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# INTENSITY OF FRUIT DROP STUDIES IN EXOTIC APPLE VARIETIES UNDER HIGH DENSITY PLANTATION

**Gepu Nyorak[1], Amit Kumar[1]*, Angrej Ali[2], Aroosa Khalil[1], Nowsheen Nazir[1], A.S. Sundouri[1] and Tajamul Farooq Wani[1]**

[1]Division of Fruit Science, FOH, SKUAST-Kashmir, Shalimar Campus, Srinagar - 190 025, J&K, India.

[2]Department of Horticulture, FOA, SKUAST-Kashmir, Wadura Campus, Sopore, Baramulla - 190 025, Jammu and Kashmir, India.

*Corresponding author E-mail : khokherak@rediffmail.com

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**ABSTRACT**

Fruit drop studies were carried out on thirteen exotic cultivars of apple grafted on M9 T337 rootstock under HDP system having age of four years planted at Experimental Farm of Division of Fruit Science, SKUAST-K, Shalimar campus (J & K) during 2021. Observations were recorded on flowering, fruiting and yield related parameters. The results showed that highest bloom density was observed in cultivar Mitch Gala (14.68) whereas maximum number of clusters/branch was observed in cultivar Red Braeburn (24.27), number of flowers/cluster was recorded in Red Velox (5.56). Maximum number of fruits/cluster was recorded in cultivars Fuji Zehn Aztec (5.00). Maximum fruit set (91.97%), fruit retention (79.43%) and minimum cumulative drop (20.57%) were recorded in cultivar Super Chief Sandidge. Early drop (Post-pollination drop) was recorded maximum in cultivar Red Chief (26.66%), while minimum in cultivar Pinova (7.95%) whereas June drop was highest in cultivar Red Velox (9.81%) and lowest in cultivar Elstar (3.20%). Pre-harvest fruit drop was maximum in cultivar Pinova (10.15%) while lowest in cultivar Mitch Gala (0.52%) and Gala Redlum (0.52%). Cultivar Golden Delicious Reinders recorded highest fruit yield per plant (30.01 kg/plant) however lowest fruit yield was recorded in Red Braeburn (11.80 kg/plant). Red Chief (90.22 %) registered maximum 'A' grade fruits.

***Key words :*** Intensity, Apple, Fruit drop, Exotic, HDP.

## Introduction

High density planting is a modern method of fruit cultivation that involves close planting of fruit trees, permitting small or dwarf plants with modified canopy for improved light interception, distribution and ease in mechanized field operations (Mir *et al.*, 8). Due to the increased number of trees per unit area, they provide better yield and return per unit area. Modern orchard planting systems are based on higher tree densities ranging from 1000 to 6000 trees per hectare. From the last decade, establishment of new orchards under high density plantation is under progress at quantum rate in the valley with new varieties raised on clonal rootstock. With stagnation in productivity, looming threat of imported fruits and land prices touching new peaks in the valley it becomes imperative to adopt high-density plantation for which shift in rootstock from vigorous to size controlling rootstock is a prerequisite.

Fruit drop is a common phenomenon which is faced by researchers and farmers. The fruit drop, which occurs in fruit trees at different stages of development, is a problem for growers. The differences in fruit drop between varieties could be due to high rates of initial fruit set, which drops due to several reasons *viz.* poor pollination soon in the post bloom period or due to auto-incompatibility, adversities in environment like water stress, poor nutrition, competition between fruits on the plant leading to hormonal imbalance or high temperature. In apples, generally three types of fruit drop occur; first drop starts shortly after petal-fall and continues for two to three weeks, second drop, commonly known as June drop (Racsko *et al.*, 2007) starts in late May or early June and is completed by the end of June. Fruitlet (immature fruits during the cell division phase) drop

happens 5–6 weeks after full bloom in the Northern hemisphere which is referred as 'June drop' (Dal Cin *et al*., 2009a, 2009b) and third drop, commonly known as pre-harvest fruit drop, in which fruits are dropped from the plants before ripening phase prior to horticultural maturity (Schupp and Greene, 2004). The intensity of drop varies by cultivar and cultivars have been classified as less, intermediate or more prone to fruit drop depending on their proclivity to fruit drop (Irish-Brown *et al.*, 2011).

