# Studies on productive behaviour of apple cultivar StarKrimson under high density plantation system

**Suneel Kumar Bhat**
**(2004-A-750-M)**

**DIVISION OF POMOLOGY**
**FACULTY OF POSTGRADUATE STUDIES**
**SHER-E-KASHMIR UNIVERSITY OF AGRICULTURAL SCIENCES & TECHNOLOGY OF KASHMIR**

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**Suneel Kumar Bhat**
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# *THESIS*

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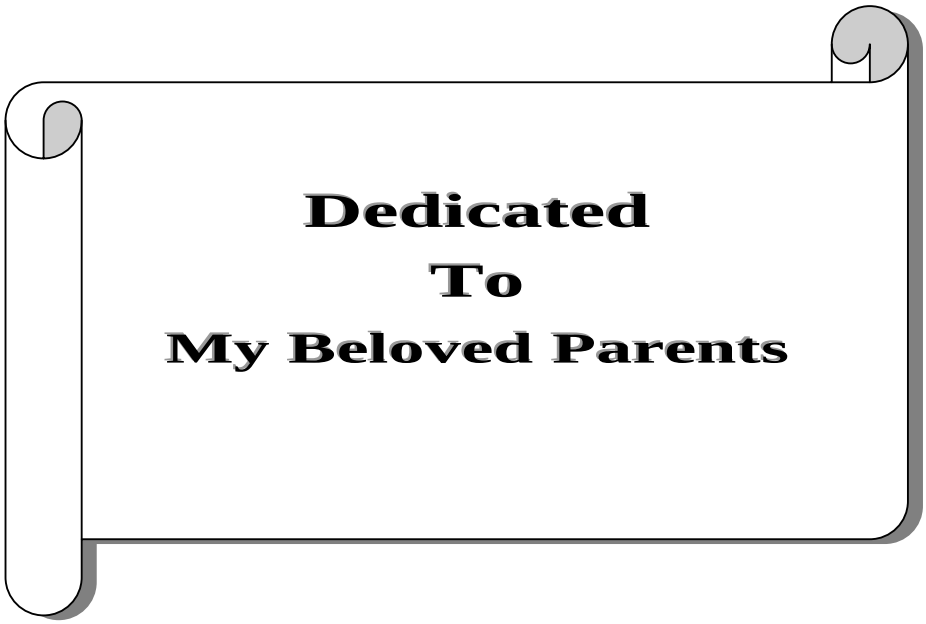
Dedicated
To
My Beloved Parents

**Sher-e-Kashmir**
**University of Agricultural Sciences & Technology of Kashmir**
**Division of Pomology,**
**Shalimar Campus Srinagar– 191 121**
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## Certificate – I

This is to certify that the thesis entitled, **"Studies on productive behaviour of apple cultivar StarKrimson under high density plantation system"** Submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science in Agriculture (Pomology)**, to the **Faculty of Postgraduate Studies, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir** is a record of bonafide research work carried out by **Suneel Kumar Bhat (Regd. No. 2004-A-750-M)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that information received during the course of investigation has duly been acknowledged.

**( Dr. A.K. Sharma)**
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Advisory Committee

Endorsed

**Prof. & Head,**
Division of Pomology, SKUAST-K, Shalimar.

**Sher-e-Kashmir**
**University of Agricultural Sciences & Technology of Kashmir**
**Division of Pomology, Shalimar Campus, Srinagar– 191 121**
**-::o::-**

## Certificate – II

We, the members of the Advisory Committee of **Mr. Suneel Kumar Bhat (Regd. No. 2004-A-750-M)**, a candidate for the degree of **Master of Science in Agriculture** have gone through the manuscript of the thesis entitled, "**Studies on productive behaviour of apple cultivar Starkrimson under high density plantation system"** and recommend that it may be submitted by the student in partial fulfilment of the requirements for the award of the degree.

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K.D Farm Srinagar

**Sher-e-Kashmir**
**University of Agricultural Sciences & Technology of Kashmir**
**Shalimar Campus Srinagar– 191 121**
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This is to certify that the thesis entitled, **"Studies on productive behaviour of apple cultivar StarKrimson under high density plantation system"** submitted by **Suneel Kumar Bhat (Regd. No. 2004-A-750-M)** to the **Faculty of Postgraduate Studies, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir** in partial fulfilment of the requirements for the award of the degree of **Master of Science in Agriculture (Pomology)** was examined and approved by the Advisory Committee and External Examiner on …….

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Advisory Committee

**External Examiner**

**Prof. & Head,**
Division of Pomology

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Postgraduate Studies, SKUAST-K

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**Division of Pomology**

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# CERTIFICATE

This is to certify that all the modifications/corrections suggested by External Examiner Dr. G. Pandey, Senior Scientist, Central Institute for Sub-tropical Horticulture, Rehmankhera, Kakori, Lucknow in the thesis manuscript entitled **"Studies on Productive Behaviour of Apple cultivar StarKrimson Under High Density Plantation System"** by Mr. Suneel Kumar Bhat **(Regd. No. 2004-A-750-M)** have been taken care of before final binding of the same.

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Advisory Committee

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**University of Agricultural Sciences and Technology of Kashmir**
**Division of Pomology**
**Shalimar, Srinagar - 191121**

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| | | |
|---|---|---|
| Name of the student | : | Suneel Kumar Bhat |
| Registration No. | : | 2004-A-750-M |
| Major Subject | : | Pomology |
| Minor Subject | : | Plant Physiology |
| Major Advisor | : | Dr. A.K. Sharma,<br>Assistant Professor,<br>Division of Pomology,<br>SKUAST-K, Shalimar |
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## ABSTRACT

The data on overall performance of exotic spur-type apple cultivars under high density plantation system in the farmers field are scarce. To fil this gap the present investigation entitled "Studies on Productive Behaviour of Apple Cultivar StarKrimson Under High Density Plantation System" was carried out during the year 2005-06. Apple cultivar StarKrimson was introduced by Department of Horticulture (J&K) planted by growers under high density in Baramulla and Pulwama districts. The spacing for HDP was 3 x 2 m and for LDP was 5 x 4 m. The cultivar StarKrimson was raised on MM106 rootstock and the trees were trained as central leader system.

Under both the districts i.e., Pulwama and Baramulla five orchards under HDP were selected at different sites one low density orchard was also identified in both the districts. Five uniform trees were selected in each and every orchard and utilized as the unit of study. The observations were recorded on vegetative, floral, fruit and yield, parameters and leaf mineral composition. The data were statistically analysed under RBD. More vegetative growth was recorded in low density plantation than high density plantation. In high density orchards early bloom and fruit set was recorded than low density plantation in both the districts.

The results showed that HDP orchards proved better in quality and quantity of fruits than LDP orchards. HDP showed a yield efficiency of 0.36 kg/cm$^2$ as against 0.25 kg/cm$^2$ of LDP at Pulwama while for Baramulla it was 0.39 kg/cm$^2$ and 0.28 kg/cm$^2$, respectively. The fruit firmness for the two locations i.e., Pulwama and Baramulla was 21.1 lbs./inch$^2$ and 20.51 lbs./inch$^2$ under HDP as against 20.03 lbs./inch$^2$ and 19.99 lbs./inch$^2$ under LDP respectively. In general colour development was better under HDP than under LDP. The total sugar percentage for the two districts was significantly higher (8.22 & 7.77) under closer spacing than conventional spacing (7.36 & 7.34). However, the colour development and the total sugar percentage at Pulwama viz., 3.57 & 8.22 under HDP was higher than those at Baramulla (2.93 & 7.77). Fruit colour was measured on a 1-4 scale. Other attributes showed a non-significant difference at the two locations. Thus, HDP proved to be significantly superior to LDP at both the locations, though the two locations were at par.

**Key words :** Apple, StarKrimson, high density, fruit quality and yield

Signature of the student
Dated ……..

Signature of Major Advisor
Dated :……

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***Suneel Kumar Bhat***

**PLACE : SHALIMAR, SRINAGAR**

*Date :* .....

# Chapter – 1

# INTRODUCTION

Introduction and adoption of superior cultivars and production technologies have boosted production of apple to manifold over the years with a significant area expansion as well. Though the productivity in India has increased from 4.12 to 10.34 MT/ha. over the last 25 years (Anonymous, 2005), yet it does not meet the international standards of quality production. In Jammu and Kashmir, most of the apple orchards have started showing a level of stagnation and decline in productivity. This dismal situation of apple industry is because of the fact that almost all the traditional apple plantations are out-dated, exhausted, comprising traditional cultivars and are heavily infested with diseases and pests and have become very much difficult to manage or rejuvenate. Such obsolete concepts of orcharding practices have resulted in heavy losses due to low productivity and inferior fruit quality.

In the light of this scenario, high density planting system has been found to be a promising endeavour, which is based on 'hi-tech' concept of orcharding for production of high grade apple by planting higher number of plants of superior cultivars per unit area, using size controlling clonal rootstocks and specialized training and pruning systems. The major advantages of high density plantation may be viewed in terms of easy to manage, lesser intensity of infestation by diseases and pests, better developed canopy, precocious in bearing, higher productivity, less fruit drop, better efficacy of sprayed chemicals, can be manageably protected from hails by covering the canopy with nets and ultimately better return on investments.

In Kashmir valley, many exotic spur type apple cultivars were introduced under Indo-Bulgarian project for high-density plantation. Amongst these cultivars vistaBella, Mollie's Delicious, Starkrimson, Cooper-IV, Granny smith and Golden spur have gained popularity (under high density planting system) especially in

Baramulla, Pulwama, Anantnag and Srinagar districts.

Since, the data on overall performance of these cultivars under HDP in the farmers field are scarce, a careful study of the same may be very much useful for their better management strategy and to convenience the farmers to adopt the system of HDP. Considering this, the present investigation was carried-out with the following objectives :

1) To study the vegetative growth parameters, flowering behaviour and foliar NPK status of apple cultivar StarKrimson.

2) To study the yield and fruit quality parameters of apple cultivar StarKrimson

# CHAPTER – 2

## Review of literature

### 2.1 Performance with regard to vegetative parameters

Schneider *et al*. (1978) studied the influence of 3 spacings, 4 rootstocks and 2 cultivars of apple on tree size, fruit yield and quality and mineral composition of leaves. They found that the largest tree size was resulted from seedling rootstocks and smallest from MM106. Loreti *et al*. (1978) also recorded a growth reduction in apple trees planted at higher densities. In a similar study 'Miller Spur Delicious' trees were largest on seedling rootstocks, intermediate on MM104 and smallest on MM111, MM106 and M7; 'Golden Spur Delicious' resembled 'Miller Spur Delicious' in size except that trees were significantly smaller on M7 than on MM111 and MM106. At the end of $9^{th}$ season, Red Prince Delicious and Golden Delicious were largest on seedling followed by MM111, MM106, M7 and M26 in descending order (Seeley *et al*., 1979). A similar increase in trunk circumference with increasing tree density was also noticed by Christensen (1979) while investigating the effect of density rectangularity and row orientation in apple trees.

Holubowicz (1981b) studied the performance of nine apple cvs. in high density orchard in western part of Poland and an adverse effect of dense planting on tree growth was recorded. Similarly, the studies on the effects of long term spacing trials with apple trees showed a negative correlation between planting density and tree growth (Mika *et al*., 1981).

Trachev (1982) evaluated the growth and reproductive performance of apple cvs. Richared, Golden Delicious, Jonathan and StarKrimson grafted on M9,

M26 or MM106 rootstocks and recorded a statistically significant reduction in the trunk growth, total annual growth increament and number of shoots of StarKrimson grown on MM106. However, there was a significant increase in shoot length. Average trunk circumference, tree height and canopy spread of standard habit strains viz., Starking and Nickell were more than spur type strain like StarKrimson. However, the highest yield was recorded from StarKrimson among spur type strains (Ferree *et al*., 1982).

Andreev (1984) studied the relative performance of the apple cultivar StarKrimson on both dwarfing rootstocks like M2, M7, M9, M26, A2, MM104, MM106, MM109, MM111 and seedling rootstocks of the cvs. Golden Winter Pearmain and Golden Delicious over a period of seven years. He observed that various vegetative parameters like trunk diameter, tree height and crown width were more on MM109 and smallest on MM106 rootstocks. The highest specific yield ($Kg/cm^2$ of trunk cross section) were produced by M9, M4 and MM106 rootstocks. Wertheim (1985) also reported a pennalized tree growth at lower densities while studying the productivity and fruit quality of apple in single row and full-field planting systems. He also recorded an inverse relationship between the trunk circumference and tree density. Mika and Piatkowski (1986) also reported an opposite movement in tree growth and tree density in their 10 years trial on high density planting of McIntosh and MacSpur apple trees. Effects of rootstock and in-row spacings on growth and yield of spur type 'Delicious' and 'Golden Delicious' apple trees was recorded by Archbold *et al.* (1987) and found that the trunk size was smallest at the narrowest spacing regardless of rootstocks and strain. A reduction in the tree growth rate was observed with increasing density in StarKrimson grown on *Malus sieversii* seedling rootstocks at 5.0 x 5.0, 4.5, 4.0, 3.5, 2.5 or 2.0 m (Urunov, 1987).

Wagenmakers (1988) studied the effects of planting system, tree shape and additional summer pruning on growth, production and flowering of apple trees at high planting densities. The planting density and pruning intensity were found to

be negatively correlated with trunk basal area increament. However, the influence of planting system was small and of minor importance compared with plant density. Callesen and Wagenmakers (1989) studied the effects of location, row distance, rectangularity and tree height on growth, flowering and fruiting habit of apple cv. 'Elstar' on M9 rootstock. Both trunk growth and circumference and tree volume decreased with increasing tree density. The trunk girth differed significantly at the two locations. Similarly, the growth increase in response to greater space availability and constriction by close spacing in apple was also recorded by Zimmerman and Steffens (1995).

Costes *et al*. (2001) studied the growth and branching pattern along the main axis of two apple cvs. Rome Beauty and StarKrimson grafted on M7 or M9 and found that StarKrimson produced greater number of spurs than Rome Beauty. A rapid decrease was observed in both the number of nodes and the length of the annual shoots for all cultivars-rootstock combinations. Spur percentage in StarKrimson was more than Red Fuji, Jonagold and Orin on M7, MM106 and M26 rootstocks (Li *et al*., 2002).

