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Influence of Aspect on Phenology of Himalayan Wild Cherry *viz. Prunus cerasoides* D. Don

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ABSTRACT

The current study was carried out on *Prunus cerasoides* at two sites: Daro in District Sirmour and Nauni in District Solan of Himachal Pradesh (August, 2022–May, 2023), aimed to understand the phenological behaviour of Himalayan wild cherry *viz. Prunus cerasoides*. The flower buds and leaves were observed during the period of their development and categorised into seven distinct stages based on their size, length and width, respectively. The leaves on the western site (Daro) were shorter in length and width, while the floral buds were longer than at the Southern site (Nauni). All the vegetative and reproductive bud swell and bud burst occurred earlier at the Southern (Nauni) than the Western aspect (Daro). The peak anthesis was observed between 12:00 noon to 2:00 pm, and there was no anthesis between 6:00 pm to 6:00 am at both aspects. The reproductive bud swell duration, reproductive bud burst duration, flowering duration, vegetative bud swell and bud burst duration, leaf growth period, petiole length, leaf fall duration and fruit development period were all negatively correlated with the aspect (west to south), leaf length and leaf width stages. However, these vegetative and reproductive characters were positively correlated with floral bud length stages. The floral bud length stages were negatively correlated with aspect, leaf width and leaf length stages.

KEYWORDS: Anthesis, aspect, correlation, development, floral biology

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1. INTRODUCTION

Prunus is a large genus of shrubs and trees that includes almond, apricot, cherry, peaches, plums, and nectarines and is a member of the Rosaceae family, holding a dominant position among all temperate fruits (Joseph et al., 2018). There are about 98 prominent varieties of the genus *Prunus* (Das et al., 2011). In India, about 36 *Prunus species* have been reported so far, and 18 species are useful for cultivation for a variety of purposes (Pandey et al., 2008). *Prunus cerasoides* commonly known as Himalayan Wild Cherry and Paja is a medium to large sized deciduous tree belonging to Rosaceae family. In India, Paja is widely distributed on hillsides, the edges of fields, woodlands, ravines, and village common areas of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Mizoram, Assam, Manipur, West Bengal and Tamil Nadu (Pandey et al., 2008; Tewari and Tewari, 2016). Paja has smooth, brownish-grey bark that peels off in thin, brilliant stripes to reveal a surface that is bright copper. It has oval, acuminate, double-serrated, and glabrous leaves. It has bisexual flowers appearing as rose-red fascicles that gradually fade to almost white. The plant flowers in the autumn or early winter rather than in the spring when its relatives are in bloom. Fertile flowers are followed by ovoid fruit supported by base of the calyx tube and containing one large seed. Fruits are initially yellow and turn red as they ripen, and the fruits of *Prunus cerasoides* ripen from April to May (Joseph et al., 2018). It flowers twice in a year, but the periods are not always the same every year (Kurniawan et al., 2021). Paja consists of cyanogenetic material in its leaves, twigs, bark, and kernels. The oil in the kernels has a strong prussic acid flavour, similar to that of bitter almonds. Flavone glucoside is produced by the sapwood of its stem. Isoflavones and flavones, Sakuranetin, Prunatin and Padmkastin are present in stem bark (Tiwari et al., 2017).

It is one of the 31 versatile species that are utilised as medicinal plants in the Himalayan area and is a great source of food, medicine, fuel, fodder, timber, dyes, tannins material (Kirtikar and Basu, 2005; Tewari and Tewari, 2016) and restoration of evergreen forests in seasonally dry tropical forestlands (Pakkad et al., 2004). This plant is used in the pharmaceutical industry as its gum possesses antioxidant (Malsawmtluangi et al., 2014) and antimicrobial properties (Arora and Mahajan, 2018, 2019). Its fruit's kernel is utilised as a treatment for kidney stones (Bawari et al., 2021) and due to the presence of secondary metabolites, it has therapeutic compounds (Kim et al., 2022). It is considered as a sacred plant in Hindu mythology and used in many religious ceremonies (Tiwari et al., 2009; Joshi, 2015).