Scattered information regarding the fruit drop at different stages under traditional system of planting in different commercially grown cultivars under natural conditions is available. However, under high density system of planting till date no such study has been conducted and no such information is available on the recently introduced cultivars. Keeping in view the above facts, the present study was conducted on the recently introduced apple cultivars planted under high density plantation.

## Materials and Methods

The present investigations were carried out in the Experimental Farm of Division of Fruit Science, SKUAST-Kashmir, Shalimar campus, Srinagar (J & K) for two consecutive year during the year 2021 and 2022. Four-year-old plants of thirteen exotic apple cultivars grafted on M9T337 rootstock were evaluated for their phonological, flowering and yield contributing characters. Plants were planted at a spacing of 1.0 × 3.0 m and experiment was laid out in Randomized Complete Block Design (RCBD) with three replications having one tree per replication.

The data on various floral, fruiting, yield and grading parameters were recorded. Bloom density was worked out as total number of blossoms divided by trunk cross sectional area in each tagged plant. The total number of clusters/branch (1.0 m), number of flowers/cluster and number of fruits/cluster under each replication and each treatment were counted and averaged. Fruit set and fruit retention were recorded as per standard methods (Westwood, 1993). Fruit drop under each replication and cultivars were calculated regularly at 15 days intervals from the date of fruit set (when ovary swells) till harvesting of the fruits and expressed in percentage. Initial drop on 15$^{th}$ May was calculated using following the formula

$$\text{Fruit drop (\%)} = \frac{\text{Number of fruits initially set} - \text{Total number of fruits counted on 15}^{th}\text{ May}}{\text{Number of fruits initially set}} \times 100$$

Subsequently, after 15$^{th}$ May onwards till harvest fruit drop was calculated at 15 days interval using the formula:

$$\text{Fruit drop (\%)} = \frac{\text{Total number of fruits at previous observation} - \text{Total number of fruits at current observation}}{\text{Total number of fruits at previous observation}} \times 100$$

The fruits harvested from each replication and each treatment was recorded and average yield was expressed in kilogram per tree. Grading was done on the basis of fruit diameter varying among different cultivars. Data generated from the present experiment were computed, tabulated and was statistically analyzed as per the procedure given by Sahu (2016). The level of significance was tested for different variable at 5 per cent level of significance.

## Results and Discussion

### Floral parameters

Significant results were obtained for all the studied floral parameters among the apple cultivars and the data is presented in Table 1. Maximum bloom density was observed in Mitch Gala (14.68) which was statistically at par with Red Jonaprince (11.69) whereas minimum bllom density was obtained in Super Chief Sandidge (2.47). Cultivar Red Braeburn (24.27) recorded maximum number of clusters/branch which was statistically at par with Pinova (22.44) and Red Chief (21.83) however Super Chief Sandidge (8.50) registered minimum number of clusters/branch. Highest number of flowers/cluster was observed in Red Velox (5.56), which was statistically at par with Golden Clone B (5.44), Fuji Zehn Aztec (5.33), Super Chief Sandidge (5.33), Pinova (5.32), Elstar (5.22) whereas lowest number of flowers/cluster was observed in Red Chief (4.56). Number of fruits per cluster (at fruit set stage) varied from 3.78 (Elstar) to 5.00 (Fuji Zehn Aztec), which was statistically higher among all the apple cultivars. Differences in all the studied floral parameters in the present study among apple cultivars may be due to genetic constitution of a particular variety which can be attributed to the hormonal fluctuations and environmental interaction within the plant. Variations in these studied floral parameters were also earlier reported by Miranda *et al.* (2005), Mushtaq (2015) and Ahad (2018).

### Fruiting parameters

Perusal of data presented in Table 2 showed significant variation for fruiting parameters. Highest fruit set (91.97%) and fruit retention (79.43%) was observed in cv. Super Chief Sandidge which was statistically at par with Golden Delicious Reinders (91.40%), Golden Clone B (90.63%) and DeCosta Robinjn (90.32%) in case of fruit set however in case of fruit retention Super Chief

