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Variability index of growth cycle of apple cultivars in Himachal Pradesh

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Abstract

The index of variability is the measure of stability in different growth stages of plants. The wide fluctuations in terms of instability in phenological stages affect the crop output. The variation in timing of development events is the interaction of weather indices with date of particular growth events and the interval between them. To estimate the magnitude of instability the present investigation was undertaken in three agro-climatic zone of Himachal Pradesh by using Cuddy-Della Valle index. The results revealed that the zone wise irregularity to attained the various phenological stages as per instability index was higher (15%) at Kullu followed by 14.1 at Shimla and 10.8% at Kinnaur district.

Keywords: Variability, growth, phenological stages, cuddy-della valle index etc

Introduction

Apple is the most important fruit crop of Himachal Pradesh which can be grown at altitudinal range from 1500- 2700 m amsl. Among commercial fruits apple alone accounts for about 46 percent of total area and more than 70% of the total fruits production. Variability analysis for fruit production and yield is of great importance to understand the nature of food and nutrition security as well as income stability of farmers. Fluctuations in production substantially affects the economy. Magnitude being dependent upon various climatic factors. Climatic conditions like temperature and rainfall are important controlling factors for active growth cycle of crop and ultimately, affect the final production. The phenological events are highly responsive to climatic factors (Rutishauser *et al.* 2009) [5]. Variability is the measure of stability in different growth stages of plants. Variation of main phenophase in phenological calendar is the measure of climate change (Fenzgyi Zheng *et al.* 2016) [2]. The warm conditions in winters where chilling requirement is not fully satisfied to overcome dormancy causes irregularity in the date of flowering (Pteri *et al.* 1996) [4]. Among the different growth stages, the flowering is considered as a critical stage as it measures the reproductive regularity of cultivars. Species showed less variability in occurrence of simultaneous flowering period and full bloom have high probability of fruit set index (Soltesz, 2003) [6]. The global warming impacts on apple orchards of Himachal Pradesh is already visible (Bhagat *et al.* 2009) [1]. There by affecting the apple productivity adversely. Increase importance of apple and declining productivity in state are of serious concern. So, the present investigation was carried to estimate the instability index of phenological stages of apple crop.

Material and Method

To analyse the extent of variability in phenological stages 5 commercial varieties of apple i.e. Royal Delicious, Red Fuji, Golden delicious, Red chief and Gale gala have been taken at selected agro-climatic zones (Kullu, Shimla and Kinnaur) during the period of 2017-2018. The instability in various growth stages of apple was measured in relative terms by using the Cuddy-Della Valle index (I).

$$I = CV * \sqrt{1 - R^2}$$

Where,

I = Instability index (in percent)

CV = Coefficient of variation (in percent) was calculated by using following formula

$$CV = \frac{SD \text{ of } X}{\text{Mean of } X} * 100$$

SD = Standard deviation was calculated by using following formula

$$S.D. = \sqrt{\frac{1}{N} \sum (x - \bar{x})^2}$$

R^2 = Coefficient of determination from time trend regression adjusted by the corresponding number of degrees of freedom.

Data Collection

The various phenological stages were recorded as per BBCH scale (Meier *et al.* 1994) [3].

Results and Discussion

The environmental changes especially climatic conditions influence the phenological cycle of plants. Thus, resilience of various cultivars will depend on the capacity of the plants to shift their phenology to track changes in environment. Therefore, the variability in phenological stages of apple crop for the study period 2017 and 2018 was analysed and presented in table 1. It was observed that during the first year (2017) irrespective of cultivars the irregularity to attain the phenophases was in the order of 14.6, 14.0 and 10.7% at corresponding zones Kullu (1000-1400 m amsl), Shimla (1400-1800 m amsl) and Kinnaur (2200-2600 m amsl). Indicating thereby irregularity to attain phenophases increased with decreasing in altitude range. Among the cultivars the Red chief showed the highest level of instability (I= 15.8%) to attain the various phenological stages followed by Gale gala (I= 15.2%), Golden delicious (I= 14.4%), Royal delicious (I = 14.2%), and Red Fuji (I= 13.5%) at Kullu. At Shimla the irregularity to attain the phenological stages was in the order of 14.8% > 14.1% > 14.0% > 13.9% > 13.3% by Gale gala, Golden delicious, Royal delicious, Red Fuji and Red chief, respectively. At this elevation range the highest level of instability showed by cultivar Gale gala. The minimum instability was recorded at Kinnaur and cultivars wise variability index was in the order of 9.90 (Red Fuji) > 10.7 (Red chief) > 10.8 (Golden delicious) > 11.1 (Royal delicious) > 11.2 (Gale gala). The highest level of instability to attain the various phenophases was showed by cultivar Gale gala. The

data further indicated that variable pattern was observed among all the selected cultivars. The coefficient of variation also found highest (CV = 40.9%) at Kullu followed by 39.9% Shimla and 29.4% (Kinnaur). The cultivar Gale gala showed maximum variation (CV = 43.1, 41.5 and 29.2%) at Kullu, Shimla and Kinnaur, respectively however at Kinnaur the cultivar Red chief showed the highest variation (CV=30.8%). This may be attributed to unstable climatic conditions in the region which influence the timing of flowering and fruit production. The present phenological pattern was in agreement with Petri *et al.*, (1996) [4] who have also reported that changing climatic conditions have possible indirect influences on phenology on pollination and fruit-set efficiency, and consequentially on bud differentiation.

