REJUVENATION STUDIES ON GROWTH, FRUITING AND FRUIT QUALITY OF APRICOT (*Prunus armeniaca* L.) cv. New Castle

Thesis

by

ROCKY THOKCHOM

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CERTIFICATE - I

This is to certify that the thesis entitled, **"Rejuvenation studies on growth, fruiting and fruit quality of apricot (*Prunus armeniaca* L.) cv. New Castle",** submitted in partial fulfillment of the requirements for the award of degree of **MASTER OF SCIENCE (HORTICULTURE) FRUIT SCIENCE** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H. P.) is a bonafide record of research work carried out by **Mr. Rocky Thokchom (H-2012-26-M)** under my guidance and supervision. No part of thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigation have been fully acknowledged.

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CERTIFICATE - II

This is to certify that the thesis entitled, **"Rejuvenation studies on growth, fruiting and fruit quality of apricot (*Prunus armeniaca* L.) cv. New Castle"** submitted by **Mr. Rocky Thokchom (H-2012-26-M)**, to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H. P.) in partial fulfillment of the requirements for the award of degree of **MASTER OF SCIENCE (HORTICULTURE) FRUIT SCIENCE** has been approved by the Student's Advisory Committee after the thesis viva-voce examination in collaboration with the internal examiner.

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This is to certify that all the mistakes and errors pointed out by the external examiner have been incorporated in the thesis entitled, **"Rejuvenation studies on growth, fruiting and fruit quality of apricot (*Prunus armeniaca* L.) cv. New Castle",** submitted to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) **by Mr. Rocky Thokchom (H-2012-26-M)** in partial fulfillment of the requirements for the award of degree of **MASTER OF SCIENCE (HORTICULTURE) Fruit Science.**

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Dated: *Rocky Thokchom*

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Chapter-1

INTRODUCTION

Apricot *(Prunus armeniaca* L.) belongs to the family Rosaceae. It is originated in China and spread all over the world. In India, the apricot was first introduced by erstwhile Maharaja of Patiala State at Kandaghat, near Solan in the year 1938. It is an important fruit of temperate region of the North India and cultivated commercially in Himachal Pradesh, Jammu and Kashmir and hilly areas of Uttarakhand. This fruit is also grown to some extent in North Eastern part of the country including Assam, Tripura, Manipur, Arunachal Pradesh, Meghalaya, Mizoram and Nagaland. Its cultivation is extended from 900 to 3000 m altitude above mean sea level.

In Himachal Pradesh, apricot is cultivated extensively in Solan, Shimla, Sirmmour, Chamba and Kinnaur districts. Out of the various apricot cultivars, New Castle has a potential in the mid hills and valley areas of Himachal Pradesh because it has low chilling requirement and ripens in the end of May when no other fresh fruit is available in the market.

In India, among stone fruits, apricot ranks next only to plum and peach with an area of 5000 ha and production of 18,000 MT (Anonymous 2012). Apricot is one of the earliest fruit crop to reach the market and hence fetch remunerative price. Fruit is a rich source of vitamin A and contains more carbohydrates, proteins, phosphorus and niacin as compared to other common fruits (Teskey and Shoemaker, 1972).

Despite congenial agro-climatic conditions in the mid hills for the apricot production, a declining trend in its production has been observed during last two decades. This is because most of the apricot plantations have become old and senile. In general, orchards of stone fruits more than 20 years of age have shown much more unfruitfulness than the young orchards. Such declining orchards do not produce adequate annual extension growth to sustain fruit production during the remaining life of the trees. Such plants require special attention with regard to pruning and fertilization practices. In Himachal Pradesh, apricot occupies an area of 3263 ha with an annual production of 2437 MT (Anonymous, 2013).

Because of limited land resources farmer are compelled to put back old orchard sites, under new plantations, which lead to drastic economic loss due to uprooting of old trees and poor establishment of new plantations on the same site owing to replant problem. Therefore, rejuvenation is one of the options prior to uprooting if the declining plants have healthy root system but are unproductive because of poor orchard management practices.

Rejuvenation of old and declining orchards has been found to be cost effective and is beneficial to the farmers as the orchard gets new lease of life for many years. On the other hand replacing the orchard is not desirable, as it is quite cumbersome, involves a longer juvenile period and entails loss of revenue to the farmers. Therefore, the rejuvenation of declining trees is an alternative strategy of prime importance rather than re-plantation.

Keeping in view these problems, the proposed investigations were carried with the following objectives:

1. To study the effect of rejuvenation treatment on growth, fruiting, yield and fruit quality
2. To study the influence of rejuvenation treatments on foliar nutrient content

Chapter-2

REVIEW OF LITERATURE

The apricot (*Prunus armeniaca* L.) is an important early maturing fruit crop of mid hills of Himachal Pradesh. Most of the commercial apricot orchards in Himachal Pradesh are planted in seventies and eighties and have out lined their economic life resulting in static production in last two decades as evident from statistics of Department of Horticulture, Himachal Pradesh. In the recent years, decreased productivity of apricot orchards has been a serious concern of the growers and researchers in the state. The appropriate combination of rejuvenation pruning and nitrogen treatments needs to be standardized for regaining growth. Production of declining apricot orchards, as pruning and nitrogen have more invigorating effect in stone fruits compared to other temperate fruits. The relevant research information pertaining to various aspects of the proposed study is presented below under suitable headings.

Effect of pruning on tree vigour:

Various plant growth characteristics like trunk girth, tree height, canopy volume, shoot length and weight of pruning wood have been commonly used as the indices to evaluate the effect of different pruning severities on tree vigour.

Increased in tree width and projection of crown which resulted in beneficial changes in fruiting zone of crown was observed in intensive pruning than that of medium and light pruning in young apricot (*Armeniaca vulgaris* Lam.) trees (Szklarz *et al*., 2011). Cultivated apricot varieties show diverse tree architectures, habit and fruiting branches in response to spring and summer pruning and the effect of pruning intensities at different times during spring and summer seasons is specific for the singular growth habits (Neri and Massetani, 2011). In a study on the effects of different pruning treatments on the growth, fruit quality and yield of ‘Hacihaliloglu’ apricot, pruning treatments significantly affected both shoot diameter and length. The highest shoot diameter and length were obtained from pre-harvest summer + winter pruning treatments where as the highest leaf area was recorded in post- harvest pruning treatment (Demirtas *et al.,* 2010) in apricot. In 'Sundrop' apricot the trees pruned to the central leader were found to be the tallest and had the largest canopy spread as compared to Spanish Bush system. Further, there was no difference in the cross-sectional area between the two pruning systems (Kappel, 2003). In Japanese apricot (*Prunus mume*), the growth of new shoots was found to be promoted with heavy thinning (3/5th cut off). While slight thinning (1/5th cut off) not only accelerated the shoot growth, but also increased the productivity (Chen *et al.,* 2003). Heavy pruning of apricot trees in some cultivars after harvest had the strongest effect on dieback (Blazkova, 2001). Early rejuvenation of apricot cv. Kompakta trees by pruning is important for continual recovery of fruit spurs (Blazkova, 1999). Higher annual shoot growth and canopy volume was reported after December pruning and least after summer pruning in 'New Castle' apricot. However, trunk girth remained unaffected by the time of pruning (Sharma *et al.,* 1997). Shoot and spur development were improved and bud quality increased with detailed annual pruning of spurs in various apricot cultivars (Svoboda, 1996). Maximum annual shoot growth, tree spread, pruning wood weight and leaf area was obtained with increase pruning intensities treatment in New Castle apricot (Thakur, 2012).

In a rejuvenation study conducted in 35-years old declining plum trees in Experimental farm of department of Fruit Science, Dr. YS Parmar UHF, Solan Himachal Pradesh, it was observed that annual shoot growth, radial growth of trunk, pruning weight, average leaf area and leaf chlorophyll content were higher in heavily (75% of HB) pruned trees whereas tree volume was higher in lightly (25% of HB) and normal pruned plum trees (Suklabaidya, 2012). Plum cultivars grafted on semi dwarfing rootstock 'Prunus Wangenheim' (*Prunus domestica*) showed rapid tree growth, much young wood, fruit bud formation on young wood and early bearing when summer training treatments were followed by renewal pruning from third year onward after fruit harvesting (Mika and Buler, 2011). In an experiment conducted on 8 year old plum trees of different cultivars, it was reported that time of pruning had no influence on vegetative growth and chemical composition of leaves (Sosna, 2010). Hristina (2008) observed vigorous growth accompanied by sprouting of leaves with greater area, without regularity in the variation of stomata number and size depending on the strength of rejuvenation pruning. Studies on rejuvenation of old plum trees conducted at experimental orchard of department of pomology, UHF, Nauni, Solan revealed that the removal of secondary branches of old plum trees at chest height was found to be the best treatment to influence tree vigour, when supplemented with double dose of nitrogen (Sharma, 1994).

Summer pruning (Summer shoot thinning and shoot heading back) in field trials of slender spindle bush type of peach trees grafted on vigorous rootstocks shows tree growth and recover proper balance between vegetative and reproductive growth (Mizutani, 2011). Studies on the effect of reproductive shoot pruning on the vegetative growth of peach trees revealed that summer pruning improved the rejuvenation of wood and enhanced the growth of basal shoots thus increasing the proportion of shoots that arose on older wood and it also shown to affect branch regrowth, leaf restoration, radial expansion of the trunk, reduction in trunk cross-sectional area and plant size (Weber *et al*., 2011). Compared to light pruning, severe pruning induced higher shoot and fruit growth on the whole tree and on the girdled fruit-bearing shoots in peach trees of 'Big Top' and 'Alexandra' (Bussi *et al.,* 2009). Regenerative pruning decreased tree height and crown width compared to unpruned trees. Trunks of the strongly pruned trees became thicker, compared with control in peach (Radajewska and Szklarz, 2009). The highest rate of vegetative growth was obtained from the more severe pruning than light pruning treatments in peach (Hassani and Razaee, 2007). Severe pruning also tended to enhance the growth of young shoots in an early maturing peach tree cv. Alexandra on the first bearing shoot and on the scaffold branch (Bussi *et al.,* 2005). The longest (43.54cm) and thickest (0.51 cm) shoots were obtained in peach tree under the 60% pruning treatment. Similarly, the shortest (16.31cm) and the thinnest shoots (0.40 cm) were recorded under the control treatment (Rathi *et al.,* 2003). Marked increase in trunk girth, shoot length and foliar 'N' content was reported in peach by heavy pruning with ½ heading back; while heavy pruning with 1/3 heading back resulted in better tree canopy (Kaundal *et al.,* 2002). Dormant season pruning of trees top and pruning of outward growth in top of trees in early summer of *Prunus persica* cv. 'Doctor Davis' shows positive result of increase in fruit wood diameter in lower portion of trees compare to control dormant pruning only with mechanical topping (Norton, 2002). Significant increase in vegetative growth i.e. terminal shoot growth, leaf area and dry weight was found with increased severity of pruning (Singh *et al.,* 1997; Zegbe *et al.,* 1998 and El_Deeb, 1999) in peach. Increasing pruning intensity resulted in an increase in annual shoot extension growth and decease in canopy volume in peach (Sharma *et al.,* 1995). Experiment on 5 - year old Qingfeng and 6 - year old Yan-hong peach trees revealed that long pruning had several advantages over short pruning as long pruning showed development in tree vigour traits (Li *et al*.,1994) Improved tree growth and leaf cover was reported in 'Mit-Ghamr' peach trees with increased number of less fruiting shoots (Hassan, 1990).

Effects of renewal pruning on shoot development and crown structure of the aging Fuji apple trees showed increase in length and diameter of newly developed shoots, lateral shoots of bearing trees, foliage branch, fruit branch, leaf area index but decrease in canopy (Du-SheNi *et al*., 2012). Renewal pruning on mountain apple tree's increased the proportion of long branches and medium branches, while significantly reduced the proportion of short branch and leafage branch and promoted branch robust development. It also increased the leaf area and chlorophyll content (Li-MingXia *et al*., 2011). Severe dormant pruning resulted in decreased number of shoots/branch, however there were increase in number of leaves/shoot and specific leaf weight in Anna apple trees (Abo-El-Ez, 2010).

Increase in extension of shoot length, shoot girth and reduction in bloom density and fruit drop were observed by (Rajkumar *et al*., 2008) in the investigation of different levels of rejuvenation pruning in apple (*Malus domestica* Borkh.) cv Red Delicious. Luchlov and Taov, (1999) has given an account that rejuvenation pruning is an effective way of assisting recovery of growth and fruit production of apple trees damaged by hail and low temperatures. Increase in trees height was reported by long dormant pruning treatment by removing weak and over vigorous branches when the canopy was kept opened (Kappel and Bouthiller, 1995).

Pruning treatments positively affected shoot length and pistillate flower cluster number and increased yield significantly on rejuvenation pruning of hazelnut (Beyhan *et al*., 1999). Increase in canopy volume was observed on the effect of renewal pruning in hazelnut orchards by (Roversi and Mozzone, 2005). Canopy with more vigorous longer branch were resulted from pruning trials conducted in 2 hazelnut plantations, aged 18 and 20 years; where in branches were pollarded at 1.3 to 1.6 m above the ground (Roversi *et al*., 2007).

Effect of pruning on productivity:

An early rejuvenation of trees by pruning has been found to be important for continual recovery of fruit spurs in apricot cv. Kompakta (Blazkova, 1999). Kuden and Kaska (1995) reported that yields were found to be more regular with summer + winter pruning and pruning also encouraged fruiting on older parts of the tree thus eliminating the bare branches which occurred on the predominantly tip-bearing, unpruned control trees of 'Priana and Beliana' apricot cultivars. In a study on the effect of different tree pruning methods on growth and yielding of 3 apricot cultivars: 'Goldrich', 'Hargrand' and 'Sirena'. Intensive pruning system showed better flower buds setting and yield of trees compared to medium and light pruning. The highest yield was obtained from trees of cultivars: 'Hargrand' and 'Sirena'(Szklarz *et al*., 2011). The effect of 5 different combined or alone pruning treatments on the growth, fruit quality and yield characteristics were studied in comparison with non-pruned trees in Hacihaliloglu apricot cultivar. The highest average yield considering trunk cross-sectional area was obtained as 0.34 $kg.cm^2$ from pre-harvest summer pruning treatment (Demirtas *et al*., 2010). Slight thinning ($1/5^{th}$ cut off) not only accelerated the shoot growth, but also increased the productivity by 28.42% and 51.14% on the 2^{nd} and 3^{rd} year, respectively in Japanese apricot (Chen *et al.,* 2003). The experiment conducted on 3 year old trees of the Precoce de Tyrinthe apricot cultivar grown in Mut-Mersin in Turkey revealed that unpruned trees were more productive; however, these gave lower yield in second year due to alternate bearing. August + winter, July + winter and September + winter pruning applications were more productive than the control trees (Son and Kuden, 2002). Yield and fruit quality were positively affected by a regular summer + winter pruning in 'Precoce de Tyrinthe' apricot cultivar (Son and Kuden, 2002).