**Table 1 :** Floral parameters of different apple cultivars.

| Parameters / Cultivars | Bloom density | Number of clusters /branch | Number of flowers /cluster | Number of fruits /cluster |
|---|---|---|---|---|
| Elstar | 7.76 | 21.39 | 5.22 | 3.78 |
| Mitch Gala | 14.68 | 18.08 | 5.11 | 4.00 |
| Fuji Zehn Aztec | 7.19 | 16.92 | 5.33 | 5.00 |
| Golden Clone B | 7.03 | 14.67 | 5.44 | 4.44 |
| DeCosta Robijn | 4.12 | 11.10 | 4.89 | 4.67 |
| Red Braeburn | 11.01 | 24.27 | 5.11 | 4.00 |
| Gala Redlum | 11.24 | 21.11 | 5.11 | 4.94 |
| Super Chief Sandidge | 2.47 | 8.50 | 5.33 | 4.78 |
| Red Velox | 5.55 | 15.39 | 5.56 | 4.83 |
| Golden Delicious Reinders | 8.48 | 19.00 | 4.89 | 4.67 |
| Pinova | 4.89 | 22.44 | 5.32 | 4.89 |
| Red Chief | 8.45 | 21.83 | 4.56 | 4.33 |
| Red Jonaprince | 11.69 | 21.39 | 4.99 | 3.98 |
| **$CD_{0.05}$** | 3.29 | 2.85 | 0.36 | 0.53 |

**Table 2 :** Fruiting parameters of different apple cultivars.

| Parameters / Cultivars | Fruit set (%) | Fruit retention (%) | Cumulative drop (%) |
|---|---|---|---|
| Elstar | 87.55 | 77.27 | 22.73 |
| Mitch Gala | 81.52 | 69.55 | 30.45 |
| Fuji Zehn Aztec | 88.00 | 74.71 | 25.29 |
| Golden Clone B | 90.63 | 75.20 | 24.80 |
| DeCosta Robijn | 90.32 | 67.61 | 32.63 |
| Red Braeburn | 83.46 | 71.99 | 28.32 |
| Gala Redlum | 85.27 | 75.91 | 24.09 |
| Super Chief Sandidge | 91.97 | 79.43 | 20.57 |
| Red Velox | 83.60 | 70.92 | 29.08 |
| Golden Delicious Reinders | 91.40 | 74.74 | 25.26 |
| Pinova | 85.79 | 73.50 | 26.50 |
| Red Chief | 80.35 | 66.18 | 33.82 |
| Red Jonaprince | 82.01 | 69.67 | 30.33 |
| **$CD_{0.05}$** | 2.83 | 1.43 | 1.43 |

Sandidge was statistically higher among all the cultivars. Lowest fruit set (80.35%) and fruit retention (66.18%) was observed in Red Chief. The variation in fruit set has been reported by several workers and is mainly attributed to several factors like genetic make-up of a variety i.e. self-compatible or self-incompatible, placement of pollinizer in an orchard and the prevailing climatic conditions at the time of flowering (Sharma, 2002; Sharma, 2011 and Singh, 2013). Kumar *et al.* (2019) and Semwal (2020) reported fruit set ranged between 17.68 to 87.68 per cent however Sharma *et al.* (2013) under Nauni conditions and Singh *et al.* (2013) at Kinnaur district also observed medium to high fruit set in different cultivars which is quite similar to the present study whereas Pramanick *et al.* (2017), Mosa *et al.* (2020) and Kumar (2020) indicated much low fruit set than the present study. The reason for low fruit set could be the prevalence of self-incompatibility while in the present study set was higher as nature of cultivars were divergent and directly or indirectly may have promoted cross pollination that resulted in higher set. Fruit set in temperate fruits has been reported to be affected by the climate during blooming time, during the fruit set period and even due to duration of flowering. Excess retention also leads to large number of low grade fruits. Aside from genetic differences, there could be several reasons for such disparities in fruit set and fruit retention among cultivars, such as temperature, weather conditions, an atmosphere favourable for bee flight, pollen compatibility, effective pollination period of cultivars and so on (Pandit *et al.*, 2017). Super Chief Sandidge registered lowest cumulative fruit drop (20.57%), which was statistically differs from all other cultivars whereas cultivar Red Chief showed the highest per cent fruit drop (33.82%).

