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Research Article

Effect of Seed Sources on Fruit and Seed Characteristics and Seed germination of *Prunus cerasoides* (D. Don) in the Garhwal Himalayas

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Abstract

Prunus cerasoides is indigenous multipurpose tree species of the Himalayan regions and is also used for religious purpose, edible fruit, seed and gum as well as different medical applications, lumber, dyestuff, tannins and beads. The present investigation was carried out to estimation the seed germination of *P. cerasoides* from different sources of Garhwal regions of Uttarakhand. The experiment consisted of six seed sources and fifteen different pre-sowing treatments, the data regarding on fruit and seed morphology were analyzed for Randomized Block Design, while seed germination and seedling growth data were analyzed for Completely Randomized Design. Among the seed source, Silyara, Kuteti and Sadargaun seed source were showed superiority with respect to fruit and seed morphology. For seed germination and growth attributes, the highest (72.86%) germination percent was recorded in Silyara seed source followed by Sadargaun (69.00%), Kuteti (66.66%), Develgaun (64.4%), Chaurangikhal (63.06%) and Ranichauri (55.00%). In pre-sowing treatments, Gibberellic acid and hot water for 100^0C at 24 hours was showed maximum germination percent and total seedling growth as compared to other treatments. The application of treatment GA3 solution and hot water for 100^0C at 24 hours was better for seed germination and seedling growth in case of *P. cerasoides*.

Keywords: Seed Source; Germination; Variation; Pre-sowing

Introduction

The geographic place where seeds are gathered or discovered is referred to as the seed source. The use of proper seed sources is essential for the development and productivity of the forest [23]. Provenance testing is used to assess the chance of discovering better populations for at least one attribute that can be used to boost planting programme productivity for future references. Seed, which is utilised to conserve genetic variety, transfer and propagate flora, makes up the majority of natural resources. A shortage of high-quality tree seeds has hampered efforts to restore land through afforestation, reforestation and agroforestry. Variability study is required for increased productivity and future breeding activities. Forest tree seed source studies are particularly useful since they assist in finding the best and most adaptable provenance. The initial phase in the forest tree enhancement programme is to find a seed source capable of generating the best-adapted trees (Fornah *et al.*, 2017).*Prunus cerasoides*is a medium sized deciduous tree species and has a smooth red brown bark that peels away in tiny horizontal stripes. The leaves have a short stem are glossy, long and pointed, toothed and have an elliptic blade 5–8 cm long with a slender petiole. The fruit of *Prunus cerasoides* is fleshy, yellow and red in colour with one stony seeded nut that is oval in shape about 1.3–1.6 cm long (Tiwari *et al,* 2010 and Joshi, 2004). *Prunus cerasoides* trees produce a large number of seeds with hard

seed coat and the regeneration of this species is very poor in its natural habitat (Tewari *et al.,* 2010).

Materials and Methods

(Table 1, Figure 1)

Seed source selection criteria

A survey was conducted in the Tehri Garhwal and Uttarkashi districts of Uttarakhand to identify seed sources of *Prunus cerasoides*. Sites were selected based on the natural occurrence of the species, considering geographical parameters such as altitude, latitude, longitude, and horizontal distance. Fully ripened fruits, weighing 1 kg, were collected from five trees at each seed source, with an average of 100 g of fruits collected per tree. The ripened fruits were soaked in water for 24 hours to soften the pulp, which was then manually removed by hand. The extracted seeds were dried in sunlight for 1–2 days and subsequently stored in a refrigerator for further experimentation.

Studies on fruit and Seed morphology

Studies on fruit morphology

The fruit morphology of *Prunus cerasoides* was analyzed through various parameters, including fruit length, width, thickness, weight, length-to-width ratio, and moisture content. The fruit lengths and widths of 20 fruits from each seed source across five replications were measured using a vernier caliper, with length recorded in centimeters and width in millimeters. The fruit length-to-width ratio was calculated by dividing the fruit length by its diameter. Fruit thickness was measured in millimeters using a vernier caliper, and the weight of 100 fruits (five replications) was determined using an electronic balance. Moisture content in the fruits was calculated as per ISTA Rule 1999, using the formula

Moisture content (%) =Fresh fruit weight- seed weight / Fresh fruit weight ×100

Seed morphology studies included measurements of seed length, width, thickness, weight, length-to-width ratio, moisture content, and peel thickness. The seed length, width, and thickness of 20 seeds (five replications) from each seed source were measured using a vernier caliper, with length recorded in centimeters and width and thickness in millimeters. The seed length-to-width ratio was calculated by dividing the seed length by the seed diameter. The weight of 100 seeds (five replications) was recorded using an electronic balance. Seed moisture content was determined using the ISTA Rule 1999 formula:

Moisture content (%) =Fresh fruit weight- seed weight / Fresh fruit weight ×100

Peel thickness was calculated using the formula:
Peel thickness (mm) =Fruit width - Seed width/2.

Pre-treatment details

- **T1:** Seedwith seed coat + cold water for 24 hours
- **T2:** Seed without seed coat + cold water for 24 hours
- **T3:** Seed nicking + cold water for 24 hours
- **T4:** Seed with seed coat + hot water for 24 hours at a temperature 100^0C
- **T5:** Seed without seed coat + hot water for 24 hours at a temperature 100^0C
- **T6:** Seed nicking + hot water for 24 hours at a temperature 100^0C
- **T7:** Seed with seed coat +cold stratification for 15 days
- **T8:** Cold stratification for 15 days + seed nicking
- **T9**: Seedwith seed coat +cold stratification for 15 days + hot water for24hoursat 100^0 C
- **T10:** Seedwith seed coat + cold stratification for 15 days +$GA_3$1000 ppm
- **T11:** Seed with seed coat + cold stratification for 15 days +$GA_3$1500 ppm
- **T12:** Cold stratification for 45 days + seed nicking
- **T13:** Seedwith seed coat +cold stratification for 45 days + hot water for 24 hours
- **T14:** Seed with seed coat + cold stratification for 45 days +$GA_3$1000 ppm
- **T15:** Seedwith seed coat + cold stratification for 45 days +$GA_3$1500 ppm

Seed germination

A study on seed germination of *Prunus cerasoides* was conducted using 20 seeds (5 replicates) from each seed source. Seeds were placed in 9.5 cm Petri dishes lined with Whatman filter paper, pre-treated as described, and kept moist with 2 ml of distilled wa-

ter. The dishes were maintained at 20°C in a germinator, and daily germination was recorded for 28 days. Germination percentage (GP) was calculated as the ratio of germinated seeds to the total seeds, expressed as a percentage. Mean germination time (MGT) and germination index (GI) were calculated using standard formulas. Seedling growth characteristics, including plumule and radicle lengths, total seedling length, and radicle/plumule length ratio, were measured on six randomly selected seedlings from each replicate. Seedling vigor index was determined using germination percentage and seedling length following Abdul-Baki and Anderson's (1973) method.