Higher fruit set and yield was recorded in lightly (25% of HB) and normal pruned trees compared to heavily (75% of HB) pruned plum trees in rejuvenation study in old Santa Rosa plum trees (Suklabaidya, 2012). Dormant-pruned trees were found to be more productive compared to the summer-pruned trees of four early ripening plum cultivars (Sosna, 2010). Based on the modern day pruning in intensive fruit culture, Neri and Sansavini (2004) observed that heavy and long pruning increased the yield of plum and long periods without pruning up to four years are considered as an alternative to high density planting. Results of pruning experiment on 'Younai' plum trees showed that no pruning-treated trees not only controlled tree height, but was increased flower bud formation and production (Lin, 2001). Significantly higher yields were obtained in plum from thinning without heading back than with the most severe heading back (Sharma *et al.,* 1995). In plum, it has been reported that in the year of pruning, yield decreased with increasing pruning severity, but in the following year it started to increase (Dinkova and Vitanova, 1995).

Studies of dormant and summer pruning were carried out on 'Early Red' and 'Glohaven' peach trees on peach seedling rootstocks. The study revealed that the dormant pruned trees had the highest trunk cross-sectional area increment and yield efficiency (Ikinci *et al*., 2014). Studies conducted through on-farm trials at farmer's fields in Ropar (Punjab) district during 2006-2009 to evaluate the technology of pruning and fruit thinning and its effects on crop yield and fruit quality in six-year-old peach cv. Shan-i-Punjab trees with three treatments viz., T_1=50% pruning of fruitful shoots + cutting of dead and diseased wood in early-January, T_2=T_1+Fruit thinning during mid-March and T_3=No pruning and no fruit thinning. It was concluded that economic fruit yield was significantly increased in 50% pruning treatment of fruited shoots and cutting of dead and diseased wood during early January followed by fruit thinning in mid-March (Singh and Saini, 2013). Singh and Saini, (2013) reported that temperate fruit required proper annual pruning when dormant to remove the non-productive parts so as to divert the energy into those parts that are capable of bearing fruits and it is quite instrumental in regulating the tree vigour, fruit quality and productivity potential in peach plants.

Reduced pruning shows more yield efficiency than that of intense pruning (Tworkoski and Glenn, 2010) in peach cultivar 'Jersey Dawn and 'Redskin'. In a study on different levels of pruning (light, medium, heavy and unpruned as check) on Flordasun, Flordaking and Sharanpur Prabhat peaches fruit yield decreased with the increase in severity of pruning in Flordaking and Sharanpur Prabhat whereas medium pruning gave highest yield in Flordasun peach (Kumar *et al*., 2010). The radical pruning of trees caused in the third year after pruning a decrease in tree yield from 30 to 40%, in comparison with the not pruned tress of peach cv. 'Harbinger' (Radajewska and Szklarz, 2009). It has been observed that increased severity of pruning had resulted in limiting the fruit yield during (2^{nd} year) or, not during 3^{rd} year in peaches (Bussi *et al.,* 2005). However, severe pruning could favour an alternation in flower setting. The highest pooled yield of 45.6 kg/tree was obtained in lightly pruned peach trees (Sharma and Chauhan, 2002). Severely pruned 'Suncrest' with supplemental cutting back of a mixed bearing branch and 'Red Heaven' with 4-fruits per mixed bearing branch gave the lowest yields. The highest fruit set was obtained in peach in the control and the lowest under 60% pruning treatment (Rathi *et al.,* 2003). Similarly, decrease in yield was reported in peach with increased pruning severity but, fruit weight and yield increased with increased N level up to 500 g/tree (Singh and Singh 2002). The highest yield (48 kg) was obtained with no pruning treatment in comparison to 25, 50 and 75% levels of pruning in peach cv. Shan-i-Punjab (Mahajan and Dhillon, 2002). A drastic reduction in fruit yield was obtained in peach cv. Partap with heavy pruning. However, medium pruning with $1/3^{rd}$ heading back produced intermediate effects on growth, yields and quality of fruits (Kaundal *et al.,* 2002). The highest yield was obtained in peach in lightly pruned trees with 8 fruits per bearing branch regardless of cultivar (Radivojevic *et al.,* 2002). Decreased crop yield and the less number of fruits per tree were recorded with increased pruning severity in peach trees. Light pruning (14-buds/shoot) enhanced fruiting (El Deeb, 1999). Decrease in yield by 43.35% and 56.08% was reported in peach with pruning to 25 or, 50% of the original shoot length, respectively, compared with the unpruned control.

Further, pruning timing did not significantly affected yield (Zegbe *et al.,* 1998). Significantly higher yield was obtained in the lightly pruned trees than medium and heavily pruned trees of 'July Elberta' peach (Sharma, 1995). Similar, observations were also recorded in 'July Elberta' peach by (Singh, 1992 and Sharma, 1995) under Rajgarh conditions of district Sirmour in Himachal Pradesh. Higher yield was observed in 'Flordasun' peach with light pruning than heavy and medium pruning severities (Chitkara *et al.,* 1991).

Renewal pruning increased significantly fruit yield and fruit mass, improved significantly orchard economic value in apple orchard in Weibei Plateau of Shaanxi Province (Li-MingXia *et al*., 2012). Effect of rejuvenation pruning (severe, light and absent) on the productivity and cold resistance of apple tree plantations under the conditions of Tambov Province showed that severe pruning reduced winter hardiness, the formation of fruit buds and yield. Light pruning encourage moderate growth and regular fruit bud formation, with no marked reduction in yield (Kuznetsova and Mantrov, 2009). Rejuvenation pruning is an effective way of assisting recovery of growth and fruit production on Jonathan apple trees which were damaged by hail and low temperature (Luchlov and Taov, 1999).

Effect of pruning on fruit quality:

Pruning treatments in different periods did not statistically affect phenological features and fruit dimensions but strongly affected total soluble solids and fruit firmness of 'Hacihaliloglu' apricot cultivar (Demirtas *et al.,* 2010). Fruit size and weight were reported to be the higher in January pruned trees compared to mid-December and mid-February pruned trees of 'New Castle' apricot (Sharma *et al.,* 1997). The influence of different pruning treatments on various fruit quality parameters like size, grade, weight, volume, TSS, acidity, and sugar content of fruits have been studied by many workers. Increase in fruit size by 7.6% and 20% was recorded in apricot cv. Lejuna and Vestar, respectively, in pruned trees compared to unpruned (Svoboda, 1996). Summer pruning led to the increased size of fruits of 'Priana and Beliana' cultivars of apricot (Kuden and Kaska, 1995). Thakur, (2012), revealed improved in fruit quality (fruit weight, fruit size, fruit firmness, TSS, total sugar, reducing sugar and non-reducing) in increase severity of pruning.

Rejuvenation pruning (75% of HB) treatment resulted in increased fruit weight, volume, size, fruit firmness, TSS, reducing and non-reducing sugars compared to lightly (25% of HB) and normal pruned plum trees (Suklabaidya, 2012). The differences of pruning severity in 'Cacanska Rodna' dried plums significantly affected qualitative properties of fresh fruits (Mitrovic *et al.,* 2001). Fruit firmness of plum fruits decreased with increasing pruning intensity and TSS peaked with ½ and ⅔ heading back. There was no consistent trend among different pruning severities on fruit acidity (Sharma *et al.,* 1995).

Effect of pruning and fruit thinning on yield and fruit weight of peach (*Prunus persica* (L) Batsch) cv. Shan-i-Punjab in sub-mountain zone of Punjab revealed that 50% pruning of fruiting shoots + cutting of dead and diseased wood in early-January + fruit thinning during mid-March increased the fruit weight (Singh and Saini, 2013). Studies on the effect of pruning severity, time and tree aspects on early fruiting, yield and quality characters of Partap peach revealed that low chilling peach Partap pruned on 30 October with 50% shoot retention yielded fruits 15 days earlier of superior quality in general (Singh *et al*., 2012). In a field trail, summer pruning was applied to slender spindle bush type of early maturing peach trees grafted on vigorous rootstocks. The fruit matured earlier and soluble solids content was greater while titratable acidity was lower in the summer-pruned trees (Mizutani, 2011). Almost all the physico-chemical characters were significantly affected by pruning in 'Flordaking' and 'Saharanpur' peaches, in which medium and heavy pruning treatments performed better, respectively. However, fruit weight, size, TSS, sugar and acid content were significantly increased by pruning in 'Flordasun' peach (Kumar *et al.,* 2010). Fruit growth and quality at maturity are shown highly dependent on the leaf-to-fruit ratio which varied with thinning and pruning intensities in peach tree cultivars 'Big Top' and 'Alexandra' (Bussi *et al.,* 2009). The highest TSS (18.70%) and fruit weight (96.97g) was obtained from the severe pruning treatments in peach (Hassani and Rezaee, 2007). Medium pruning (20 cm from the top) resulted in significantly better fruit size (4.33, 4.45 and 4.70 cm, respectively, in Sharbati, Flordasun and

Prabhat cultivars) than severe pruning (30 cm from the top) (Kumar *et al.,* 2005). Larger and heavier fruits along with higher TSS, acidity, total sugars and soluble proteins were obtained in peach with heavy pruning (Rathi *et al.,* 2001 and Sharma and Chauhan, 2004). Heavy pruning with ½ heading back significantly increased fruit size and quality, but fruit firmness was drastically reduced by heavy pruning in peach cv. Partap (Kaundal *et al.,* 2002). Pruning at 75% level produced the highest fruit weight (65.00 gm), pulp weight (59.00 gm), stone weight (5.64 gm), fruit size diameter (4.96 cm) and total soluble solids content (12.33%), in comparison with 25 and 50% levels of pruning in peach cv. Shan-i-Punjab (Mahajan and Dhillon, 2002). The fruit quality parameters were found to be influenced by pruning treatments. Light pruning (14-buds/shoot) enhanced fruiting, whereas, severe pruning (6-buds/shoot) improved fruit quality (El-Deeb, 1999). The fruit weight, volume, and size increased significantly with the increasing severity of pruning. The largest fruits were produced in heavily pruned trees and smallest with lightly pruned trees, similarly the TSS content; fruit firmness; total, reducing and non-reducing sugars in fruits tended to increase significantly with the increasing pruning severity in peach cv. July Elberta (Sharma, 1995). In July Elberta cultivar of peach the highest percentage of three layer grade fruits were produced in heavily pruned trees than in medium and lightly pruned trees, whereas, the loose grade fruits were more in lightly pruned trees (Singh, 1992 and Sharma,1995). Similar observations were recorded by Singh and Bajwa, 1976. No significant effects on fruit size, pulp content and pulp: stone ratio was reported in 'Flordasun' peach by pruning treatments (Chitkara *et al.,* 1991). Compared with short pruning (SP); long pruning (LP) resulted in excellent fruit quality, with higher TSS contents and improved colour in peach trees (Li *et al.,* 1994). Various workers have observed that pruning improved fruit size, grade and weight in peach (Kanwar and Nijjar, 1983; Daulta and Singh, 1986; Badiyala and Awasthi, 1989; Awasthi and Singh, 1990 and Hassan 1990). Increased TSS and TSS: acid ratio was reported in 'July Elberta' peach with the increase in severity of pruning, whereas, acidity decreased (Badiyala and Awasthi, 1989). Similar results were found by Singh (1992) in 'July Elberta' peach. Fruit size, fruit soluble contents and total acids content significantly increased with severe pruning in cherry (Radivojevic *et al.* 2006). Du-SheNi., *et al.* (2012) reported that renewal pruning on the aging Fuji apple tree increased fruit weight and fruit yield, however no significant effect on fruit eating quality. Similarly, (Li-MingXia., *et al*.2011) reveled that renewal pruning increased leaf area, chlorophyll content, fruit weight, fruit vitamin C and organic acid contents, but had no significant effects on fruit firmness, soluble solids, total sugar, and coloring area.

Effect of nitrogen on tree vigour:

Nitrogen is a basic major mineral nutrient that plays an important role in growth and maintenance of tree vigour. It is a constituent of proteins enzymes, vitamins and plant hormones. It imparts vegetative growth and dark green colour to plants, produces early growth, delays maturity of plants (Singh, 2005). Enhancement of vegetative growth with high 'N' application in dried apricot 'Hacihaliloglu' has been reported by Asma *et al*., (2007). In a study on apricot cultivar Moorpark, it was reported that trunk circumference was significantly higher in those trees which received 750 and 1000g N/tree/year than from those trees that received no nitrogen (Rettke *et al.,* 2006). The fertigation of nitrogenous fertilizers markedly improved the tree vigour over soil fertilizer application both with/without irrigations in apricot cv. New Castle (Raina *et al.,* 2005). High 'N' fertilization enhanced vegetative growth in apricot11 cv. Bergeron (Bussi *et al*. 2003). In a study, on the effect of nitrogen and potassium fertilization on the growth of apricot trees, it was found that increasing levels of 'N' enhanced the vegetative growth while the application of 'K' didn't affect the tree trunk circumference (Bussi and Amiot, 1998). Marked increase in the tree girth and annual shoot growth was reported in apricot cv. Trevatt with the application of 6 and 5 kg NPK/tree under different levels of NPK (Swati *et al.,* 1990). The relationship between leaf nutrient content and tree growth was investigated by Marinov (1983) in apricot cv. Hungarian and found a positive correlation between leaf 'N' content and the total length of annual shoot increment. The maximum increase in trunk girth (5.3%) was reported in apricot cultivar New Castle when 600g 'N' was applied to the soil (Sud and Bhutani, 1988). Tree growth in terms of height, spread, girth and shoot extension growth increased with soil application of N and P (Joolka *et al.,* 1989). A direct correlation between 'N' and the girth of tree trunk was also found in apricot by Kecskemeti and Nyujto (1985).

