



Phenological Features of Four Exotic Apple Cultivars on M9T337 Rootstock under High Density Plantation in North Himalayan Region of India

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Authors' contributions

This work was carried out in collaboration between all authors. Author RM designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Author AP designed the study. Authors MTA and RHSR managed the analyses of the study. Authors MKS, NN and AK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study was conducted to define the phenology of flowering of four apple cultivars grafted on M9T337 rootstock and cultivated in the Experimental Orchard of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir, Shalimar, Srinagar, Jammu & Kashmir during the year 2014. In the study it were recorded days to bud break, silver tip stage, green tip stage, leafing out, pink bud, initial and final bloom, duration of flowering and days to petal fall of apple cultivars viz. Super Chief Sandidge, Gala Red Lum, Fuji Zhen Aztec and Golden Clone B. The results reveal that bud break, green tip, silver tip and leaf initiation showed significant differences for the different cultivars. Cv. Gala Red Lum took minimum number of days for starting bud break (15.27 days after reference date) and silver tip stage (20.20 DARD), while 'Golden Clone B' was the last to attain these different phenological stages. Full bloom was earliest (52.29 DARD)

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on 'Gala Red Lum' and later (58.79 DARD) on 'Golden Clone B'. The duration of flowering ranged from 12.28 days on 'Super Chief Sandidge' to 13.69 days on 'Golden Clone B'. Remarkable variations were thus observed in the phenology of flowering of the investigated varieties under temperate conditions of Jammu and Kashmir.

Keywords: Apple varieties; phenological data; flowering; high density; temperate climate.

1. INTRODUCTION

Jammu and Kashmir state, as being endowed with natural advantages of topography and climate with an enormous diversity of agro-climatic conditions, has immense scope for horticultural development. Horticulture industry in the J&K State made rapid strides during the last few decades. Compared to 1954-1955, the area under fruits in the State has increased by 16 times and the production has shoot up to 60 times. Among the temperate fruits, apple ranks first, covering 43.30 per cent in area and 80.18 per cent for production. Productivity of apple has shown an increase from 4.12 to 10.60 MT/ha from 1975 to 2017. Though it appears to be the principal among the apple producing States in the country, yet it is far below the level achieved by horticulturally advanced countries where productivity is in between 50-60 MT/ha [1]. The reason behind which appears to be the use of inadequate rootstocks.

Almost entire apple plantation in the J&K State is on seedling rootstocks. The excessive vigor of this type of rootstock leads to larger trees and have long juvenility. Also, there is more competition between vegetative growth and fruit production within these kind of trees and their internal self-shading makes them more vulnerable to various diseases. When using vigorous rootstocks, only few trees can be accommodated per hectare, making the productivity less profitable. With stagnation in productivity, looming threat of imported fruits and land prices touching new peaks in the State, it becomes imperative to invest on high-density plantation, for which changing rootstock from vigorous to size controlling (dwarfing) rootstocks is a prerequisite.

Orchards with new cultivars and on dwarfing rootstocks are also few in the State. The number of orchard with new cultivars grafted on dwarf and semi-dwarf clonal rootstocks should be increased in order to increase yield and fruit quality, as these rootstocks are more effective. Therefore, it is necessary to determine suitable cultivars for the region. Otherwise apple shows

gametophytic self and cross- incompatibility, showing that at least two genetically distinct cultivars are necessary for stable apple production. SKUAST-K has recently introduced new apple cultivars from outside the country which were grafted on the dwarfing clonal rootstock M9T337, a suitable combination for high density plantation. However their features on flowering phenology under temperate conditions of Kashmir remains to be studied. Thus this study was conducted to fill this gap.

2. MATERIALS AND METHODS

The study was conducted in the Experimental Orchards of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir, Srinagar, Jammu & Kashmir, during the year 2014 (Fig. 1). The orchard was established at a mean of 1500 meters above sea level. The climate is cold temperate. Rainfall is about 800mm well distributed, mostly in the form of snow during winter with the main rainfall during March-April. Uniform plants of four exotic cultivars of apple viz. Super Chief Sandidge, Gala Red Lum, Fuji Zhen Aztec and Golden Clone B grafted on M9T337 rootstock were introduced by SKUAST-Kashmir in spring 2013 from the Italian nursery GRIBA. The selected trees for this study were planted at a spacing of 3 m x 1.5 m in the orchard. The experiment was laid in Randomized Complete Block Design (RCBD) with five replications and two trees per treatment as plot size. For this study, it was recorded the following phenological characteristics: days to bud break, silver tip stage, green tip stage and leafing out recorded visually by observing peculiar stages of each parameter (Fig. 2).

Flowering stages including initial and final bloom in each variety was recorded when 10 and 80 per cent of the flowers had opened, respectively (Fig. 3). The period from the date of flowering initiation to the date of petal fall was calculated as duration of flowering. The date for petal fall was recorded when 80% of petals were fallen. The dates thus recorded were converted to days from day after reference date (DARD), 1st of March.

The data recorded during the course of investigation were subjected to statistical analysis using the method of 'Analysis of Variance' [2]. The significance and non-

significance of treatment effects were judged with the help of software OPSTAT. The significant differences of the means were tested against the critical difference at 5% level.