Hampson *et al*. (2004) tested Royal Gala and Summerland McIntosh at 5 different planting densities and found that the tree size decreased as the planting density increased but leaf area index and light interception showed a positive correlation with planting density. Over the range of density tested the effect on height was less (~7%) than that on spread (~23%). Policarpo *et al*. (2006) while studying the vegetative and productive responses of 'Conference', and 'Williams' pear trees planted at different in-row spacings, found that the tree growth was heavily taxed at higher densities. As spacing increased, stem length increased quadratically in both cultivars but average stem diameter increased linearly only in "Conference". Mika and Piskor (1992) in their experiment on growth and cropping of dwarf Jonagold (Jonica) apple trees planted at various densities and subjected to various training systems observed that very dense planting suppressed the growth of shoots and trunk increment.

## 2.2 PERFORMANCE WITH REGARD TO PHENOLOGICAL PARAMETERS AND REPRODUCTIVE PARAMETERS

Zyl *et al*. (1975) in his study on various apple cultivars under HDP reported StarKrimson Delicious apple to be a heavy bearer. The assessment of flowering, fruit set and yield in Delicious cultivars of apple indicated that Golden Delicious and StarKrimson were the earliest and highest yielding cultivars (Predescu *et al*., 1977). Schneider *et al*. (1978) performed an experiment to observe the effects of rootstock, spacing and cultivar on various growth and yield parameters of 'Golden Spur and Red Spur' apple cultivars and reported that the yield of trees grown on seedling stocks was only 60 per cent of those grown on MM106. Golden spur trees produced the highest yield on MM111 while Red Spur produced the most on MM106. Though the yield $ha^{-1}$ was proportional to tree spacing, but average total yield per tree and per ha. was greater on Golden Spur than on Red spur.

Agafonov *et al*. (1979) while evaluating various apple cultivars under HDP found that the number of spurs, number of flowers/tree, fruit set and yield were better under high densities. Miller (1980) carried out an investigation to record the performance of 76 cultivars including 26 Delicious strains and ten 'Golden Delicious' strains in middle Georgia, spur strains were more precocious and produced higher yields than standard strains. Hugard (1981a) quoted yields of 10-13 t/ha for the II year and 25-30 t $ha^{-1}$ for the III year in case of Golden Delicious planting under HDP under French conditions. Holubowicz (1981) studies the bearing performance of Azwellspur and StarKrimson cultivars budded on MM106 rootstocks and reported that the average yields from the densely planted trees ranged from 41.4-41.6 t $ha^{-1}$ for the 2 cultivars and for the wider spaced trees from 32.5 – 33.1 t $ha^{-1}$. Likewise, the trials with 8 apple cutivars on M26 and MM106 planted at 8,800 and 20,000 trees $ha^{-1}$ recorded highest yields in StarKrimon on MM106 and M26 (Holubowicz, 1981a). A sixteen year study on apple by Larsen and Fritts (1982) revealed that closer tree spacings and spur type

cultivars yielded higher than wider spacings and non spur cultivars comparing commulative yields after 16 years with 9 rootstocks within spur strains and showed that highest yields were with MM106.

Trachev (1982) monitered the growth and reproductive behaviour of several apple cultivars for several years and found that StarKrimson, Jonathan, Golden Delicious and Richared did best on MM106, M26, M4 and M9, respectively. The behaviour of StarKrimson and Golden Delicious on seedling rootstocks with M4, M7, M8, M9 or MM106 as interstocks and planted at 4 x 2 m was studied by Parnia *et al*. (1983). It was observed that the interstocks induced early bearing and the trees needed no support in the first 6 years after planting.

Stoyanov and Atanasov (1983) studied the performance of StarKrimson and Yellow Spur on MM106 and M9 and spaced at 3.5 x 1.3 m. StarKrimson and Yellow Spur on M9 gave 14.64 and 18.94 kg/tree and on MM106 they gave 27.27 and 36.84 kg/tree, respectively. Similarly, an evaluation over 16 years of Delicious strains and other cultivars on several rootstocks and hardy interstems by Ferree (1989) revealed that StarKrimson gave the highest yield among spur habit strains. Isac *et al*. (1983) planted eleven strains of apple on 3 rootstocks viz., M9, M7 and MM106 at five spacings. It was observed that the most suitable cultivars were those with low vigour and precocious flowering, such as Golden Delicious, Gold Spur, StarKrimson, Jonathan and Frumosde Voinseti, and the best rootstocks were M9 and MM106. Andreev (1984) studied the performance of StarKrimson on M2, M7, M9, M26, MM04, A2, MM106, MM109, MM111 and seedling rootstocks over a period of 7 years. It was found that the yields were highest on A2, M2, MM106 and lowest on the seedling rootstocks but the highest specific yields were produced on A2, M2 and MM106 and the lowest by the seedling rootstocks.

Granger (1984) grafted Spartan cultivar on M9, M26, Ott 3 and M7 and McIntosh cultivar on M26 and M7 in order to study their response to different combinations of rootstocks, tree densities and training systems. It was observed

that high and medium densities produced the highest yield while the low density proved a failure. Cardaklija (1985) evaluated some apple and pear strains for yield in Lim valley of Montenegro and found StarKrimson and Conference pear among the best performers. The earliest flowering recorded in Kloz and the latest in Melrose cultivars of apple. Westwood *et al*. (1986) studied the tree size and performance of 9 apple cultivars on several dwarfing rootstocks and concluded that trees on EMLA-9 and M9 had high yield efficiency whereas those on EMLA-27 were less yield efficient. Trees on seedling stock were less efficient than those on MM111, MM106 and M7. Callensen and Wagenmakers (1989) examined the significance of density, rectangularity and tree height for growth, flowering and fruit production and reported higher number of flowers and fruits per ha. in narrow spacings. The trees at the highest densities tended to be less efficient but those at 1 : 1 rectangularity and the lowest height (1.5 m) were the most efficient to produce fruit and had a lower tendency for biennial flowering.

Nesterov (1988) studied the growth and fruiting of 50 varieties of apple at Alma-Ata (Kazakistan) and found that spur types like Starkspur and Golden Delicious were the most precocious and highest yielding in terms of crown volume and projection, the highest yield tree$^{-1}$ and the highest yield ha$^{-1}$. StarKrimson figured among the best performers. Mika and Piskor (1992) planted feathered 'Jonagold' cv. (Jonica clone) apple trees on M9 at different densities and observed that the increasing planting density decreased proportionally yield per tree but increased yield per ha.

Parra-Quezada *et al*. (1994) studied the effect of MM111, MM106, M7 and M26 on the yield, vigour and yield efficiency of StarKrimson Spur 'Golden Delicious' and Spur Red Rome Beauty and found that StarKrimson yielded 20.3 t ha$^{-1}$ on M26 and 30.9 t ha$^{-1}$ on MM106. Fallahi *et al*. (1994) evaluated 26 Delicious cultivars of apple over several years for growth, yield and fruit quality at harvest and after 6 months of storage. Apex, Improved Ryan Spur, Silverspur, StarKrimson and Wellspur were among the cultivars with high commulative

yields and yield efficiency. Yu *et al*. (1995) conducted an experiment for early and top quality production of Nagaju-2 Fuji and StarKrimson, apple cultivars both grafted on *Malus micromalus* and spaced respectively at 6 x 4 m and 4 x 2 m. Nagaju-2 Fuji yielded 56.9 t $ha^{-1}$ with 87 per cent first grade fruit but StarKrimson produced 47.7 t $ha^{-1}$ with 90 per cent first grade fruit.

Costa *et al*. (1997) studied the response of apple cultivars, Golden Reinders, Jonagored, Staymared, Braeburn and Fuji on M9 and Red Chief on M26, in terms of yield, performance and fruit quality to high density planting system and reported that high and medium density planting performed better than the low density. However, fruit weight decreased with tree density. Hampson *et al*. (2004) conducted a research trial to study the effect of varying density but constant rectangularity on 'Royal Gala' and Summerland McIntosh. The yield/tree was found to be vary indirectly with the density but yield/ha. directly with the planting density. Karkara *et al*. (2004) raised Real Mecoy Red Delicious, Mutsu and Criterion on EMLA26, EMLA7 and EMLA106 and recorded maximum average yield of 57.10 MT $ha^{-1}$ in trees raised on EMLA106. The rootstock cultivar interaction was also significant with Mutsu/EMLA 106 producing the highest yield.

### 2.3 Performance with regard to fruit quality parameters

Greenhalgh and Godley (1976) made a survey of influencing the development of 'typiness' in apple cultivars and found Richared, Royal Red and StarKrimson to be far more 'typy' than the common Red Delicious, while as Hiearly and Royden Red were inferior in this respect. The extent to which 'typiness' developed in the fruit was found to be related to mean air temperature in the 7 day following full bloom. Miller (1980) studied the performance of 76 apple cultivars for various growth and yield attributes in Georgia and observed that Topred and StarKrimson developed good red skins when allowed to reach maturity. Crassweller *et al*. (1991) performed colour measurements on several apple cultivars collected at 145-150 DAFB and found that StarKrimson and

Redspur had higher coloured fruits at harvest.

Fallahi *et al.* (1994) evaluated 26 cultivars of apple over several years for growth, yield and fruit quality and found that Red Spur and Starkspur Supreme had the largest length to diameter ratio. Hardispur, Nured Royal, Silver Spur and StarKrimson had high soluble solids concentrations at harvest and after storage. The fruit of Hardispur, Silverspur, StarKrimson and Starkspur Supreme were firm at harvest and after storage. In a similar study, Vercammen and Boonen (1997) also reported a negative correlation of fruit size, colour development, soluble solid concentrations and hardness with plant density. Mirzalon and Karaeali (2000) carried out a study on Starking, StarKrimson, Golden Delicious and Starkspur and found that fruit size, specific gravity, size of parenchymatic cells and cell number of both Red Delicious mutants were almost the same but the specific gravity of fruit was higher in StarKrimson than Starking. Drake *et al.* (2001) evaluated six strains of Delicious apple over four seasons for colour, flesh firmness, soluble solids content, titratable acidity, individual and total carbohydrate content and disorder. Spur type apples (StarKrimson, 'Starkspur ultra red' Oregon spur II) were more mature at harvest than non spur types (Early Red One, Topred, Classic) but contained less titratable acidity than nonspur types. The proportion of total carbohydrates content made up of sucrose was higher for non-spur types.

Thybo *et al*. (2005) while determining the effect of plant density and two colour gradings and yield, fruit weight, appearance, texture, sugar, acid, volatile compounds and sensory attributes of 'Elshof', 'King Jonagold and Topaz' found that the surface redness and soluble solids concentration of all the three cultivars decreased with an increase in plant density. The results showed that plant density had a strong effect on fruit yield and colour, and a minor effect on the soluble sugars and acid contents of the apples.

### 2.4 Performance with regard to foliar NPK status

Schneider *et al.* (1978) studied the effect of rootstock, scion cultivar and

the spacing on foliar mineral composition of apple and found that closely spaced trees had least amount of foliar P and K but Ca Mg and Mn were high in the same trees. Velemis *et al*. (1999) studied leaf nutrient levels of StarKrimson in relation to crop yield and found that yield was closely related to leaf N, P, K, Ca, Mg, Mn, Zn and Fe contents. Moreover, K and Zn were identified as significant for yield prediction. However, spacing did not affect N, Fe, Zn or Cu content of the leaves. Trees on M7 had the highest N, P and Cu and those on MM106 were highest in Ca. Yim and Jang (2003) also observed similar results in their study on apple.

# Chapter – 3

# MATERIALS AND METHODS

The present investigation entitled "Studies on productive behaviour of apple cultivar StarKrimson under high density plantation system" was carried out during the year 2005-06. The details on cultivar, rootstock , training system, spacing, age of trees per hectare, location, etc. are described below :

Apple cultivar Starkrimson introduced by Department of Horticulture and presently under cultivation at Baramulla and Pulwama districts were used for the study. The details of the study are given as under :

| | | | | |
|---|---|---|---|---|
| I) | Cultivar | : | StarKrimson | |
| II) | Rootstock | : | MM106 | |
| III) | Training system | : | Central leader | |
| IV) | Spacing | : | a) | 3 x 2 m (HDP) |
| | | | b) | 5 x 4 m (Check) |
| V) | Age | : | c) | 09 years |
| VI) | Plantation year | : | 2000 | |
| VII) | Trees/ha | : | 1,666 (HDP)<br>500 (Check) | |
| VIII) | Location | : | a) | Pulwama |
| | | | i) | Lajoora |
| | | | ii) | Malikpora |
| | | | iii) | Noru |
| | | | iv) | Safnagri |
| | | | v) | Peerpora |

vi) Tenghar (Check)

b) Baramulla

i) Delena

ii) Ladoora

iii) Chakula

iv) Mirangund

v) Kunan

vi) Chakula (check)

Five plants of uniform age, size, vigour and health from each of the above mentioned locations were selected randomly. All standard cultural practices like hoeing, fungicidal spray and training and pruning were adopted during the course of study to ensure uniform growth of the experimental plants. The observations regarding vegetative, floral, fruit and yield attributes were recorded. The fruit were harvested and after discarding the misshaped, damaged and diseased fruit only firm and uniform fruit were selected for further studies. The various physico-chemical characters of the fruit were studied in the Laboratories of Division of Pomology, SKUAST-K, Shalimar.

**Observations recorded**

The procedures used to record various observations are described below :

### 3.1 Vegetative growth characteristics

#### 3.1.1 Annual shoot growth

The annual shoot growth of each experimental tree was recorded by measuring the current season's growth of four randomly selected shoots with a measuring tape and the average expressed in centimetres.

#### 3.1.2 Tree trunk circumference

The trunk circumference of each experimental plant was measured at 10 cms above the graft union with the help of a measuring tape at the end of the

growing season and the mean expressed in centimetres.

### 3.1.3 Tree height

Height of each experimental plant was measured from the ground level to the tip of the main branch or leader with the help of a measuring tape and was expressed in centimetres.

### 3.1.4 Tree volume

The total above ground volume of each tree was expressed as the product of its height and spread and the average tree volume taken in $m^3$.

### 3.1.5 Average number of spurs/tree

The spurs of every experimental tree were counted and then averaged.

## 3.2 Phenological studies

### 3.2.1 Initial bloom (Date of first flower open)

Initial bloom was recorded by counting the number of days taken from the reference date till the appearance of 10 per cent flowering. The reference date was taken as 1$^{st}$ March, 2006.

### 3.2.2 Full bloom

Full bloom was recorded by counting the number of days from the reference date till the appearance of 80-100 per cent flowering.

### 3.2.3 Petal fall

This stage was recorded when the experimental trees exhibited 80-100 per cent of the petal fall.