The effects of nitrogenous fertilizers on growth, yield and quality in plum cv. Santa Rosa, the maximum increase in plant growth in terms of trunk girth, shoot growth, tree volume and leaf area was observed with the treatment of urea (500 g N/tree) by Saini (2011). The highest trunk girth, shoot growth and leaf area in 80 per cent of recommended dose (NPK) as compared to 40 per cent of recommended (NPK) dose. Better tree growth was found with higher dose of nitrogen as compared to lower dose of nitrogen in plum (Chauhan, 2008). Increased shoot growth with increasing 'N' rate was reported in plum cv. Santa Rosa by Sharma and Bhargava (2003). Increased vegetative growth in terms of increase in trunk growth, shoot growth, weight of abscised leaves and pruned wood and their higher values were recorded in 'Santa Rosa' plum at 800g N/tree with increased N rates (Kumar and Bhutani, 1999). Increase in trunk circumference in plum with increased 'N' rates was reported by Wooldridge *et al.,* (1995). Sharafat *et al.,* (1997) reported that applying 'N' at 1.5kg/tree resulted in maximum shoot growth in plum 'Fazli Manani'.

The moderate autumn fertilization of nitrogen improved young peach orchard productivity, but favoured vegetative growth in the crown outer parts (Jordan *et al*., 2009). Additional pruning may therefore be required to control tree shape. It was reviewed that 500g N/tree is the best and most economical treatment for improving the growth in peach (Singh and Singh, 2002). Improved growth was reported in peach trees with increasing 'N' rates (Bussi *et al.,* 1991). However, the application of nitrogen to soil has been reported to increase vegetative growth and vigour of peach trees by many workers (Soing *et al.,* 1998 and Arora *et al.,* 1999).

An experiment conducted on apple cv. Red Delicious to study the effect of N (0, 700, 1050 and 1400 g N per tree) on shoot growth, shoot girth, fruit set, trunk diameter, bloom density, fruit retention and fruit drop, leaf nitrogen content and available nitrogen in the soil revealed that the supplementation of N to the old and unproductive apple plants improved the vegetative growth, flowering attributes and nutrient uptake to a great extent (Rajkumar *et al*., 2008). The investigations carried out on the influence of Urea concentration on the growth of shoots during active period of growth in tree, 'Golden Delicious', 'Florina' and 'Idared' apple varieties grafted on the rootstock M26 revealed that higher dose of N gave the positive results of the investigation (Vamasescu, 2011). On the contrary, Tojnko *et al*., (2012) reported that there was no significant effect of N treatment on the trunk cross sectional area and fruit size.

Effect of nitrogen on productivity:

The higher level of soil applied nitrogen (100g N/tree) increased the production of apricot by 78% in a case study regarding the chemical fertilization upon growth, fruit bearing and pre- mature death of apricot tree by Bucurean 2009**.** High 'N' (96 kg/ha) application was found to increase the vegetative growth and yield of quality fruits of dried apricot cv. Hacihaliloglu (Asma *et al.,* 2007). Studies on the growth and yield response of 12 years old apricot cv. Moorpark to applied nitrogen at different rates of 0, 250, 500, 750, 1000 and 1250 g/tree/year for 3 years revealed that yield of fresh fruit and dry fruit were significantly increased by nitrogen treatment of 1000 g/tree/year than the other treatments (Rettke *et al*., 2006). High N application on apricot cv. Bergeron enhanced vegetative growth, yield and average fruit weight (Bussi *et al*., 2003). The highest yield was obtained from the trees of apricot 'New Castle' fertilized with 600g N (Sud and Bhutani, 1988). Significant increases in yields were recorded in apricot with increasing 'N' amounts levels (Bussi and Amiot, 1998; Marinov *et al.,* 1999). Application of nitrogen on soil surface twice a year at rate of 300kg/ha in combination with P and K gives high yield of apricot in a field experiment carried out in Silistra (Marinov, 1995). Again Marinov (1995) in a multifactorial experiment, interactions between 4 cultivars, 3 N fertilizers rates (200, 400 and 600 kg/ha), 2 irrigation treatments and 3 planting densities observed highest yield in all cultivars planted in 4X4 or 3 m incorporate with irrigation and 400 kg N/ha dose. The best yield was obtained in apricot cv. Hungarian by applying 300, 160 and 200 kg/ha of N, P_2O_5 & K_2O respectively (Marinov, 1983). Significantly higher yields were obtained in 'New Castle' apricot with NPK fertilization in comparison to control and further, it was reported that application of P and /or K without N had no effect on fruit yields.

Calcium nitrate as well as urea + lime 50% gives higher production of plum fruits in cultivar Santa Rosa raised on wild apricot seedling rootstock (Saini *et al*., 2013). Saini (2011) obtained maximum yield of plum with application of urea (500 g N/tree). The maximum yield with higher dose of nitrogen as compared to lower dose in Santa Rosa plum was observed by Chauhan (2008). The maximum yield (53 kg/tree) was recorded in plum trees with N+P+K application (Sharma *et al.,* 2006). It was reported that out of various fertilizer combinations, the application of N + manure to trees of 'Spring Time' resulted in the highest fruit yield (Chatzitheodorou *et al.,* 2004). The highest fruit yield (23.45 kg/tree) was obtained in 'Santa Rosa' plum with 'N' fertilization (Sharma and Bhargava, 2003). Increased yield was reported in some of the plum cultivars with 'N" fertilization (Pipitone *et al*., 1994). Elevated levels of 'N' alone or, combined with 'K' increased fruit yield of 'Stanley' prunes, but a rise in 'K' without a corresponding rise in 'N' didn't (Kwong, 1973).

The best and most economical treatment for improving the yield and quality of fruits in peaches was obtained with 500g N/tree along with the basal dose of 200g P_2O_5 and 480g K_2O (Singh and Singh, 2002). Increased yield was recorded in peaches with increasing 'N' level up to 500g/tree (Singh and Chauhan, 2002). Higher yield (37.9 kg) and large fruits were obtained under 1000g N and 1200g each of P and K per tree (Khan *et al.,* 2000). The fruit yield of peach was found to be directly associated with 'N' levels (Arora *et al.,* 1999). It was concluded that 'N' application stimulates peach yield by increasing the assimilate availability or fruit growth (Saenz *et al.,* 1997). The yield was found to be increased as 'N' rate was increased up to 1.0 kg /tree (Sharafat *et al.,* 1997). The fertilizer rate or date of application had no effect on fruit yield has been reported in peach (Marangoni *et al.,* 1995). The yield was found to be influenced by the higher rate of N in 3 of the 6 growing years in 'Fairhaven' peach (Meheriuk *et al.,* 1995). It was reported that minimum fruit drop and maximum yield (71.07 kg/tree, compared with 48.51 kg/tree in control) occurred with the application of 3.0 kg NPK/tree (Swati *et al.,* 1990). Many research workers have reported increase in yield in stone fruits up to a certain level of nitrogen and decreased thereafter (Kwong, 1973; Szucs, 1986; Joolka *et al.,* 1989).

The effect of different levels of nitrogen (600, 700 and 800 g/tree) on fifteen year old apple tree cv. Starking Delicious on tree growth, fruit yield and leaf nutrient status revealed that nitrogen had significant effect on tree growth and fruit yield. 700 g N/tree was observed to be the treatment with maximum production followed by 600 and 800 g N/tree (Kaith and Kumar, 2010).

Effect of nitrogen on fruit quality:

The various attributes which governs the quality of fruits include size, shape, fruit, firmness, TSS, acidity, proteins and fruit colour etc. These quality parameters are significantly affected by nitrogen fertilization in fruit crops. Increased average fruit weight was recorded with high ‘N’ application; but reduced total soluble solid content of dried apricot cv. Hacihaliloglu (Asma *et al.,* 2007). Significant reduction in fruit firmness was reported in apricot cv. Moorpark with the increased rate of applied nitrogen. The flesh of individual fruits ripened more evenly when 0 or 250g N/tree/year was applied compared with rates in the ranges (500-1250g) N/tree/year (Rettke *et al.,* 2006). Apricot fruits from trees treated with 80 kg N ha^{-1} showed a significantly higher content in phenolic compounds, a slightly higher sugar concentration and a lower organic acid concentration than those treated with 150 kg N ha^{-1} (Mohamed *et al.,* 2003). The normal fruit size and acidity was obtained in apricot cultivar New Castle under fertilizer treatment but total sugar contents was significantly reduced with 5.0 and 6.0 kg NPK $tree^{-1}$ (9.18 and 9.16, respectively) as compared with control (Swati *et al.,* 1990). Increased fruit weight was observed in apricot ‘New Castle’ with the increasing levels of N and P treatments. Further, it was noted that increased dose of nitrogen increased the total soluble solids (18.93%) but decreased the fruit acidity (1.48%) with the application of N fertilizers in apricot (Joolka *et al.,* 1989). It was observed that urea application increased leaf N content, fruit yield and, at highest concentration; fruit weight and size but reduced the percentage of TSS; reducing sugars; total sugars and vitamin C contents of the fruit and had no effect on fruit dry weight and total acidity of apricot cv. Cheletano (Taha and Abbass, 1987). The highest average diameter (3.63 cm), weight (25.59 gm) was recorded in fruits of apricot cultivar New Castle with the use of nitrogen and potash while TSS (18.02%) was obtained under NPK treatment but the highest acidity (1.43%) was found with the single application of ‘N’ treatment (Nijjar *et al.,* 1972). The highest average weight per fruit (30.4g) and total soluble solids (18.4%) was reported in ‘New castle’ apricot with the application of nitrogen in combination with phosphorous while the application of potash alone gave low acid contents 0.70, 0.75 and 0.56% in comparison to 0.94, 1.20 and 1.10% in control (Chadha and Bajwa, 1966). The maximum fruit size and quality attributes were obtained in apricot cultivar New castle with the use of NPK fertilizers (Bajwa and Chadha, 1968).

Calcium nitrate as well as urea + lime 50% gives best fruit quality, viz. total sugar, reducing sugar, anthocyanin pigment and fruit firmness of plum fruits in cultivar Santa Rosa raised on wild apricot seedling rootstock (Saini *et al*., 2013). Saini (2011) recorded maximum fruit size, weight, total sugars, reducing and non reducing sugars with the treatment of urea (500 g N/tree) in plum. The maximum fruit size, weight, sugars and TSS of plum was obtained with higher dose of nitrogen as compared to lower dose (Chauhan, 2008). No significant differences were found between various nitrogen fertilizers in prune 'Hanita' in terms of tree growth, yields and fruit quality (Lipecki *et al.,* 2004). Furthermore, there were no significant effects on the weight, dry matter, sugar and organic acid contents of fruits of both plum cvs. Bluefre and Top supplied with 0, 50 and 100 kg N/ha (Szwedo and Murawska*.,* 2004). No reduction in the fruit quality was being observed in plum by the application of fertilizers even at higher rates (Vitanova, 1984). The best quality fruits were obtained from trees of plum cv. Satsuma receiving N: P: K at 101.4:199.3:101.4g/tree (Verma and Ghosh*.,* 1982). In another study, nitrogen at 125 and 250 kg /ha applied annually for 5-years old peach cv. Redhaven, delayed fruit ripening (Janjic, 1979). The bigger fruits of 'Stanley' prunes were obtained in plots receiving 476.3g N plus 612.4g K. Further, it was observed that nitrogen had no effect on titratable acidity and soluble solids of the fruit (Kwong, 1973).

Increased treatment of N from 0, 22, 44, 66 and 88 kg/N/ha/year simultaneously increased nitrogen content in leaves as well as in fruit of peach (Brunetto *et al*., 2007). In peach with various fertilizer treatments 500g N/tree was the best and most economical treatment for improving the growth, yield and fruit quality in peach and thus revealed that nitrogen is the most limiting element in peach production due to its bearing on previous year growth by Singh and Singh (2002). TSS, sucrose content and major constituent of aroma of peach cv. Hakuho was found highest in medium level of complete liquid fertilizer which contain 80 ppm N compared to high and low levels of complete liquid fertilizer which contain 160 ppm and 80 ppm N respectively but tritatable acidity, citric acid and malic acid content found highest in high levels of complete liquid fertilizer (Jia *et al*., 1999). Prenkie (1994) observed that N at 50, 100 or 150 kg/ha increased fruit weight and total acid content of peach cultivar 'Spring Gold', Early Cornet and Cornet grown on peach rootstocks, but all rates of N reduced the soluble solids contents of fruit.

Treatment of nitrogen fertilizers rates up to N_{360} with P_{90} and K_{180} respectively on apple cv. Rubinovoe Duki on MM 106 rootstock revealed that high N doses promote excessive growth, increased fruit quality and other physiological and biochemical process (Tartachinik, 1997). Increased in fruit weight and improved fruit shape were observed in apple cultivar Strakrimson when N dose were increased in N containing fertilizers (Potassium nitrate, calcium nitrate, ammonium sulphate and urea) by Sotiropoulos *et al*., (2008). Kumar and Singh (1995) observed that 600 g N/tree on apple cultivar Red Delicious increased fruit weight and fruit size and increased in N rate also increased TSS and total sugar content.

Effect of pruning and nitrogen fertilization on tree vigour:

Pruning and nitrogen had been found to have significant effect on annual shoot growth, tree spread and pruning wood weight in senile plum trees (Suklabaidya, 2012). Heavy pruning along with the highest dose of nitrogen produced significantly more growth than other pruning and nitrogen treatment combinations in New Castle apricot (Thakur, 2012). The highest leaf area, total chlorophyll content, net photosynthesis and stomatal conductance were recorded with 750g N+900g K/tree along with cutting back of annual shoots to 75% of their original length in July Elberta' peach trees (Sharma and Chauhan, 2004). The pruning and fertilizer interaction was found to be significant only in respect of tree volume and pruning wood weight in July Elberta' peach (Sharma, 1995).