Prunus cerasoides is considered a blessing for beekeepers as it flowers at the time of famine and frequently visited by the three native Asian bee species, *Apis cerana* indica, *A. dorsata* and *A.* florae, as well as the *Apis mellifera*, an introduced European species (Wang et al., 2025, Tiwari et al., 2009). The phenological stages in cherry are influenced by the climate-related interferences (Hamed and Ghezlaoui-Bendi-Djelloul, 2020). Stigma receptivity was optimum two days before anthesis (Normasiwi et al., 2023) but weather in the area impacted the length of the blossoming of *Prunus cerasoides* (Oktavia et al., 2023) and *P. domestica* (Woznicki et al., 2019). The reproductive and vegetative phenology was shifted by shade that influenced berry (*Vaccinium myrtilloides* and *V. angustifolium*) yield (Dyukaryeva and Malik, 2023). One of the major factors influencing the quantity, distribution, and genetic diversity of species is their reproductive pattern. *Prunus* cerasoides have a unique flowering pattern, and this study aimed to understand the phenological behaviour.

2. MATERIALS AND METHODS

2.1. Study area

The present study on *Prunus cerasoides was* conducted from August, 2022 to May, 2023 at two locations, namely Daro in District Sirmour and Nauni in District Solan of Himachal Pradesh. Site Nauni is located in the southern aspect at an altitude of 1241 m above the mean sea level with 31.277 °N latitude and 76.943°E longitude, whereas, site Daro is located in the western aspect at an altitude of 1552 m above the mean sea level with 30.712°N latitude and 77.215°E longitude in Himachal Pradesh, India.

2.2. Phenological characters

Various vegetative and reproductive characters, including vegetative bud swell and bud burst, leaf growth period, leaf fall, reproductive bud swell and bud burst, floral bud development stages, anthesis, flowering and fruit development duration, were observed for the phenology and floral biology study. The vegetative and reproductive characters were observed on the nine branches marked on each tree, and for both vegetative and reproductive bud swell and bud burst characters total of five buds were selected on each branch at both sites, and the observation was recorded. The anthesis was observed between different time intervals at both sites. Flowering was characterized by the opening of all sepals and petals lobes and the completion of flowering was characterised when the petals started to fall off from the flowers. The analysis was carried out using randomised block design.

3. RESULTS AND DISCUSSION

3.1. Vegetative characters

The vegetative bud swell started on 13-10-2022 and lasted up to 07-11-2022 at western aspect (Daro), however, vegetative bud swell initiated on 5-10-2022 and continued until 31-10-2022 at southern aspect (Nauni) (Figure 1). The vegetative bud burst commenced on 26-10-2022 and lasted up to 16-11-2022 at western aspect (Daro), whereas, bud burst initiated on 20-10-2022 and continued until 11-11-2022 at southern aspect (Nauni). The leaf growth initiation was first observed at the western aspect (Daro) on 08-11-2022 and continued to grow till 27-12-2022, whereas, leaf growth initiation was first observed at the southern aspect (Nauni) on 02-11-2022 and the leaves continued to grow till 21-12-2022 which characterized the period of leaf growth completion and the trees at site Daro took more days for leaf growth as compared to southern aspect (Nauni) (Figures 2, 3 & 4). All the vegetative parameters occurred earlier at site Nauni followed by western aspect (Daro) and this finding is supported by the finding of Gunaga (2002) who reported in Teak, that among central and southern provenance, early commencement of leaf flushing was shaped by the early onset of monsoon as compared to northern provenances. Whittet et al. (2021) showed that the timing of bud burst was inversely correlated with latitude, in the provenance trial of the English sycamore (*Acer pseudoplatanus* L.), demonstrating adaptive differentiation among provenances. Leaves were divided into seven distinct developmental stages and leaves at the western aspect (Daro) were less in length and width than Nauni, however, the petiole length was more at the western aspect (Daro) than southern aspect (Nauni) (Tables 1 and 2) which is consistent with the findings of Ke et al. (2022) who observed that leaf size decreased significantly at higher altitudinal areas than at lower altitudes. The leaf fall occurred earlier at southern aspect (Nauni) than at western aspect (Daro), which could be due to the difference in the locality factors of both sites, and the leaf fall lasted for more days at site Daro than southern aspect (Nauni) (Figure 1). Orlandi et al. (2007) reported that phenology being the study of the seasonal timing of life cycle events of plants including leaf bud