Statistical Analysis

The data obtained during the course of this investigation was analysed by applying Analysis of variance (ANOVA) using the WASP software with version 1.0. For morphological study, RBD (Randomized Block Design) and for germination study, CRD (Completely Randomized Design) was used which was developed by Ashok Kumar Jangam and PranjaliNinad32Wadekar at ICAR Research Complex, Goa. To compare the mean and standard deviation, critical difference (1 % and 5% level of significance) was calculated. Test for significance was determined by applying Analysis of variance (ANOVA)

S.No.	Seed source	Block	Elevation (m.asl)	Latitude (N)	Longitude (E)	Temperature (^{0}C)	Rainfall (mm)	pH
1.	Silyara	Ghansali	965	30^{0}45'54"	78^{0}63'84"	25	53.87	5.73
2.	Develgaun	Ghansali	996	30^{0}37'06"	78^{0}58'58"	23	55.30	5.46
3	Kuteti	Uttarkashi	1,654	30^{0}82'42"	78^{0}62'76"	21	76.62	5.60
4.	Ranichauri	Chamba	1,863	30^{0}31'20"	78^{0}40'98"	18	83.72	5.98
5.	Sadargaun	Pratapnagar	1,981	30^{0}57'45"	78^{0}45'79"	21	67.63	6.12
6.	Chaurangikhal	Uttarkashi	2,305	30^{0}64'44"	78^{0}48'84"	16	89.41	5.89

Table 1: Description of seed source of *Prunus cerasoides* in Garhwal Himalaya.

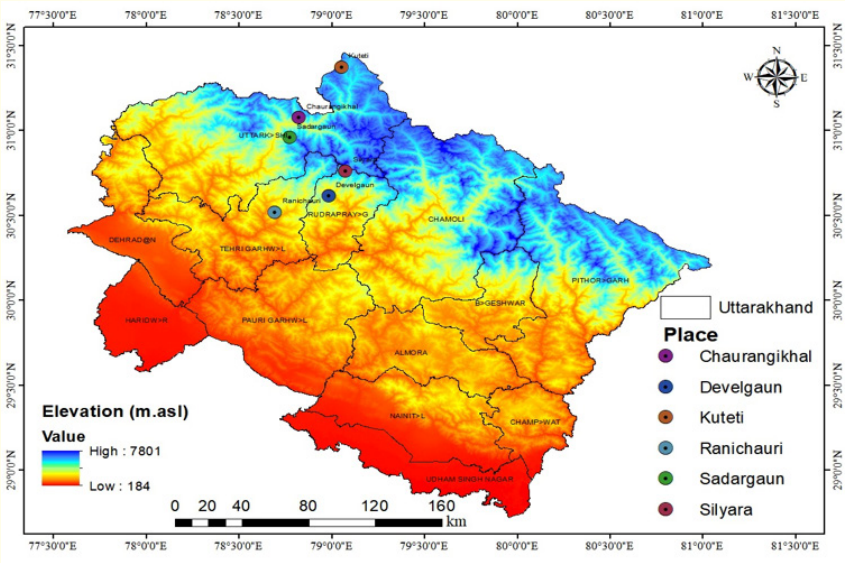

Figure 1

Results

Morphological variation of fruit in *Prunus cerasoides*

The study of fruit characteristics of *Prunus cerasoides* across different seed sources revealed significant ($p \leq 0.05$) variations in fruit length, width, length/width ratio, weight, and moisture content, while fruit thickness showed no significant variation. Fruit length ranged from 1.06 cm (Chaurangikhal) to 1.53 cm (Silyara) with an average of 1.31 cm, and fruit width varied from 0.75 mm (Sadargaun) to 1.02 mm (Develgaun) with an average of 0.87 mm. Fruit thickness ranged from 0.91 mm (Chaurangikhal) to 1.02 mm (Develgaun) with a mean of 0.96 mm. The fruit length/width ratio ranged from 1.33 (Develgaun) to 1.97 (Silyara) with an average of 1.63. The weight of 100 fruits varied between 82.93 gm (Develgaun) and 116.72 gm (Silyara) with a mean of 108.63 gm. Fruit moisture content ranged from 45.08% (Develgaun) to 75.65% (Sadargaun), with an average of 64.83%. These results indicate notable variations in fruit traits among seed sources.

Seed Source	Fruit Length (cm)	Fruit width(mm)	Fruit thickness(mm)	Fruit Length/ width ratio	Fruit weight (gm)	Moisture (%)
Silyara	1.53 ± 0.08^{b}	0.77 ± 0.07^{c}	1.00 ± 0.05	1.97 ± 0.10^{a}	116.72 ± 1.26^{a}	71.24 ± 3.09^{ab}
Develgaun	1.35 ± 0.08^{c}	1.02 ± 0.10^{a}	1.02 ± 0.04	1.33 ± 0.19^{b}	82.93 ± 2.05^{b}	45.08 ± 12.48^{c}
Kuteti	1.42 ± 0.09^{a}	0.97 ± 0.09^{bc}	0.93 ± 0.09	1.47 ± 0.14^{a}	115.56 ± 10.10^{a}	66.85 ± 14.12^{ab}
Ranichauri	1.13 ± 0.15^{d}	0.78 ± 0.11^{c}	0.93 ± 0.08	1.46 ± 0.18^{b}	114.54 ± 9.91^{a}	71.48 ± 9.01^{ab}
Sadargaun	1.39 ± 0.12^{c}	0.75 ± 0.12^{c}	0.93 ± 0.08	1.79 ± 0.31^{a}	108.71 ± 11.21^{a}	75.65 ± 13.10^{a}
Chaurangikhal	1.06 ± 0.17^{bc}	0.90 ± 0.02^{b}	0.91 ± 0.09	1.78 ± 0.19^{b}	113.34 ± 6.06^{a}	58.67 ± 9.92^{b}
Mean	1.31	0.87	0.96	1.63	108.63	64.83
CV	5.73	11.60	9.83	12.35	8.360	15.75

Table 2: Variation on fruit characteristics influenced by seed sources.

CV= Coefficient of Variation, S. D.= Standard Deviation

Morphological variation of seeds in *Prunus cerasoides*

The study of seed morphology of *Prunus cerasoides* revealed significant ($p \leq 0.05$) variations among seed sources in most parameters. Seed length ranged from 0.43 cm (Ranichauri) to 0.97 cm (Silyara) with an average of 0.82 cm, and seed width varied from 0.58 cm (Kuteti) to 0.69 cm (Silyara) with an average of 0.64 cm. Seed thickness showed no significant variations, ranging from 0.48 mm (Kuteti) to 0.61 mm (Sadargaun) with a mean of 0.52 mm. The seed length/width ratio ranged from 1.11 (Ranichauri) to 2.46 (Silyara) with a mean of 1.63. Seed moisture content varied significantly, ranging from 4.79% (Develgaun) to 8.17% (Sadargaun) with an average of 6.77%. Peel thickness showed no significant variation, ranging from 0.32 mm (Sadargaun) to 0.52 mm (Develgaun) with a mean of 0.44 mm. Lastly, the weight of 100 seeds varied from 22.59 gm (Ranichauri) to 31.00 gm (Develgaun) with an average of 27.54 gm. These findings highlight notable differences in seed traits across the seed sources.

Seed Sources	Seed length (cm)	Seed width(mm)	Seed thickness (mm)	Moisture%	Seed length/ width ratio	Peel thickness(mm)	Seed weight (gm)
Silyara	0.97 ± 0.17^{a}	0.69 ± 0.13^{b}	0.49 ± 0.03	7.39 ± 1.76^{a}	2.46 ± 0.84^{a}	0.51 ± 0.03	28.90 ± 1.41^{b}
Develgaun	0.90 ± 0.08^{a}	0.66 ± 0.19^{a}	0.51 ± 0.12	4.79 ± 0.29^{b}	1.43 ± 0.32^{b}	0.52 ± 0.14	31.00 ± 1.23^{a}
Kuteti	0.88 ± 0.14^{a}	0.58 ± 0.08^{a}	0.48 ± 0.12	6.72 ± 1.99^{a}	1.52 ± 0.05^{b}	0.49 ± 0.15	29.83 ± 0.99^{c}
Ranicharui	0.43 ± 0.18^{c}	0.62 ± 0.11^{b}	0.51 ± 0.04	7.06 ± 1.63^{ab}	1.19 ± 0.78^{b}	0.44 ± 0.08	22.59 ± 1.44^{d}
Sadargaun	0.77 ± 0.15^{b}	0.62 ± 0.13^{ab}	0.61 ± 0.15	8.17 ± 1.56^{a}	1.64 ± 0.56^{b}	0.32 ± 0.15	26.59 ± 1.70^{c}
Chaurangik-hal	0.96 ± 0.12^{ab}	0.64 ± 0.17^{ab}	0.53 ± 0.09	6.46 ± 1.18^{a}	1.56 ± 0.33^{b}	0.38 ± 0.10	26.32 ± 1.55^{b}
Mean	0.82	0.64	0.52	6.77	1.63	0.44	27.54
Cv	12.050	24.802	19.718	19.78	24.802	28.508	5.512

Table 3: Variation on seed characteristics influenced by seed source.