**Fruit drop parameters**

Post-pollination drop or early drop was found minimum in cultivar Pinova (7.95%) however maximum post pollination fruit drop was observed in Red Chief (26.66%) (Fig. 1). June drop was found to be highest in cultivar Red Velox (9.81%) and lowest June drop was registered in cultivar Elstar (3.20%) however pre-harvest fruit drop was found maximum in cultivar Pinova (10.15%) and minimum in cultivar Mitch Gala (0.52%) and Gala Redlum (0.52%). In the earlier reports, Teskey and Shoemaker (1972) asserted that when fruit set is abundant, fruit with fewer than three seeds are shed first. Fruit species that produce fruits with more than one seed (apple, pear and quince) drop more frequently than those that produce fruits with lesser seeds. Such fruits are truly more vulnerable to environmental adversities, such as water stress, low nutrition, and so on, and are thus more prone to fruit drop (Stosser, 2002). Present research findings are in the accordance with Sharma (2011), Mushtaq (2015), Singh *et al.* (2016), Sharma *et al.* (2017) and Semwal (2020) who indicated lower to medium values for the fruit drop however more fruit drop than the present study was reported by Mosa *et al.* (2020)

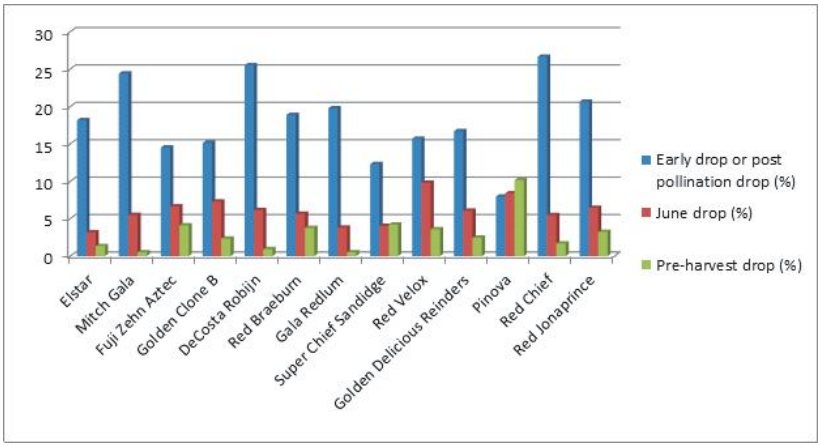


**Fig. 1 :** Fruit drop on the basis of post pollination drop, June drop and pre-harvest drop among different apple cultivars.

**Table 3 :** Fruit yield and fruit grading of different apple cultivars.

| Parameters / Cultivars | Yield (kg/plant) | Fruit grading (%) | | |
|---|---|---|---|---|
| | | Grade A | Grade B | Grade C |
| Elstar | 24.28 | 76.47 | 18.94 | 4.59 |
| Mitch Gala | 12.19 | 84.94 | 11.34 | 3.72 |
| Fuji Zehn Aztec | 26.94 | 85.73 | 9.80 | 4.47 |
| Golden Clone B | 18.35 | 81.28 | 10.05 | 8.68 |
| DeCosta Robijn | 16.48 | 88.80 | 9.43 | 1.77 |
| Red Braeburn | 11.80 | 86.91 | 6.64 | 6.45 |
| Gala Redlum | 21.24 | 83.62 | 11.98 | 4.40 |
| Super Chief Sandidge | 17.73 | 76.09 | 19.15 | 4.77 |
| Red Velox | 14.36 | 88.46 | 9.70 | 1.84 |
| Golden Delicious Reinders | 30.01 | 81.53 | 9.66 | 8.81 |
| Pinova | 21.25 | 82.92 | 10.83 | 6.25 |
| Red Chief | 19.53 | 90.22 | 6.49 | 3.29 |
| Red Jonaprince | 21.88 | 79.69 | 14.10 | 6.21 |
| $CD_{0.05}$ | 3.20 | 5.77 | 5.45 | 3.99 |

who reported higher fruit drop in the range of 28.47 per cent to 83.96 per cent. The low temperature nearing bloom, followed by higher-than-optimal warmth, is responsible for fruit drop, the latter through stimulating strong shoot growth (Soltesz, 2002). The impact of temperature in generating fruit drop decreases after the cleaning drop. Racsko *et al*. (2007) reported that the key component responsible for the June drop in apples is the effect of preceding temperatures. High temperatures during the fruit growing stage increase transpiration (water loss) from the leaves and fruits, making them unable to endure moisture stress and promptly shed. Miller and Racsko (2011) reported that Galaxy Gala recorded highest rate of pre-harvest fruit drop (10 %) whereas Golden Delicious Reinders apple observed highest fruit drop in the first wave than the June drop.