### 3.2.4 Fruit set

Fruit set was recorded by counting the number of days from the reference date till the appearance of pea stage.

## 3.3 Fruit production characteristics

### 3.3.1 Leaf/fruit ratio

The number of leaves per fruit of each experimental tree were counted and averaged.

### 3.3.2 Fruit retention at harvest

Fruit retention was calculated by counting the number of fruit-lets and the number of matured fruits and expressed in percentage by using the formula :

$$\text{Fruit retention} = \frac{\text{Number of matured fruits}}{\text{Number of fruitlets}} \times 100$$

### 3.3.3 Yield/tree

The crop harvested from each experimental tree was weighed and the average weight was expressed in kilograms/tree.

### 3.3.4 Yield efficiency

The yield efficiency of the experimental trees was calculated and expressed as kg $cm^{-2}$ by using the formula given by Westwood, 1993.

$$\text{Yield efficiency} = \frac{\text{Yield (kg's)}}{\text{Tree trunk cross sectional area } (cm^2)} \times 100$$

## 3.4 Fruit physical characteristics

### *3.4.1 FRUIT LENGTH*

Fruit length was measured with the help of vernier calliper and the average expressed in millimetres (mm).

### 3.4.2 Fruit diameter

The diameter of sampled fruit was measured with the help of vernier calliper and expressed in millimetres (mm).

### 3.4.3 Fruit length/diameter ratio

It was calculated by dividing length by respective diameter of each fruit

sample.

### 3.4.4 Fruit colour

A random sample of 5 fruits from each experimental plant was taken and observed for colour scores. The fruits were rated for the colour of skin on a scale of 1-4 as :

| S. No. | Colour intensity | Scale |
|---|---|---|
| a) | 0-25% red skin colour | 1 |
| b) | 26-50% red skin colour | 2 |
| c) | 51-75% red skin colour | 3 |
| d) | 76-100% red skin colour | 4 |

### *3.4.5 FRUIT FIRMNESS*

Fruit firmness was measured with the help of Zeiss penetrometer. Each fruit was punched at three different places on its surface after removing one square inch of peel and the average firmness was expressed in Lb./inch$^2$.

### 3.4.6 Total soluble solids

TSS of fresh fruit was measured with the help of a Brix hand refractometer by placing a drop of the juice on the prism of the instrument. The readings were recorded in $^{o}$Brix and corrected at 20 $^{o}$C (A.O.A.C., 1984).

## 3.5 Fruit chemical characteristics

### 3.5.1 Reducing sugars

The reducing sugar content was determined by using standard methods of A.O.A.C. (1984) and expressed in per cent.

### 3.5.2 Total sugars

Total sugar content was determined in terms of glucose after acid hydrolyis as per 14$^{th}$ edition 'Association of Officials Agriculture Chemists' (1984) on percentage basis.

### 3.5.3 Fruit acidity

Acidity was determined by diluting a known volume of apple juice and titrating it against sodium hydroxide (NaoH) solution, using phenolphthalein as an indicator. Acidity was expressed as per cent malic acid.

## 3.6 Foliar N, P, K and Ca status

### 3.6.1 Leaf nitrogen

For nitrogen estimation leaf samples so collected were digested in a digestion mixture of potassium sulphate, ferrous sulphate and copper sulphate in a 10 : 1 : 0.5 ratio and then leaf nitrogen content (%) was determined by Kjeldhal's method.

### 3.6.2 Leaf phosphorus

For phosphorus estimation leaf samples of each experimental plant were digested in a di acid mixture of $HNO_3$ and $HclO_4$, in a 9 : 4 ratio and the leaf phosphorus content (%) was determined by Vanadomolybo phosphate yellow colour method as described by Jackson (1963).

### 3.6.3 Leaf potassium

The leaf samples of each experimental plant were digested in a di acid mixture of $HNO_3$ and $HclO_4$ in a 9: 4 ratio and the estimation of potassium was done on a flame photometer as described by Jackson (1963).

### 3.6.4 Leaf Calcium

The leaf samples of each experimental plant were digested in a di acid mixture of $HNO_3$ and $HclO_4$, in a 9 : 4 ratio and the estimation of calcium was done on a flame photometer as described by Jackson (1963).

## *3.7 Experimental design*

The data were statistically analysed under Complete Randomized Block Design

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# Chapter – 4

## Experimental findings

Various high density plantation apple orchards in Pulwama and Baramulla districts laid in randomised block design, each replicated 5 times were evaluated at different stages of growth and development for various characters and the results are presented under the following captions.

### 4.1 Vegetative growth parameters (Pulwama)

The results of vegetative growth parameters in district Pulwama are presented in Table-1.

#### 4.1.1 ANNUAL SHOOT GROWTH

Data presented in Table-1 reveal that high density orchards differed significantly from low density orchard with respect to annual shoot growth. Maximum annual shoot growth (74.73 cm) was recorded in low density orchard (Tenghar). Among high density orchards maximum annual shoot growth i.e., 57.53 cm was noted in orchard of Malikpora followed by Noru (56.87 cm). Minimum annual shoot growth of 42.45 cm was recorded in Lajoora orchard and closely followed by Peerpora (42.88 cm) and Safnagri (43.52 cm).

#### 4.1.2 TREE TRUNK CIRCUMFERENCE

Significant differences were observed when high density orchards were compared with low density orchard in respect of tree trunk circumference. Maximum trunk circumference (29.20 cm) was recorded at low density orchard i.e., Tenghar (Table-1). Minimum tree trunk circumference was noted in orchard of Lajoora (18.20 cm) and found statistically at par with orchards of Malikpora (19.58 cm) and Peerpora (20.60 cm). Non-significant difference were noted in all high density orchards excepting Lajoora.

#### 4.1.3 TREE HEIGHT

High density orchards at different locations in Pulwama were significantly different from low density orchard with regard to tree height. Maximum tree height of 258.20 cm was measured in the Safnagri orchard among the high density orchards which was at par with Lajoora (252.40 cm) and Noru (248.00 cm). Minimum tree height i.e., 223.60 cm was noted in Peerpora orchard. However, a height of 313.20 cm was measured in low density orchard at Tenghar (Table-1).

### 4.1.4 TREE VOLUME

Perusal of Table-1 indicates non-significant differences in tree volume among high density orchards and ranged between 2.15 $m^3$ to 2.64 $m^3$. However, the tree volume of low density orchards i.e., 9.16 $m^3$ was significantly high than high density orchards.

### 4.1.5 AVERAGE NUMBER OF SPURS/TREE

Among the high density orchards, the average number of spur/tree were nooted between 114.20 (Peerpora) to 133.40 (Lajoora) with significant differences. On an average of 123.08 spurs/tree were found in high density orchards which significantly lesser than the value of 172.20 spurs/tree from Tenghar orchard of low density (Table –1).

**4.2 Vegetative growth parameters (Baramulla)**

The results of vegetative growth parameters in district Baramulla are presented in Table-2.

### 4.2.1 ANNUAL SHOOT GROWTH

The annual shoot growth of high density orchard was ranged from 42.34 cm to 58.63 cm with the mean value of 48.76 cm. Minimum annual shoot growth 42.34 cm was recorded in Kunan orchard and was at par with the values of 42.87 cm and 43.52 cm in orchards of Mirangund and Delena, respectively. The annual shoot growth of low density orchard (79.49 cm) of Chakula was significantly higher than all high density orchards (Table-2).

### 4.2.2 TREE TRUNK CIRCUMFERENCE

Significant differences were observed from high and low density orchards with regard to trunk circumference. As evident from Table-2 that maximum tree trunk circumference (28.90 cm) was recorded in low density orchards. However, maximum trunk circumference among the high density orchards was recorded in orchard of Ladoora (20.50 cm) and found statistically at par with all high density orchards which was at par with Kunan (18.20 cm).

### 4.2.3 TREE HEIGHT

Maximum tree height (302.00 cm) was recorded at low density orchard (Chakula). However, among high density orchards maximum tree height of 244. 00 cm was recorded at Ladoora followed by Delena (241.00 cm), Chakula (240.60 cm), Kunan (234.60 cm) and Mirangund (232.80 cm) and differences among high density orchards were non-significant (Table-2).

### 4.2.4 TREE VOLUME

Among the high density orchards the tree volume was varied from 2.15 to 2.82 $m^3$ and differences were non-significant. However, the tree volume at low density orchard of Chakula was 8.25 m3 which was significantly higher over the high density orchards.

### 4.2.5 AVERAGE NUMBER OF SPURS/TREE

As evident from Table-2, significantly variations were noted in the average number of spurs/tree among high and low density orchards. Data reveals that maximum number of spurs/tree (184.40) were recorded in low density orchard (Chakula) which was significantly higher over high density orchards. Among high density orchards maximum number of spurs/tree (138.80) were recorded in orchard of Delena and closely followed by Ladoora, Chakula and Mirangund with the values of 131.20, 128.60 and 126.80, respectively, and among these orchards the differences were non-significant.

### 4.3 Phenological characters (Pulwama)

Results of phenological characters in district Pulwama are presented in Table-3.

#### 4.3.1 1nitial bloom

The data presented in Table-3 indicate that initial bloom (10% flowering) at various high density apple orchards at different locations in Pulwama varied significantly with low density apple orchard. The days after reference date initial bloom among high density orchards were ranged from 41.24 to 42.83. The differences were non-significant in all high density orchards excepting orchard of Peerpora.

#### 4.3.2 Full bloom

Minimum days (44.42 DARD) for full bloom was noted in orchard or Naru and found at par with orchards of Malikpora (44.72 DARD), Safnagri (45.21 DARD) and Lajoora (45.58 DARD). Maximum days for full bloom (46.23 DARD) among high density orchards was recorded in orchard of Peerpora and found at par with the low density orchard of Tenghar (47.82 DARD) (Table-3)

#### 4.3.3 Petal fall

Days for petal fall among high density orchards was varied from 48.96 to 50..84 (DARD) with the mean value of 49.58 (DARD). Non-significant differences were recorded among all high density orchards with the minimum value excepting 50.84 days which were noted from orchard of Peerpora (Table-3). The days required for petal fall in low density orchard (52.87 DARD) were significantly higher from high density orchards.

#### 4.3.4 Fruit set

With regard to fruit set, all the high density orchards differed significantly from low density. Data in Table-3 reveal that earlier fruit set was attained in high density orchards than low density. Earliest fruit set was attained at Malikpora (51.18 DARD) followed by Safnagri, (52.78), Noru (52.57 DARD), Lajoora (52.78 DARD) and Peerpora (53.47 DARD) . However, low density orchard at

Tenghar required 55.84 days to attaining the pea sized fruits.

### 4.4 Phenological characters (Baramulla)

Results of phenological characters in district Baramulla are presented in Table-4.

#### 4.4.1 Initial bloom (10% flowering)

As is evident from Table-4 all the high density orchards varied significantly from low density with respect to initial bloom. Initial bloom was significantly late at low density orchard (44.31 DFRD) than all other high density orchards. However, initial bloom was much earlier at Delena (40.33 DARD), followed by Ladoora (40.63), Chakula (41.00 DARD), Mirangund (41.75 DARD) and Kunan (42.33 DARD)

#### 4.4.2 Full bloom (80-100 per cent flowering)

All the high density orchards differed significantly in respect of full bloom with low density orchard (Table-4). Data indicate that the full bloom appeared significantly late in low density orchard (48.55 DARD) than high density orchards. High density orchards, Delena initiated full bloom earlier (43.36 DARD) followed by Ladoora (43.51 DARD), Chakula (44.92 DARD) Mirangund (45.91 DARD) and Kunan (46.21 DARD). The differences among Delena, Ladoora and Chakula were non-significant for days required for full bloom.

#### 4.4.3 Petal fall (80-100%)

Table-4 indicates that petal fall (days after reference date) in various high density orchards varied significantly with low density orchard. At an average petal fall (53.10 DARD) in low density orchard was significantly as compared to high density orchards where petal fall initiated significantly with the mean value of 48.99 (DARD ) much earlier. Earliest petal fall was observed in orchard of Ladoora and closely followed by Delena and Chakula orchards.

#### 4.4.4 Fruit set

Significant difference was observed between high density orchards and low density orchard in respect of days required for fruit set. It is evident from Table-4 that all the high density orchards attained fruit set earlier than low density location. Minimum days for attaining for pea size were recorded in orchard of Ladoora (49.66 DARD) and differed non significantly with Chakula (50.28 DARD) ad Deelana (51.45 DARD).

### 4.5 Fruit production characters (Pulwama)

Results of fruit production characters in district Pulwama are presented in Table-5.

#### 4.5.1 Leaf/fruit ratio

Table-5 reveals that significant variations were noted in the leaf/fruit ratio between high and low density orchards at different locations in Pulwama district. Data depicts that higher number of leaves per fruit ratio (28.93) were recorded at low density orchard as compared to leaf/fruit ratio in high density orchards. Among high density orchards maximum leaf fruit ratio was recorded in orchard of Noru (25.24) closely followed by Lajoora (24.17), Malikpora (23.12) and Safnagri (22.13). Minimum leaf fruit ratio was recorded in orchard at Peerpora (21.78).

#### 4.5.2 Fruit retention at harvest

Significant variations in fruit retention at harvest between various high density orchards and low density orchard. The retention of fruits in high density orchards was varied form 68.83 to 64.94 per cent and differences among high density orchards were non-significant (Table-5). Duly 52.28 per cent fruit retention was recorded in low density orchard of Tenghar.

#### 4.5.3 Yield/tree

All high density orchards were found at par in case of yield per tree.

However, it varied from 10.72 (Peerpora) to 12.96 (Noru) kg/tree. The low density orchard produced maximum yield per tree i.e., 17.24 per tree which was significantly superior over high density orchards (Table-5).

### 4.5.4 Yield efficiency

Maximum yield efficiency (0.46) kg/cm$^2$ was observed in orchard of Lajoora and minimum (0.31 kg cm$^2$) was noted in Safnagri and Peerpora orchards. Non-significant differences were recorded in all high density orchards excepting Lajoora. The yield efficiency of low density orchard was significantly lower than Noru and Lajoora orchards (Table-5).

## 4.6 Fruit production characters (Baramulla)

Results of fruit production characters in district Baramulla are presented in Table-6.

### 4.6.1 Leaf/fruit ratio

It is evident from Table-6 that all the high density orchards varied significantly from low density orchard with respect to leaf fruit ratio. Low density exhibited maximum leaf/fruit ratio (32.17). Among the high density orchards minimum leaf fruit ratio (21.76) was recorded in orchard of Mirangund and maximum leaf/fruit ratio was (25.53) in orchard of Delena. All high density orchards differed non-significantly in respect of leaf/fruit ratio.