Table 1: Petiole length (cm) at different aspects in *Prunus cerasoides*

Tree	Western aspect (Daro)	Southern aspect (Nauni)
T_1	1.67	1.27
T_2	1.63	1.40
T_3	1.73	1.47
T_4	1.63	1.40
T_5	1.57	1.33
Mean	1.65	1.37
CD(p=0.05) Trees	0.13	0.10
CD(p=0.05) Aspect	0.06	

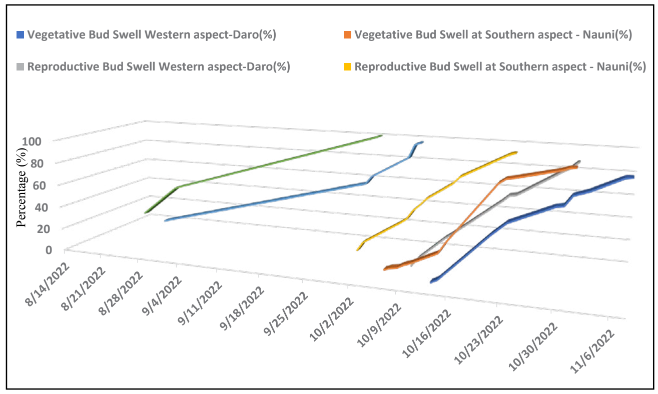

Figure 1: Date of initiation and completion of vegetative and reproductive bud swell and leaf fall in *Prunus cerasoides*

initiation, leaf unfolding, flowering, leaf fall and any other observable cyclic phenomenon are the result of internal factors viz biorhythms i.e., the rhythms which are regulated by the genetic constitution of the species and external environmental conditions, particularly climatic factors.

3.2. *Reproductive characters*

Reproductive characters started to appear from September 2022 onwards. The reproductive bud swell was noticed firstly at southern aspect (Nauni) on 30-09-2022 and ended on 22-10-2022, whereas bud swell occurred at western aspect (Daro) on 08-10-2022 which continued to take place till 31-10-2022 (Figure 2). Reproductive bud burst was noticed firstly at southern aspect (Nauni) on 11-10-2022 and ended on 31-10-2022, whereas bud burst initiation was noticed at the western aspect (Daro) on 23-10-2022 and was completed on 10-11-2022 (Figure 2). Both the reproductive bud swell and bud burst took more days for their completion at the western aspect (Daro) than the southern aspect (Nauni) (Figures 4 and 6). These findings coincide with findings of Le Provost et al. (2023) who worked on oak species and in his findings suggested

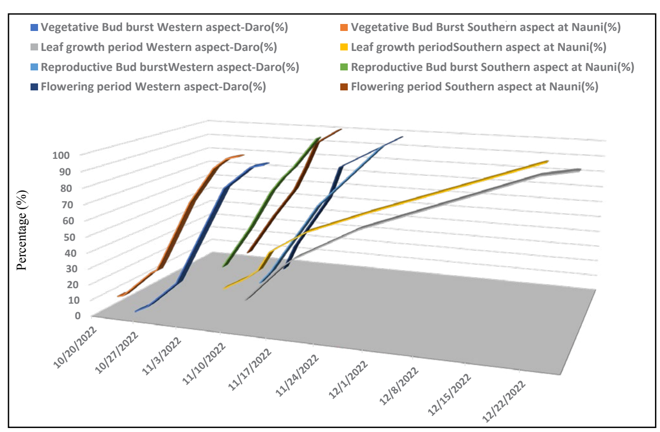

Figure 2: Date of initiation and completion of vegetative and reproductive bud burst, leaf growth and flowering period in *Prunus cerasoides*