Fig. 1. A view of the experimental orchard at SKUAST-Kashmir



Fig. 2. Different phenological stages of bud break on apple



(a) Initial bloom

(b) Full bloom

Fig. 3. Flowering stages of initial bloom and final bloom of apple

3. RESULTS AND DISCUSSION

Most of the phenological stages viz. bud break, green tip, silver tip and leaf initiation, showed significant differences during the study (Table 1). The cv. Gala Red Lum took minimum number of days to attain bud break (15.27 DARD), silver tip stage (20.20 DARD), green tip stage (23.57 DARD) and leaf initiation (29.48 DARD), while 'Golden Clone B' was the last to attain these different phenological stages i.e. bud break at 21.50 DARD, silver tip at 25.49 DARD, green tip at 28.36 DARD and leaf initiation at 36.66 DARD. The cv. Fuji Zhen Aztec also showed longer DARD than cv. Gala Red Lum, the results being in accordance with the findings of Baytekin, [3], who stated that dates of bud break for 'Fuji'/'M9' were later than for 'Gala'/'M9'.

Remarkable variations were observed in the flowering behaviour of the different cultivars from the pink bud to complete petal fall (Table 2). Pink bud stage was first noticed after 39.44 DARD for cv. Gala Red Lum followed by cv. Super Chief Sandidge, that took 40.68 DARD. The last was 'Golden Clone B' with 44.86 DARD to get pink buds.

Likewise, the initial bloom was first (44.41 DARD) on cv. Gala Red Lum, while 'Golden Clone B' reached at this stage much later (48.46 DARD). Full bloom stage was observed first (52.29 DARD) on cv. Gala Red Lum and again much later (58.79 DARD) on 'Golden Clone B'. The differences in the phenological stages of different cultivars, certainly, are due to the differential chilling requirements of these varieties. Further, these cultivars may be different in their photo sensitivity and response to temperature resulting in these variations. These results are in accordance with the findings of Gasser [4] who has reported that beginning of blooming depends highly on the site of cultivation. Beginning of bloom can be observed with higher accuracy which indicates the genetic differences among varieties. Bodor and Toth [5] reported that high spring temperature causes shorter blooming period and main bloom takes only few days for the whole cultivar assortment. Soltesz, [6] investigated the stability of the blooming order of 86 varieties for 20 years and pointed out that the beginning of blooming never shows the same trend even under similar circumstances.

Table 1. Phenological stages of exotic apple cultivars under high density plantation for the 2014 season at the Experimental Orchards of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir, Srinagar, Jammu & Kashmir - North Himalayan region of India

Variety	Days after reference date (DARD) (1 st March)			
	Days to bud break	Days to silver tip stage	Days to green tip stage	Days to leafing out
Super Chief Sandidge	16.42 ±0.17	21.36 ±0.16	25.92 ±0.66	32.26 ±0.09
Gala Red Lum	15.27 ±0.21	20.20 ±0.10	23.57 ±0.05	29.48 ±0.15
Fuji Zhen Aztec	18.49 ±0.18	23.50 ±0.50	27.60 ±0.16	34.52 ±0.13
Golden Clone B	21.50 ±0.20	25.49 ±0.20	28.36 ±0.16	36.66 ±0.18
CD (p≤ 0.05)	0.59	0.45	0.57	0.43

Table 2. Flowering behavior of exotic apple cultivars under high density plantation at the Experimental Orchards of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Science & Technology of Kashmir, Srinagar, Jammu & Kashmir during the 2014 season - North Himalayan region of India

Variety	Days after reference date (DARD) (1 st March)				Duration of flowering (days)
	Days to pink bud stage	Days to initial bloom (10%) ^{1/}	Days to full bloom (85-90%) ^{1/}	Days to petal fall (80%) ^{2/}	
Super Chief Sandidge	40.68 0.40	45.35 ±0.11	55.54±0,08	65.05 ±0.43	12.28±0,11
Gala Red Lum	39.44 ±0.13	44.41 ±0.14	52.29±0,06	60.67 ±0.19	13.51±0,18
Fuji Zhen Aztec	43.69 ±0.09	47.85 ±0.04	56.50±0,15	65.88 ±0.25	12.36±0,10
Golden Clone B	44.86 ±0.06	48.46 ±0.17	58.79±0,08	66.24 ±0.34	13.69±0,34
CD (p≤ 0.05)	0.70	0.40	0.32	0.84	0.64

^{1/} Refers to the percentage of opened flowers. ^{2/} Refers to the percentage of fallen petals

The petal fall was observed first of all on the cv. Gala Red Lum (60.64 DARD) and last on 'Golden Clone B' (66.24 DARD). Usually, these differential results are due to the different level of satisfaction of the buds on a chilling requirement. These results are in conformity with the findings of Facticeau et al. [7] who reported that beginning of flowering, full bloom and end of flowering were different for the different cultivars under study. Such divergent results might be due to the difference between the temperatures during an early stage of vegetative development. Flowering date and period of blooming varies according to cultivar aptitude as well as ecological and cultural conditions [7].

Duration of flowering ranged from 12.28 days for cv. Super Chief Sandidge to 13.69 days for 'Golden Clone B'. The results are in accordance with the findings of Blazek et al. [8] who reported 17 days of flowering in different apple cultivars. Kumar [9] also recorded from 10 to 17 days for different apple cultivars. Sharma et al. [10] reported that duration of flowering in Himachal Pradesh ranged from 10 to 17 days in apple.

4. CONCLUSIONS

From the obtained results, it was concluded that the different exotic cultivars studied had different flowering phenological features which will permit to establish proper varietal combinations for pollination to improve profitability of high density apple orchards.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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