### 4.6.2 Fruit retention at harvest

Data presented in Table-6 indicates that higher fruit retention (72.67%) was recorded in high density orchard of Delena and minimum (64.28%) in Mirangund. All high density orchards were found at par with Mirangund, except orchard of Delena. In case of fruit retention, high density orchards were significantly superior over low density orchard.

### 4.6.3 Yield/tree

Among the high density orchards yield per tree was varied from 9.45

(Mirangund) to 17.12 kg (Delena) with the mean of 12.36 kg. All high density orchards were statistically at par with orchard of Mirangund excluding orchard of Delena. However, Chakula (low density orchard) produced more yield/tree (18.93 kg) and found superior over high density orchards of Kunan, Chakula and Mirangund (Table06).

### 4.6.4 Yield efficiency

The yield efficiency of high density orchards was ranged 0.31 to 0.52 kg/cm2. High density orchard of Chakula recorded minimum yield efficiency among high density orchards. And non-significant differences were observed with Ladoora, Mirangund and Kunan. Low density orchard at Chakula recorded yield efficiency of 0.28 kg per cm2 which was at par with high density orchards except Delena orchard (Table-6).

## 4.7 Fruit physical characters (Pulwama)

Results of fruit physical characters in district Pulwama are presented in Table 7.

### 4.7.1 Fruit length

Among the high density orchards, fruit length was ranged from 61.12 (Noru)to 62.89 mm (Lajoora) with mean of 61.89 mm. However, Tenghar (low density orchard) showed fruit length of 57.23 mm which was significantly lesser than all the high density orchards (Table-7).

### 4.7.2 Fruit diameter

Fruit diameter of high density orchards were varied 67.27 to 70.28 mm. High density orchard Noru produced minimum fruit diameter among high density orchards and non-significant differences were observed with Malikpora, Safanagri and Peerpora. Low density at Tenghar produced fruit diameter of 66.92 mm which was significantly lesser than high density orchards except Noru (Table-7).

### 4.7.3 Fruit length/diameter ratio

High density orchards were found at par except Malikpora in case of fruit length diameter ratio. However, it varied from 0.89 to 0.91 mm. Minimum frit length/diameter ratio i.e., 0.85 mm was recorded in the fruit samples of low density orchard (Tenghar) which was significantly lower than all the high density orchards (Table-7).

### 4.7.4 Fruit colour

Significant variations were recorded in fruit colour of fruit samples of various high density orchards and low density orchard in Pulwama. From Table-7, it is evident that maximum fruit colour awarded to fruit samples of high density orchards locations while as minimum colour scores were awarded to fruit samples of low density orchard. However, high density orchards, Peerpora recorded with highest colour rating (3.84%) followed by Malikpora (3.72%), Noru (3.48%), Lajoora (3.45%) and Safnagri (3.40%) as compared to low density orchard of Tenghar (2.84%).

### 4.7.5 Fruit firmness

Data in Table-7 depict, significant differences between the high density orchards and low density orchard with respect to fruit firmness. However, high density orchards yielded more firmer fruits than low density orchard. Maximum fruit firmness was noted from the fruits of high density orchards, viz., Lajoora (20.28 lb/inch$^2$), Malikpora (21.01 lb/inch$^2$), Noru (21.99 l/b inch2), Safnagri (21.15 lb/inch$^2$) and Peerpora (21.26 lb/inch2) while as the fruits of the low density orchard showed the least firmness i.e., 20. 03 lb/inch$^2$.

## 4.8 Fruit physical characters (Baramulla)

Results of on fruit physical characters in district Baramulla are presented in Table-8.

### 4.8.1 Fruit length

Among high density orchards the fruit length was ranged from 60.49 (Kunan) to 61.96 mm (Ladoora). The significantly longer fruits were produced by high density orchards than low density orchard were this value was only 54.32 mm (Table-8).

### 4.8.2 Fruit diameter

Significant differences were observed in fruit diameter of various high density orchards from low density orchard in district Baramulla. It is evident from Table 8 higher fruit diameter was observed in high density ochards. The fruit diameter of high density orchards was noted between 67.00 to 68.94 mm while as the low density orchard produced fruits with the diameter of 66.23 mm.

### 4.8.3 Fruit length/diameter ratio

Among high density orchard fruit length diameter ratio was ranged from 0.89 to 0.90 mm and the range was significantly differed with low density orchard (Table 8). Maximum fruit length diameter ratio was observed in the fruit samples of high density orchard, viz., Mirangund (0.90 mm) and minimum fruit length diameter ratio was recorded in the fruit samples of low density orchard Chakula (0.82 mm).

### 4.8.4 Fruit colour

Significant differences were found between the high density orchard and low density orchard with respect to fruit colour. The mean overall red colour of fruits under high density orchard was greater than in low density orchard. The fruit colour rating of high density orchards varied from 2.85 to 3.02 while as least red colour intensity (2.67) was observed at L.D. orchard of Chakula (Table-8).

### 4.8.5 Fruit firmness

Data in Table-8 depict significant differences existed between the high density orchards and low density orchard with respect to fruit firmness. However,

high density orchards yielded more firmer fruits than the fruits of the high density orchards fruit firmness was observed from the fruits of high density orchards, viz., Delena, Ladoora, Chakula, Mirgund and Kunan with the values of 20.15, 21.56, 20.22, 20.27 and 20.35 lb/inch$^2$, respectively as compared to low density orchard, Chakula where this value was only 19.99 lb inch$^2$.

### 4.9 Fruit chemical characters (Pulwama)

Results on chemical characters of fruits n district Pulwama are presented in Table-9.

#### 4.9.1 T.S.S.

Significant differences were observed between various high density orchards and low density orchard with regard to their effect on total soluble solids. As evident from Table-9, an average higher content of total soluble solids were recorded in the fruits of high density orchards than low density orchard. Higher soluble solid content of 12.80, 12.40, 12.00, 10.70, and 10.60 and $^o$Brix were recorded at Peerpora, Noru, Lajoora, Safnagri and Malikpora, respectively which were significantly higher than low density orchard of Tenghar. Where TSS content in fruits was only 10.40 $^o$Brix.

#### 4.9.2 Reducing sugars

The reducing sugars in fruits of high density orchards was varied significantly from low density orchard. It is evident from Table-9, high density orchards recorded higher reducing sugar content in fruits with the values of 6.22, 6.14, 5.82, 5.82, 5.70 per cent in orchards of (Peerpora , Noru, Lajoora, Safnagri and Malikpora respectively). However, the reducing sugar content of fruits from low density orchard of Tenghar was only 5.28 per cent.

#### 4.9.3 Total sugars

The total sugar content in fruits of high density orchards was varied from 8.75 to 7.85 per cent. Maximum total sugar content was noted in fruits of

Peerpora followed by Noru (8.56%) and Lajoora (8.1%) while as only 7.36 per cent sugar content was recorded in fruits of low density orchard.

### 4.9.4 Fruit acidity

Significant variations in the acid content of apple samples in high density orchards and low density orchard were recorded (Table-9). Maximum acid content was recorded in low density orchard, which was significantly higher than the acid contents recorded in the fruits of high density orchards. At Tenghar (low density orchard.) acid content of 0.21 per cent was recorded which was significantly more than acid content of high density orchards, Lajoora, (0.16%) Malikpora (0.18%) Noru (0.14%) Safanagri (0.17%) and Peerpora (0.41%).

## 4.10 Fruit chemical characters (Baramulla)

Results of fruit physio-chemical characters in district Baramulla are presented in Table-10.

### 4.10.1 T.S.S.

Significant differences were observed between fruits from high density orchards and fruits of low density orchard with regard to their effect on total soluble solids. As evident from Table-10, at an average higher content of total soluble solids were recorded in the fruit samples of high density orchards as compared to low density orchard. Maximum total soluble solids content of 12.10 $^{o}$Brix was recorded from of Kunan orchard followed by 12.00 $^{o}$Brix (Ladoora), 11.60 $^{o}$Brix (Delena), 11.10 $^{o}$Brix (Chakula) and 11.00 $^{o}$Brix (Mirangund). While as only 10.10 $^{o}$Brix TSS was obtained from the fruits of low density orchard of Chakula.

### 4.10. 2 Reducing sugars

Perusal of Table-12 reveal that reducing sugars of high density orchards varied from 5.49 to 5.99 per cent. Maximum reducing sugars noted from orchard

of Kunan followed by Ladoora (5.79%), Delena (5.71%) and Mirangun (5.80%). Low density orchard of Chakula recorded on 5.21 per cent reducing sugars (Table-10).

### 4.10.3 Total sugars

As evident from Table-10, significance variations were recorded in total sugars of various apple high density orchards with low density orchard. Data reveal that total sugar content in the fruits of high density orchards was significantly higher than sugar content recorded in the fruits of low density orchard. In the high density orchards maximum sugar content (8.14%) was recorded in orchard of Kunan followed by Ladoora, Delena, Chakula and Mirangund (8.14, 8.00, 7.85, 7.47 and 7.41 respectively).

### 4.10.4 Fruit acidity

Significant variation in the acid content of various apple high density orchards and low density orchard were recorded. Data presented in Table-10 reveal that higher acid content was recorded in the low density orchard, which was significantly higher than the acid contents recorded at high density orchards. Low density orchard, Chakula recorded acid content of 0.21 per cent which was significantly more than acid content of high density orchards, Delena (0.19%), Ladooura (0.17%), Chakula (0.19%), Mirangund (0.20%), and Kunan (0.16%).

## 4.11 Foliar N,P,K and Ca status (Pulwama)

Results of foliar NPK status in district Pulwama are presented in Table-11.

### 4.11.1 N content

Significant differences were observed in the foliar N content of the high density orchards and low density orchards. Foliar N, content of high density orchards ranged between 2.46 to 2.85 per cent. While as the foliar N concentration of superior of low density orchard of Tenghar was 3.04 per cent which was significantly superior over high density orchards (Table-11).

### 4.11.2 P content

Significant differences in the P content were observed in response to various high density orchards and low density orchard. However, higher leaf P content were observed in high density orchards, ranged from 0.24 to 0.26 per cent. The low density orchard of Tenghar recorded foliar P content of 0.22 per cent (Table – 11).

### 4.11.3 K content

The maximum foliar K content was noted in Lajoora orchard (1.44%) followed by Malikpora (1.37%) and Safnagri (1.34%). Among the high density orchards minimum foliar K content was recorded from orchard of Noru (0.92%). However, only 0.84 per cent K content was noted from Tenghar orchard which is low density orchard (Table-11).

### 4.11.4 Ca content

Table-11 reveals that significant differences exhibited between high density orchards and low density orchard with respect to leaf calcium content. In high density orchards foliar calcium content was varied from 1.33 per cent in Safnagri to 1.22 per cent in orchard of Peerpora. Only 0.93 per cent calcium content in leaves was noted from low density orchard.

## 4.12 Foliar N, P, K and Ca status (Baramulla)

Results of foliar N, P, K and Ca status in district Baramulla are presented in Table-12.

### 4.12.1 N content

Significant differences in the leaf N content existed between the high density orchards and low density orchard. The leaf N content from high density orchards were 2.42, 2.54, 2.57, 2.35 and 2.44 per cent in orchards of Delena, Ladoora, Chakula, Mirangund and Kunan, respectively. While as higher leaf N contents was recorded at LDP locations. The N content of Chakula (2.92%) orchard was significantly higher than high density orchards (Table-12).

### 4.12.2 P content

Significant differences in the leaf P content were in response to high density orchards (Table-12). Higher leaf P contents were recorded in high density orchards viz., Delena (0.27%), Ladoora, (0.25%) , Chakula (0.277%), Mirangund (0.23%) and Kunan (0.26%) as compared to low density orchard of Chakula (0.20%).

### 4.12.3 K content

Maximum K content i.e., 1.43 per cent was estimated in Ladoora orchard and minimum i.e., 0.94 per cent was recorded from orchard of Kunan. The content of K in leaves was in low density orchard of Chakula i.e., 0.87 per cent which was significantly lower than high density orchards (Table-12).

### 4.12.4 Ca content

Table-12 reveals that significant differences were noted between high density orchards and low density orchard with respect to leaf calcium content. In high density orchards, calcium content was ranged between 0.98 in Delena to 1.18 per cent in Ladoora. In low density orchard of Chakula only 0.87 per cent calcium leaf content was estimated.

## 4.13 INTER-DISTRICT COMPARISON OF HIGH DENSITY ORCHARDS

### *4.13.1 Vegetative growth parameters*

Two district different non-significantly with regard to various vegetative growth parameters (Table-13). Higher annual shoot growth (48.76 cm) was recorded in Baramulla than in Pulwama (48.65 cm). Tree trunk circumference was greater in Pulwama (20.13 cm) than in Baramulla (19.54 cm). However, tree height was more in Baramulla (244.52 cm) than Pulwama (238.60 cm). Tree volume was more in Baramulla (2.59 $m^3$) as compared to Pulwama (2.35 $m^3$). Higher average number of spurs per tree (129.80) was recorded in Baramulla than in Pulwama (123.08) (Fig.-1).

### 4.13.2 Phenological characters

Phenological characters viz., initial bloom, full bloom, petal fall and fruit set at pea stage recorded under the present study did not differed significantly in both the districts (Table-14). Pulwama attained the initial bloom stage in 41.82 days after the reference date while as in Baramulla this stage was reached a little earlier (41.20 days). Baramulla attained full blooming stage little earlier (44.78 DARD) as compared to Pulwama (45.23 DARD). However, in Pulwama, petal fall occurred 49.58 days after the reference date than in Baramulla, where it occurred after 48.99 days. The time taken for fruit set at pea stage was 52.43 DARD in Pulwama and 51.48 DARD in Baramulla (Fig-2).

### 4.13.3 Fruit production characters

Non-significant differences existed between two districts with respect to fruit production characters recorded (Table-15). There were under present study 23.28 leaves per fruit in Pulwama while as 23.25 leaves/fruit were recorded in Baramulla. Higher retention (67.79 %) was recorded in Baramulla as compared to Pulwama (66.72%). Maximum yield of 12.36 kg/tree was recorded in Baramulla while as minimum yield of 11.81 kg/tree was recorded in Pulwama. However, higher yield efficiency (0.39 kg/$cm^2$) was noted in Baramulla as compared to Pulwama (0.36 kg/$cm^2$) (Fig-3).