During the second year (2018) the similar trend of variability was observed. The variability decreased with increase in altitude range (Table 1). The altitude wise variability was in the order of 15.8% > 14.2% > 11.4% at Kullu, Shimla and Kinnaur, respectively. The highest values of instability were pertained to Kullu where instability was 15.1%, 15.8%, 18.6%, 13.4%, 16.3% for Red chief, Royal delicious, Golden delicious, Red fuji and Gale gala, respectively and lowest level at Kinnaur i.e. 11.0%, 11.6%, 10.0%, 10.8% and 13.7% for Red chief, Royal delicious, Golden delicious, Red fuji and Gale gala. The coefficient of variation was also found highest (CV=41.8%) at Kullu followed by 40.9% (Shimla), and 30.5% (at Kinnaur).

The pooled effect of both the year also indicated similar pattern of variability which was in the order of 15.8% > 14.2% > 11.4% at Kullu, Shimla and Kinnaur respectively. The variation was found highest (CV = 41.3%) at Kullu followed by 40.4% Shimla and 29.9% (Kinnaur). Indicating thereby highest degree of variability at lower zone which decreased with increase in altitude may be attributed to abrupt increase in temperature, early accumulation of GDD and less accumulation of chilling units at lower altitude range might have induced irregularity in phenology of all the cultivars. The results are in line with Petri (1996) [4] who have also advocated higher temperature and less chill unit accumulation as the cause of irregularity in attaining phenological stages of apple.

Table 1: Variability index for phenophases of apple crop at different zones

Zones Cultivars	CV (%)	R ²	I	CV (%)	R ²	I	CV (%)	R ²	I
	2017			2018			Pooled		
Kullu									
Red Chief	41.4	0.854	15.8	41.8	0.888	15.1	41.6	0.872	14.9
Royal Delicious	39.9	0.872	14.2	40.7	0.861	15.8	40.3	0.867	14.7
Golden Delicious	38.6	0.867	14.4	40.2	0.877	18.6	39.4	0.873	14.1
Red Fuji	40.4	0.887	13.5	40.5	0.889	13.4	40.5	0.889	15.5
Gale Gala	43.1	0.875	15.2	45.8	0.873	16.3	44.5	0.874	15.8
Mean	40.9	0.871	14.6	41.8	0.878	15.8	41.3	0.875	15.0
Shimla									
Royal Delicious	40.4	0.88	14.0	40.7	0.847	15.1	40.6	0.865	14.0
Red Fuji	39.5	0.876	13.9	37.4	0.904	11.6	38.5	0.890	12.8
Golden Delicious	40.4	0.872	14.1	40.2	0.778	14.0	40.3	0.844	13.9
Red Chief	37.6	0.879	13.3	41.6	0.859	13.9	39.6	0.871	14.2
Gale Gala	41.5	0.872	14.8	44.5	0.865	16.3	43.0	0.869	15.6
Mean	39.9	0.876	14.0	40.9	0.851	14.2	40.4	0.868	14.1
Kinnaur									
Royal Delicious	30.1	0.837	11.1	31.4	0.863	11.6	31	0.867	11.3
Red Fuji	29.4	0.844	9.9	29.4	0.864	10.8	28.9	0.878	10.1
Golden Delicious	30.2	0.844	10.8	29.3	0.885	10	29.5	0.877	10.3
Red Chief	30.8	0.812	10.7	28.4	0.848	11	28.3	0.86	10.6
Gale Gala	29.2	0.873	11.2	33.9	0.834	13.7	31.9	0.859	12.1
Mean	29.9	0.842	10.7	30.5	0.858	11.4	29.9	0.868	10.9

CV- Coefficient of variance, R- Coefficient of determination, I- Variability index

Instability index from the period 2014-2018

The instability index was calculated for the last five year to analyse the irregularity to attain the various phenological stage and presented in table 2. The level of instability was in the order of 2.34%, 1.64%, 1.21% and 0.59% at Kullu, Shimla and Kinnaur. This indicated the highest level of variability to attain the phenophases was at Kullu in last five years (2013-2018). Irrespective of altitude the cultivar Royal delicious showed highest (I=2.50%) variability at Kullu and Shimla followed by 0.58% (Kinnaur). Indicating thereby with decreased in elevation the irregularity to attain phenological stages increased. Similar pattern of variation was observed among different cultivars. The highest percent of 3.31 variability was observed in cultivar Gale gala at Kullu and lowest level of instability 1.26% was found at Kinnaur followed by 2.43% (Shimla). Indicating there by with increase in altitude range the selected cultivars attain the various phenophases regular bases as compare to cultivars grown at lower elevations.

Table 2: Comparison of instability index of apple crop phenology at different zones (2014-2018)

Zone Cultivars	1000-1400	1400-1800	2200-2600
Royal Delicious	2.50	2.50	0.58
Red Fuji	1.99	1.97	0.20
Golden Delicious	0.90	0.45	0.34
Red Chief	3.00	0.87	0.59
Gale Gala	3.31	2.43	1.26
Mean	2.34	1.64	0.59

Conclusion

The study clearly revealed that, the higher elevations of the state are found to more suitable for cultivar of apple crop due to high chill accumulation and less increase in temperature as compare to lower zone (Kullu).

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