The better shoot length (142.9cm) and more buds (121.0) were reported in 'Golden Delicious' apple with moderate pruning plus fertilizer application (Ahmed and Raza, 2005). Increased terminal shoot growth was recorded in 25-years apple trees by spraying during 4 consecutive years with urea at 6 lb/100gal, 4 times at weekly intervals starting at petal fall + mulching (materials unspecified) + hard pruning (in the 1^{st} year) (Cahoon and Donoho, 1982). Significantly higher shoot growth was reported in young apple trees at higher 'N' rate, but the proportion of flower buds on short shoots was greater with low 'N' (Goldschmidt, 1972).

Periodic and continuous pruning methods coupled with urea fertilization at different period had the maximum length and weight of new shoot growth as observed by Gholiyan *et al*., (2013). Stimulated shoot growth was found in viniferous grapes with increasing 'N' levels, whereas P and K lowered them. However, high rates of all NPK fertilizers resulted in the greatest root and shoot growth. Vines allowed to trail on the ground during their 1^{st} year were more vigorous than vines supported on stakes, whereas, in Red Roumi vines, however, were vigorous enough when well fertilized to be trained on stakes in their first year (Shehata, 1976).

Effect of pruning and nitrogen fertilization on productivity:

In peach, yield was reported to be decreased with increasing pruning intensity and increased with increasing N level up to 500g/tree (Singh and Chauhan, 2002). The effects of pruning and fertilizer interaction on yield were found to be non-significant during both the years of study in 'July Elberta' peach (Sharma, 1995). The highest yield increase was recorded in 'Mit Ghamr' peach trees pruned to 200 shoots and treated with 180g N (Hassan, 1990). Effect of pruning and nitrogen fertilization had no significant effect on productivity of New Castle after two years of rejuvenation pruning (Thakur, 2012).

Moderate pruning plus fertilizer application gave more fruit set (390.0) and fruit retention (320.3) in apple cultivar 'Golden Delicious' (Ahmed and Raza, 2005). Increase in the 2-year average yields from 8.3 bushels/tree in control to 11 bushels/tree were recorded in 25-year old delicious apple trees (Cahoon and Donoho, 1982).

The highest yield (5.50 kg/bush) was recorded in Phalsa with pruning at 75 cm above ground level along with 100 g N/bush (Singh and Singh, 2003). It has been concluded that pruning and N application improved both yield and quality of grapes (Al-Khayat and Al-Dujaili, 2001). Increased yields were obtained in Concord grapes with balance pruning to 60+10 (60 nodes retained for the first lb of pruning and 10 nodes for each additional lb) for the first two years; after which it gave yields similar to those obtained by pruning to 30+10. Nitrogen application (high or low) had little effect on yield (Morris *et al.,* 1983).

The effect of rejuvenation pruning (at 5, 50 and 100 cm height above ground) and nitrogen application (at 75 and 150 kg/ha) on yield of the 13 year old highbush blueberry (*Vaccinium corymbosum*) cv. Bluecrop revealed that plants on the control plots and those pruned at a height of 100 cm recorded the highest total yields but no differences in yield were found in relation to nitrogen fertilizer applied was reported by Smolarz (2005). Maximum yield was recorded in mango 'Fazli' when the leader remained intact, removal of first order branch and pruning of secondary branches along with application of 1kg each of N and K_2O and 0.5 kg P_2O_5 per plant per year along with 3% urea spray in the month of September (Banik and Sen, 2002). Significant improvement in fruit production and yield was reported in mandarin orange with rejuvenation pruning of dead, decayed and infected shoots of 48-year old trees followed by application of 200, 400 or 600g N, 200g K and 200g P/tree together with 0.5 % Zn and/or 0.4% Cu sprays. The highest yield of 15.45 t/ha was obtained with 600g N + 200g P + 200g K/tree +0.4% Cu + 0.5% Zn. Of the nutrients applied, N had more pronounced effect on the yield (Kar *et al.,* 1988). It was reported that rejuvenation pruning increased the yield of apple cv. Antonovka Obyknovennay by 22. 9 centners/ha, N fertilization by (27.1-27.7) centners/ha and the two treatments combined by 44.3 centners/ha, i.e. the yield was more than double compared with that of the non-treated control trees (Eliseeva, 1985).

Effect of pruning and nitrogen fertilization on quality and foliar nutrient contents:

Amongst the various physico-chemical characteristics, pruning and nitrogen interaction had a significant effect only on diameter of plum fruits (Suklabaidya, 2012). Heavy pruning in combination with standard dose of nitrogen produced significantly heavier and larger fruits, improved fruit firmness and resulted in an increased in various physico-chemical fruit parameters (TSS, total sugar, reducing sugar and non-reducing sugar) than all other treatments in New Castle apricot (Thakur, 2012). Again Thakur (2012) recorded maximum foliar nutrient content (N, Fe, Mn and Zn) with the heavy pruning treatment along with increasing levels of nitrogen, while P, K, Ca and Mg showed declining trends with the increasing pruning severity and nitrogen levels in leaves of rejuvenated New Castle apricot tree. Analysis on fruit grading and maturity of peach cv. July Elberta showed that heavy pruning combined with N at 250g/tree + K at 900g/tree produce large fruits and resulted in early fruit harvest and higher returns (Sharma *et al.,* 2001). The interactions of pruning and fertilizer treatments were significant in respect of fruit diameter, fruit length and fruit weight in peach cv. July Elberta (Sharma, 1995). Large and good quality fruits were reported in 'Mit Ghamr' peach trees with 100 fruiting shoots supplied with high rate of nitrogen (Hassan, 1990). Enhanced fruit maturity was reported in peach 'Flordasun' more by heavy pruning than by moderate or light pruning. High N rates delayed fruit maturity but PK had no consistent effect (Kanwar and Nijjar, 1983). Contrary to it, Lanzelotti (1987) and Walsh *et al.,* (1989) did not observe significant effect of N fertilization on fruit size in peaches.

Significant interaction between traditional pruning and nitrogen fertilization at different (0,800, 1000, 1200 g/tree) levels on nut weight, nut splitting and other characteristics was observed in Pistachio nut by Okay *et al*., (2010). The total soluble sugar content of fruit was highest in mango cv. Fazli by pruning the first order branches of the leader branch with the leader intact and N, P and K at 1.0, 0.5 and 1.0 Kg/ha combined with 3% urea (Banik and Sen, 2002). Two consecutive years of heavy pruning in 'Bing' sweet cherry was reported to increase leaf contents (N, P, and Cu, K) and fruit contents as compared to non pruned trees. Non- pruned trees had fruits with higher TSS and more colour, however; high 'N' rates delayed fruit maturity (Fallahi *et al.,* 1993).

Chapter-3

MATERIALS AND METHODS

The present investigation entitled “Rejuvenation studies on growth, fruiting and fruit quality of apricot (*Prunus armeniaca* L.) was carried out in the experimental orchard of department of Fruit Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan, Nauni, (H.P.) during the year 2013 and 2014. The details of experiment site, materials used and methodology adopted during the course of studies are given as under:

EXPERIMENTAL SITE

Location and Climate

The experimental orchard of the department is located at $30^{0}50^{'}45$” latitudes and 77^{0} 88’33” longitudes and at an elevation of 1250 mean sea level, representing mid hill zone of Himachal Pradesh.

The experimental orchard falls under the sub-temperate, sub-humid mid-hills agro-climatic zone of Himachal Pradesh, where summer is moderately hot during May-June while, winter months from December-January experiences cold. The annual rainfall ranges between 110-120 cm out of which 75% is received during June to September months.

Soil Status

The physico-chemical characteristics of orchard soil were determined before the start of experiment and detail of information is presented in table given below.

Table 1: Physico-chemical properties of experimental orchards soil

Sr. No.	Particulars	Results	Method used
1	**Mechanical analysis**		
	Bulk density (mg/m^3)	1.26	Specific gravity method (Kanwar and Chopra, 1976)
	Field capacity	28.08%	Specific gravity method (Kanwar and Chopra, 1976)

2	**Chemical analysis**		
	pH	6.6	1:2 Soil water suspension method (Jackson, 1967) Digital pH meter
	Electrical conductivity (dSm^{-1})	0.44	1:2 Soil water suspension method (Jackson, 1967) Digital conductivity meter
	Organic Carbon (%)	1.62 %	Walkley and Black's rapid titration method (1934)
	Available N (Kg/ha.)	319.67	Alkaline potassium per manganate method (Subbiah and Asija, 1956)
	Available P (Kg/ha.)	16.76	Extraction with 0.05 M $NaHCO_3$ (pH 8.5) and development of colour by stannous chloride reduce ammonium molybdate method (Olsen *et al*., 1954)
	Available K (Kg/ha.)	180	Extraction with neutral normal ammonium acetate and determination by flame photometer (Merwin and Peech, 1951)

EXPERIMENTAL DETAILS

The present studies were conducted on 25-years old rejuvenated trees of New Castle apricot raised on wild apricot rootstocks spaced at 3 x 3 m and trained to modified central leader system. These experimental trees were given rejuvenation treatments (combination of 3 pruning severities and 3 levels of nitrogen) in the winter of the year 2011. The rejuvenation pruning were given only once during winter pruning in 2011. The standard pruning is being practiced afterwards but the combination of different level of nitrogen in the experimental trees is being applied as at the start of experiment. To ascertain the effect of rejuvenation treatment on tree vigour, fruiting, and productivity the study was further continued for another 2 years i.e. 2013 and 2014. Therefore present studies will be carried out on the same rejuvenated trees of New Castle apricot during 2013 and 2014 in the experimental orchard of department of Fruit Science, Nauni, Solan.

a) Pruning Treatments:

1) Light pruning

It consisted of 20% heading back of scaffolds and 45 to 50 percent thinning out.

Pruning 20 % heading back of scaffolds

Pruning 40 % heading back of scaffolds

Pruning 60 % heading back of scaffolds

Normal pruning (Control)

Plate 1: Different rejuvenation pruning intensities in apricot cv. New Castle

2) Medium Pruning

It consisted of 40% heading back of scaffolds and 45 to 50 percent thinning out.

3) Heavy pruning

It consisted of 60% heading back of scaffolds and 45 to 50 percent thinning out.

The 45 to 50 percent thinning out of one year old shoots was done uniformly in all the above pruning intensities.

b) Nitrogen Treatments:

Three different levels of N consisted of 500, 625 and 750 g per tree. Full dose of nitrogen was applied in the form of Urea in two split doses, first half of N along with basal dose of P_2O_5 and K_2O was applied in the first week of February and second half of N was applied in third week of March just after fruit set. To neutralize the effect of urea exactly half quantity of lime to that of urea was also supplemented in each experimental plant.

Standard recommended doses of FYM, P and K were applied in all the experimental trees.

Layout of experiment

The experiment was laid out in January, 2013 with the following details:

Treatments combination

T_1 = Heading back of scaffolds (20%) + 500g N
T_2 = Heading back of scaffolds (20%) + 625g N
T_3 = Heading back of scaffolds (20%) + 750g N
T_4 = Heading back of scaffolds (40%) + 500g N
T_5 = Heading back of scaffolds (40%) + 625g N
T_6 = Heading back of scaffolds (40%) + 750g N
T_7 = Heading back of scaffolds (60%) + 500g N

T_8 = Heading back of scaffolds (60%) + 625g N

T_9 = Heading back of scaffolds (60%) + 750g N

T_{10} (control) = Heading back at secondary branches level + 500g N

Number of Treatments	:	10
Number of Replications	:	3
Experimental Design	:	Randomized block design
Variety	:	New Castle

The studies conducted and procedures followed are detailed below:

OBSERVATIONS RECORDED

Tree growth and yield

Annual shoot growth

Ten shoots of current season's growth were randomly selected in all directions at a working height in the end of growing season before pruning in 2013 and 2014 respectively and measured in cm for calculating average annual shoot growth during the course of studies.

Trunk girth

The tree trunk was marked with red paint at 15cm above the graft union before the start of experiment. The trunk girth was measured at this point with a measuring tape in the end of the growing season during both the years of study. The results were expressed as per cent increase in trunk girth.

Tree spread

The spread of the trees from each replication were measured once in 2013 and in 2014 with the help of a measuring tape across the tree in North-South and East-West directions and average of both the measurements was worked out to express mean value in meters.

Tree volume

Total above ground volume of the each experimental tree was calculated from height and spread measurements according to the formulae given by Westwood (1978) and expressed in cubic meters.

i) For a tree that was taller than its width

Volume $=4/3\ \pi\ ab^2$ if a>b

ii) For a tree that was wider than height

Volume $=4/3\ \pi\ a^2b$ if a<b

Where, r = 3.1416

a = ½ the length of major axis

b = ½ the length of minor axis

Pruning weight

The weight of pruning wood was recorded at the time of pruning each year in January, 2012 and 2013 to have an estimate of the effect of pruning intensities and N levels on the tree growth. The pruning weight was expressed in kg $tree^{-1}$.

Leaf area

Fully developed 20 leaves were randomly collected during the last week of June from all around the periphery of the tree. The leaf area was measured with the help of Automatic Leaf Area Meter (Licor Model 3100) and expressed as square centimeters.

Chlorophyll contents

The leaf samples for the estimation of chlorophyll content were taken during the month of July. Leaf samples comprising 20 representative leaves were collected during morning hours (Halfacre *et al.,* 1968), from each experimental tree and collected in ice box in the field and then kept in the refrigerator at 0ºC prior to estimation to avoid degradation of chlorophyll pigment. Samples were then chopped to fine pieces under subdued light and 100 mg of chopped leaf samples were placed in vials containing 7 ml of Dimethyle Sulphoxide (DMSO). The contents of the vials were incubated at 65ºC for half an hour and then the extract was transferred to graduated test tube and the final volume was made to 10 ml with Dimethyle Sulphoxide as suggested by Hiscox and Israeistam, (1979).