Effect of pre-treatments on seed germination of *Prunus cerasoides* from different seed sources.

Seed germination percent

Effects of various pre-treatments on seed germination of *P.cerasoides* were studied and the observations regarding on seed germination percent are presented in table 2.

The seed germination study on *P. cerasoides* across six seed sources and fifteen pre-sowing treatments revealed notable variations. In cold water treatment (T-1, T-2, T-3), the highest germination was 72.00 ± 6.80% in Silyara (T-2 and T-3), while the lowest was 44.00 ± 5.26% in Chaurangikhal (T-1). In hot water treatment (T-4, T-5, T-6), Kuteti seed source recorded the highest germination (84.00 ± 7.86%) in T-4, while Ranichauri had the lowest (48.00 ±

Seed Sources	Elevation (masl)	Seed length (cm)	Seed width(mm)	Seed thickness (mm)	Moisture%	Seed length/ width ratio	Peel thickness(mm)	Seed weight (gm)
Silyara	965	0.97 ± 0.17^{a}	0.69 ± 0.13^{b}	0.49 ± 0.03	7.39 ± 1.76^{a}	2.46 ± 0.84^{a}	0.51 ± 0.03	28.90 ± 1.41^{b}
Develgaun	996	0.90 ± 0.08^{a}	0.66 ± 0.19^{a}	0.51 ± 0.12	4.79 ± 0.29^{b}	1.43 ± 0.32^{b}	0.52 ± 0.14	31.00 ± 1.23^{a}
Kuteti	1654	0.88 ± 0.14^{a}	0.58 ± 0.08^{a}	0.48 ± 0.12	6.72 ± 1.99^{a}	1.52 ± 0.05^{b}	0.49 ± 0.15	29.83 ± 0.99^{c}
Ranicharui	1863	0.43 ± 0.18^{c}	0.62 ± 0.11^{b}	0.51 ± 0.04	7.06 ± 1.63^{ab}	1.19 ± 0.78^{b}	0.44 ± 0.08	22.59 ± 1.44^{d}
Sadargaun	1981	0.77 ± 0.15^{b}	0.62 ± 0.13^{ab}	0.61 ± 0.15	8.17 ± 1.56^{a}	1.64 ± 0.56^{b}	0.32 ± 0.15	26.59 ± 1.70^{c}
Chaurangik-hal	2305	0.96 ± 0.12^{ab}	0.64 ± 0.17^{ab}	0.53 ± 0.09	6.46 ± 1.18^{a}	1.56 ± 0.33^{b}	0.38 ± 0.10	26.32 ± 1.55^{b}
Mean		0.82	0.64	0.52	6.77	1.63	0.44	27.54
Cv		12.050	24.802	19.718	19.78	24.802	28.508	5.512

Table 4: Variation on seed characteristics (Mean ± S.D.) influenced by seed source.

C.V= Coefficient of variation, S.D. ± Standard deviation

Treatment	Seed sources						Mean
	Silayara	Develgaun	Ranichauri	Sadargaun	Chaurangikhal	Kuteti	
T-1	55.00 ± 5.28	46.00 ± 5.73	52.00 ± 5.47	45.00 ± 5.54	44.00 ± 5.26	56.00 ± 5.23	49.50
T-2	72.00 ± 6.80	56.00 ± 5.73	52.00 ± 5.45	68.00 ± 6.70	72.00 ± 6.75	68.00 ± 6.30	64.66
T-3	64.00 ± 6.60	72.00 ± 6.80	60.00 ± 4.73	56.00 ± 5.84	56.00 ± 5.82	64.00 ± 6.20	62.00
T-4	82.00 ± 8.14	82.00 ± 8.14	65.00 ± 6.59	72.00 ± 6.80	64.00 ± 6.35	84.00 ± 7.86	74.66
T-5	60.00 ± 6.14	56.00 ± 5.73	48.00 ± 4.73	58.00 ± 5.73	68.00 ± 6.35	64.00 ± 6.12	59.00
T-6	68.00 ± 6.75	68.00 ± 6.70	52.00 ± 5.42	76.00 ± 6.86	64.00 ± 5.75	60.00 ± 6.03	64.66
T-7	56.00 ± 5.94	64.00 ± 6.20	48.00 ± 4.70	72.00 ± 5.42	60.00 ± 6.12	76.00 ± 6.21	62.66
T-8	74.00 ± 6.83	58.00 ± 5.73	56.00 ± 5.73	76.00 ± 6.73	72.00 ± 5.62	64.00 ± 6.31	66.00
T-9	72.00 ± 5.95	56.00 ± 5.73	52.00 ± 4.39	72.00 ± 9.88	60.00 ± 6.10	52.00 ± 4.32	60.66
T-10	80.00 ± 7.14	60.00 ± 6.28	52.00 ± 4.23	60.00 ± 6.30	64.00 ± 6.21	64.00 ± 5.97	63.33
T-11	80.00 ± 7.14	64.00 ± 6.60	52.00 ± 4.45	64.00 ± 6.78	60.00 ± 6.13	68.00 ± 6.45	64.66
T-12	82.00 ± 7.50	72.00 ± 5.75	56.00 ± 5.84	60.00 ± 5.97	62.00 ± 6.10	58.00 ± 4.85	65.33
T-13	76.00 ± 5.98	80.00 ± 7.31	56.00 ± 5.80	68.00 ± 6.65	64.00 ± 6.03	56.00 ± 8.94	66.66
T-14	92.00 ± 5.94	76.00 ± 5.98	72.00 ± 6.01	76.00 ± 6.54	76.00 ± 5.41	86.00 ± 8.54	79.66
T-15	80.00 ± 7.95	56.00 ± 4.26	52.00 ± 5.42	52.00 ± 5.40	60.00 ± 6.01	80.00 ± 7.31	63.33
Mean	72.86	64.4	55.00	69.00	63.06	66.66	64.19

Table 5: Variation on seed germination percent (%) of different pre-treatments with seed sources.

T-1:Seed with seed coat +cold water for 24 hours, T-2:Seed without seed coat +cold water for 24 hours, T-3:Seed nicking +cold water for 24 hours, T-4:Seed with seed coat +hot waterfor100^{0} C at 24 hours, T-5:Seed without seed coat + hot waterfor100^{0}C at 24 hours, T-6: Seed nicking + hot water for100^{0} C at 24 hours, T-7: Seed with seed coat + cold stratification for 15 days, T-8: Cold stratification for 15 days+Seed nicking, T-9: Seed with seed coat + cold stratification for 15 days + hot water for100^{0}C at 24 hours, T-10: Seed with seed coat + cold stratification for 15 days+ GA_3 1000 ppm,T-11: Seed with seed coat + cold stratification for 15 days+$GA_3$1500ppm,T-12: Cold stratification for 45 days+Seed nicking, T-13: Seed with seed coat +cold stratification for 45 days + hot water for100^{0}C at 24 hours,T-14: Seed with seed coat + cold stratification for 45 days+$GA_3$1000 ppm,T-15: Seed with seed coat + cold stratification for 45 days+$GA_3$1500 ppm.