### 4.13.4 Fruit physical characters

It is evident from Table-16 that both the districts differed non-significant with respect to fruit physical characteristics except fruit colour. Fruit length and diameter were higher in Pulwama (61.89 and 68.63 mm) than in Baramulla (61.34 mm and 68.38 mm). However, fruit length/diameter ratio was same (0.89) in both the districts. Higher fruit firmness (21.13 lbs./$inch^2$) was recorded in Pulwama than Baramulla (20.51 lbs.$inch^2$). Significantly more fruit colour (3.57 %) was recorded in Pulwama than Baramulla (2.93 %) (Fig-4) .

### 4.13.5 Fruit chemical characters

Both the districts were differed significantly with respect to fruit chemical characteristics except reducing sugars. Slightly higher TSS (11.70 $^{o}$Brix) was found in Pulwama than in Baramulla (11.56 $^{o}$Brix). Lower acidity (0.15%) was recorded in Pulwama than Baramulla (0.18%). However, higher reducing sugar content (5.94%) was recorded in Pulwama than Baramulla (5.69%). Significantly higher total sugar content was recorded in Pulwama (8.22%) than Baramulla (7.77%) (Table-17 & Fig-5).

**4.13.6 Foliar N, P, K and Ca status**

No significant differences in the leaf N, P, K. and Ca contents existed between the two districts (Table-18). However, the leaf N content was higher (2.68 %) in Pulwama than Baramulla (2.46%). Leaf phosphorus content was same (0.25%) in both the districts. Leaf K and Ca contents were higher in Pulwama (1.20 and 1.21%) than in Baramulla (1.18 and 1.14 %) (Fig-6).

**Chapter – 5**

# DISCUSSION

High density planting has been an important role in increasing productivity and earlier yields. Increasing planting density represents a powerful tool to increase fruit yield and orchard efficiency. In the Netherlands at present, apple orchards are fully productive from the fifth growing year and start yielding even in the second year. Much attention has been given to controlling the balance between growth and fruit production in high density plantings. Although dwarfing rootstock are of prime importance for controlling growth, cultural techniques such as pruning and orchard design also have an influence in tree development. The economics of apple productive have encouraged the widespread adoption of high density planting in the past two decades. Relative to large trees, dwarf trees have a great proportion of well-illuminated canopy, lower pesticide requirement, and higher labour efficiency. High density systems have, therefore, steadily increased in popularity where small family farms are the rule. Dwarfing root stock such as M9 also increase the proportion of harvested plant yield (Lakso *et al*., 1999, Wagenmakers, 1991a).

## 5.1 Vegetative growth characters

The data resulted with vegetative growth parameters of high density orchards in Pulwama and Baramulla districts or presented in Table-1 & 2. The significant difference were recorded among the high density orchards of district Pulwama in respect to annual shoot growth, tree trunk circumference, tree height and average number of spurs/tree. However, non significant different were noted in case of tree volume. Maximum tree trunk circumference (21.20 cm), tree height (258.20 cm) and tree volume (2.64 $m^3$) were noted in high density orchards of Malikpora and Safnagri. However, maximum annual shoot growth (57.53 cm) and average number of spurs/tree (133.40) were noted in orchards of Malikpora and Lajoora, respectively. Higher values for each and every parameters, maximum

values were noted from low density orchard. The differences between high density orchards and low density orchards were significant. The same pattern was followed in case of district Baramulla. Again among high density orchards significant difference were noted and maximum values in relation to vegetative growth characters was again observed in low density orchards. Reduction in growth parameters was noted in apple trees planted at higher densities (Lorete *et al*., 1978). An adverse effect of dense planting on tree growth was noted by (Holubowicz ,1981). The trunk girth differed significantly at the two locations (Callesen and Wagenmakers, 1989). Zimmerman and Steffens (1995) concluded that the growth increase in response to greater space availability and constriction by close spacing in apple. Non-significant differences were noted in all vegetative growth parameters when two districts were compared (Table-13).

### 5.2 Phenological characters

It is clear from the data of Table 3 and 4 that significant differences were noted when comparison was made among high density orchards in respect to days required for initial bloom, full bloom, petal fall and attaining a P stage fruits. However, in both the districts earliness was recorded for initial bloom, full bloom, petal fall and fruit set in high density orchards when comparison was made with low density orchards. When comparison was made between high density of both the districts in relation to days required for various phonological stages, non-significant differences were obtained (Table-14). Plants under high density plantation tend to bloom and set fruit earlier than low density, due to greater light interception and comparatively higher temperature in dense planting (Predescu *et al.,* 1977).

### 5.3 Productive characters

The data presented in Table 5 & 6 related to production characters such as leaf-fruit ratio, fruit retention at harvest, yield per tree and yield efficiency revealed that differences were noted among high density orchards of both the

districts. High leaf-fruit ratio and yield per tree was noted in low density orchards of both the districts over high density orchards. While as significantly more fruit retention at harvest and yield efficiency was noted in high density orchards. However, non-significant differences were noted when high density orchards of districts of Pulwama and Baramulla were compared (Table-15). Afafonov *et al*. (1979) recorded better fruit set and yield under high density orchards. The increasing planting densities resulted in decreased yield per tree but increased yield per hectare. Costa *et al*. (1997) concluded that high and medium density planting system performed better than low density when evaluation was made apple yield under high density systems.

### 5.4 Fruit physical characters

Fruit length, diameter and length diameter ratio showed higher values in case of high density plantation, though the high density orchards among themselves differed non-significantly (Table-16). The fruit colour difference better the orchards under low density plantation and high density plantation were compared. Plants under high density plantation produced between coloured fruit than those under low density plantation. Though the high density plantation orchards, among themselves showed a statistically invalid variation but fruit at Pulwama were redder than those at Baramulla, which might be due to cooler night temperatures in the former district. These results are in agreement with those obtained by Crassweller *et al*. (1991) for StarKrimson and Red Spur. Greater light interception as a result of heavier pruning and small size may be attributed to the rich colour of high density plantation fruits. With regard to fruit firmness at maturity, the difference between the low density plantation and high density plantation were significant. However, location had no influence on fruit firmness. These results confirm the reports by Thybo *et al*. (2005). Higher fruit firmness under high density plantation may be due to higher percentage of soluble solids.

### 5.5 Fruit chemical characters and foliar N, P, K and Ca contents

The TSS of the fruit at harvest in high density plantation proved be significantly superior to that of the fruit under low density planting. However, the variations between the two district were non-significant. Callesen (1983) also reported a higher percentage of TSS for 'Spartan' apple with more than 75 per cent red blush. Greater penetration of photoradiations in high density plantation may explain the higher percentage of TSS in them. A comparison of low density orchard with high density orchards showed that the fruit from the latter had higher total sugars. However, the values obtained at Pulwama differed significantly from those at Baramulla. Higher sugar content in high density plantation can be explained by faster formation of sugars from starch due to greater penetration of radiation. Significant variations were recorded in the acidity of fruit from lower and higher density plantations. Low density orchards were found to have more acidic fruit than high density orchards. Drake *et al*. (2001) reported similar results from his experiment on various strains of Delicious apple. Slower conversion of starch into sugar due to greater shading in low density plantation can be attributed to greater acidity in low density plantation fruit. Spacing had a significant effect on leaf mineral composition. Leaves, from the wider spaced trees had more N but lesser P, K and Ca contents. However, the locations had no effect on leaf mineral composition. Wider spacing trees being vigorous assimilate greater amounts of N but lesser amounts of P, K and Ca.

**Chapter – 6**

# SUMMARY AND CONCLUSION

The present investigation entitled " Studies on productive behaviour of apple cultivar StarKrimson under high density plantation system" was carried out in Pulwama and Baramulla districts during 2005-06. Seven-year-old apple cultivar, StarKrimson on MM106 of uniform size and vigour was taken to study for various growth and reproductive characters. The data on various vegetative, phenolgoical reproductive, fruit quality parameters and leaf mineral composition were noted. The leaf samples were collected during 1$^{st}$ week of August and analysed for N, P, K and Ca content while as fruit was harvested during 1$^{st}$ week of September and analysed for different physico-chemical characters.

1) Annual shoot growth of high density orchards ranged from 42.45 to 57.53 and 42.34 to 58.63 cm in Pulwama and Baramulla, respectively. However, the significantly higher growth was observed in low density orchard of Pulwama (74.73 cm) and Baramulla (79.45 cm).

2) Highest tree trunk circumference of 29.20 and 28.90 cm was recorded in low density orchards of Pulwama and Baramulla districts respectively, while as, lowest mean values of tree trunk circumference of 20.13 and 19.54 cm was observed in high density orchards of both the districts.

3) Maximum plant height of 313.20 and 302.00 cm was observed in plants under low density orchards of two districts which was significantly higher than all high density orchards. Minimum plant height of 244.52 and 238.60 cm was observed in high density orchards of the two districts.

4) Highest tree volume (9.16 and 8.25 $m^3$) was exhibited by plants under low density plantation. However, plants under high density plantation

showed lowest tree volume of 2.35 and 2.59 $m^3$ in Pulwama and Baramulla districts respectively.

5) Overall average number of spurs per tree was higher i.e., 172.20 and 184.40 in low density orchards of two districts than high density orchards i.e., 123.08 and 129.80.

6) Earliest initial blooming at 41.82 and 41.20 DARD was recorded in plants under high density plantation, while as initial blooming was significantly delayed in plants under low density plantation i.e., 44.13 and 44.31 DARD.

7) Full bloom stage was significantly delayed (47.82 and 48.55 DARD) by plants under low density plantation, while as, plants under high density plantation resulted in earliest attainment of this stage at 45.23 and 44.78 DARD in Pulwama and Baramulla districts respectively.

8) High density plantation resulted in early petal fall at 49.58 and 48.99 DARD. Petal fall stage was significantly delayed ( 52.87 and 53.10 DARD) in plants under low density plantation.

9) Earliest fruit set at 52.43 and 51.48 DARD was observed in plants under high density plantation, while as the fruit set was much delayed at 55.84 and 57.94 DARD in the plants under low density plantation in two districts.

10) Highest leaf-fruit ratio (28..93 and 32.17) was recorded in low density plantation while as lowest leaf-fruit ratio (23.28 and 23.25) was observed in plants under high density plantation.

11) Fruit retention was maximum (67.72 and 67.79%) in plants under high density plantation in two districts while as lowest fruit retention at harvest (52.28 and 54.43%) was recorded in low density plantation in both the districts.

12) Highest average yield/tree (17.24 and 18.93 Kg) was recorded in plants under low density plantation while as the least yield (11.81 and 12.36 kg ) was found on trees under high density plantation in Pulwama and Baramulla districts

13) Highest yield efficiency (0.36 and 0.39 kg/$cm^2$) was recorded in high density plantation while as lowest yield efficiency (0.25 and 0.28 kg $cm^2$) was observed in plants under low density plantation in both the districts.

14) Highest fruit length of 61.89 mm and 61.34 mm was measured in plants under high density plantation while as low density plantation resulted in lowest fruit length (57.23 mm and 54.32 mm) in two districts.

15) Highest fruit diameter of 68.63 mm and 68.38 mm was recorded in plants of the high density orchards in Pulwama and Baramulla respectively. While as, lowest fruit diameter (66.92 mm and 66.23 mm) was recorded in plants under low density plantation.

16) Highest fruit length-diameter ratio (0.89 and 0.89 mm) was recorded in the fruits harvest from plants under high density plantation in both the two districts, while as, lowest fruit length-diameter ratio (0.85 mm and 0.82) ratio was recorded in the fruit samples of low density plantation in Pulwama and Baramulla respectively.

17) Fruit samples from high density plantation were observed to have highest colour intensity (3.57 and 2.93 on a 4 point scale) while as least red colour intensity (2.84 and 2.67/4) was recorded in the fruits of trees under low density plantation in two districts.

18) Firmest fruits (21.13 and 20.51 lbs./$inch^2$) were seen on plants under high density plantation while as the trees under low density plantation yielded the least firm fruits (20.03 and 19.99 lbs./$inch^2$).

19) Highest TSS of 11.66 and 11.56 $^{o}$Brix was recorded in fruits of plants under high density plantation while as lowest TSS (l10.60 and 10.10 $^{o}$Brix) was observed in fruits of trees under low density plantation in Pulwama and Baramulla districts.

20) Reducing sugar percentage of 5.94 and 5.69 was observed in fruits of plants under high density plantation while as the lowest mean value of reducing sugar percentage (5.28 and 5.21) was seen in plants under low density plantation.

21) Highest content of total sugars (8.22 and 7.77 %) was observed in fruits of plants under high density plantation, while as lowest value of total sugar (7.36 and 7.34) was recorded in fruits of plants under low density plantation.

22) Most acidic fruits (0.21 and 0.21 %) was recorded under low density plantation, while as least acidic fruits (0.15 and 0.18 %) were found on trees under high density plantation in two districts.

23) Highest leaf N content of 3.04 and 2.92 % was observed in plants under low density plantation while as the least value (2.68 and 2.46 %) was seen in plants under high density plantation in two districts.

24) Plants exhibited the highest leaf P concentration (0.25 and 0.25 .%) while as the lowest leaf P concentration (0.22 and 0.20 %) was observed in plants under low density plantation.

25) Leaves of plants under high density plantation have maximum K concentration i.e., 1.20 and 1.18 % while as, the lowest leaf K concentration (0.84 and 0.87 %) was observed in plants under low density plantation

26) Highest leaf Ca content of 1.21 and 1.14 % was observed in plants under high density plantation while as the least value (0.93 and 0.87

%) was observed in plants under low density plantation in both districts.

## Conclusion

On the basis of experimental findings it was found that the vegetative growth characters significantly differed among high density orchards in both the districts except tree volume and higher values were recorded in low density orchards. The early blooming and fruit set was recorded in high density orchards. The superior yield efficiency and quality fruits were obtained from high density orchards, however, yield per tree was more in low density orchards. The more N foliar content was noted in low density orchards of both the districts. While as P, K and Ca content was more in high density orchards. Non-significant differences were noted when the high density orchards of Pulwama and Baramulla were compared.