Analysed data pertaining to fruit drop showed a significant difference among the studied cultivars and is presented in the Table 3. Highest fruit drop upto 15th May was recorded in cultivar Red Chief (14.17%) which was statistically higher among all the studied cultivars whereas lowest fruit drop upto 15th May was recorded in Red Velox (3.92%). After 15 days of observation DeCosta Robijn (13.59%) registered maximum fruit drop i.e. on 1st June and minimum was recorded in Pinova (3.31%). Maximum fruit drop on 15th June was recorded in Red Velox (7.85%) which was statistically higher among all the cultivars studied whereas minimum fruit drop was observed in Elstar (1.01%). Highest fruit drop on 1st July was observed in cultivar Golden Clone B (3.40%), which was statistically at par with Pinova (3.31%) Lowest fruit drop was recorded in Super Chief Sandidge (0.23%). Maximum fruit drop on 15th July was recorded in Red Jonaprince (2.58%) which was statistically at par with Pinova (2.43%) whereas Red Velox recorded minimum fruit drop (0.33%). On 1st August maximum fruit drop was recorded in cultivar Red Velox (2.61%), which was statistically at par with Super Chief Sandidge (2.45%) however minimum fruit drop on 1st August was recorded in Elstar (0.17%). Pinova (3.31%) observed highest fruit drop on 15th August which was statistically at par with Red Braeburn (2.82%) whereas lowest fruit drop on 15th August was recorded in Mitch Gala (0.26%). Maximum fruit drop on 1st September was recorded in cultivar Pinova (5.96%) which was statistically higher among all the studied cultivars whereas minimum fruit drop on 1st September was obtained in cultivar Super Chief Sandidge (0.23%). After that on 15th September Golden Clone B registered 0.52 per cent of fruit drop and Fuji Zehn Aztec observed 0.18 per cent as other cultivars were harvested before that and on 1st October only Fuji Zehn Aztec cultivar was left for harvesting and the average fruit drop was 0.37 per cent. Different researchers have reported varying levels/ranges of fruit drop percentage in cultivars they selected for the study. Fruit drop is a distinctive character of a cultivar and direct or indirect variation could have resulted from the interaction of conditions such as high heat, dry wind, a lack of field and atmospheric moisture, or the cultivar's

**Table 4 :** Fruit drop percentage (at 15 days interval) in different apple cultivars.

| Dates / Cultivars | 15th May | 1st June | 15th June | 1st July | 15th July | 1st Aug | 15th Aug | 1st Sept | 15th Sept | 1st Oct. |
|---|---|---|---|---|---|---|---|---|---|---|
| Elstar | 8.08 (3.01) | 10.10 (3.33) | 1.01 (1.42) | 1.51 (1.57) | 0.68 (1.27) | 0.17 (1.08) | 0.34 (1.15) | 0.84 (1.36) | - | - |
| Mitch Gala | 11.82 (3.58) | 12.60 (3.69) | 3.68 (2.16) | 1.04 (1.43) | 0.79 (1.34) | 0.26 (1.11) | 0.26 (1.11) | - | - | - |
| Fuji Zehn Aztec | 6.45 (2.73) | 8.07 (3.01) | 2.15 (1.78) | 2.53 (1.85) | 1.98 (1.72) | 1.61 (1.61) | 1.43 (1.56) | 0.53 (1.23) | 0.18 (1.08) | 0.37 |
| Golden Clone B | 6.46 (2.70) | 8.68 (3.05) | 2.35 (1.75) | 3.40 (2.09) | 1.56 (1.57) | 1.04 (1.42) | 0.35 (1.15) | 0.43 (1.19) | 0.52 (1.22) | - |
| DeCosta Robijin | 11.92 (3.59) | 13.59 (3.81) | 2.38 (1.84) | 2.38 (1.82) | 1.42 (1.48) | 0.24 (1.10) | 0.71 (1.29) | - | - | - |
| Red Braeburn | 10.38 (3.37) | 8.50 (3.08) | 3.15 (2.03) | 0.63 (1.26) | 1.89 (1.70) | 0.65 (1.24) | 2.82 (1.95) | 0.31 (1.13) | - | - |
| Gala Redlum | 10.31 (3.36) | 9.45 (3.22) | 1.72 (1.56) | 1.58 (1.60) | 0.51 (1.20) | 0.52 (1.23) | - | - | - | - |
| Super Chief Sandidge | 5.37 (2.52) | 6.93 (2.81) | 2.24 (1.80) | 0.23 (1.10) | 1.57 (1.60) | 2.45 (1.84) | 1.55 (1.54) | 0.23 (1.10) | - | - |
| Red Velox | 3.92 (2.22) | 11.77 (3.57) | 7.85 (2.97) | 1.63 (1.62) | 0.33 (1.14) | 2.61 (1.87) | 0.65 (1.27) | 0.33 (1.14) | - | - |
| Golden Delicious Reinders | 4.46 (2.34) | 12.25 (3.62) | 3.29 (2.05) | 2.29 (1.77) | 0.50 (1.21) | 1.49 (1.57) | 0.33 (1.15) | 0.32 (1.14) | 0.33 (1.15) | - |
| Pinova | 4.64 (2.37) | 3.31 (2.08) | 2.65 (1.91) | 3.31 (2.08) | 2.43 (1.85) | 0.88 (1.37) | 3.31 (2.08) | 5.96 (2.64) | - | - |
| Red Chief | 14.17 (3.89) | 12.49 (3.66) | 3.34 (2.05) | 0.96 (1.39) | 1.19 (1.47) | 0.24 (1.10) | 0.47 (1.19) | 0.97 (1.38) | - | - |
| Red Jonaprince | 12.26 (3.64) | 8.39 (3.06) | 1.96 (1.65) | 1.92 (1.66) | 2.58 (1.89) | 0.65 (1.28) | 0.84 (1.29) | 1.74 (1.60) | - | - |
| **C.D. (p≤0.05)** | **1.81 (0.30)** | **3.13 (0.49)** | **1.98 (0.58)** | **1.63 (0.48)** | **1.01 (0.44)** | **0.91 (0.36)** | **0.82 (0.48)** | **0.96 (0.46)** | **0.14** | |