4.73%) in T-5. Cold stratification for 15 days (T-7, T-8, T-9) showed Kuteti with the highest germination (76.00 ± 6.21%) in T-7, and Ranichauri with the lowest (48.00 ± 4.70%) in T-7. The addition of GA3 (T-10, T-11) improved germination in Silyara (80.00 ± 7.14%) but remained lowest in Ranichauri (52.00 ± 4.23%). In cold stratification for 45 days (T-12, T-13, T-14, T-15), Silyara consistently showed the highest germination (92.00 ± 5.50% in T-14), while Ranichauri exhibited the lowest (56.00 ± 5.84% in T-12 and T-13).

Mean germination time (MGT)

The results of mean germination time of different pre-treatments with seed sources are presented in table 6. The mean germination time (MGT) study showed varying results across treatments and seed sources. In cold water treatment (T-1, T-2, T-3), Sadargaun exhibited the lowest MGT (19.92 ± 0.92 days in T-1), while Kuteti had the highest (24.56 ± 5.94 days in T-1). Silyara showed the lowest MGT in T-2 (16.28 ± 3.53 days) and Sadargaun the highest (18.8 ± 1.11 days). Seed nicking in cold water (T-3) showed the lowest MGT in Sadargaun (17.44 ± 0.43 days) and the highest in Ranichauri (20.16 ± 1.10 days). In hot water treatment (T-4, T-5, T-6), Develgaun had the lowest MGT (16.92 ± 1.27 days in T-4), and Silyara the highest (18.32 ± 0.64 days). For seed with seed coat and hot water (T-5), Develgaun had the lowest MGT (19.48 ± 2.36 days), and Ranichauri the highest (20.62 ± 1.40 days). Seed nicking with hot water (T-6) had the lowest MGT in Kuteti (17.16 ± 2.12 days) and the highest in Silyara (20.20 ± 1.23 days). Cold stratification for 15 days (T-7, T-8, T-9) resulted in Chaurangikhal showing the lowest MGT (16.62 ± 4.059 days in T-7), while Silyara had the highest (17.33 ± 4.68 days). Seed nicking with cold stratification (T-8) showed the lowest MGT in Sadargaun (16.68 ± 2.22 days) and the highest in Chaurangikhal (18.78 ± 0.54 days). Combining cold stratification with hot water (T-9) showed the lowest MGT in Chaurangikhal (17.00 ± 1.34 days) and the highest in Sadargaun (19.16 ± 2.21 days).

Treatment	Seed sources						Mean
	Silayara	Develgaun	Ranichauri	Sadargaun	Chaurangikhal	Kuteti	
T-1	21.26 ± 0.90	20.34 ± 1.05	22.18 ± 0.99	19.92 ± 0.92	20.90 ± 1.11	24.56 ± 5.94	21.52
T-2	16.28 ± 3.53	17.22 ± 3.84	16.95 ± 3.80	18.8 ± 1.11	18.74 ± 0.89	16.42 ± 1.02	17.40
T-3	18.74 ± 1.20	17.74 ± 0.64	20.16 ± 1.10	17.44 ± 0.43	18.4 ± 0.66	18.44 ± 0.66	18.48
T-4	18.32 ± 0.64	16.92 ± 1.27	18.20 ± 2.97	17.82 ± 1.15	18.04 ± 0.85	17.0 ± 1.934	17.71
T-5	19.84 ± 1.29	19.48 ± 2.36	20.62 ± 1.40	20.62 ± 1.23	20.52 ± 0.67	20.44 ± 0.78	20.25
T-6	20.20 ± 1.23	18.58 ± 1.47	19.60 ± 0.46	19.06 ± 0.75	18.98 ± 1.14	17.16 ± 2.12	18.93
T-7	17.33 ± 4.68	17.02 ± 3.68	17.32 ± 4.68	16.92 ± 1.36	16.62 ± 4.05	16.98 ± 2.75	17.03
T-8	18.14 ± 0.85	18.02 ± 1.46	18.06 ± 0.52	16.68 ± 2.22	18.78 ± 0.54	18.34 ± 1.16	18.00
T-9	18.14 ± 0.903	18.34 ± 0.66	17.78 ± 0.97	19.16 ± 2.21	17.00 ± 1.34	17.76 ± 0.86	18.03
T-10	14.82 ± 3.60	16.2 ± 2.70	16.72 ± 2.48	12.56 ± 0.88	16.74 ± 1.54	15.6 ± 1.677	15.41
T-11	17.04 ± 0.70	16.98 ± 2.10	18.22 ± 0.30	18.99 ± 0.67	17.60 ± 1.04	18.98 ± 1.04	19.88
T-12	23.64 ± 1.44	20.76 ± 0.92	24.64 ± 0.89	21.58 ± 1.64	22.28 ± 0.65	21.10 ± 0.88	18.23
T-13	18.04 ± 3.21	19.72 ± 3.14	19.78 ± 0.31	21.1 ± 1.43	18.38 ± 3.22	21.74 ± 4.23	19.79
T-14	12.26 ± 0.27	10.96 ± 2.00	11.24 ± 2.58	10.26 ± 2.42	12.54 ± 1.19	13.28 ± 3.10	11.75
T-15	13.92 ± 1.58	15.22 ± 2.31	13.90 ± 0.78	13.62 ± 2.86	13.82 ± 0.90	15.56 ± 3.36	14.50
Mean	17.85	17.56	18.35	17.63	17.95	18.22	15.03

Table 6: Variation on mean germination time of different pre-treatments with seed sources.

T-1: Seed with seed coat +cold water for 24 hours, T-2: Seed without seed coat +cold water for 24 hours, T-3: Seed nicking +cold water for 24 hours, T-4: Seed with seed coat +hot waterfor100^0 C at 24 hours, T-5: Seed without seed coat + hot waterfor100^{0}C at 24 hours, T-6: Seed nicking + hot water for100^0 C at 24 hours, T-7: Seed with seed coat + cold stratification for 15 days, T-8: Cold stratification for 15 days+Seed nicking, T-9: Seed with seed coat + cold stratification for 15 days + hot water for100^{0}C at 24 hours, T-10: Seed with seed coat + cold stratification for 15 days+ GA_3 1000 ppm,T-11: Seed with seed coat + cold stratification for 15 days+$GA_3$1500ppm,T-12: Cold stratification for 45 days +Seed nicking, T-13: Seed with seed coat +cold stratification for 45 days + hot water for100^{0}C at 24 hours,T-14: Seed with seed coat + cold stratification for 45 days+$GA_3$1000 ppm,T-15: Seed with seed coat + cold stratification for 45 days+$GA_3$1500 ppm.