**Table 1. Effect of locations on vegetative growth characters in apple cv. StarKrimson in district Pulwama**

| LOCATIONS | Annual shoot growth (cm) | Tree trunk circumference (cm) | Tree height (cm) | Tree volume ($m^3$) | Av. No. of spurs/tree |
|---|---|---|---|---|---|
| Lajoora | 42.45 | 18.20 | 252.40 | 2.62 | 133.40 |
| Malikpora | 57.53 | 19.58 | 240.40 | 2.15 | 118.40 |
| Noru | 56.87 | 21.10 | 248.00 | 2.17 | 126.00 |
| Safnagri | 43.52 | 21.20 | 258.20 | 2.64 | 123.40 |
| Peerpora | 42.88 | 20.60 | 223.60 | 2.19 | 114.20 |
| **MEAN** | **48.65** | **20.13** | **244.52** | **2.35** | **123.08** |
| [c] Tenghar | 74.73 | 29.20 | 313.20 | 9.16 | 172.20 |
| **lsd $_{(0.05)}$** | **2.28** | **2.55** | **14.34** | **2.02** | **13.87** |
| **± S.E. of mean diff.** | **1.08** | **0.91** | **5.28** | **0.73** | **4.60** |

[c] check (low density)

**Table 2. Effect of locations on vegetative growth characters in apple cv. StarKrimson in district Baramulla**

| Locations | Annual shoot growth (cm) | Tree trunk circumference (cm) | Tree height (cm) | Tree volume ($m^3$) | Av. No. of spurs/tree |
|---|---|---|---|---|---|
| Delena | 43.52 | 20.20 | 241.00 | 2.82 | 138.80 |
| Ladoora | 56.47 | 20.50 | 244.00 | 2.68 | 131.20 |
| Chakula | 58.63 | 19.80 | 240.60 | 2.69 | 128.60 |
| Mirangund | 42.87 | 19.00 | 232.80 | 2.15 | 126.80 |
| Kunan | 42.34 | 18.20 | 234.60 | 2.62 | 123.60 |
| **Mean** | **48.76** | **19.54** | **238.60** | **2.59** | **129.80** |
| [c] Chakula | 79.45 | 28.90 | 302.00 | 8.25 | 184.40 |
| **lsd $_{(0.05)}$** | **3.34** | **2.14** | **13.43** | **1.86** | **12.57** |
| **± S.E. of mean diff.** | **1.13** | **0.77** | **5.17** | **0.68** | **4.22** |

[c] check (low density)

**Table 3. Effect of locations on phenological characters in apple cv. StarKrimson in district Pulwama**

| Locations | Initial-bloom (10% flowering) (*DARD) | Full-bloom (80-100% flowering) (*DARD) | Petal-fall (80-100%) (*DARD) | Fruit-set (Pea-stage) (*DARD) |
|---|---|---|---|---|
| Lajoora | 41.24 | 45.58 | 49.45 | 52.78 |
| Malikpora | 41.93 | 44.72 | 48.96 | 51.18 |
| Noru | 41.85 | 44.42 | 49.35 | 52.57 |
| Safnagri | 41.26 | 45.21 | 49.33 | 52.17 |
| Peerpora | 42.83 | 46.23 | 50.84 | 53.47 |
| **Mean** | **41.82** | **45.23** | **49.58** | **52.43** |
| [c] Tenghar | 44.13 | 47.82 | 52.87 | 55.84 |
| **lsd (0.05)** | **1.06** | **1.53** | **1.15** | **1.38** |
| **± S.E. of mean diff.** | **0.38** | **0.55** | **0.41** | **0.49** |

* DARD : Days after reference date (1st March 2006)
[c] : check (low density)

**Table 4. Effect of locations on phenological characters in apple cv. StarKrimson in district Baramulla**

| LOCATIONS | Initial-bloom (10% flowering) (*DARD) | Full-bloom (80-100% flowering) (*DARD) | Petal fall (80-100%) (*DARD) | Fruit-set (pea-stage) (*DARD) |
|---|---|---|---|---|
| Delena | 40.33 | 43.36 | 48.51 | 51.45 |
| Ladoora | 40.63 | 43.51 | 47.38 | 49.66 |
| Chakula | 41.00 | 44.92 | 48.64 | 50.28 |
| Mirangund | 41.75 | 45.91 | 50.27 | 52.22 |
| Kunan | 42.33 | 46.21 | 50. 19 | 53.83 |

| | | | | |
|---|---|---|---|---|
| **MEAN** | **41.20** | **44.78** | **48.99** | **51.48** |
| [c] Chakula | 44.31 | 48.55 | 53.10 | 57.94 |
| **lsd $_{(0.05)}$** | **0.91** | **2.27** | **1.36** | **1.90** |
| **± S.E. of mean diff.** | **0.33** | **0.78** | **0.48** | **0.66** |

* DARD : Days after reference date (1st March 2006)
[c] : check (low density)

**Table 5 . Effect of locations on fruit production characters in apple cv. StarKrimson in district Pulwama**

| Locations | Leaf/fruit ratio | Fruit retention at harvest (%) | Yield/tree (kg) | Yield efficiency (kg/cm$^2$) |
|---|---|---|---|---|
| Lajoora | 24.17 | 67.54 | 12.28 | 0.46 |
| Malikpora | 23.12 | 66.37 | 10.93 | 0.35 |
| Noru | 25.24 | 68.83 | 13.96 | 0.40 |

| | | | | |
|---|---|---|---|---|
| Safnagri | 22.13 | 65.96 | 11.18 | 0.31 |
| Peerpora | 21.78 | 64.94 | 10.72 | 0.31 |
| **Mean** | **23.28** | **66.72** | **11.81** | **0.36** |
| [c] Tenghar | 28.93 | 52.28 | 17.24 | 0.25 |
| **lsd $_{(0.05)}$** | **3.41** | **6.15** | **5.34** | **0.14** |
| **± S.E. of mean diff.** | **1.23** | **2.21** | **1.92** | **0.05** |

[c] : check (low density)

**Table 6. Effect of locations on fruit production characters in apple cv. StarKrimson in district Baramulla**

| LOCATIONS | Leaf/fruit ratio | Fruit retention at harvest (%) | Yield/tree (kg) | Yield efficiency (kg/cm$^2$) |
|---|---|---|---|---|
| Delena | 24.53 | 72.67 | 17.12 | 0.52 |
| Ladoora | 24.32 | 70.22 | 14.34 | 0.42 |
| Chakula | 22.37 | 64.67 | 9.93 | 0.31 |
| Mirangund | 21.76 | 64.28 | 9.45 | 0.32 |
| Kunan | 23.28 | 67.12 | 10.96 | 0.41 |
| **Mean** | **23.25** | **67.79** | **12.36** | **0.39** |
| [c] Chakula | 32.17 | 54.43 | 18.93 | 0.28 |
| **lsd $_{(0.05)}$** | **3.56** | **6.81** | **5.43** | **0.17** |
| **± S.E of mean diff.** | **1.28** | **2.43** | **1.95** | **0.06** |

[c] : check (low density)

**Table 7. Effect of locations on fruit physical characters in apple cv. StarKrimson in district Pulwama**

| Locations | Fruit length (mm) | Fruit diameter (mm) | Fruit length/diameter ratio | Fruit colour (1-4 scale) | Fruit firmness (lbs./inch$^2$) |
|---|---|---|---|---|---|
| Lajoora | 62.89 | 70.28 | 0.89 | 3.45 | 20.28 |

| | | | | | |
|---|---|---|---|---|---|
| Malikpora | 62.38 | 68.35 | 0.91 | 3.72 | 21.01 |
| Noru | 61.12 | 67.27 | 0.90 | 3.48 | 21.99 |
| Safnagri | 61.79 | 68.75 | 0.89 | 3.40 | 21.15 |
| Peerpora | 61.31 | 68.50 | 0.89 | 3.84 | 21.26 |
| **Mean** | **61.89** | **68.63** | **0.89** | **3.57** | **21.13** |
| [c] Tenghar | 57.23 | 66.92 | 0.85 | 2.84 | 20.03 |
| **lsd $_{(0.05)}$** | **1.22** | **1.85** | **0.02** | **0.26** | **1.09** |
| **± S.E. of mean diff.** | **0.43** | **0.66** | **0.01** | **0.09** | **0.39** |

[c] : check (low density)

**Table 8. Effect of locations on fruit physical characters in apple cv. StarKrimson in district Baramulla**

| LOCATIONS | Fruit length (mm) | Fruit diameter (mm) | Fruit length/diameter ratio | Fruit colour (1-4 scale) | Fruit firmness (lbs./ Inch$^2$) |
|---|---|---|---|---|---|
| Delena | 61.02 | 68.29 | 0.89 | 2.95 | 20.15 |

| | | | | | |
|---|---|---|---|---|---|
| Ladoora | 61.96 | 68.94 | 0.89 | 2.93 | 21.56 |
| Chakula | 61.29 | 68.39 | 0.89 | 2.85 | 20.22 |
| Mirangund | 61.94 | 68.70 | 0.90 | 2.94 | 20.27 |
| Kunan | 60.49 | 67.60 | 0.89 | 3.02 | 20.35 |
| **Mean** | **61.34** | **68.38** | **0.89** | **2.93** | **20.51** |
| [c] Chakula | 54.32 | 66.23 | 0.82 | 2.67 | 19.99 |
| **lsd $_{(0.05)}$** | **1.76** | **1.58** | **0.05** | **0.20** | **1.03** |
| **± S.E. of mean diff.** | **0.61** | **0.57** | **0.02** | **0.07** | **0.37** |

[c] : check (low density)

**Table 9. Effect of locations on fruit chemical characters in apple cv. StarKrimson in district Pulwama**

| Locations | T.S.S ($^{o}$Brix) | Fruit acidity (%) | Reducing sugars (%) | Total sugars (%) |
|---|---|---|---|---|
| Lajoora | 12.00 | 0.16 | 5.82 | 8.14 |
| Malikpora | 10.60 | 0.18 | 5.70 | 7.85 |
| Noru | 12.40 | 0.14 | 6.14 | 8.56 |

| | | | | |
|---|---|---|---|---|
| Safnagri | 10.70 | 0.17 | 5.82 | 7.98 |
| Peerpora | 12.80 | 0.14 | 6.22 | 8.57 |
| **Mean** | **11.70** | **0.15** | **5.94** | **8.22** |
| [c] Tenghar | 10.40 | 0.21 | 5.28 | 7.36 |
| | **1.69** | **0.02** | **0.34** | **0.55** |
| **lsd $_{(0.05)}$** | | | | |
| **± S.E. of mean diff.** | **0.61** | **0.01** | **0.12** | **0.20** |

[c] : check (low density)

**Table 10. Effect of locations on fruit chemical characters in apple cv. StarKrimson in district Baramulla**

| LOCATIONS | T.S.S. ($^0$Brix) | Fruit acidity (%) | Reducing sugars (%) | Total sugars (%) |
|---|---|---|---|---|
| Delena | 11.60 | 0.18 | 5.71 | 7.85 |
| Ladoora | 12.00 | 0.17 | 5.79 | 8.00 |

| | | | | |
|---|---|---|---|---|
| Chakula | 11.10 | 0.19 | 5.49 | 7.47 |
| Mirangund | 11.00 | 0.20 | 5.50 | 7.41 |
| Kunan | 12.10 | 0.16 | 5.99 | 8.14 |
| **Mean** | **11.56** | **0.18** | **5.69** | **7.77** |
| [c] Chakula | 10.10 | 0.21 | 5.21 | 7.34 |
| **lsd $_{(0.05)}$** | **1.48** | **0.02** | **0.28** | **0.31** |
| **± S.E. of mean diff.** | **0.54** | **0.00** | **0.10** | **0.12** |

[c] : check (low density)

**Table 11. Effect of locations on foliar N, P, K and Ca status in apple cv. StarKrimson in districts Pulwama**

| Locations | Leaf nitrogen (%) | Leaf phosphorus (%) | Leaf potassium (%) | Leaf calcium (%) |
|---|---|---|---|---|
| Lajoora | 2.62 | 0.24 | 1.44 | 1.27 |

| | | | | |
|---|---|---|---|---|
| Malikpora | 2.85 | 0.25 | 1.37 | 1.32 |
| Noru | 2.76 | 0.26 | 0.92 | 0.97 |
| Safnagri | 2.72 | 0.26 | 1.34 | 1.31 |
| Peerpora | 2.46 | 0.25 | 0.95 | 1.22 |
| **Mean** | **2.68** | **0.25** | **1.20** | **1.21** |
| [c] Tenghar | 3.04 | 0.22 | 0.84 | 0.93 |
| **$lsd_{(0.05)}$** | **0.16** | **0.03** | **0. 35** | **0.27** |
| **± S.E. of mean diff.** | **0.05** | **0.01** | **0.12** | **0.09** |

[c] : check (low density)

**Table 12. Effect of locations on foliar N, P, K and Ca contents in apple cv. StarKrimson in districts Baramulla**

| LOCATIONS | Leaf nitrogen (%) | Leaf phosphors (%) | Leaf potassium (%) | Leaf calcium (%) |
|---|---|---|---|---|
| Delena | 2.42 | 0.27 | 1.12 | 0.98 |
| Ladoora | 2.54 | 0.25 | 1.43 | 1.18 |
| Chakula | 2.57 | 0.27 | 1.32 | 1.14 |
| Mirangund | 2.35 | 0.23 | 1.10 | 1.23 |
| Kunan | 2.44 | 0.26 | 0.94 | 1.17 |
| **Mean** | **2.46** | **0.25** | **1.18** | **1.14** |
| [c] Chakula | 2.92 | 0.20 | 0.87 | 0.87 |
| **lsd $_{(0.05)}$** | **0.13** | **0.06** | **0.41** | **0. 21** |
| **± S.E. of mean diff.** | **0.04** | **0.02** | **0.14** | **0.07** |

[c] : check (low density)

**Table 13. Comparison of vegetative growth characters in apple cv. StarKrimson in two districts under HDP system**

| *District* | Annual shoot growth (cm) | Tree trunk circumference (cm) | Tree height (cm) | Tree volume ($m^3$) | Average number of spurs per tree |
|---|---|---|---|---|---|
| **Pulwama** | 48.65 | 20.13 | 244.52 | 2.35 | 123.08 |
| **Baramulla** | 48.76 | 19.54 | 238.60 | 2.59 | 129.80 |
| | **NS** | **NS** | **NS** | **NS** | **NS** |

Table 14. Comparison of phenological characters in apple cv. StarKrimson in two districts under HDP system

| *District* | **Initial bloom (10% flowering) *DARD** | **Full bloom (80-100% flowering) *DARD** | **Petal fall (80-100%) *DARD** | **Fruit set (pea stage) *DARD** |
|---|---|---|---|---|
| **Pulwama** | 41.82 | 45.23 | 49.58 | 52.43 |
| **Baramulla** | 41.20 | 44.78 | 48.99 | 51.48 |
| | **NS** | **NS** | **NS** | **NS** |

