |
| KP2 | April-May | September |
| KP3 | April-May | September |
| KP4 | April-May | September |
| KP5 | April-May | September |
| BP1 | April-May | September |
| BP2 | April-May | September |
| BP3 | April-May | September |
| BP4 | April-May | September |
| BP5 | April-May | September |
| CP1 | April-May | September |
| CP2 | April-May | September |
| CP3 | April-May | September |
| CP4 | April-May | September |
| CP5 | April-May | September |
| GP1 | April-May | September |
| GP2 | April-May | September |
| GP3 | April-May | September |
| GP4 | April-May | September |
| GP5 | April-May | September |
| MP1 | April-May | September-October |
| MP2 | April-May | September |
| MP3 | April-May | September |
| MP4 | April-May | September |
| MP5 | April-May | September |
| SP1 | April-May | September-October |
| SP2 | April-May | September |
| SP3 | April-May | September |
| SP4 | April-May | September |
| SP5 | April-May | September |

**Seed colour and shape of seed tip**

The parameter seed colour varied from brown to dark brown in colour (Table 6). All the studied population,90 per cent had brown seed colour except MP1, MP2, MP3, MP4 and MP5 which showed dark brown seed colour. The shape of seed tip was pointed in all the 100 per cent studied population (Fig 14).

**Table 6:** Variation in morphological descriptors in seed colour and shape of seed tip among and between selected Seabuckthorn (*Hippophae salicifolia* D. Don) populations in Himachal Pradesh.

| Populations | Seed Colour | Shape of Seed tip |
|---|---|---|
| KP1 | Brown | Pointed |
| KP2 | Brown | Pointed |
| KP3 | Brown | Pointed |
| KP4 | Brown | Pointed |
| KP5 | Brown | Pointed |
| BP1 | Brown | Pointed |
| BP2 | Brown | Pointed |
| BP3 | Brown | Pointed |
| BP4 | Brown | Pointed |
| BP5 | Brown | Pointed |
| CP1 | Brown | Pointed |
| CP2 | Brown | Pointed |

| | | |
|---|---|---|
| CP3 | Brown | Pointed |
| CP4 | Brown | Pointed |
| CP5 | Brown | Pointed |
| GP1 | Brown | Pointed |
| GP2 | Brown | Pointed |
| GP3 | Brown | Pointed |
| GP4 | Brown | Pointed |
| GP5 | Brown | Pointed |
| MP1 | Dark Brown | Pointed |
| MP2 | Dark Brown | Pointed |
| MP3 | Dark Brown | Pointed |
| MP4 | Dark Brown | Pointed |
| MP5 | Dark Brown | Pointed |
| SP1 | Brown | Pointed |
| SP2 | Brown | Pointed |
| SP3 | Brown | Pointed |
| SP4 | Brown | Pointed |
| SP5 | Brown | Pointed |

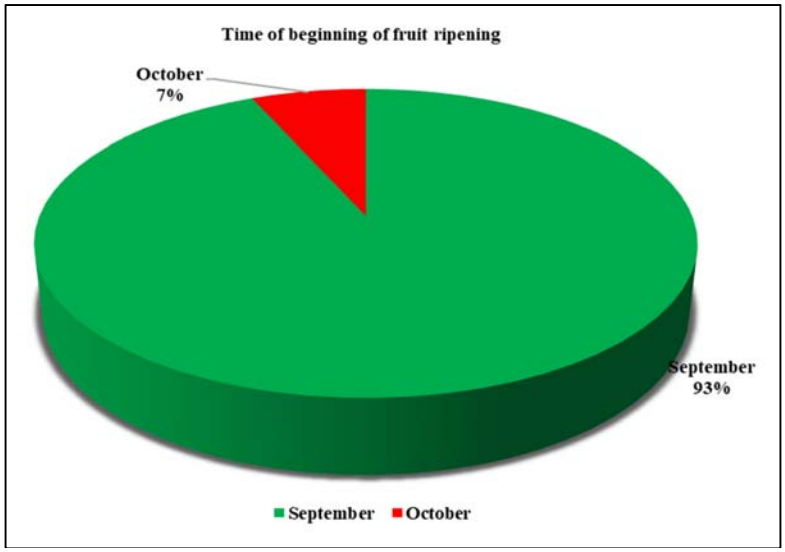


**Fig 13:** Morphological descriptor of time of beginning of fruit ripening among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