The study results presented in Tables 4 and 5 indicate varying effects of pre-treatments on mean germination time (MGT) and germination index (GI) across different seed sources. Treatment (T-10), seed with seed coat + cold stratification for 15 days + GA3 1000 ppm, showed the lowest MGT of 12.56 ± 0.88 days in Sadargaun seed source, while the highest MGT of 16.74 ± 1.54 days was found in the same seed source. In treatment (T-11), seed with seed coat + cold stratification for 15 days + GA3 1500 ppm, Develgaun seed source exhibited the minimum MGT of 16.98 ± 2.10 days, with Sadargaun showing the highest at 18.99 ± 0.67 days. For treatment (T-12), cold stratification for 45 days + seed nicking resulted in the lowest MGT of 20.76 ± 0.92 days in Develgaun seed source and the highest MGT of 24.64 ± 0.89 days in Ranichauri. Treatment (T-13), seed with seed coat + cold stratification for 45 days + hot water at 100°C for 24 hours, showed the minimum MGT of 18.04 ± 3.21 days in Silyara, with Kuteti having the highest at 21.74 ± 4.23 days. In treatment (T-14), seed with seed coat + cold stratification for 45 days + GA3 1000 ppm, Sadargaun seed source exhibited the lowest MGT of 10.26 ± 2.42 days, while Kuteti showed the highest at 13.08 ± 3.10 days. For treatment (T-15), seed with seed coat + cold stratification for 45 days + GA3 1500 ppm, Sadargaun showed the lowest MGT of 13.62 ± 2.896 days, while Kuteti had the highest at 15.56 ± 3.36 days.

Regarding germination index (GI), in treatment (T-1) seed with seed coat + cold water, Kuteti seed source had the highest GI of 0.14 ± 0.02, while Ranichauri had the lowest at 0.08 ± 0.01. Treatment (T-2), seed without seed coat + cold water, showed the highest GI of 0.18 ± 0.02 in Sadargaun and the lowest of 0.09 ± 0.03 in Develgaun. For treatment (T-3), seed nicking + cold water, Develgaun exhibited the highest GI of 0.14 ± 0.01, with Ranichauri showing the lowest at 0.08 ± 0.01. In hot water treatment, treatment (T-4) seed without seed coat + hot water at 100°C for 24 hours showed the highest GI of 0.14 ± 0.02 in Chaurangikhal and the lowest of 0.09 ± 0.03 in Ranichauri. Treatment (T-5), seed with seed coat + hot water at 100°C for 24 hours, recorded the highest GI of 0.18 ± 0.09 in Chaurangikhal, with Ranichauri having the lowest at 0.11 ± 0.06. In treatment (T-6), seed nicking + hot water at 100°C for 24 hours, Chaurangikhal showed the highest GI of 0.18 ± 0.03, while Ranichauri had the lowest at 0.08 ± 0.03.

Treatment	Seed source						Mean
	Silayara	Develgaun	Ranichauri	Sadargaun	Chaurangikhal	Kuteti	
T-1	0.13 ± 0.03	0.09 ± 0.22	0.08 ± 0.01	0.09 ± 0.02	0.10 ± 0.02	0.14 ± 0.02	0.10
T-2	0.10 ± 0.04	0.09 ± 0.03	0.14 ± 0.99	0.18 ± 0.02	0.14 ± 0.01	0.10 ± 0.01	0.12
T-3	0.12 ± 0.01	0.14 ± 0.01	0.08 ± 0.01	0.11 ± 0.01	0.10 ± 0.02	0.12 ± 0.03	0.11
T-4	0.13 ± 0.02	0.12 ± 0.03	0.09 ± 0.03	0.12 ± 0.02	0.14 ± 0.02	0.13 ± 0.03	0.12
T-5	0.13 ± 0.6	0.12 ± 0.10	0.11 ± 0.06	0.14 ± 0.09	0.18 ± 0.09	0.17 ± 0.07	0.18
T-6	0.12 ± 0.01	0.13 ± 0.02	0.08 ± 0.03	0.14 ± 0.03	0.18 ± 0.03	0.12 ± 0.02	0.13
T-7	0.11 ± 0.04	0.14 ± 0.03	0.12 ± 0.24	0.15 ± 0.02	0.18 ± 0.02	0.14 ± 0.03	0.14
T-8	0.14 ± 0.04	0.18 ± 0.03	0.12 ± 0.02	0.16 ± 0.02	0.14 ± 0.03	0.13 ± 0.02	0.14
T-9	0.20 ± 0.03	0.18 ± 0.02	0.17 ± 0.03	0.19 ± 0.03	0.18 ± 0.05	0.16 ± 0.03	0.18
T-10	0.18 ± 0.02	0.15 ± 0.02	0.10 ± 0.02	0.17 ± 0.04	0.15 ± 0.04	0.15 ± 0.02	0.15
T-11	0.15 ± 0.02	0.14 ± 0.04	0.17 ± 0.10	0.13 ± 0.03	0.12 ± 0.02	0.15 ± 0.04	0.16
T-12	0.16 ± 0.01	0.13 ± 0.03	0.18 ± 0.24	0.21 ± 0.13	0.12 ± 0.04	0.08 ± 0.02	0.16
T-13	0.13 ± 0.03	0.14 ± 0.02	0.11 ± 0.03	0.12 ± 0.02	0.13 ± 0.01	0.10 ± 0.01	0.12
T-14	0.19 ± 0.03	0.17 ± 0.02	0.16 ± 0.02	0.18 ± 0.01	0.17 ± 0.02	0.18 ± 0.02	0.17
T-15	0.17 ± 0.08	0.14 ± 0.03	0.14 ± 0.03	0.16 ± 0.03	0.12 ± 0.02	0.14 ± 0.04	0.14
Mean	0.14	0.14	0.13	0.16	0.14	0.13	0.14

Table 7: Variation on germination index of different pre-treatments with seed sources.

T-1: Seed with seed coat +cold water for 24 hours, T-2: Seed without seed coat +cold water for 24 hours, T-3: Seed nicking +cold water for 24 hours, T-4: Seed with seed coat +hot waterfor100^0 C at 24 hours, T-5: Seed without seed coat + hot waterfor100^{0}C at 24 hours, T-6: Seed nicking + hot water for100^0 C at 24 hours, T-7: Seed with seed coat + cold stratification for 15 days, T-8: Cold stratification for 15 days+Seed nicking, T-9: Seed with seed coat + cold stratification for 15 days + hot water for100^{0}C at 24 hours, T-10: Seed with seed coat + cold stratification for 15 days+ GA_3 1000 ppm,T-11: Seed with seed coat + cold stratification for 15 days+$GA_3$1500ppm,T-12: Cold stratification for 45 days +Seed nicking, T-13: Seed with seed coat +cold stratification for 45 days + hot water for100^{0}C at 24 hours,T-14: Seed with seed coat + cold stratification for 45 days+$GA_3$1000 ppm,T-15: Seed with seed coat + cold stratification for 45 days+$GA_3$1500 ppm.

The results of the study on various seed treatments and their effects on germination and growth parameters revealed significant variations among the different seed sources and treatments. In terms of the Germination Index (GI), the highest value (0.20 ± 0.03) was recorded in the Silyara seed source under treatment (T-9) with seed coat + cold stratification for 15 days + hot water at 100°C for 24 hours, while the lowest GI (0.08 ± 0.03) was recorded in Ranichauri seed source under treatment (T-7) with seed coat + cold stratification for 15 days. In treatment (T-12), cold stratification for 45 days + seed nicking produced the highest GI (0.21 ± 0.13) in Sadargaun, with Kuteti seed source showing the lowest GI (0.08 ± 0.02).

For Plumule Length, treatment (T-6) seed nicking + hot water for 100°C for 24 hours produced the longest plumule (3.82 cm) in Sadargaun, whereas the shortest length (0.52 cm) was observed in Sadargaun under treatment (T-2) with seed without seed coat + cold water. Radicle Length was highest in Sadargaun (6.00 cm) under treatment (T-1) with seed coat + cold water, and lowest (1.25 cm) in Develgaun. For Seedling Length, the maximum length (8.15 cm) was found in Develgaun under treatment (T-11) with GA3 1500 ppm, while the minimum length (3.16 cm) was observed in Ranichauri under treatment (T-1).