* DARD = Days after reference date

Table 15. Comparison of fruit production characters in apple cv. StarKrimson in two districts under HDP system

| *District* | **Leaf/fruit ratio** | **Fruit retention at harvest (%)** | **Yield/tree (kg)** | **Yield efficiency ($kg/cm^2$)** |
|---|---|---|---|---|
| **Pulwama** | 23.28 | 66.72 | 11.81 | 0.36 |
| **Baramulla** | 23.25 | 67.79 | 12.36 | 0.39 |
| | **NS** | **NS** | **NS** | **NS** |

Table 16. Comparison of fruit physical characters in apple cv. StarKrimson in two districts under HDP system

| *District* | **Fruit length (mm)** | **Fruit diameter (mm)** | **Fruit length/diameter ratio** | **Fruit colour (1-4 scale)** | **Fruit firmness (lbs./inch$^2$)** |
|---|---|---|---|---|---|
| **Pulwama** | 61.89 | 68.63 | 0.89 | 3.57 | 21.13 |
| **Baramulla** | 61.34 | 68.38 | 0.89 | 2.93 | 20.51 |
| **Lsd $_{(0.05)}$** | **NS** | **NS** | **NS** | **0.20** | ***NS*** |
| **± S.E. of mean diff.** | **NS** | **NS** | **NS** | **0.07** | **NS** |

Table 17. Comparison of fruit chemical characters in apple cv. StarKrimson in two districts under HDP system

| *District* | **TSS ($^{o}$Brix)** | **Fruit acidity (%)** | **Reducing sugars (%)** | **Total sugar (%)** |
|---|---|---|---|---|
| **Pulwama** | 11.70 | 0.15 | 5.94 | 8.22 |
| **Baramulla** | 11.56 | 0.18 | 5.69 | 7.77 |
| $lsd_{(0.05)}$ | **NS** | **0.02** | **NS** | **0.43** |
| ± S.E. of mean diff. | **NS** | **0.00** | **NS** | **0.16** |

Table 18. Comparison of foliar N, P, K and Ca contents in apple cv. StarKrimson in two districts under HDP system

| *District* | **Leaf nitrogen (%)** | **Leaf Phosphorus (%)** | **Leaf potassium (%)** | **Leaf calcium (%)** |
|---|---|---|---|---|
| **Pulwama** | 2.68 | 0.25 | 1.20 | 1.21 |
| **Baramulla** | 2.46 | 0.25 | 1.18 | 1.14 |

| | | | | |
|---|---|---|---|---|
| | **NS** | **NS** | **NS** | **NS** |

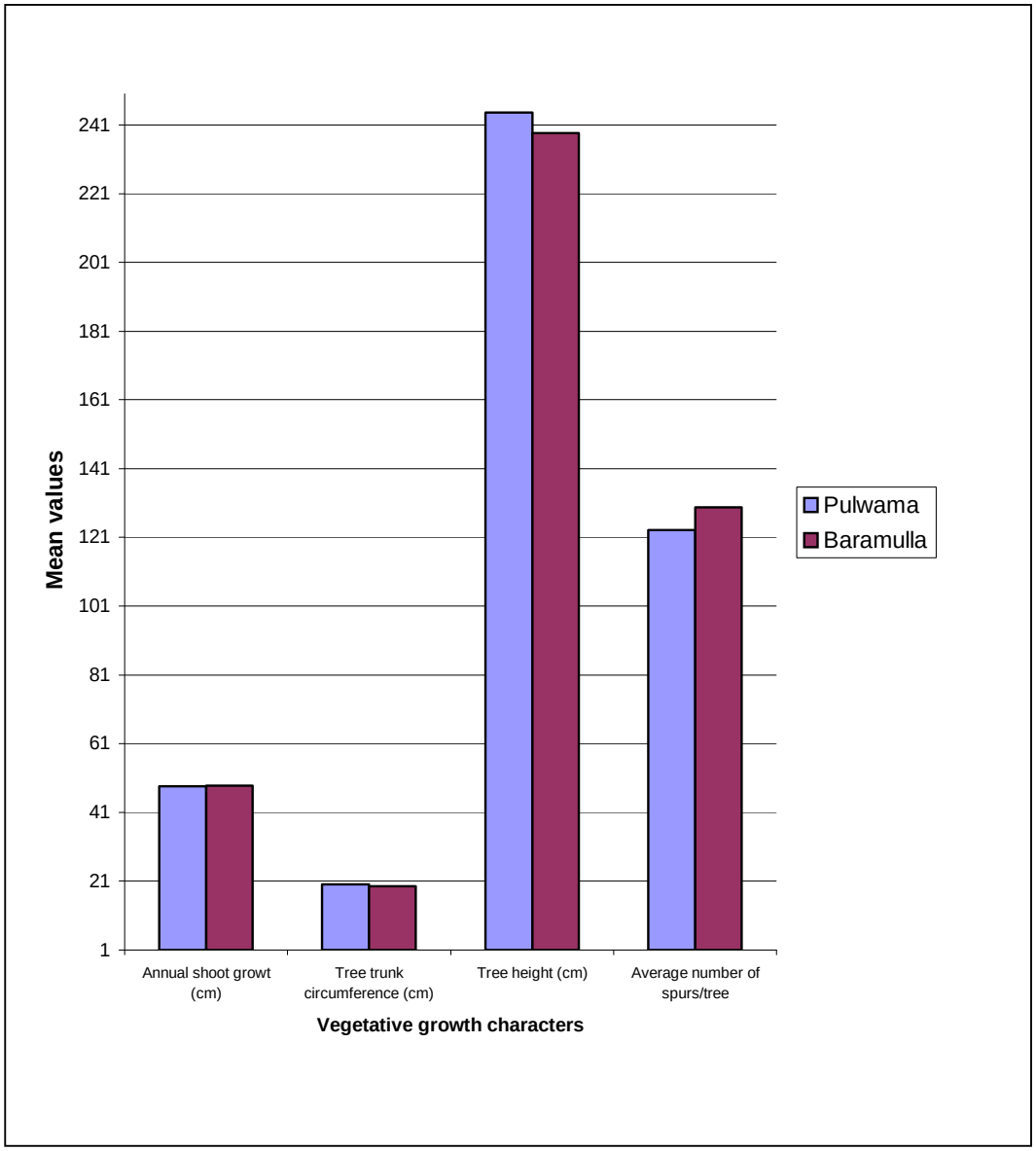


Fig. 1. Comparison of vegetative growth characters in apple cv. StarKrimson in two districts under HDP system

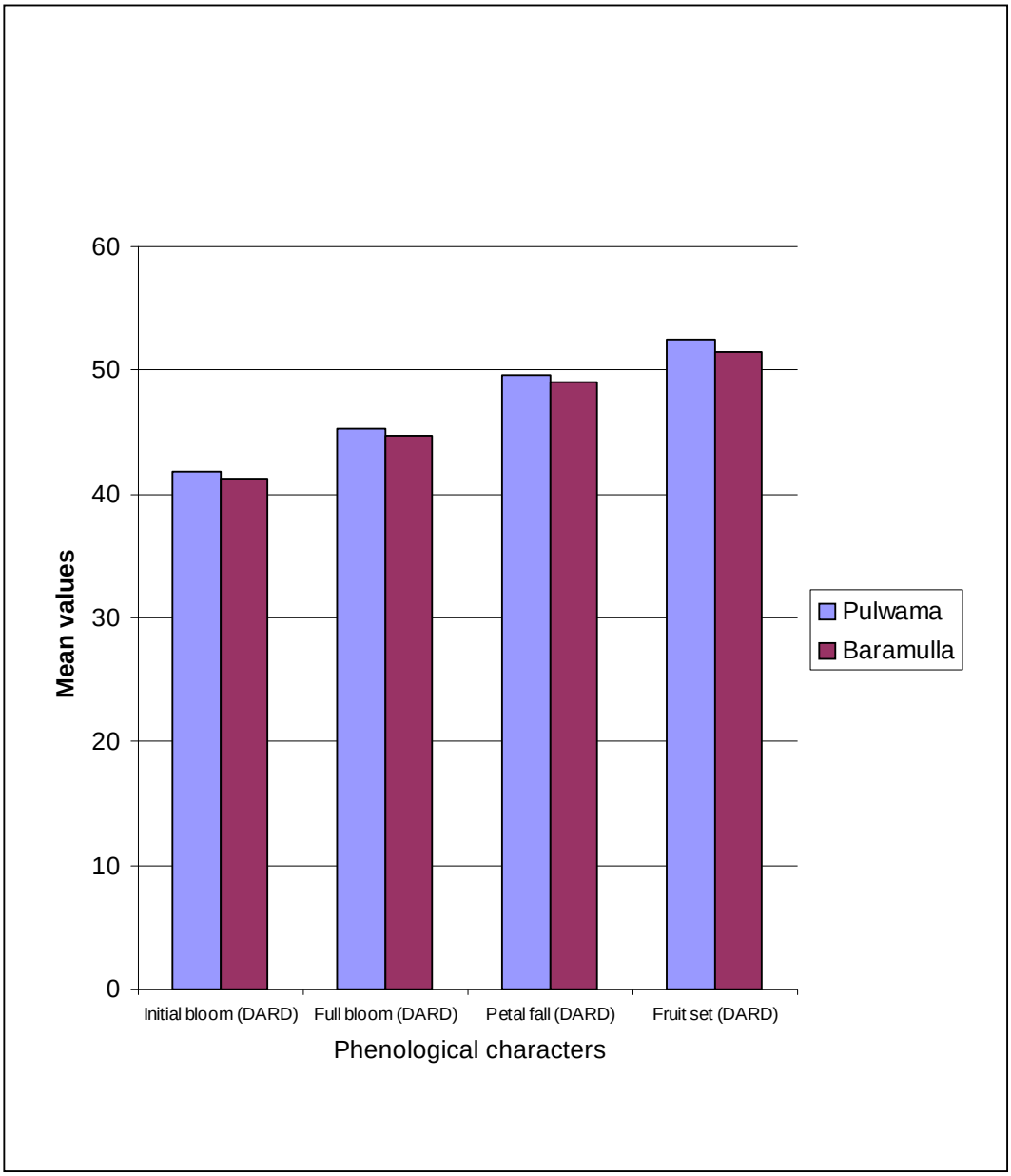


Fig. 2 Comparison of phenological characters in apple cv. StarKrimson in two districts under HDP system

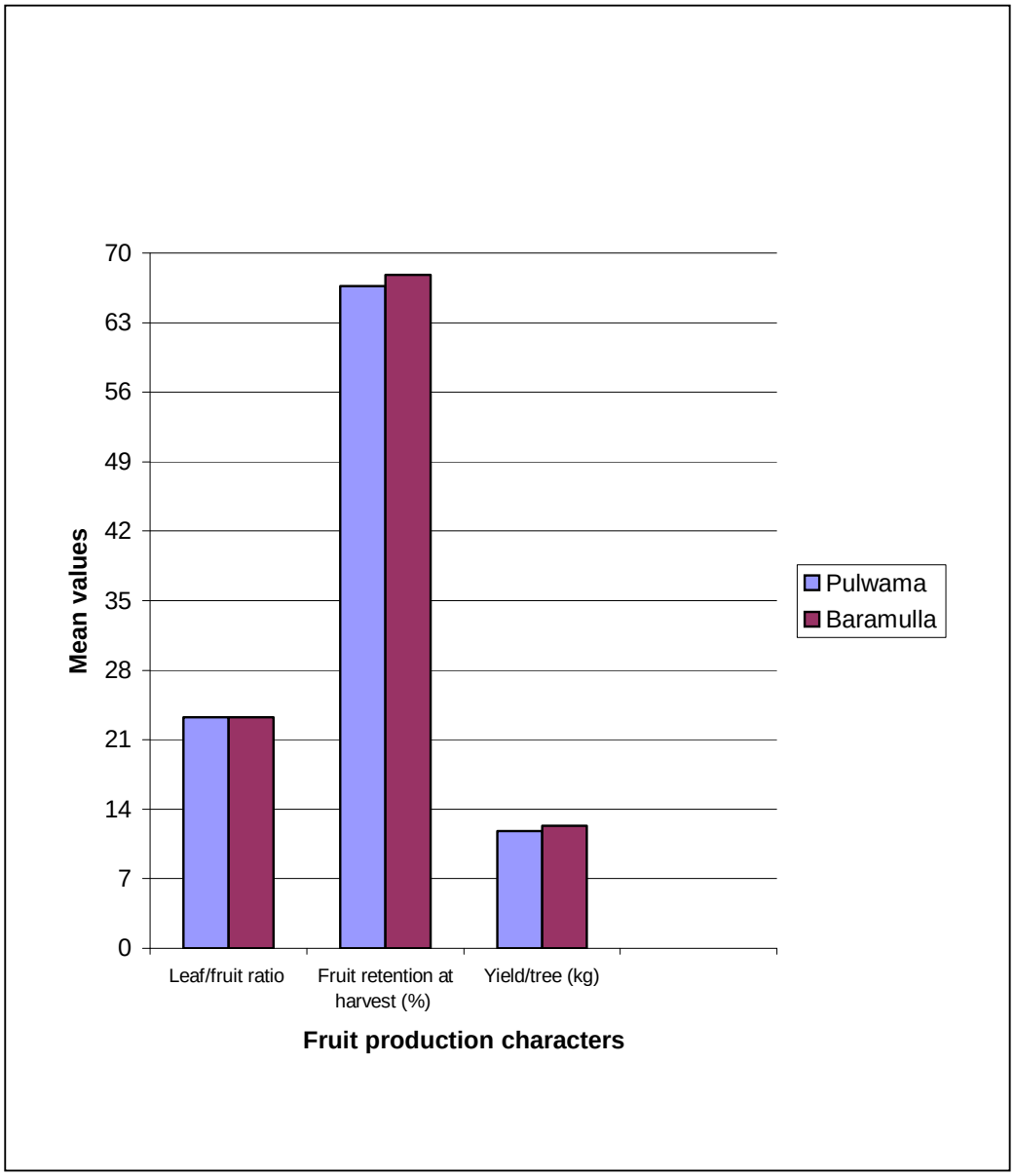


Fig. 3 Comparison of fruit production characters in apple cv. StarKrimson in two districts under HDP system