Estimation

The O.D. values of the above extracts were recorded in Spectronic-20 at 645 nm and 663 nm wavelengths against a Dimethyle Sulphoxide blank. The total chlorophyll content was calculated by using the formula:

$$\text{Total chlorophyll} = \frac{20.2A_{645} + 8.02A_{663}}{a \times 1000 \times W} \times v$$

Where,

V	=	Volume of the extract made
a	=	Length of the light path in cell (usually 1 cm)
w	=	Weight of the sample
A_{645}	=	Absorbance at 645nm
A_{663}	=	Absorbance at 663nm

Fruit set (%)

Five branches on different aspects of the tree were tagged for counting flowers and number of fruit set in both the years. Fruit set was recorded three weeks after petal fall and percent fruit set was calculated by using the formula given by Westwood (1978) as given, below:

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit set}}{\text{Number of flower}} \times 100$$

Yield

The yield was recorded both in 2013 and 2014 by weighing the total number of fruits on a tree at the time of harvest and expressed as kg $tree^{-1}$.

Physico-chemical fruit characteristics

FRUIT SIZE:

Fruit length (mm)

Polar length of selected fruits from each replication was recorded between calyx and styler end and mean value was worked out

Fruit breadth (mm)

Breadth of the same fruits, which were used for measuring length, was recorded by measuring distance between cheeks of the fruits with the help of digital Vernier Callipers.

Fruit weight

Ten randomly selected fruits were weighed on electric top pan balance. The values so obtained were averaged and expressed in g fruit^{-1}.

Fruit volume

Volume of fruits was measured by water displacement method. Selected fruits were immersed in a measuring cylinder filled with water to obtain certain graduation. The difference between initial and final readings gave the measure of volume of fruit samples. The results were averaged and expressed in cubic centimeter fruit^{-1}.

Fruit firmness

The fruit firmness was determined by a Portable Penetrometer which recorded the pressure needed for the plunger to penetrate the flesh. The fruit firmness was expressed in kilogram per centimeter square (Kg/cm^2).

Total soluble solids (TSS)

Total soluble solids content were determined by Erma hand refractometer (0-32ºBrix). The refractometer was calibrated with distilled water before use. A temperature correction was applied when it was above or below 20ºC (A.O.A.C., 1980). The total soluble solids were expressed as percentage of fresh juice.

Titratable acidity

Twenty five grams of fruit pulp was thoroughly mixed with distilled water in a Warring blender, the volume was made to 250 ml. The solution was filtered through Whatman No.1 filter paper. 25ml of this solution was titrated against N/10 NaOH using phenolphthalein indicator. The total titratable acidity was calculated in terms of malic acid on the basis of 1 ml N/10 NaOH equivalent to 0.0067g anhydrous malic acid. The results were expressed as per cent titratable acid on pulp weight basis.

Total sugars

To the remaining filtered stock solution 10 ml of saturated lead acetate was added and volume made to 250 ml, then solution was filtered into flask containing potassium oxalate and the filtrate was again filtered. 100 ml of this deleaded and clarified solution was hydrolyzed by adding 3ml of concentrated HCl and leaving it overnight. The excess of HCI was neutralized by 10 per cent NaOH solution. The total sugars were estimated by titrating the boiling mixture containing 5ml each of Fehling A and Fehling B solution against the hydrolyzed aliquot (A.O.A.C., 1980) and results were expressed as per cent on pulp weight basis.

Reducing sugars

Boiling mixture of 5ml each of Fehling A and Fehling B solution were titrated against the remaining unhydrolyzed, deleaded and clarified pulp solution. The results were expressed as per cent on pulp weight basis.

Non-reducing sugars

The amount of non- reducing sugars were calculated by subtracting the amount of reducing sugars from the total sugars and multiplying by standard factor 0.95 and results were expressed as per cent non-reducing sugars.

DETERMINATION OF LEAP NUTRIENT STATUS

Collection and preparation of samples

For estimation of macro and micronuirients status of foliage, forty-five fully mature and expanded current seasons' leaves located at the 8^{th} position from the apex were collected all round the periphery of the plant. The collected leaf samples were washed first under tap water followed by 0.1 M HC1, distilled water and finally with double distilled water. The drying, grinding and storing of samples were carried out in accordance with the procedure described by Kenworthy (1964).

Digestion of leaf samples and estimation of Nitrogen elements

One gram well dried and grinded leaf samples were used for estimation of leaf nitrogen. The samples were digested on automatic digestion system using one gram of digestion mixture and 20 ml of concentrated sulphuric acid. The digestion mixture was prepared by mixing 400 parts potassium sulphate, 20 part copper sulphate. The boiling of samples was continued till the appearance of light blue color. The samples were cooled and diluted to 100 ml with distilled water. The samples were fed to Auto analyzer Kjeltec FOSS Tecator Model 2300 for auto distillation and titration of the samples. The end point was the appearance of slight red colour.

Digestion of leaf samples for other nutrients estimation

For the estimation of other nutrients, one gram of dried and grinded sample was transferred into 250 ml conical flasks. 20 ml of diacid mixture (comprising of 4 parts of nitric acid and 1 part of perchloric acid) was added to these flasks. The samples were digested on electric hot plate. The digestion continued till 2-3 ml of clear digested material was left in the conical flasks. After complete digestion the samples were diluted to 100 ml with the help of distilled water.

Estimation of phosphorous, potassium and other elements in leaf samples

Total phosphorous was estimated by vanado molybdo phosphoric acid method (Jackson, 1973). Five ml of extract (digested sample) was taken in 25 ml of volumetric flask. To this flask 20 ml of working solution was added and final volume was made to 25 ml with distilled water. The contents were mixed and used for estimation of phosphorous on Spectronic-20 D at 470 nm wavelength using red filter. The colour intensity (yellow) was recorded and the phosphorous content was depicted with the help of standard curve.

The potassium in plant tissue was estimated on flame photometer (Jackson, 1973). The digested samples were diluted to 100 ml with distilled water 5 ml of this prepared sample was diluted to 50 ml with distilled water. The samples vis-a-vis to standards are fed one by one to the instrument and readings were recorded in percent. Same procedure was followed for estimation of Ca also.

The determination of other elements i.e. Mg and micronutrients (Zn, Cu, Mn and Fe) were carried out on Atomic absorption spectrophotometer model 4141 by using 10 ml of 100 ml prepared sample, which was further diluted to 5 ml with distilled water. The macro and micronutrients of leaves were computed on dry weight basis and expressed as per cent and ppm, respectively.

SOIL ANALYSIS

Soil samples representing 0-45 cm depth were collected from four sites of each experimental tree basin with the help of screw auger during first week of February, 2013. The samples were dried in shade, ground, passed through 2 mm sieve and stored in cloth bags. The soil analysis for various characteristics viz. pH, electrical conductivity, organic carbon, available N, P and K, Bulk density and Field capacity were carried out as per method given in Table 1.

Chapter-4

EXPERIMENTAL RESULTS

The present investigation entitled "Rejuvenation studies on growth, fruiting and fruit quality of apricot (*Prunus armeniaca* L.) cv. New Castle" were carried out in the experimental orchard of department of Fruit Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan, Nauni, (H.P.) during the year 2013 and 2014 and revealed the following results.

Trunk girth (cm)

The perusal of data given in Table 1 in respect of trunk girth increased from 2013 to 2014 revealed that different rejuvenation treatments had significant influence on per cent increase in trunk girth. The maximum increase in trunk girth (3.20%) was recorded in T_5 (40% heading back of scaffolds+625g Nitrogen) and minimum per cent increase in trunk girth (2.12%) in control (heading back at secondary branches level+500g Nitrogen) which was statistically at par to T_1 (Heading back of scaffolds 20% + 500g N), T_2 (Heading back of scaffolds 20% + 625g N), and T_4 (Heading back of scaffolds 40% + 500g N).

Annual shoot growth (cm)

Annual shoot growth was influenced by different rejuvenation treatments significantly as evident from the data given in Table 1 during both the years of study. In the year 2013, markedly highest annual shoot growth (169.00 cm) was recorded in treatment T_9 (60% heading back of scaffolds+750g Nitrogen) which was significantly at par with T_8 (Heading back of scaffolds 60% + 625g N). The significantly lowest annual shoot growth (156.27 cm) was obtained in control (heading back at secondary branches level+500g Nitrogen) compared to all other treatments.

Similar results were obtained during the year 2014, as treatment T_9 (60% heading back of scaffolds+750g Nitrogen) resulted in maximum (165.12 cm) annual shoot growth which was again at par with T_8 while the minimum (151.05

cm) annual shoot growth was recorded in control (heading back at secondary branches level+500g Nitrogen).

The pooled data of both the years also showed highest annual shoot growth (167.06 cm) in T_9 (60% heading back of scaffolds+750g Nitrogen) and minimum annual shoot growth (153.66 cm) in control (heading back at secondary branches level+500g Nitrogen).

Table 1: Effect of rejuvenation pruning and nitrogen levels on trunk girth and annual shoot growth of apricot

Treatment Code	Treatment	Increased in trunk girth (%)	Annual shoot growth(cm)		
		2013-2014	2013	2014	Pooled
T_1	Pruning 20%+500g Nitrogen	2.35	160.30	156.15	158.23
T_2	Pruning 20%+625g Nitrogen	2.41	161.18	157.22	159.20
T_3	Pruning 20%+750g Nitrogen	3.01	162.37	158.57	160.47
T_4	Pruning 40%+500g Nitrogen	2.29	163.07	159.04	161.06
T_5	Pruning 40%+625g Nitrogen	3.20	164.13	160.88	162.50
T_6	Pruning 40%+750g Nitrogen	3.05	166.47	162.22	164.35
T_7	Pruning 60%+500g Nitrogen	2.71	165.37	161.82	163.60
T_8	Pruning 60%+625g Nitrogen	2.74	167.06	163.41	165.24
T_9	Pruning 60%+750g Nitrogen	2.67	169.00	165.12	167.06
T_{10}	Control	2.12	156.27	151.05	153.66
$CD_{(0.05)}$		**0.35**	**1.80**	**2.75**	**1.58**

Tree height (m)

The effect of different treatments of rejuvenation pruning and nitrogen levels in respect of tree height is given in Table 2. It is evident from the data that different treatments influenced tree height significantly. Maximum tree height (5.70 m and 5.85 m) was recorded in T_3 (20% heading back of scaffolds+750g Nitrogen) during the year 2013 and 2014, respectively. The minimum tree height (3.80 m and 4.09 m) was found in control (heading back at secondary branches level+500g Nitrogen) during consecutive years of study.

The pooled data of both the years also revealed that highest annual shoot growth (5.77 cm) and minimum annual shoot growth (3.95 cm) in both the years were observed in T_3 (20% heading back of scaffolds+750g Nitrogen) and control (heading back at secondary branches level+500g Nitrogen) respectively.

Tree spread (m)

The perusal of data given in Table 2 indicates that different pruning intensities and nitrogen levels had significant effect on tree spread of rejuvenated apricot trees. The maximum tree spread (4.61 m and 4.65 m in 2013 and 2014, respectively) was recorded in T_9 (60% heading back of scaffolds +750g Nitrogen) treatment and in the year 2014 and it was at par (4.61m) with T_8 (Heading back of scaffolds 60% + 625g N) treatment. The minimum tree spread (3.85 m and 3.90 m in 2013 and 2014, respectively) was observed in control.

The pooled data of both the years also show that T_9 (Heading back of scaffolds 60% + 750g N) had highest tree spread (4.63 m) and control (Heading back at secondary branches level + 500g N) with lowest tree spread (3.88 m).

Table 2: Effect of rejuvenation pruning and nitrogen levels on tree height and tree spread of apricot

Treatment Code	Treatment	Tree height (m)			Tree Spread (m)		
		2013	2014	Pooled	2013	2014	Pooled
T_1	Pruning 20%+500g Nitrogen	4.98	5.14	5.06	4.32	4.38	4.35
T_2	Pruning 20%+625g Nitrogen	5.13	5.26	5.19	4.43	4.48	4.45
T_3	Pruning 20%+750g Nitrogen	5.70	5.85	5.77	4.51	4.53	4.52
T_4	Pruning 40%+500g Nitrogen	4.63	4.84	4.73	4.38	4.39	4.39
T_5	Pruning 40%+625g Nitrogen	4.72	4.98	4.85	4.46	4.48	4.56
T_6	Pruning 40%+750g Nitrogen	5.33	5.51	5.42	4.55	4.57	4.47
T_7	Pruning 60%+500g Nitrogen	4.53	4.68	4.61	4.48	4.56	4.52
T_8	Pruning 60%+625g Nitrogen	4.87	4.76	4.82	4.57	4.61	4.59
T_9	Pruning 60%+750g Nitrogen	4.74	4.84	4.79	4.61	4.65	4.63
T_{10}	Control	3.80	4.09	3.95	3.85	3.90	3.88
$CD_{(0.05)}$		**0.35**	**0.26**	**0.21**	**0.02**	**0.06**	**0.03**

Pruning wood weight (kg/tree)

The data on the effect of pruning intensities and nitrogen levels on pruning wood weight presented in Table 3 showed that different treatments had significant effect on pruning weight in both the years. The heavily pruned trees significantly produced more pruning wood weight followed by other treatment combination. Results on pruning wood weight reveal that removal of more pruning wood (10.17 kg/tree and 8.21 kg/tree) in heavily pruned trees during 2013 and 2014 respectively where observed in treatment T_9 (60% heading back of scaffolds+750g Nitrogen). In 2014, T_8 (Heading back of scaffolds 60% + 625g

N) (7.53 kg/tree) was statistically at par to T_9 (Heading back of scaffolds 60% + 750g N).

The minimum pruning wood weight (5.23 and 4.41 kg per tree during 2013 and 2014, respectively) was recorded in control (heading back at secondary branches level+500g Nitrogen). T_1 (Heading back of scaffolds 20% + 500g N) (5.34 kg/tree), T_2 (Heading back of scaffolds 20% + 625g N) (5.36 kg/tree), T_3 (Heading back of scaffolds 20% + 750g N) (5.57 kg/tree) in 2013 and T_1 (Heading back of scaffolds 20% + 500g N) (4.63 kg/tree), T_2 (Heading back of scaffolds 20% + 625g N) (4.83 kg/tree) in 2014 were at par with each other in respect of pruning wood weight.