Treatment	Seed Sources																	
	Silyara			Develgaun			Ranichauri			Sadargaun			Chaurangikhal			Kuteti		
	PL	RL	SL	PL	RL	SL	PL	RL	SL	PL	RL	SL	PL	RL	SL	PL	RL	SL
T-1	2.60 ± 1.60	5.45 ± 1.28	8.05 ± 2.0	1.60 ± 0.96	1.25 ± 0.75	3.83 ± 1.65	1.08 ± 1.40	2.08 ± 0.95	3.16 ± 1.30	1.30 ± 0.90	6.00 ± 2.90	7.3 ± 3.12	1.92 ± 0.85	3.40 ± 2.50	5.32 ± 3.12	1.64 ± 0.85	4.46 ± 2.55	6.1 ± 3.18
T-2	2.5 ± 1.27	4.40 ± 1.15	6.9 ± 1.40	1.60 ± 0.95	0.58 ± 0.25	4.16 ± 2.30	2.42 ± 1.78	2.21 ± 0.25	4.16 ± 2.40	0.52 ± 0.25	5.18 ± 2.50	5.7 ± 3.12	1.92 ± 0.90	2.10 ± 1.40	4.02 ± 2.60	2.34 ± 0.25	3.18 ± 2.78	5.52 ± 2.98
T-3	3.1 ± 1.15	4.11 ± 1.10	7.21 ± 1.70	0.22 ± 0.11	2.4 ± 1.90	4.24 ± 2.72	0.67 ± 0.80	1.44 ± 1.30	4.24 ± 2.41	2.44 ± 1.40	2.96 ± 1.95	5.4 ± 3.14	2.50 ± 1.15	2.52 ± 1.62	5.02 ± 2.48	2.54 ± 1.26	3.32 ± 2.90	5.86 ± 3.45
T-4	1.56 ± 0.92	4.01 ± 1.14	5.57 ± 1.25	1.33 ± 0.85	1.90 ± 0.86	3.00 ± 1.45	1.36 ± 1.15	1.91 ± 0.85	3.00 ± 1.02	1.68 ± 0.98	4.36 ± 2.75	6.04 ± 3.45	0.78 ± 0.56	2.66 ± 1.72	3.44 ± 2.72	3.82 ± 2.15	3.18 ± 2.78	7 ± 3.56
T-5	1.93 ± 1.40	5.12 ± 1.12	7.05 ± 1.30	2.47 ± 1.45	2.58 ± 1.25	3.18 ± 1.56	1.04 ± 0.46	2.58 ± 1.40	3.18 ± 1.20	2.38 ± 1.35	2.90 ± 1.90	5.28 ± 3.26	2.30 ± 1.12	2.56 ± 1.63	4.86 ± 2.88	2.20 ± 1.35	3.24 ± 2.80	5.44 ± 3.25
T-6	2.41 ± 1.87	4.2 ± 1.24	6.61 ± 1.17	1.70 ± 1.25	1.58 ± 0.97	2.47 ± 2.90	1.68 ± 0.59	1.92 ± 0.75	2.47 ± 1.56	3.82 ± 2.10	3.42 ± 2.10	7.24 ± 3.06	1.48 ± 0.92	3.02 ± 2.65	4.5 ± 3.01	2.74 ± 1.52	3.30 ± 2.85	6.04 ± 3.06
T-7	0.64 ± 1.40	3.5 ± 1.30	4.14 ± 1.11	2.09 ± 1.60	5.37 ± 3.95	6.21 ± 3.30	1.99 ± 0.54	3.07 ± 1.25	6.21 ± 2.56	1.08 ± 0.75	2.86 ± 2.06	3.94 ± 2.98	3.56 ± 2.80	2.48 ± 159	6.04 ± 3.20	1.47 ± 0.68	3.30 ± 2.85	4.77 ± 2.68
T-8	1.47 ± 0.95	4.1 ± 1.20	5.57 ± 1.25	1.40 ± 0.82	4.5 ± 2.35	5.92 ± 2.29	2.3 ± 0.70	4.50 ± 1.25	5.92 ± 1.65	1.02 ± 0.65	2.68 ± 2.01	3.7 ± 2.60	2.60 ± 1.25	3.22 ± 2.70	5.82 ± 2.38	0.56 ± 0.23	3.70 ± 2.92	4.26 ± 2.26
T-9	3.20 ± 1.97	3.10 ± 1.11	6.30 ± 1.06	2.70 ± 1.56	2.98 ± 1.23	6.82 ± 3.30	2.1 ± 1.91	2.98 ± 1.45	6.82 ± 2.59	0.88 ± 0.45	2.94 ± 2.15	3.82 ± 2.65	1.84 ± 0.74	3.20 ± 2.68	5.04 ± 2.99	2.40 ± 1.24	1.06 ± 0.75	3.46 ± 2.47
T-10	2.41 ± 1.01	5.12 ± 1.52	7.53 ± 1.75	3.29 ± 1.35	3.02 ± 1.30	4.14 ± 2.99	0.98 ± 1.20	3.02 ± 1.80	4.14 ± 2.40	3.88 ± 2.12	2.34 ± 1.90	6.22 ± 2.06	2.74 ± 1.48	4.56 ± 3.01	7.3 ± 3.18	1.64 ± 0.85	3.08 ± 2.18	4.72 ± 2.56
T-11	1.44 ± 0.87	3.17 ± 1.37	4.61 ± 1.15	3.2 ± 1.25	5.85 ± 3.60	8.15 ± 4.30	1.86 ± 1.30	3.85 ± 1.40	8.15 ± 3.40	6.10 ± 3.20	3.32 ± 2.09	9.42 ± 3.90	2.64 ± 1.38	3.22 ± 2.80	5.86 ± 2.86	2.82 ± 1.35	2.74 ± 2.26	5.56 ± 3.65
T-12	2.96 ± 1.20	3.81 ± 1.08	6.77 ± 1.27	2.56 ± 1.55	2.14 ± 1.56	2.89 ± 1.60	2.06 ± 0.85	2.14 ± 1.20	2.89 ± 1.62	2.06 ± 1.20	3.36 ± 2.12	5.42 ± 3.40	2.46 ± 1.24	1.78 ± 0.95	4.24 ± 2.80	1.22 ± 0.90	3.40 ± 2.95	4.62 ± 2.65
T-13	3.30 ± 1.46	4.62 ± 1.10	7.92 ± 2.12	0.99 ± 0.45	3.92 ± 1.85	6.59 ± 3.16	1.34 ± 1.45	3.92 ± 1.89	6.59 ± 3.02	2.31 ± 1.20	3.97 ± 2.58	6.28 ± 3.55	1.1 ± 0.71	2.24 ± 1.42	3.34 ± 2.28	3.14 ± 099	3.50 ± 2.98	6.64 ± 2.85
T-14	1.20 ± 0.98	5.10 ± 1.17	6.30 ± 1.10	3.09 ± 1.95	5.28 ± 3.60	7.15 ± 3.90	1.92 ± 1.82	4.28 ± 1.95	6.15 ± 4.02	3.66 ± 1.95	4.54 ± 2.98	8.2 ± 3.90	3.68. 75	3.46 ± 2.55	7.14 ± 3.12	4.25 ± 2.15	4.64 ± 2.95	8.89 ± 3.94
T-15	3.6 ± 1.60	4.12 ± 1.01	7.72 ± 1.80	2.37 ± 1.30	5.28 ± 3.54	6.98 ± 3.65	1.54 ± 1.48	3.47 ± 2.14	3.98 ± 3.56	2.12 ± 1.13	3.22 ± 2.78	5.34 ± 2.92	2.32 ± 1.56	3.44 ± 2.90	5.76 ± 2.25	2.68 ± 0.12	3.60 ± 2.98	6.28 ± 2.35
Mean	2.26	4.262	6.55	2.04	3.18	5.04	1.62	2.91	4.64	2.35	3.60	5.738	2.25	2.94	5.18	2.36	3.31	5.45

Table 8: Plumule, Radicle and Seedling length of *P.cerasoides*.