* - where the fruits were already harvested. ** values in parenthesis are square root transformation of the original values.

innate proclivity for natural fruit drop.

Significant results were obtained for yield and fruit grading among the studied cultivars (Table 4). Highest fruit yield was recorded in cultivar Golden Delicious Reinders (30.01 kg/plant) which was statistically at par with Fuji Zehn Aztec (26.94 kg/plant) whereas lowest fruit yield was recorded in cultivar Red Braeburn (11.80 kg/plant), respectively. Present results are in line with the findings of Kumar *et al.* (2006), Pramanick *et al.* (2017) and Irfan *et al.* (2020) however much low yield was also reported by Sharma and Chauhan (2008), Sharma *et al.* (2017) and Verma and Thakur (2019). Miller *et al.* (2015) and Ghazaeian *et al.* (2017) have reported that different apple cultivars varied in yield potential under different agro-climatic conditions. The variation in yield in the studied cultivars might be due to variation in number of fruit harvested and variation in fruit weight in each year, genetic difference of different cultivars, cultural practices might be another possible reason for variation in yield (Rackso *et al*., 2004).

Grading of apples is done according to fruit size and fruit appearance or quality. In the present study, grading of apple was done on the basis of fruit diameter. Maximum 'A' Grade apple were obtained in Red Chief (90.22%), which was statistically at par with DeCosta Robijin (88.80%), Red Velox (88.46%), Red Braeburn (86.91%), Fuji Zehn Aztec (85.73%) and Mitch Gala (84.94%) whereas minimum was observed in cultivar Super Chief Sandidge (76.09 %). Maximum 'B' grade apples were recorded in cultivar Super Chief Sandidge

(19.15%) which was statistically at par with Elstar (18.94%) and Red Jonaprince (14.10 per cent) however minimum 'B' grade apples were obtained in cultivar Red Chief (6.49%). Cultivar Golden Delicious Reinders (8.81%) obtained maximum Grade 'C' apples however minimum 'C' grade apples were obtained in cultivar DeCosta Robijin (1.77%). Maximum percentage of Grade A apple in Red Chief may be due to the fact that it had a maximum post-pollination drop or cleaning drop, the number of fruits decreased and the overall yield of exportable fruits increased. In the earlier reports, researchers (Banday, 2006; Kosser, 2017) obtained different results as the grading of apples was done only on Red Delicious cultivar of apple under traditional planting system. The lesser the number of fruits, higher will be the availability of carbohydrates or photosynthates for the development of quality fruits.

## Conclusion

It is clear from the present study, overall minimum fruit drop was obtained in Super Chief Sandidge where minimum post pollination drop, June drop and pre-harvest fruit drop was recorded in cultivar Pinova, Elstar and Mitch Gala, respectively.

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