The pooled data also revealed that maximum pruning wood weight 9.19 kg/tree was obtained from T_9 (60% heading back of scaffolds+750g Nitrogen) and minimum pruning wood weight 4.82 kg/tree in control (heading back at secondary branches level+500g Nitrogen) and was at par (5.37 kg/tree, 4.99 kg/tree and 5.10 kg/tree) with T_1 (Heading back of scaffolds 20% + 500g N) , T_2 (Heading back of scaffolds 20% + 625g N) and T_3 (Heading back of scaffolds 20% + 750g N) treatments respectively.

Tree volume (m^3)

Different rejuvenations treatments significantly influenced tree volume as is evident from Table 3 during both the years of investigations. The significantly higher tree volume (31.76 and 33.13 m^3 in 2013 and 2014, respectively) was obtained with T_3 (20% heading back of scaffolds+750g Nitrogen) treatment and was at par with T_6 (Heading back of scaffolds 40% + 750g N) and T_9 (Heading back of scaffolds 60% + 750g N) in both the years. The lowest tree volume (13.27 and 16.31 m^3 in 2013 and 2014, respectively) was recorded in control (heading back of scaffolds+500g Nitrogen).

The pooled data also showed similar trend as, T_3 (20% heading back of scaffolds+750g Nitrogen) with highest tree volume of 32.45 m^3 and that of control with lowest tree volume of 14.79 m^3. The treatment T_3 (20% heading back of scaffolds+750g Nitrogen) were at par with T_6 (Heading back of scaffolds 40% + 750g N) and T_9 (Heading back of scaffolds 60% + 750g N) treatments.

Table 3: Effect of rejuvenation pruning and nitrogen levels on pruning wood weight and tree volume of apricot

Treatment Code	Treatment	Pruning wood weight (kg/tree)			Tree volume (m^3)		
		2013	2014	Pooled	2013	2014	Pooled
T_1	Pruning 20%+500g Nitrogen	5.34	4.63	4.99	26.46	28.09	27.28
T_2	Pruning 20%+625g Nitrogen	5.36	4.83	5.10	28.30	29.83	29.07
T_3	Pruning 20%+750g Nitrogen	5.57	5.18	5.37	31.76	33.13	32.45
T_4	Pruning 40%+500g Nitrogen	6.21	5.32	5.76	26.54	27.87	27.20
T_5	Pruning 40%+625g Nitrogen	6.43	5.98	6.21	29.54	30.72	30.13
T_6	Pruning 40%+750g Nitrogen	7.08	6.29	6.69	31.61	32.96	32.29
T_7	Pruning 60%+500g Nitrogen	7.16	6.53	6.85	26.54	28.93	27.74
T_8	Pruning 60%+625g Nitrogen	8.25	7.53	7.89	29.51	31.27	30.39
T_9	Pruning 60%+750g Nitrogen	10.17	8.21	9.19	31.09	32.68	31.86
T_{10}	Control	5.23	4.41	4.82	13.27	16.31	14.79
$CD_{(0.05)}$		**0.95**	**0.71**	**0.57**	**1.60**	**1.15**	**0.94**

Leaf area (cm^2)

The data presented in Table 4 clearly shows that combination of different levels of pruning and nitrogen exhibited a significant influence on the leaf area of apricot in 2013 and 2014. The significantly highest (37.05cm^2) leaf area was recorded in treatment T_9 (60% heading back of scaffolds+750g Nitrogen) in 2013 which was statistically at par (36.49 cm^2) with T_8 (Heading back of scaffolds 60% + 625g N) treatment. The lowest (31.92 cm^2) leaf area was recorded in control (heading back at secondary branches level+500g Nitrogen), which was statistically at par (32.31 cm^2) with T_2 (Heading back of scaffolds 20% + 625g N) treatment.

In the year 2014, treatment T_9 (60% heading back of scaffolds+750g Nitrogen) resulted in maximum (35.24 cm^2) leaf area than all other treatments. The minimum (30.15 cm^2) leaf area was recorded in control (heading back at secondary branches level+500g Nitrogen), which was significantly at par with treatments T_1 (Heading back of scaffolds 20% + 500g N), T_2 (Heading back of scaffolds 20% + 625g N) and T_4 (Heading back of scaffolds 40% + 500g N).

The pooled data also resembles with the above results with highest value 36.15 cm^2 in T_9 (Heading back of scaffolds 60% + 750g N) treatment which was statistically at par with T_1 (Heading back of scaffolds 20% + 500g N) and T_2 (Heading back of scaffolds 20% + 625g N) treatments. Control treatment recorded the lowest result of leaf area 31.04 cm^2 which was at par (2.13 cm^2 and

2.11 cm^2) with T_1 (Heading back of scaffolds 20% + 500g N) and T_2 (Heading back of scaffolds 20% + 625g N) treatment respectively.

Chlorophyll content (mg/100g)

Data given in Table 4 indicates that different treatment combinations of pruning and nitrogen had significant effect on the accumulation of leaf chlorophyll content during 2013 and 2014. The treatment T_9 (60% heading back of scaffolds+750 g Nitrogen) accumulated more chlorophyll content (2.47 and 2.77 mg/100g in 2013 and 2014, respectively) than all other treatments. Minimum leaf chlorophyll content (2.10 and 2.09 mg/100g during 2013 and 2014, respectively) was recorded in control (heading back at secondary branches level+500g Nitrogen), which was found to be statistically at par with T_1 (Heading back of scaffolds 20% + 500g N), T_2 (Heading back of scaffolds 20% + 625g N), T_3 (Heading back of scaffolds 20% + 750g N) and T_4 (Heading back of scaffolds 40% + 500g N) treatments in 2013 and T_1 (Heading back of scaffolds 20% + 500g N) and T_2 (Heading back of scaffolds 20% + 625g N) treatments in 2014, respectively.

Pooled data recorded highest value of 2.62 mg/100g in T_9 treatment in respect of leaf chlorophyll. The lowest value of 2.10 mg/100g was observed in control treatment and was at par with T_1 (Heading back of scaffolds 20% + 500g N) and T_3 (Heading back of scaffolds 20% + 750g N).

Table 4: Effect of rejuvenation pruning and nitrogen levels on leaf area and chlorophyll content of apricot

Treatment Code	Treatment	Leaf area (cm^2)			Chlorophyll content (mg/100 g)		
		2013	**2014**	**Pooled**	**2013**	**2014**	**Pooled**
T_1	Pruning 20%+500g Nitrogen	32.76	30.48	31.62	2.10	2.12	2.11
T_2	Pruning 20%+625g Nitrogen	32.31	30.27	31.29	2.11	2.15	2.13
T_3	Pruning 20%+750g Nitrogen	35.15	32.22	33.69	2.12	2.13	2.12
T_4	Pruning 40%+500g Nitrogen	33.73	31.10	32.42	2.13	2.25	2.19
T_5	Pruning 40%+625g Nitrogen	35.35	33.42	34.39	2.25	2.24	2.25
T_6	Pruning 40%+750g Nitrogen	34.14	32.96	33.55	2.27	2.33	2.30
T_7	Pruning 60%+500g Nitrogen	35.31	33.36	34.34	2.31	2.52	2.41
T_8	Pruning 60%+625g Nitrogen	36.49	34.01	35.25	2.38	2.62	2.50
T_9	Pruning 60%+750g Nitrogen	37.05	35.24	36.15	2.47	2.77	2.62
T_{10}	Control	31.92	30.15	31.04	2.10	2.09	2.10
$CD_{(0.05)}$		**0.72**	**1.03**	**0.60**	**0.03**	**0.04**	**0.02**

Fruit set (%)

Combination of different pruning intensities and nitrogen levels had significant effect on per cent fruit set during 2013 and 2014 as is evident from Table 5. The highest fruit set (56.59 % and 41.32 %) was recorded with T_5 (40% heading back of scaffolds+625g Nitrogen) and T_6 (40% heading back of scaffolds+750g Nitrogen) treatments during 2013 and 2014, respectively, however T_1 (Heading back of scaffolds 20% + 500g N) was at par with T_5 (Heading back of scaffolds 40% + 625g N) in the year 2014.

The lowest (44.72 % and 35.56 %) fruit set was observed with T_7 (60% heading back of scaffolds+500g Nitrogen) and T_8 (60% heading back of scaffolds+625g Nitrogen) treatments in 2013 and 2014 respectively. During the year 2014 treatments T_7 (Heading back of scaffolds 60% + 500g N) and T_{10} (Heading back at secondary branches level + 500g N) were found to be statistically at par.

Pooled data recorded highest value of 47.85 % in T_5 (40% heading back of scaffolds+625g Nitrogen) treatment in respect of fruit yield which is at par with T_1 (Heading back of scaffolds 20% + 500g N) treatment. The lowest value of 40.85 % was observed in T_7 (Heading back of scaffolds 60% + 500g N) treatment and was at par with T_8 (Heading back of scaffolds 60% + 625g N) treatment.

Fruit yield (kg/tree)

The data pertaining to yield presented in Table 5 reveals that different treatments had significant effect on fruit yield per tree. Maximum fruit yield (25.41 and 19.86 kg per tree) was recorded in T_7 (60% heading back of scaffolds+500g Nitrogen) treatment during 2013 and 2014, respectively which was at par with T_1 (Heading back of scaffolds 20% + 500g N) and T_4 (Heading back of scaffolds 40% + 500g N) in both the years of study.

The minimum fruit yield (20.51 and 15.42 kg per tree in 2013 and 2014, respectively) were recorded in T_9 (60% heading back of scaffolds+750gNitrogen) and T_6 (40% heading back of scaffolds+750g Nitrogen) treatments respectively. T_3 (Heading back of scaffolds 20% + 750g N) and T_8 (Heading back of scaffolds

60% + 625g N) treatments were at par with T_9 (Heading back of scaffolds 60% + 750g N) during 2013. Similar trend was observed in 2014.

The pooled data also revealed that maximum fruit yield 22.64 kg/tree was obtained from T_7 (60% heading back of scaffolds+500g Nitrogen) which was at par with T_1 (Heading back of scaffolds 20% + 500g N) and T_4 (Heading back of scaffolds 40% + 500g N). The minimum fruit yield 18.69 kg/tree was obtained from T_9 (60% heading back of scaffolds+750gNitrogen) which was at par to T_3 (Heading back of scaffolds 20% + 750g N), T_6 (Heading back of scaffolds 40% + 750g N), T_8 (Heading back of scaffolds 60% + 625g N) treatments.

Table 5: Effect of rejuvenation pruning and nitrogen levels on fruit set and fruit yield of apricot

Treatment Code	Treatment	Fruit set (%)			Fruit yield (kg/tree)		
		2013	**2014**	**Pooled**	**2013**	**2014**	**Pooled**
T_1	Pruning 20%+500g Nitrogen	53.71	40.79	47.25	24.87	19.45	22.16
T_2	Pruning 20%+625g Nitrogen	50.22	38.09	44.16	23.40	17.75	20.58
T_3	Pruning 20%+750g Nitrogen	50.80	37.94	44.37	20.58	17.36	18.97
T_4	Pruning 40%+500g Nitrogen	51.32	38.09	44.71	24.25	19.10	21.68
T_5	Pruning 40%+625g Nitrogen	56.59	39.10	47.85	21.83	17.49	19.66
T_6	Pruning 40%+750g Nitrogen	49.94	41.32	45.63	22.67	15.42	19.05
T_7	Pruning 60%+500g Nitrogen	44.72	36.97	40.85	25.41	19.86	22.64
T_8	Pruning 60%+625g Nitrogen	48.04	35.56	41.80	21.50	17.34	19.42
T_9	Pruning 60%+750g Nitrogen	49.21	38.68	43.95	20.51	16.87	18.69
T_{10}	Control	50.05	37.07	43.56	22.55	17.51	20.03
$CD_{(0.05)}$		**1.81**	**1.76**	**1.19**	**1.26**	**1.61**	**0.96**

Fruit size

Length (cm)

A perusal of data given in Table 6 shows that pruning intensities and nitrogen levels exerted a significant influence on fruit length during both the years of study. However, the longest fruit length (33.25 mm in the year 2013 and 34.48 mm in the year 2014) was produced by heavily pruned trees with standard dose of nitrogen T_7 (60% heading back of scaffolds+500g Nitrogen). T_4 (Heading back of scaffolds 40% + 500g N), T_5 (Heading back of scaffolds 40% + 625g N), T_6 (Heading back of scaffolds 40% + 750g N), T_7 (Heading back of scaffolds 60% + 500g N) and T_8 (Heading back of scaffolds 60% + 625g N) were statistically at par with highest value of 2013. T_4 (Heading back of scaffolds 40%

+ 500g N) and T_8 (Heading back of scaffolds 60% + 625g N) were statistically at par with highest value of 2014.

The shortest fruit length (29.47 mm in the year 2013 and 30.85 mm in the year 2014) was observed in T_1 (20% heading back of scaffolds + 500g nitrogen) in 2013 and T_2 (20% heading back of scaffolds+625g Nitrogen) treatment in 2014. T_2 (20% heading back of scaffolds+625g Nitrogen) was statistically at par with 2013 value and T_{10} (Heading back at secondary branches level + 500g N) was statistically at par with 2014 value.

In pooled data, the largest fruit length (33.87 mm) was resulted by T_7 (60% heading back of scaffolds+500g Nitrogen) treatment and was on par with T_8 (Heading back of scaffolds 60% + 625g N) and the shortest fruit length (30.34 mm) was resulted by T_2 (20% heading back of scaffolds+625g Nitrogen) treatment.

Breadth (cm)

The data presented in Table 6 shows that pruning intensities and nitrogen levels exerted a significant influence on fruit breadth during both the years of study. However, the longest fruit breadth (33.37 mm in the year 2013 and 34.56 mm in the year 2014) was produced by heavily pruned trees with standard dose of nitrogen T_7 (60% heading back of scaffolds+500g Nitrogen). T_4 (Heading back of scaffolds 40% + 500g N), T_5 (Heading back of scaffolds 40% + 625g N), T_6 (Heading back of scaffolds 40% + 750g N), T_8 (Heading back of scaffolds 60% + 625g N) and T_9 (Heading back of scaffolds 60% + 750g N) were at par with value of 2013. T_2 (20% heading back of scaffolds+625g Nitrogen) and T_{10} (Heading back at secondary branches level + 500g N) were at par with value of 2014.