T-1: Seed with seed coat +cold water for 24 hours, T-2: Seed without seed coat +cold water for 24 hours, T-3: Seed nicking +cold water for 24 hours, T-4: Seed with seed coat +hot waterfor100^0 C at 24 hours, T-5: Seed without seed coat + hot waterfor100^{0}C at 24 hours, T-6: Seed nicking + hot water for100^0 C at 24 hours, T-7: Seed with seed coat + cold stratification for 15 days, T-8: Cold stratification for 15 days+Seed nicking, T-9: Seed with seed coat + cold stratification for 15 days + hot water for100^{0}C at 24 hours, T-10: Seed with seed coat + cold stratification for 15 days+ GA_3 1000 ppm,T-11: Seed with seed coat + cold stratification for 15 days+$GA_3$1500ppm,T-12: Cold stratification for 45 days +Seed nicking, T-13: Seed with seed coat +cold stratification for 45 days + hot water for100^{0}C at 24 hours,T-14: Seed with seed coat + cold stratification for 45 days+$GA_3$1000 ppm,T-15: Seed with seed coat + cold stratification for 45 days+$GA_3$1500 ppm.

Treatment	Seed Sources											
	Silyara		Develgaun		Ranichauri		Sadargaun		Chaurangikhal		Kuteti	
	P/R Ratio	SVI	P/R Ratio	SVI	P/R Ratio	SVI	P/R Ratio	SVI	P/R Ratio	SVI	P/R Ratio	SVI
T-1	0.47 ± 0.38	483 ± 213	2.064 ± 1.10	214.48 ± 115.33	0.51 ± 0.24	164.32 ± 75.62	0.21 ± 0.12	467.2 ± 257.65	0.56 ± 0.30	234.08 ± 121.4	0.36 ± 0.17	341.6 ± 125.41
T-2	0.56 ± 0.42	496.8 ± 154.00	6.17 ± 3.13	232.96 ± 139.45	1.09 ± 2.98	240.76 ± 79.56	0.10 ± 0.2	387.6 ± 125.98	0.91 ± 0.25	289.44 ± 87.56	0.73 ± 0.50	375.4 ± 54.21
T-3	0.75 ± 0.65	461.4 ± 170.0	0.76 ± 0.18	305.28 ± 82.65	0.47 ± 0.43	99.36 ± 79.56	0.82 ± 0.48	302.4 ± 114.58	0.99 ± 0.28	281.44 ± 78.54	0.76 ± 0.34	375.04 ± 135.66
T-4	0.38 ± 0.35	512.44 ± 201.0	0.57 ± 0.9	228 ± 116.3	0.71 ± 0.38	281.22 ± 113.25	0.38 ± 0.15	459.04 ± 147.52	0.29 ± 0.15	261.44 ± 64.58	1.20 ± 2.21	420 ± 146.00
T-5	0.37 ± 0.32	423 ± 145.00	0.23 ± 0.05	178.08 ± 79.56	0.40 ± 0.12	173 ± 7.21	0.82 ± 0.32	295.68 ± 86.74	0.89 ± 0.35	330.48 ± 106.54	0.67 ± 0.54	348 ± 124.32
T-6	0.57 ± 0.29	449.48 ± 145.00	0.56 ± 0.20	167.92 ± 85.47	0.87 ± 0.37	187 ± 65.12	1.11 ± 0.95	550.68 ± 142.95	0.49 ± 0.28	288 ± 89.74	0.83 ± 0.64	362 ± 123.54
T-7	0.18 ± 0.10	231.84 ± 98.23	0.15 ± 0.05	397.44 ± 84.57	0.64 ± 0.42	242.88 ± 55.86	0.37 ± 0.14	283.63 ± 88.57	1.43 ± 0.95	362.4 ± 107.1	0.44 ± 0.18	362.52 ± 191.42
T-8	0.35 ± 0.20	401.4 ± 146.00	0.31 ± 0.14	331.52 ± 1.10.5	0.51 ± 39	380.8 ± 145.85	0.38 ± 0.15	281.2 ± 78.54	0.80 ± 0.35	419.04 ± 134.25	0.15 ± 0.02	272.64 ± 75.21
T-9	1.03 ± 0.92	453.6 ± 148.00	1.28 ± 0.27	381.92 125.87	0.70 ± 0.52	246.16 ± 125.65	0.29 ± 0.16	275.04 ± 67.41	0.57 ± 0.30	302.4 ± 134.25	2.26 ± 1.54	179.92 ± 87.56
T-10	0.47 ± 0.35	602.4 ± 219.36	0.37 ± 0.16	248.4 ± 137.58	0.32 ± 0.19	208 ± 141.02	1.65 ± 1.02	373.2 ± 118.45	0.60 ± 0.28	467.04 ± 257.64	0.53 ± 0.21	302.08 ± 98.54
T-11	0.45 ± 0.28	368.8 ± 135.00	0.39 ± 0.18	521.6 ± 118.24	0.48 ± 0.22	296.92 ± 154.16	0.83 ± 0.65	396.16 ± 172	0.81 ± 0.48	351.6 ± 124.74	1.02 ± 0.72	378.08 ± 63.21
T-12	0.77 ± 0.35	649.92 ± 182.0	0.35 ± 0.19	208.08 ± 138.45	0.96 ± 0.20	235.2 ± 50.23	0.61 ± 0.35	325.00 ± 101.25	1.38 ± 0.98	254.4 ± 70.35	0.35 ± 0.18	221.76 ± 67.41
T-13	0.71 ± 0.26	601.92 ± 180.92	0.68 ± 0.25	527.2 ± 81.54	0.34 ± 0.21	294.56 ± 89.36	0.58 ± 0.28	427.04 ± 139.2	0.49 ± 0.24	213.76 ± 124.40	0.89 ± 0.16	371 ± 78.24
T-14	0.23 ± 0.15	516.6 ± 208.00	0.35 ± 0.19	586.3 ± 150.74	0.41 ± 0.24	418.56 ± 116.35	0.80 ± 0.45	590.4 ± 158.45	1.06 ± 0.87	456.96 ± 130.10	0.91 ± 0.38	746.44 ± 215.20
T-15	0.87 ± 0.35	617.6 ± 113.20	0.57 ± 0.28	307.32 ± 114.65	0.44 ± 0.26	260.52 ± 118.54	0.65 ± 0.38	277.68 ± 58.45	0.67 ± 0.24	345.6 ± 124.12	0.74 ± 0.50	502.4 ± 121.2
Mean treatment	0.54	484.659	0.99	322.423	0.59	249.88	0.64	379.45	0.80	323.86	0.79	370.70

Table-9 : Plumule/radicle length ratio and seedvigour index of *P. cerasoides*.