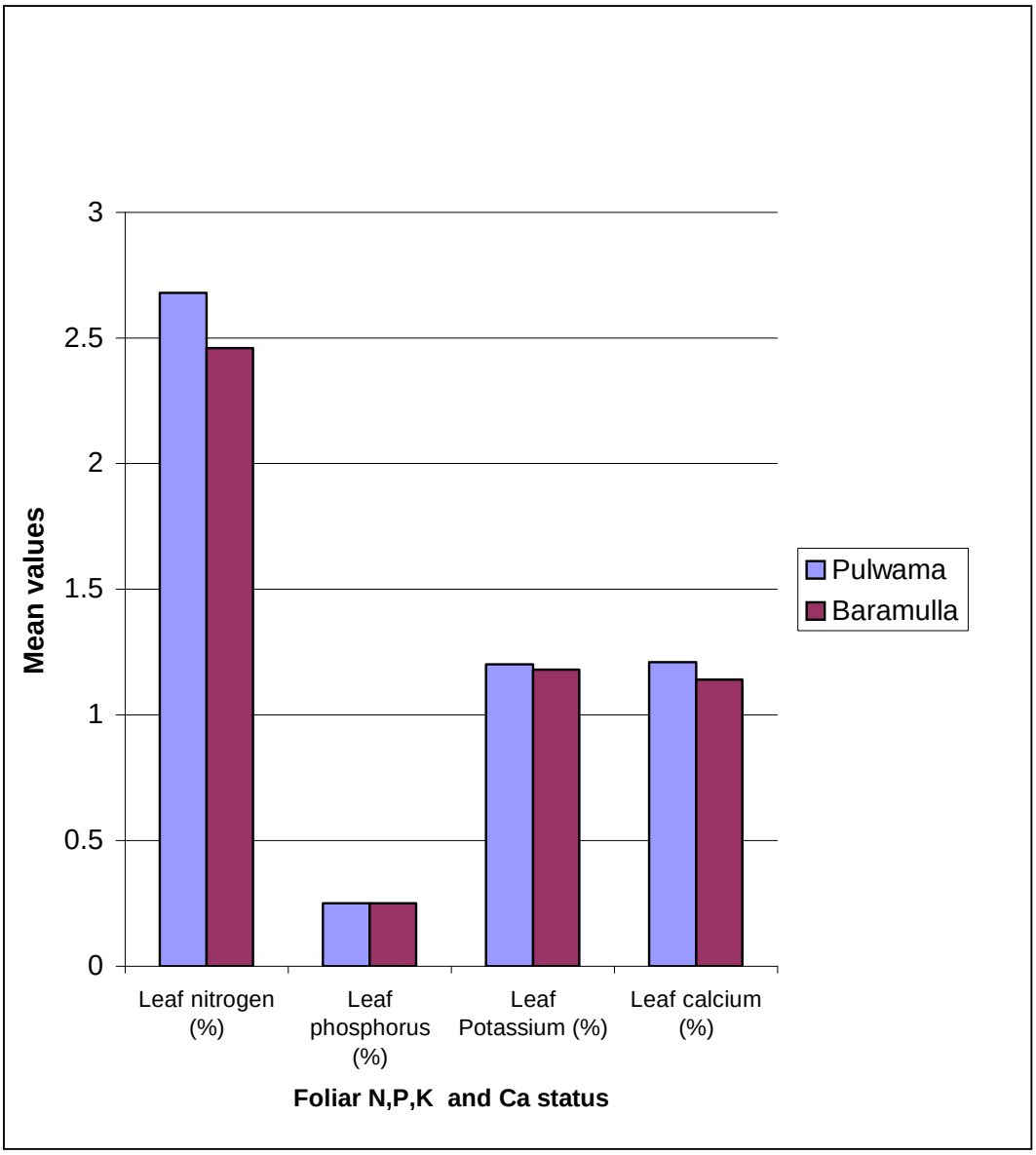


Fig. 6. Comparison of foliar N,P,K and Ca status in apple cv. StarKrimson in two districts under HDP system

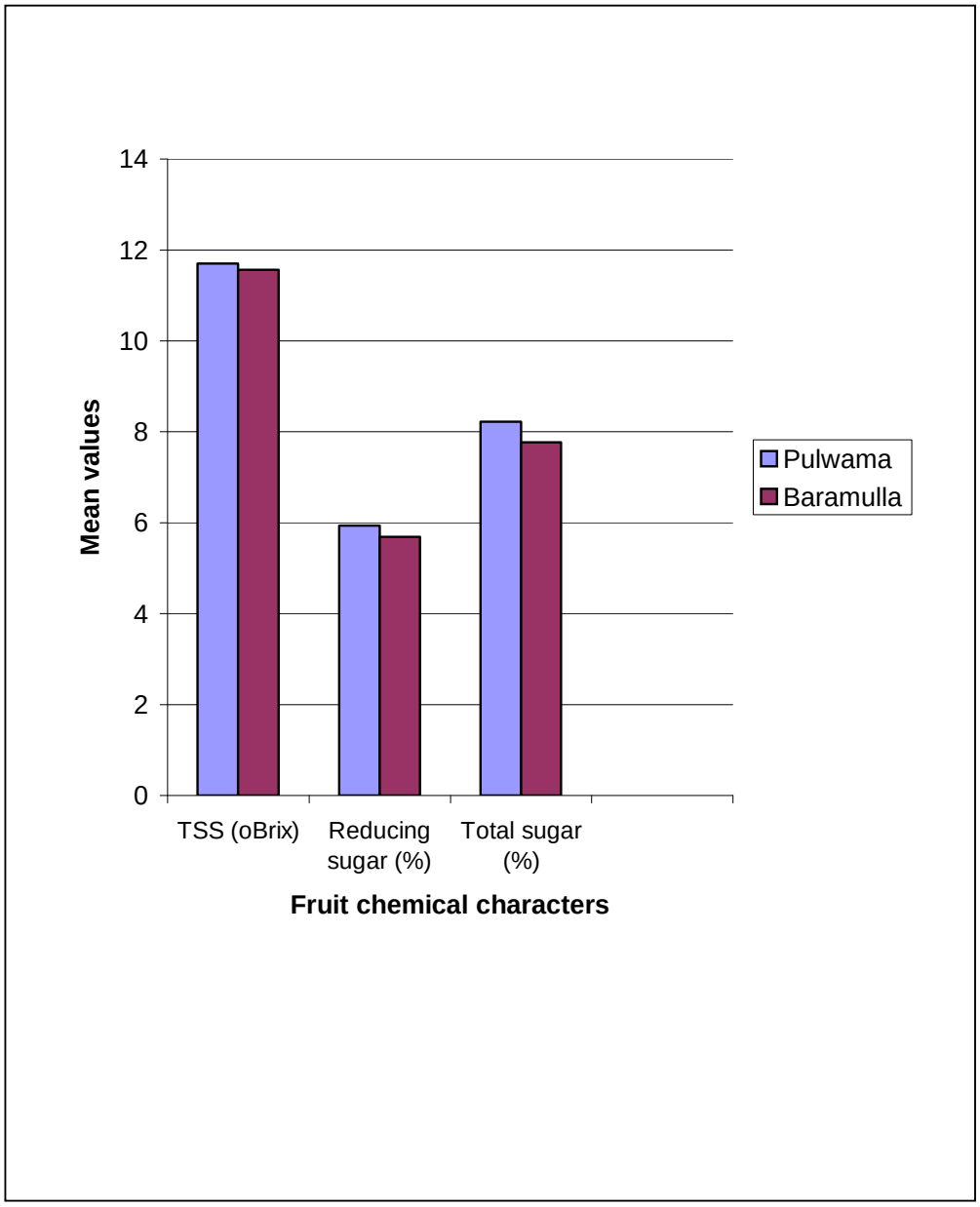


**Fig. 5. Comparison of fruit chemical characters in apple cv. StarKrimson in two districts under HDP system**

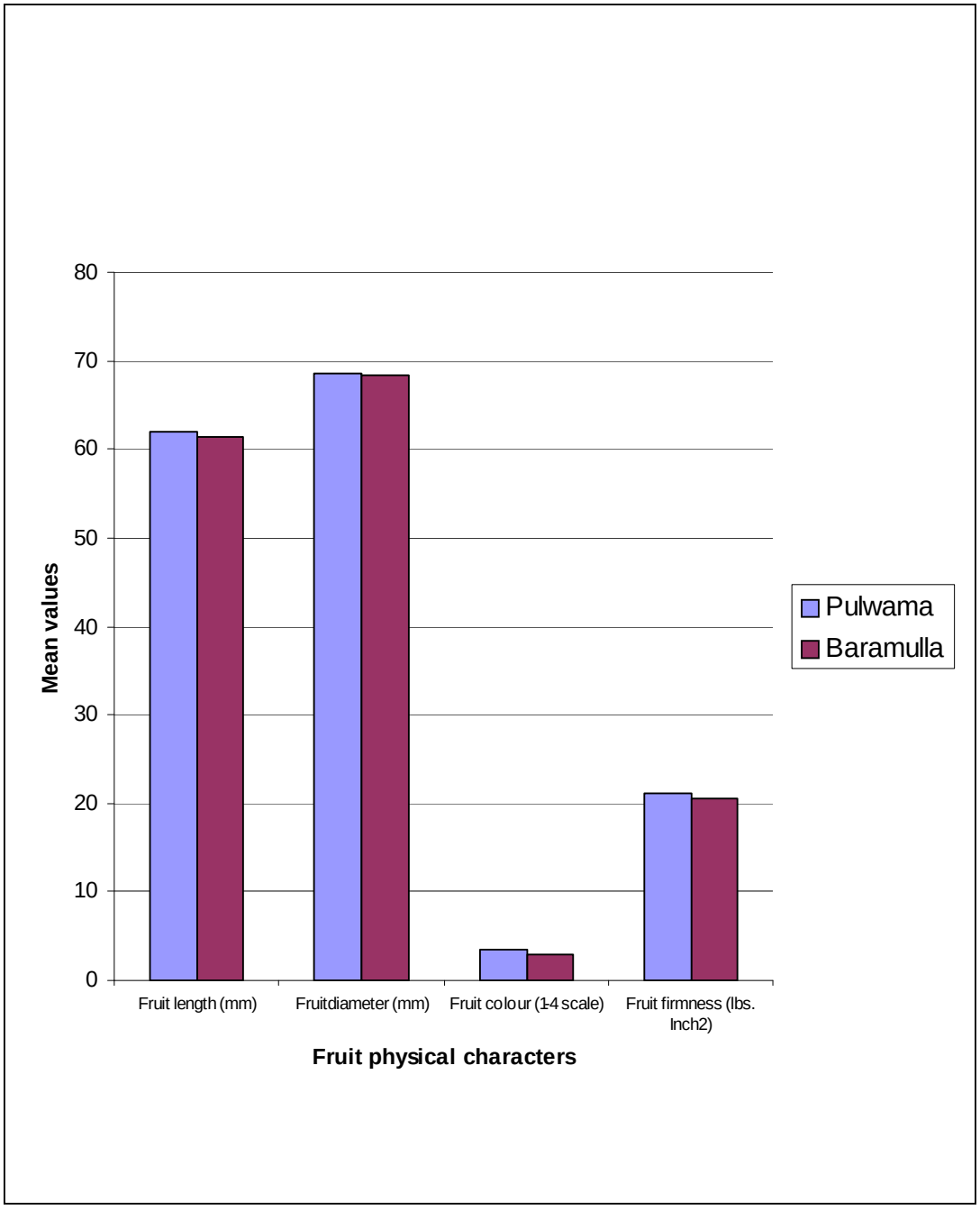


**Fig. 4. Comparison of fruit physical characters in apple cv. StarKrimson in two districts under HDP system**

**Plate 7:** **StarKrimson in bearing at Tenghar (LDP)**


**Plate 8 :** **StarKrimson in bearing at Chakula (LDP)**

**Plate 5 :** **StarKrimson in bearing at Noru (HDP)**

**Plate 6 :** **StarKrimson in bearing at Delena (HDP)**

**Plate 1 : StarKrimson in full bloom at Lajoora (HDP)**

**Plate 2 : StarKrimson in full bloom at Ladoora (HDP)**

**Plate 3 : StarKrimson in full bloom at Tenghar (LDP)**

**Plate 4 : StarKrimson in full bloom at Chakula (LDP)**

**Plate 11 : Fruit samples of apple Cv. StarKrimson from an HDP orchard at Malikpora, Pulwama district**

**Plate 12 : Fruit samples of apple Cv. StarKrimson from an HDP orchard at Mirangund , Baramulla district**

**Plate 9 :** **Fruit samples of apple Cv. StarKrimson from an HDP orchard at Safnagri , Pulwama district**

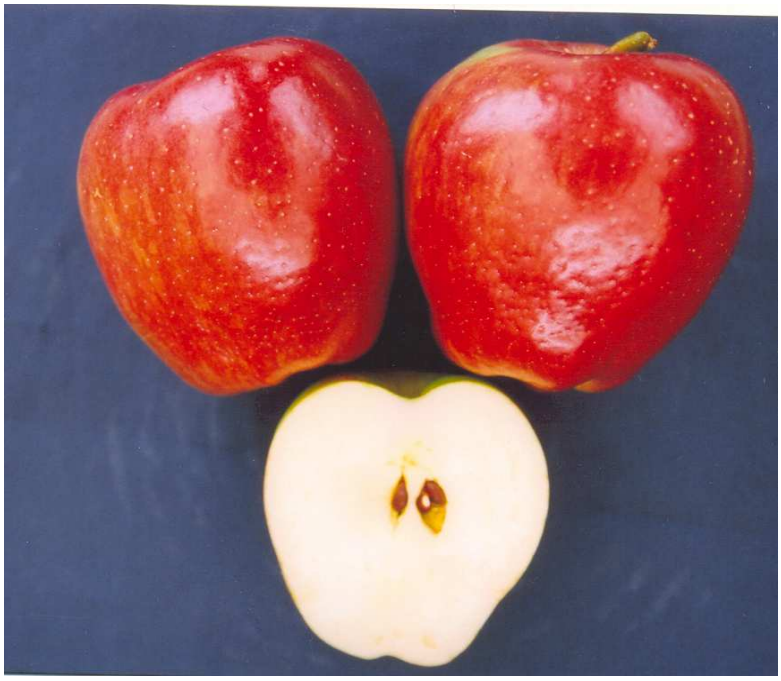

**Plate 10 :** **Fruit samples of apple Cv. StarKrimson from an HDP orchard at Kunan, Baramulla district**

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*Original not seen