The shortest fruit breadth (30.15 mm) was observed in T_1 (20% heading back of scaffolds + 500g nitrogen) in 2013, which was statistically at par with T_8 (Heading back of scaffolds 60% + 625g N). In 2014, shortest fruit breadth (30.96 mm) was observed in T_2 (20% heading back of scaffolds+625g Nitrogen) treatment.

In pooled data, the largest fruit breadth (33.97 mm) was resulted by T_7 (60% heading back of scaffolds+500g Nitrogen) treatment which was at par with T_8 (Heading back of scaffolds 60% + 625g N) treatment. The shortest fruit breadth (31.08 mm) was resulted by T_2 (20% heading back of scaffolds+625g Nitrogen) treatment and was at par with T_1 (20% heading back of scaffolds + 500g nitrogen) and T_{10} (Heading back at secondary branches level + 500g N) treatments.

Table 6: Effect of rejuvenation pruning and nitrogen levels on fruit size (length and breadth) of apricot

Treatment Code	Treatment	Fruit size (mm)					
		Fruit Length			Fruit Breadth		
		2013	**2014**	**Pooled**	**2013**	**2014**	**Pooled**
T_1	Pruning 20%+500g Nitrogen	29.47	32.65	31.06	30.15	33.14	31.65
T_2	Pruning 20%+625g Nitrogen	29.82	30.85	30.34	31.19	30.96	31.08
T_3	Pruning 20%+750g Nitrogen	31.19	32.45	31.82	31.68	32.67	32.18
T_4	Pruning 40%+500g Nitrogen	32.46	33.58	33.02	32.64	33.63	33.14
T_5	Pruning 40%+625g Nitrogen	32.58	32.39	32.60	32.73	33.42	33.08
T_6	Pruning 40%+750g Nitrogen	32.62	33.06	32.84	32.71	33.14	32.93
T_7	Pruning 60%+500g Nitrogen	33.25	34.48	33.87	33.37	34.56	33.97
T_8	Pruning 60%+625g Nitrogen	33.03	33.86	33.45	33.08	33.96	33.52
T_9	Pruning 60%+750g Nitrogen	31.96	32.31	32.14	32.13	32.38	32.26
T_{10}	Control	30.86	31.53	31.20	31.07	31.65	31.36
$CD_{(0.05)}$		**0.94**	**0.93**	**0.66**	**1.08**	**0.65**	**0.61**

Fruit weight (g)

It is clear from the data presented in Table 7 that the maximum fruit weight (25.64g in 2013 and 27.54g in 2014) was obtained with T_7 (60% heading back of scaffolds+500gNitrogen), which was markedly higher than all other treatments in both the years. Minimum fruit weight (20.71g in 2013 and 22.31g in 2014) was recorded in T_1 (20% heading back of scaffolds + 500g nitrogen) in 2013, which is at par with T_{10} (Heading back at secondary branches level + 500g N) where as T_2 (20% heading back of scaffolds+625g Nitrogen) treatment recorded minimum fruit weight in 2014 which was at par with T_1 (20% heading back of scaffolds + 500g nitrogen), T_5 (Heading back of scaffolds 40% + 625g N) and T_{10} (Heading back at secondary branches level + 500g N) treatment.

T_{10} (control) = Heading back at secondary branches level + 500g N

T_7 = Heading back of scaffolds (60%) + 500g N

Plate 2: Smallest and Largest fruit of apricot resulted from rejuvenation treatment

In pooled data, the maximum fruit weight 26.59g was obtained in T_7 (60% heading back of scaffolds+500gNitrogen), which was markedly higher than all other treatments. Minimum fruit weight 21.85g was obtained in T_2 (20% heading back of scaffolds+625g Nitrogen) which were at par with T_2 (Heading back of scaffolds 20% + 625g N), T_5 (Heading back of scaffolds 40% + 625g N) and T_{10} (Heading back at secondary branches level + 500g N) treatments.

Fruit volume (cc)

It is evident from the data presented in Table 7 that combination of different pruning and nitrogen treatments had significant effect on the fruit volume during 2013 and 2014. The highest fruit volume (22.50 cc) in 2013 and 23.33 cc in 2014) was observed in T_7 (60% heading back of scaffolds + 500g Nitrogen) which were statistically at par with T_8 (Heading back of scaffolds 60% + 625g N) (21.76 cc) in 2013 and T_8 (Heading back of scaffolds 60% + 625g N) (22.79 cc) and T_9 (Heading back of scaffolds 60% + 750g N) (22.51cc) in 2014 respectively.

The markedly lowest fruit volume (17.92 cc and 18.22 cc) was obtained in T_1 (20% heading back of scaffolds + 500g nitrogen) in 2013 and T_2 (20% heading back of scaffolds+625g Nitrogen) treatment in 2013 and 2014 respectively.

Table 7: Effect of rejuvenation pruning and nitrogen levels on fruit weight and fruit volume of apricot

Treatment Code	Treatment	Fruit weight (g)			Fruit volume (cc)		
		2013	2014	Pooled	2013	2014	Pooled
T_1	Pruning 20%+500g Nitrogen	20.71	22.31	21.85	17.92	20.48	19.20
T_2	Pruning 20%+625g Nitrogen	22.40	22.99	22.36	19.79	18.22	19.01
T_3	Pruning 20%+750g Nitrogen	22.23	23.96	23.09	19.53	20.75	20.14
T_4	Pruning 40%+500g Nitrogen	23.77	23.40	23.59	20.92	21.48	21.20
T_5	Pruning 40%+625g Nitrogen	22.17	22.43	22.30	20.63	21.21	20.92
T_6	Pruning 40%+750g Nitrogen	23.36	23.52	23.44	20.88	21.81	21.34
T_7	Pruning 60%+500g Nitrogen	25.64	27.54	26.59	22.50	23.33	22.91
T_8	Pruning 60%+625g Nitrogen	23.97	24.27	24.12	21.76	22.79	22.28
T_9	Pruning 60%+750g Nitrogen	23.85	23.37	23.61	21.49	22.51	22.00
T_{10}	Control	21.27	22.87	22.07	19.35	20.14	19.75
$CD_{(0.05)}$		**1.16**	**0.69**	**0.63**	**0.94**	**0.94**	**0.62**

In pooled data, the maximum fruit volume 22.91 cc was obtained in T_7 (60% heading back of scaffolds+500gNitrogen), which was markedly higher than all other treatments. Minimum fruit volume 19.01 was obtained in T_2 (20% heading back of scaffolds+625g Nitrogen) which was at par with T_1 (20% heading back of scaffolds + 500g nitrogen) (19.20 cc) treatment.

Fruit firmness (kg/cm^2)

The data presented in Table 11 shows that different levels of pruning and nitrogen had significant effect on fruit firmness. The fruits from trees receiving heavy pruning intensity along with 500g nitrogen (T_7- 60% heading back of scaffolds+500g Nitrogen) exhibited significantly higher fruit firmness (5.52 kg/cm^2) which was statistically at par with T_8 (Heading back of scaffolds 60% + 625g N) (5.40 kg/cm^2) and T_9 (Heading back of scaffolds 60% + 625g N) (5.23 kg/cm^2). While the lowest fruit firmness (4.15 kg/cm^2) was recorded with control (heading back at secondary branches level+500g Nitrogen) in the year 2013 and it was at par with T_3 (Heading back of scaffolds 20% + 750g N) (4.45 kg/cm^2) treatment.

Similar, results were obtained during 2014, with maximum (5.28 kg/cm^2) fruit firmness in T_7 (60% heading back of scaffolds + 500g nitrogen) which was on par with T_8 (Heading back of scaffolds 60% + 625g N) (5.05 kg/cm^2). The minimum (3.19 kg/cm^2) fruit firmness was recorded in control (heading back at secondary branches level+500g Nitrogen) which was at par with T_2 (Heading back of scaffolds 20% + 625g N) (3.69 kg/cm^2) and T_3 (Heading back of scaffolds 20% + 750g N) (3.67 kg/cm^2) treatments.

The pooled data of both the years also showed highest fruit firmness in T_7 (60% heading back of scaffolds + 500g nitrogen) with 5.40 kg/cm^2 which was at par with T_8 (Heading back of scaffolds 60% + 625g N) (5.22 kg/cm^2) treatment. Lowest 3.67 kg/cm^2 fruit firmness was observed in control (heading back at secondary branches level+500g Nitrogen) compared to all other treatments.

Table 8: Effect of rejuvenation pruning and nitrogen levels on fruit firmness of apricot

Treatment Code	Treatment	Firmness (kg/cm^2)		
		2013	2014	Pooled
T_1	Pruning 20%+500g Nitrogen	4.69	3.72	4.20
T_2	Pruning 20%+625g Nitrogen	4.64	3.69	4.17
T_3	Pruning 20%+750g Nitrogen	4.45	3.67	4.06
T_4	Pruning 40%+500g Nitrogen	4.93	3.96	4.45
T_5	Pruning 40%+625g Nitrogen	4.84	3.94	4.39
T_6	Pruning 40%+750g Nitrogen	4.78	3.89	4.34
T_7	Pruning 60%+500g Nitrogen	5.52	5.28	5.40
T_8	Pruning 60%+625g Nitrogen	5.40	5.05	5.22
T_9	Pruning 60%+750g Nitrogen	5.23	4.54	4.88
T_{10}	Control	4.15	3.19	3.67
$CD_{(0.05)}$		**0.45**	**0.51**	**0.35**

Total soluble solids (^{0} Brix)

The result on total soluble solids content in the fruits is given in Table 8. In 2013, the maximum (15.59 ^{0} B) TSS was recorded in T_7 (60% heading back of scaffolds + 500g Nitrogen), which were statistically at par with T_3 (Heading back of scaffolds 20% + 750g N) (15.11^0 B), T_8 (Heading back of scaffolds 60% + 625g N) (15.56^0 B) and T_9 (Heading back of scaffolds 60% + 750g N) (15.14^0 B). The lowest total soluble solid contents (13.56 ^{0} B) was observed in controls (heading back at secondary branches level+500g Nitrogen) which were significantly lower than all other values.

Similarly, significantly maximum TSS content (16.40^0 B) was recorded in T_7 (60% heading back of scaffolds + 500g Nitrogen), which were statistically at par with T_3 (Heading back of scaffolds 20% + 750g N) (16.13^0 B), T_8 (Heading back of scaffolds 60% + 625g N) (16.16^0 B) and T_9 (Heading back of scaffolds 60% + 750g N) (16.21^0 B). The minimum TSS (14.75 ^{0} B) content was obtained in control (heading back at secondary branches level+500g Nitrogen) during the year 2014.

In pooled data, the maximum (15.99^0 B) TSS was recorded in T_7 (60% heading back of scaffolds + 500g Nitrogen), which were statistically at par with T_3 (Heading back of scaffolds 20% + 750g N) (15.62^0 B), T_8 (Heading back of scaffolds 60% + 625g N) (15.86^0 B) and T_9 (Heading back of scaffolds 60% + 750g N) (15.68^0 B). The lowest total soluble solid contents (14.16^0 B) were observed in controls (heading back at secondary branches level+500g Nitrogen) which were significantly lower than other treatments.

Total sugars (%)

It is clear from the data presented in Table 8 that the total sugars were significantly influenced by the heavy pruning severity in combination with the application of nitrogen. The significantly higher total sugars content (9.68% and 10.01%) was recorded in T_7 (60% heading back of scaffolds+500g Nitrogen) during 2013 and 2014 respectively. However minimum total sugar content (5.37% and 6.08%) was recorded in controls (heading back at secondary branches level+500g Nitrogen) during 2013 and 2014 respectively; which was at par with the values of T_2 (Heading back of scaffolds 20% + 625g N) (6.38%) and T_3 (Heading back of scaffolds 20% + 750g N) (6.36%) in 2014.

Pooled data's shows the maximum total sugars content (9.84%) was recorded in T_7 (60% heading back of scaffolds+500g Nitrogen) treatment which was significantly higher than all other treatments. The markedly lowest total sugar content (5.73%) was recorded in controls (heading back at secondary branches level+500g Nitrogen).

Table 9: Effect of rejuvenation pruning and nitrogen levels on TSS and total sugar of apricot

Treatment Code	Treatment	TSS (^{0} B)			Total sugar (%)		
		2013	2014	Pooled	2013	2014	Pooled
T_1	Pruning 20%+500g Nitrogen	14.64	15.47	15.05	6.43	7.38	6.90
T_2	Pruning 20%+625g Nitrogen	14.24	15.23	14.73	6.36	6.38	6.37
T_3	Pruning 20%+750g Nitrogen	15.11	16.13	15.62	5.90	6.36	6.13
T_4	Pruning 40%+500g Nitrogen	14.22	15.21	14.72	8.61	8.65	8.63
T_5	Pruning 40%+625g Nitrogen	14.30	15.33	14.82	7.85	8.16	8.01
T_6	Pruning 40%+750g Nitrogen	14.53	15.42	14.97	7.44	7.50	7.47
T_7	Pruning 60%+500g Nitrogen	15.59	16.40	15.99	9.68	10.01	9.84
T_8	Pruning 60%+625g Nitrogen	15.56	16.16	15.86	8.54	8.82	8.68
T_9	Pruning 60%+750g Nitrogen	15.14	16.21	15.68	6.31	7.17	6.74
T_{10}	Control	13.56	14.75	14.16	5.37	6.08	5.73
$CD_{(0.05)}$		**0.66**	**0.46**	**0.40**	**0.13**	**0.33**	**0.17**

Reducing sugar (%)

The data given in Table 9 reveals that pruning intensities and nitrogen levels had significant effect on per cent reducing sugar content of fruits. The highest reducing sugars (3.67 and 3.73% in 2013 and 2014, respectively) was observed in T_7 (60% heading back of scaffolds+500g Nitrogen), which was significantly higher than all other treatments.

The lowest per cent of reducing sugar (2.08 and 2.12 % during 2013 and 2014, respectively) was obtained in T_3 (20% heading back of scaffolds + 750g nitrogen) treatments which were at par with T_9 (Heading back of scaffolds 60% + 750g N) (2.25 %) and T_{10} (Heading back at secondary branches level + 500g N) (2.18 %) in 2013 and T_6 (Heading back of scaffolds 40% + 750g N) (2.33 %) and T_{10} (Heading back at secondary branches level + 500g N) (2.34 %) in 2014.