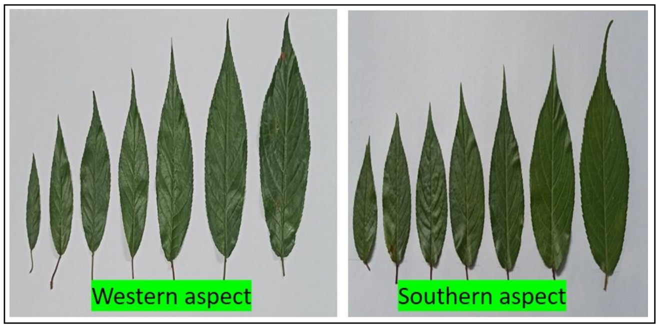

Figure 3: Leaf growth duration at Western (Daro) and Southern (Nauni) aspects in *Prunus cerasoides*

that populations from high altitudes showed delayed flowering time as compared to low elevation, where buds were reported to flush earlier as they have evolved distinct molecular strategies in order to adapt their bud phenology concerning temperature. Hamed and Ghezlaoui (2020) observed that breaking of dormancy is influenced by the climatic factors represented by temperature. Li et al. (2010) worked on sweet cherry (*Prunus avium* L.) and their findings suggested that earlier phenological stages were noticed in subtropical monsoon areas than the temperate climatic zone. The floral buds of *Prunus cerasoides* were categorized into seven different development stages on the basis of their size (Table 2 and Figure 5), which was supported by the finding of Kour (2018) who divided the floral buds of *Prunus salicina* into seven distinct stages. Similar findings have been reported by Kurniawan et al. (2021) in *Prunus cerasoides* D. Don where floral bud development stages passed through seven distinct stages from bud burst to anthesis stage. The anthesis per cent between the different time intervals and the peak anthesis occurred between 12.00 noon to 2.00 pm and anthesis did not occur between 6.00 pm to 6.00 am at both sites (Table 2). The present findings on anthesis are supported by the findings of Wadhwa and Sihag (2019) who experienced the maximum anthesis between 12.00 hours and 14.00 hours in European plum (*Prunus domestica* L.). Similarly, Kour (2018) also observed that maximum anthesis took place between noon and two in the afternoon in subtropical plum (*Prunus salicina* Lindl.). The flowering

Table 2: Time of anthesis in *Prunus cerasoides*

Aspect	Treatment	Anthesis between different timing (%)						
		6 pm–6 am	6–8 am	8–10 am	10–12 am	12–2 pm	2–4 pm	4–6 pm
Western	S1T1	0	6.66	13.33	33.33	35.55	11.11	0
	S1T2	0	4.44	8.88	31.11	35.55	17.77	2.22
	S1T3	0	4.44	13.33	33.33	37.77	11.11	0
	S1T4	0	4.44	11.11	31.11	35.55	15.55	2.22
	S1T5	0	6.66	11.11	28.88	35.55	15.55	2.22
Mean		0	5.32	11.55	31.55	35.99	14.21	1.33
Southern	S2T1	0	6.66	15.55	28.8	33.33	13.33	2.22
	S2T2	0	6.66	15.55	31.11	31.11	13.33	2.22
	S2T3	0	4.44	11.11	33.33	35.55	13.33	2.22
	S2T4	0	6.66	13.33	33.33	31.11	15.55	0
	S2T5	0	6.66	15.55	31.11	35.55	11.11	0
Mean		0	6.21	14.21	31.53	33.33	13.33	1.33

Table 3: Leaf length, width and floral bud length in different stages in *Prunus cerasoides*

	Leaf length (cm)		Leaf width (cm)		Floral bud length (cm)	
	Western (Daro)	Southern (Nauni)	Western (Daro)	Southern (Nauni)	Western (Daro)	Southern (Nauni)
Stage 1	4.24	4.57	1.39	2.21	0.63	0.51
Stage 2	5.30	5.75	2.30	2.51	0.93	0.76
Stage 3	6.23	6.59	2.68	3.21	1.23	1.01
Stage 4	7.32	7.99	3.04	3.44	1.48	1.24
Stage 5	8.18	8.82	3.3	3.74	1.76	1.49
Stage 6	9.00	9.51	3.65	4.16	2.02	1.81
Stage 7	9.73	10.33	4.13	4.46	2.31	2.18