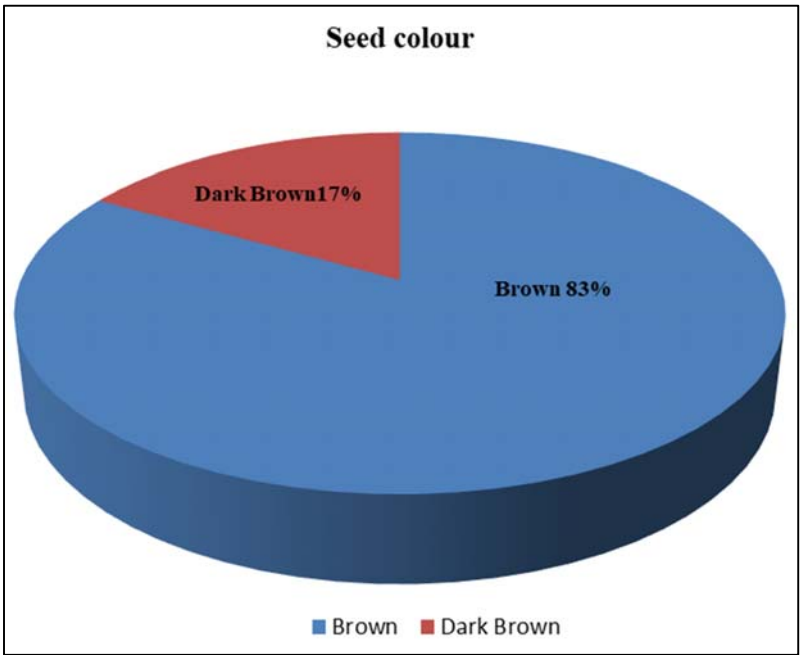


**Fig 14:** Morphological descriptor of Seed colour among and between population of *Hippophae salicifolia* D. Don (Seabuckthorn)

Similar plant growth habit from shrub to tree and plant height up to 6 m was recorded by Yadav *et al.* (2006) [6] and tree vigour medium to strong was studied by Rati and Radukanu, (2018) [4]. Nawaz *et al.* (2018) [3] also showed dark green colour intensity of leaf on ventral surface than dorsal surface. The linear shape of leaf blade was also studied by Mir *et al*. (2018) [2]. The flowering behaviour in present study was recorded as the time of beginning of flowers was April to May in among and between the population, similar findings were also reported by Kaushal and Sharma (2012) [1]. Similar variation was also recorded in a study conducted by Nawaz *et al*. (2018) [3] also found strong orange yellow colour in ripened berries of seabuckthorn. Yadav *et al*., (2006) [6] reported almost similar fruit shape round to ovate respectively. The variation in seed characters are in line with the findings of Mir *et al.,* (2018) [2]; Kaushal and Sharma (2012) [1] for seed colour that ranged from greyish brown or dark brown respectively.

On the basis of qualitative characters, the population of Badseri and Kupa sites are found more promising for growth habit, plant vigour, density of shoot, number of thorns and length of thorns. It is also suggested that for further propagation programmes, genepool from Sangla Valley should be used.

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**References**

1. Kaushal M, Sharma PC. Seabuckthorn (*Hippophae* sp.): A Potential Nutritional Goldmine of Western Himalayas. *Forestry Bulletin.* 2012; 12:65-68.
2. Mir NA, Geelani SM, Bhat RA, Qadri H, Beigh BA. Seabuckthorn (*Hippophae* species.): A Unique high altitude multipurpose plant species growing in cold regions. International Journal of Plant Research in Science and Engineering. 2018; 7:1941-1952.
3. Nawaz MA, Krutovsky KV, Mueller M, Gailing O, Khan AA, Buerkert A *et al*. Morphological and genetic diversity of seabuckthorn (*Hippophae rhamnoides* L.) in the Karakoram Mountains of Northern Pakistan. Diversity. 2018; 10:2-23.
4. Raţi IV, Raducanu D. Description of some patented and certified seabuckthorn cultivar in Bacau county. *Biology* 2018; 27:19-25.
5. Sankhya HP, Thakur S, Sharma SS, Negi A. Analysis on morphological descriptors of Seabuckthorn (*Hippophae rhamnoides* L.) in cold desert eco-system of Himachal Pradesh. International Journal of Fauna and Biological Studies 2018; 5:136-139.
6. Yadav VK, Sah VK, Singh AK, Sharma SK. Variations in morphological and biochemical characters of Seabuckthorn (*Hippophae salicifolia* D. Don) populations growing in Harsil area of Garhwal Himalaya in India. Tropical Agricultural Research and Extension. 2006; 9:1-7.