T-1: Seed with seed coat +cold water for 24 hours, T-2: Seed without seed coat +cold water for 24 hours, T-3: Seed nicking +cold water for 24 hours, T-4: Seed with seed coat +hot waterfor100^0 C at 24 hours, T-5: Seed without seed coat + hot waterfor100^{0}C at 24 hours, T-6: Seed nicking + hot water for100^0 C at 24 hours, T-7: Seed with seed coat + cold stratification for 15 days, T-8: Cold stratification for 15 days+Seed nicking, T-9: Seed with seed coat + cold stratification for 15 days + hot water for100^{0}C at 24 hours, T-10: Seed with seed coat + cold stratification for 15 days+ $GA_3$1000 ppm,T-11: Seed with seed coat + cold stratification for 15 days+$GA_3$1500ppm,T-12: Cold stratification for 45 days +Seed nicking, T-13: Seed with seed coat +cold stratification for 45 days + hot water for100^{0}C at 24 hours,T-14: Seed with seed coat + cold stratification for 45 days+$GA_3$1000 ppm,T-15: Seed with seed coat + cold stratification for 45 days+$GA_3$1500 ppm.

The Plumule/Radicle Length Ratio (P/R) was highest (6.17) in Develgaun under treatment (T-2) with seed without seed coat + cold water, while the lowest ratio (0.10) was seen in Sadargaun under the same treatment. The Seed Vigour Index (SVI) showed the highest value (746.76) in Kuteti under treatment (T-14) with cold stratification for 45 days + GA3 1000 ppm, and the lowest value (232.96) was recorded in Develgaun under treatment (T-2). Overall, seed treatments such as seed nicking, GA3 application, and hot water treatment enhanced growth and vigour, with significant variation in performance depending on both seed source and treatment applied.

Discussion

Morphological variation of fruit

Significant ($p \leq 0.05$) variation was recordedfor fruit length, width, weight, moisture and fruit length/width ratio while fruit thickness was not showed significant ($p \leq 0.05$) variation between the seed source. Among the seed source, maximum fruit length, weight of 100 fruits and fruit length/width ratio were recorded in Silyara seed source, while highest fruit width and fruit thickness were observed in Develgaun seed source and fruit moisture was recorded in Sadargaun seed source as compared to other seed source.The minimum fruit length and fruit thickness were recorded in Chaurangikhal seed source, while the lowest fruit length/width ratio, fruit weight and fruit moisture were observed in Develgaun seed source andSadargaun seed source was showed minimum fruit width as compared to other seed source.

Fruit size and fruit weight are important characteristics of plant species which depends on a different factor such as; seed source, genetic makeup and geographical environment where it is growing was reported by [2] The present study supports earlier work done by [21] where in they concluded that all *Prunus* ***cerasoides*** fruit parameters showed significant variation between the seed source. On other hand, [3] reported that *Pinusnigra* produced largest number of seeds, when the environmental conditionswere dry and windy of seed sourcethat potentially would increase the proportion of scattered-seeds in a far distance. The size of fruit is influenced by internal factors such as the success of reproduction, environmental factors and availability of nutrients. Similarly, [5] also reported that relationship among the fruit size and environmental condition was observed on *Vitellariaparadoxa*, where the size of fruit was significantly influenced by agroecology zones. Our results are in line with [1] assessed the seed source variation in fruit, seed and seedling traits of *Hippophaesalicifolia* and the seeds were collected from various 12 seed sources of Uttarakhand. They found that significant variation on fruit morphological parameters. Similarly, [22] in *Albiziaprocera*and [10] in *Celtisaustralis.*

Morphological variation of seeds in *Prunus cerasoides*

Significant ($p \leq 0.05$) differencewererecorded for seed length, seed width,seed moisture, seed weight, seed length/width ratio while seed thickness and peel thickness was not showed significant ($p \leq 0.05$) variation between the seed source. Between the seed source, maximum seed length, seed width and seed length/width ratio were recorded in Silyara seed source, while the highestseed thickness and seed moisture were observed in Sadargaun seed source withDevelgaun seed source were showed maximum seed weightand peel thickness. The minimum seed length, seed length/width ratio and seed weight were observed in Ranichauri seed source, while lowest seed width and seed thickness were recorded in Kuteti seed source with lowest seed moisture and peel thickness were recorded in Develgaun and Sadargaun seed source respectively.

The present investigation supports earlier work done by [20] where in they concluded that the seed length, width and weight were varied significantly across sites. Similarly, [13] also reportedthat seed source variation among the seed source inPongamiapinnata. On other hand similar work also done by other workers in various forest tree species. [19] in Prunus armenica, [17] in QuercusglaucaThunb., [12] inBauhinia variegata lin., [16] in Cassia fistula, [14] in Swieteniamacrophylla, [22] in Albiziaproceraand, [10] in Celtisaustralis.

Effect of pre-treatments on seed germination of *Prunus cerasoides* from different seed sources.

Seed germination characteristics

Significant ($p \leq 0.05$) variation was recorded between the treatments and seed source with respect to seed germination percent. Seeds of *prunus cerasoides*with seed coat were kept stored for 45 days in refrigerator for cold stratification to break the dormancy of seeds. After 45 days of stratification seeds were dipped in GA_3

solution with various concentrations to increase the germination rate and growth of seedlings. There after, these seeds were put in petri dish and placed on germinator for germination. The highest (79.66%) germination percent was recorded in treatment (T-14) seed with seed coat + cold stratification for 45 days+ $GA_3$1000 ppm and lowest (49.50%) was recorded in treatment (T-1) seed with seed coat +cold water for 24 hours. Scientist have used the variety of pre-treatments to break the dormancy of *Prunus* seeds with stratification being the most popular was reported by [7]. GA_3 is a most effective growth hormone and it is also used to break the dormancy of seeds which increase the germination percent rapidly. On other hand, [6] reported that variation in germination may be attributed by dormancy of seed caused by im-permeability of hard seed coat or may be dormancy in embryo.

The present findings supports earlier work done by [11]wherein they examined the effect of Gibberellic acid (GA_3) on seed germination of *Penstemon digitalis and* found that GA_3 increased the germination percentage and rate of seed germination, the treatment 1000 mg/L–^{1} GA_3 was found best for seed germination in all three experiments. Similarly, [5] investigated theeffects of seed coat removal, GA_3, H_2SO_4, preserved in cold and hot water and stratification (20-24°C and 2-4°C) in seed germination of *Prunus mahaleb*. Whereas they observed that the highest mean germination was recorded in a solution of GA_3 at 1000 ppm + cold stratification for twelve weeks on 2-4°C. On the country, [15] examined the seed germination response of *Pyrus pashia*andthey concluded that the highest (94 %) germination percent was observed in the seeds pre-treated with GA_3 500 ppm. Similarly, [6] in *Prosopis africana*.

In seed source, maximum (72.86%) germination percent was observed in Silyara seed source and Ranichauri seed source being least (55.00%). The variation in germination percent might be due to the seed size,while the highest seed length, seed width and seed length/width ratiowas recorded in Silyara seed source. Large size seed hold more reserve food [9] which are expectant to give higher germination percent. Our results are in line with [18] they concluded that the highest germination percent varied from 61.90% to 95.23% in heavy and large seed followed by medium seed 47.61% to 91.47% and small seed 39.09% to 71.42% in *Jatropha curcus.* Similar observations were also reported by [7] in *Pongamia pinnata,* [19] in *Prunus armenica*, [21] in *Prunus cerasoides,* [8] in (*Calophyllum inophyllum* L.) and [10] in *Celtis australis.*

Conclusion

The study on the effect of seed sources and pre-sowing treatments on the germination of *Prunus cerasoides* in the Garhwal Himalaya reveals that both factors significantly influence germination rates. Seeds sourced from different elevations and environmental conditions exhibited varying germination capacities, indicating the importance of seed provenance for successful regeneration. Pre-sowing treatments, such as scarification and stratification, were found to enhance germination percentages by breaking seed dormancy and promoting faster seedling emergence. The results suggest that selecting optimal seed sources and applying appropriate pre-sowing treatments can substantially improve the germination and establishment of *P. cerasoides* in reforestation and conservation efforts in the region.

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