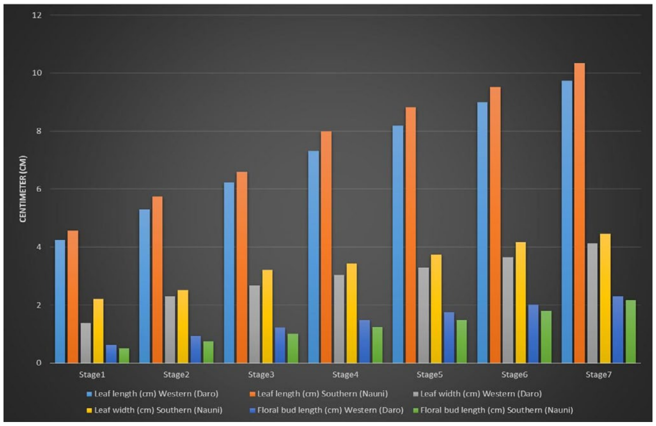

Figure 4: Leaf length, width and floral bud length in different stages in *Prunus cerasoides*

was initiated on 06-11-2022 and ended on 26-11-2022 at site Daro, whereas, at the southern aspect (Nauni) floral period started on 28-10-2022 and got completed on 14-11-2022 (Figure 2) and the flowers persisted for more days at western aspect (Daro) than the southern aspect (Nauni)

Table 4: Duration (Days) of phenological characters in *Prunus cerasoides*

Character	Western aspect (Daro)	Southern aspect (Nauni)
Vegetative bud swell	15.33	14.05
Vegetative bud burst	10.33	9.32
Leaf growth duration	37.36	35.5
Leaf fall duration	37.33	35.06
Reproductive bud swell	15.33	14.05
Reproductive bud burst	9.67	9.32
Flowering period	10.38	8.2
Fruit development	117.02	112.13

Table 5: Correlation among aspect, vegetative and reproductive bud, flower, leaf and fruit characters

	RBSD	RBBD	FD	VBSD	VBBD	LGP	PL	LFD	FDD
Asp	-0.920**	-0.658**	-0.945**	-0.833**	-0.907**	-0.873**	-0.833**	-0.847**	-0.822**
LWS1	-0.868**	-0.594**	-0.925**	-0.822**	-0.917**	-0.836**	-0.799**	-0.828**	-0.838**
LWS2	-0.603**	-0.492**	-0.618**	-0.684**	-0.653**	-0.540**	-0.686**	-0.631**	-0.534**
LWS3	-0.751**	-0.466**	-0.800**	-0.723**	-0.881**	-0.750**	-0.691**	-0.776**	-0.656**
LWS4	-0.650**	-0.433*	-0.653**	-0.642**	-0.692**	-0.624**	-0.640**	-0.730**	-0.540**
LWS5	-0.742**	-0.545**	-0.725**	-0.757**	-0.773**	-0.724**	-0.672**	-0.736**	-0.622**
LWS6	-0.833**	-0.659**	-0.768**	-0.842**	-0.763**	-0.732**	-0.761**	-0.806**	-0.628**
LWS7	-0.803**	-0.699**	-0.758**	-0.759**	-0.727**	-0.668**	-0.760**	-0.791**	-0.560**
LLS1	-0.463**	-0.185	-0.508**	-0.375*	-0.544**	-0.359	-0.442*	-0.587**	-0.296
LLS2	-0.589**	-0.345	-0.660**	-0.436*	-0.657**	-0.518**	-0.536**	-0.593**	-0.538**
LLS3	-0.611**	-0.383*	-0.571**	-0.534**	-0.609**	-0.578**	-0.534**	-0.546**	-0.399*
LLS4	-0.815**	-0.599**	-0.743**	-0.705**	-0.738**	-0.645**	-0.769**	-0.842**	-0.511**
LLS5	-0.715**	-0.447*	-0.736**	-0.616**	-0.818**	-0.676**	-0.571**	-0.716**	-0.637**
LLS6	-0.728**	-0.513**	-0.725**	-0.683**	-0.782**	-0.603**	-0.600**	-0.748**	-0.543**
LLS7	-0.725**	-0.397*	-0.798**	-0.630**	-0.748**	-0.695**	-0.643**	-0.690**	-0.685**
FBS1	0.819**	0.555**	0.875**	0.717**	0.843**	0.793**	0.709**	0.703**	0.743**
FBS2	0.897**	0.639**	0.921**	0.784**	0.908**	0.835**	0.790**	0.799**	0.788**
FBS3	0.898**	0.603**	0.929**	0.753**	0.860**	0.893**	0.764**	0.767**	0.839**
FBS4	0.885**	0.587**	0.940**	0.763**	0.877**	0.851**	0.779**	0.753**	0.821**
FBS5	0.922**	0.674**	0.943**	0.828**	0.900**	0.858**	0.836**	0.833**	0.824**
FBS6	0.920**	0.665**	0.936**	0.795**	0.844**	0.909**	0.809**	0.821**	0.830**
FBS7	0.785**	0.595**	0.773**	0.680**	0.626**	0.756**	0.691**	0.638**	0.692**

*,** significant at *p*: 0.05 and *p*: 0.01 level, respectively; Where, Asp: Aspect; RBSD: Reproductive bud swell duration; RBBD: Reproductive bud burst duration; FP: Floral period; VBSD: Vegetative bud swell duration; VBBD: Vegetative bud burst duration; LGP: Leaf growth period; PL: Petiole length; LFD: Leaf fall duration; FDD: Fruit development duration; LWS: Leaf width stage; LLS: Leaf length stage; FBS: Floral bud length stage

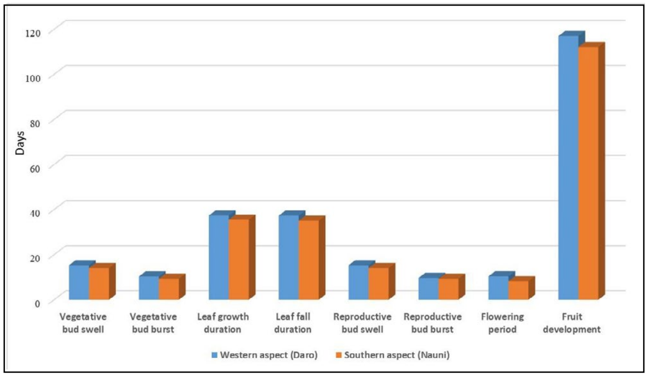

Figure 5: Duration (Days) of phenological characters in *Prunus cerasoides*

(Table 3, Figure 4). The present findings are supported by the findings of Kurniawan et al. (2021) who observed in their study that paja flowered in October, they also reported that *Prunus cerasoides* flowered two times a year but the period of flowering was not always the same every year and the climate could be the reason for affecting this biological phenomenon. Agus et al. (2016) encoded that weather conditions may impact the length of the flowering period. The fruit development started to occur at western aspect (Daro) on 01-12-2022 and lasted up to 10-04-2023 until they got fully mature,whereas at southern aspect (Nauni) fruit development started on 22-11-2022 and lasted up to 23-03-2023 which revealed that fruit developed earlier at site southern aspect (Nauni) than site western aspect (Daro) (Table 4, Figure 5). More days were registered at the

Figure 6: Development stages of floral buds in *Prunus cerasoides*

western aspect (Daro) for fruit development than at Nauni (Figures 5 and 7). Parmar and Bisht (1992) also encoded that the ripening of paja occurs in the month of April to May. The climatic factors represented by temperature (Hamed and Ghezlaoui, 2020) and shade (Dyukaryeva and Malik, 2023) have an impact on fruit setting and the period of ripening.

3.3. Correlation studies

The reproductive bud swell duration, reproductive bud burst duration, flowering duration, vegetative bud swell and bud burst duration, leaf growth period, petiole length, leaf fall duration and fruit development period were all negatively correlated with the aspect (west to south), leaf length and leaf width stages. However, these vegetative and reproductive characters were positively correlated with floral bud length stages. The floral bud length stages were negatively correlated with aspect, leaf width and leaf length stages (Tables 5 and 6). The present results on correlation

Table 6: Correlation among aspect, leaf development and floral bud stages in *Prunus cerasoides*

	FBLS1	FBLS2	FBLS3	FBLS4	FBLS5	FBLS6	FBLS7
Asp	-0.909**	-0.977**	-0.967**	-0.964**	-0.992**	-0.967**	-0.795**
LWS1	-0.872**	-0.928**	-0.923**	-0.932**	-0.961**	-0.910**	-0.696**
LWS2	-0.474**	-0.595**	-0.576**	-0.568**	-0.669**	-0.609**	-0.494**
LWS3	-0.773**	-0.834**	-0.819**	-0.822**	-0.854	-0.804**	-0.551**
LWS4	-0.530**	-0.630**	-0.643**	-0.621**	-0.701**	-0.649**	-0.420*
LWS5	-0.679**	-0.737**	-0.746**	-0.728**	-0.803**	-0.772**	-0.560**
LWS6	-0.691**	-0.787**	-0.786**	-0.755**	-0.844**	-0.831**	-0.744**
LWS7	-0.662**	-0.770**	-0.769**	-0.727**	-0.834**	-0.805**	-0.734**
LLS1	-0.470**	-0.554**	-0.535**	-0.526**	-0.540**	-0.498**	-0.538**
LLS2	-0.580**	-0.621**	-0.604**	-0.613**	-0.672**	-0.631**	-0.450*
LLS3	-0.740**	-0.653**	-0.565**	-0.651**	-0.636**	-0.587**	-0.318
LLS4	-0.756**	-0.829**	-0.764**	-0.767**	-0.839**	-0.788**	-0.611**
LLS5	-0.698**	-0.779**	-0.795**	-0.782**	-0.810**	-0.749**	-0.449*
LLS6	-0.701**	-0.769**	-0.731**	-0.739**	-0.787**	-0.695**	-0.449*
LLS7	-0.756**	-0.815**	-0.837**	-0.817**	-0.822**	-0.811**	-0.648**

*,** significant at *p*: 0.05 and *p*: 0.01 level, respectively; Where, Asp: Aspect; LWS: Leaf width stage; LLS: Leaf length stage; FBLS: Floral bud length stage

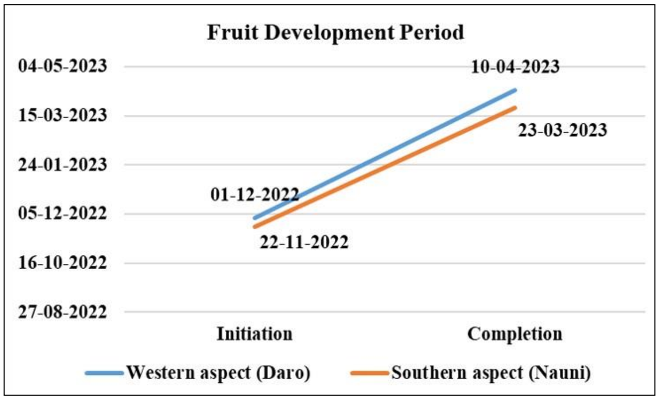

Figure 7: Date of initiation and completion of fruit development in *Prunus cerasoides*

are supported by the findings of Wenjuanet al. (2017), who found that a significant negative correlation was present between length/width and petiole length of leaves in *Populus euphratica*. According to Ducousso et al. (1996), Sessile Oak (*Quercus petraea*) bud burst revealed significant provenance-based variation that was predominantly clinal and linked to the origin's latitude and altitude. Additionally, they observed that the southern provenances had an earlier flush than the northern provenances. Similarly, Bucharova et al. (2021) observed that the probability of flowering and flowering time was affected by the plant provenances and the southern provenance showed relatively earliest flowering in the selected insect pollinated plant species than the western and northern provenances, which was similar with the results of our study. Diatta et al. (2022) conducted research on phenology of *Acacia Senegal* trees procured from several range wide populations and grown in a common garden to find the correlation between phenology and climate of site of origin and they concluded that variability in phenology among trees were related to climatic variations at their place of origin since there was a strong correlation between the period of leaf development in a common garden and the timing as well as the rainy season's duration at the place of origin.

4. CONCLUSION

Phenological events in *Prunus cerasoides* occurred earlier and were completed faster at the southern aspect (Nauni) than the western aspect (Daro), likely due to local differences. Peak anthesis was observed between 12:00 and 2:00 pm at both sites.

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