The pooled data of both the years also recorded markedly highest per cent of reducing sugar in T_7 (60% heading back of scaffolds+500g Nitrogen) with (3.70 %). The lowest reducing sugar content was recorded in T_3 (20% heading back of scaffolds + 750g nitrogen) which was at par with $T_{10.}$ (Heading back at secondary branches level + 500g N) (2.10 %)

Non-reducing sugars (%)

Non-reducing sugars were significantly influenced by the combination of different pruning and nitrogen treatments during both the years of study. Significantly higher non-reducing sugars (5.71 % and 5.97 %) was observed in T_7 (60% heading back of scaffolds + 500g Nitrogen) compared to all other treatments in 2013 and 2014 respectively.

The minimum (3.03%) non -reducing sugars was recorded in control (Heading back at secondary branches level + 500g N) which was at par (3.36%) with T_2 (Heading back of scaffolds 20% + 625g N) in 2013. However, in year 2014 minimum (3.49%) non-reducing sugar was found in T_2 (Heading back of scaffolds 20% + 625g N) which was at par (3.55%) with control (Heading back at secondary branches level + 500g N).

Table 10: Effect of rejuvenation pruning and nitrogen levels on reducing and non-reducing sugar content of apricot

Treatment Code	Treatment	Reducing sugar (%)			Non-reducing sugar (%)		
		2013	2014	Pooled	2013	2014	Pooled
T_1	Pruning 20%+500g Nitrogen	2.46	3.04	2.75	3.77	4.12	3.95
T_2	Pruning 20%+625g Nitrogen	2.82	2.71	2.77	3.36	3.49	3.43
T_3	Pruning 20%+750g Nitrogen	2.08	2.12	2.10	3.63	4.03	3.83
T_4	Pruning 40%+500g Nitrogen	3.20	3.21	3.20	5.14	5.17	5.16
T_5	Pruning 40%+625g Nitrogen	2.74	2.80	2.77	4.85	5.09	4.97
T_6	Pruning 40%+750g Nitrogen	2.34	2.33	2.34	4.84	4.91	4.88
T_7	Pruning 60%+500g Nitrogen	3.67	3.73	3.70	5.71	5.97	5.84
T_8	Pruning 60%+625g Nitrogen	3.22	3.28	3.25	5.05	5.26	5.16
T_9	Pruning 60%+750g Nitrogen	2.25	2.66	2.46	3.86	4.28	4.07
T_{10}	Control	2.18	2.34	2.26	3.03	3.55	3.29
$CD_{(0.05)}$		**0.24**	**0.37**	**0.22**	**0.35**	**0.48**	**0.28**

Pooled data of both the year revealed that T_7 (Heading back of scaffolds 60% + 500g N) produced maximum non-reducing sugar of 5.84 % and control treatment produced minimum (3.29%) per cent of non-reducing sugar, which was quite close (3.43%) to that of T_2 (Heading back of scaffolds 20% + 625g N) value.

Acidity (%)

Data on acidity as influenced by combination of different pruning intensities and nitrogen levels are given in Table 10, which reveals significant differences among different treatments with respect to titratable acidity. Fruits of trees under T_7 (60% heading back of scaffolds+500g Nitrogen) had the highest acid content (1.26% and 1.31% during the years 2013 and 2014, respectively), which was markedly higher than all other treatments.

The lowest acid content (0.79%) was recorded in control (heading back at secondary branches level+500g Nitrogen) in 2013, which was statistically at par (0.92%, 0.86%, 0.84%, 0.92% and 0.93%) with T_1 (Heading back of scaffolds 20% + 500g N), T_2 (Heading back of scaffolds 20% + 625g N), T_3 (Heading back of scaffolds 20% + 750g N), T_5 (Heading back of scaffolds 40% + 625g N) and T_6 (Heading back of scaffolds 40% + 750g N) treatments respectively, while during the year 2014, the lowest significantly fruit acidity (0.74%) was obtained in treatment T_2 (20% heading back of scaffolds + 625g Nitrogen).

The pooled data of both the years also shows highest per cent of fruit acidity in T_7 (60% heading back of scaffolds+500g Nitrogen) with 1.29% and lowest 0.80% in T_2 (20% heading back of scaffolds + 625g Nitrogen) which was at par (0.89%, 0.85% and 0.94%) with T_1 (Heading back of scaffolds 20% + 500g N), T_3 (Heading back of scaffolds 20% + 750g N) and T_{10} (Heading back at secondary branches level + 500g N) treatments respectively.

Ascorbic acid (mg/100g)

A perusal of data of 2013 in Table 10 reveals that treatment T_9 (60% heading back of scaffolds + 750g Nitrogen) produced fruits with significantly high ascorbic acid (15.14 mg/100g) content which was at par with T_8 (Heading back of scaffolds 60% + 625g N) (14.74 mg/100g) treatment. However, the lowest (8.38 mg/100g) ascorbic acid content was recorded in control (heading back at secondary branches level+500g Nitrogen), which was statistically at par with T_1 treatment.

Almost similar, trend was noticed during 2014, with highest (16.16 mg/100g) ascorbic acid content in treatment T_9 (60% heading back of scaffolds + 750g Nitrogen), which was found to be significantly higher than any other treatment. The lowest ascorbic acid content (10.05 mg/100g) was recorded in control (heading back at secondary branches level+500g Nitrogen), which was statistically at par with T_1 (Heading back of scaffolds 20% + 500g N) and T_2 (Heading back of scaffolds 20% + 625g N) treatment.

The pooled data of both the years also registered highest per cent of ascorbic acid in T_9 (60% heading back of scaffolds + 750g Nitrogen) with 15.65 mg/100g and lowest in control (heading back at secondary branches level+500g Nitrogen) with 9.26 mg/100g, which was at par with T_1 (Heading back of scaffolds 20% + 500g N) (9.36 mg/100g) treatment.

Table 11: Effect of rejuvenation pruning and nitrogen levels on acidity and ascorbic acid content of apricot

Treatment Code	Treatment	Acidity (%)			Ascorbic acid (mg/100g)		
		2013	2014	Pooled	2013	2014	Pooled
T_1	Pruning 20%+500g Nitrogen	0.92	0.86	0.89	8.41	10.31	9.36
T_2	Pruning 20%+625g Nitrogen	0.86	0.74	0.80	8.87	10.36	9.61
T_3	Pruning 20%+750g Nitrogen	0.84	0.85	0.85	9.34	10.57	9.96
T_4	Pruning 40%+500g Nitrogen	0.94	1.12	1.03	9.60	12.53	11.07
T_5	Pruning 40%+625g Nitrogen	0.92	1.08	1.00	12.58	13.28	12.93
T_6	Pruning 40%+750g Nitrogen	0.93	1.09	1.01	13.57	13.48	13.52
T_7	Pruning 60%+500g Nitrogen	1.26	1.31	1.29	10.20	10.86	10.53
T_8	Pruning 60%+625g Nitrogen	1.00	1.11	1.05	14.74	15.51	15.12
T_9	Pruning 60%+750g Nitrogen	0.98	1.16	1.07	15.14	16.16	15.65
T_{10}	Control	0.79	1.08	0.94	8.38	10.05	9.26
$CD_{(0.05)}$		**0.14**	**0.10**	**0.14**	**0.46**	**0.49**	**0.31**

LEAF NUTRIENT STATUS

Nitrogen (%)

The perusal of the data given in Table 12 reveals that, heavy pruning treatment along with increased dose of nitrogen influenced leaf N content significantly. During the years of study, 2014 highest leaf N (2.97 %) content was recorded in T_9 (60% heading back of scaffolds+750g Nitrogen) treatment which was significantly higher than any other treatments. Markedly lowest N (2.19%) content was obtained in control.

Phosphorus (%)

The data presented in Table 12 shows that different pruning intensities and nitrogen levels had significant influence on per cent P content of the leaves. The highest P (0.247 %) content was recorded with T_1 (20 % heading back of scaffolds+500g Nitrogen) which was at par with T_2 (Heading back of scaffolds 20% + 625g N), T_3 (Heading back of scaffolds 20% + 750g N), T_4 (Heading back of scaffolds 40% + 500g N) and T_5 (Heading back of scaffolds 40% + 625g N) treatments. The lowest P content (0.208 %) was recorded with control (heading back at secondary branches level+500g Nitrogen) treatment which was at par (0.217%, 0.218%, 0.213% and 0.210% respectively) with T_6 (Heading back of scaffolds 40% + 750g N), T_7 (Heading back of scaffolds 60% + 500g N),T_8

(Heading back of scaffolds 60% + 625g N) and T_9 (Heading back of scaffolds 60% + 750g N) treatments respectively.

Potassium (%)

Different pruning intensities and nitrogen levels had significant effect on per cent K content of leaves (Table 12). The significantly higher (2.57 %) leaf K content was recorded with T_7 (60% heading back of scaffolds+500g Nitrogen) treatment.

However, the lowest (2.13 %) leaf K content was observed with control (heading back at secondary branches level+500g Nitrogen) treatment. The treatments T_3 (20% heading back of scaffolds+750g Nitrogen) was found to be on par (2.15 %) with the lowest leaf K content.

Calcium (%)

Different treatments influenced the leaf Ca content significantly as evident from the data given in Table 12. Highest foliar Ca (3.07 %) content was recorded in treatment T_1 (20% heading back of scaffolds+500g Nitrogen) which was significantly superior to all other treatments and minimum Ca (2.61%) content was obtained in T_9 (60% heading back of scaffolds+750g Nitrogen) which was also significantly lowest among all the other treatments.

Table 12: Effect of rejuvenation pruning and nitrogen levels on foliar macro nutrient content of apricot

Treatment Code	Treatment	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)
		2014	**2014**	**2014**	**2014**	**2014**
T_1	Pruning 20%+500g Nitrogen	2.77	0.247	2.34	3.07	0.92
T_2	Pruning 20%+625g Nitrogen	2.80	0.237	2.27	2.98	0.86
T_3	Pruning 20%+750g Nitrogen	2.85	0.236	2.15	2.93	0.82
T_4	Pruning 40%+500g Nitrogen	2.83	0.240	2.47	2.89	0.78
T_5	Pruning 40%+625g Nitrogen	2.89	0.242	2.31	2.81	0.72
T_6	Pruning 40%+750g Nitrogen	2.92	0.217	2.26	2.76	0.69
T_7	Pruning 60%+500g Nitrogen	2.86	0.218	2.57	2.71	0.65
T_8	Pruning 60%+625g Nitrogen	2.87	0.213	2.44	2.68	0.60
T_9	Pruning 60%+750g Nitrogen	2.97	0.210	2.36	2.61	0.58
T_{10}	Control	2.19	0.208	2.13	3.03	0.87
$CD_{(0.05)}$		**0.04**	**0.015**	**0.02**	**0.01**	**0.04**

Magnesium (%)

Magnesium content of leaves was significantly influenced by different combinations of pruning intensities and nitrogen levels as is evident from the data presented in Table 12. In general, leaf Mg content decreased with the increasing intensity of pruning from light to heavy and with the increasing levels of N in both the years of study. However, markedly highest leaf Mg content (0.92 %) was recorded with T_1 (20% heading back of scaffolds+500g Nitrogen). The minimum leaf Mg content (0.57 %) was found in T_9 (60% heading back of scaffolds+750g Nitrogen) treatment which was at par (0.60 %) with T_8 (Heading back of scaffolds (60%) + 625g N) treatment.

Iron (ppm)

A perusal of data in Table 13 reveals that different levels of pruning and nitrogen had a significant influence on leaf Fe content. The highest leaf Fe content (248.26 ppm) was recorded in T_9 (60% heading back of scaffolds+750g Nitrogen) treatment, which was significantly higher than all other treatments. The lowest leaf Fe content (178.27 ppm) was recorded with control (heading back at secondary branches level+500g Nitrogen) which was markedly lower than all other treatments.

Manganese (ppm)

The data pertaining to leaf Mn content, presented in Table 13, show that different treatments had significant influence on Mn content of the leaves. The significantly higher (158.19 ppm) Mn content was recorded with heavy pruning along with increased nitrogen level (T_9-60% heading back of scaffolds+750g Nitrogen) than all the other treatments, whereas, the lowest Mn (111.43 ppm) content was recorded with control.

Zinc (ppm)

The data in Table 13 show that the foliar Zn content was significantly affected by different pruning and nitrogen fertilizer treatments. However, the highest (11.77 ppm) leaf Zn content was recorded in treatments T_9 (60% heading back of scaffolds+750g Nitrogen) which was on par (11.42 ppm and 11.12 ppm) with T_6 (Heading back of scaffolds 40% + 750g N) and T_8 (Heading back of scaffolds 60% + 625g N) treatments respectively. The lowest (7.51 ppm) leaf Zn content was recorded with control (heading back at secondary branches level+500g Nitrogen) and was at par (8.07 ppm) with T_1 (Heading back of scaffolds 20% + 500g N) treatment.

Table 13: Effect of rejuvenation pruning and nitrogen levels on foliar micro-nutrient content of apricot

Treatment Code	Treatment	Iron (ppm)	Manganese (ppm)	Zinc (ppm)	Copper (ppm)
		2014	**2014**	**2014**	**2014**
T_1	Pruning 20%+500g Nitrogen	183.71	114.97	8.07	14.56
T_2	Pruning 20%+625g Nitrogen	188.54	120.64	7.35	13.21
T_3	Pruning 20%+750g Nitrogen	193.40	142.00	9.22	13.58
T_4	Pruning 40%+500g Nitrogen	218.71	143.68	9.69	12.33
T_5	Pruning 40%+625g Nitrogen	225.34	148.07	10.89	12.17
T_6	Pruning 40%+750g Nitrogen	230.87	148.63	11.42	11.36
T_7	Pruning 60%+500g Nitrogen	241.61	152.41	10.49	11.55
T_8	Pruning 60%+625g Nitrogen	244.30	156.57	11.12	11.71
T_9	Pruning 60%+750g Nitrogen	248.26	158.19	11.77	10.94
T_{10}	Control	178.27	111.43	7.51	13.18
$CD_{(0.05)}$		**1.41**	**1.01**	**0.76**	**0.03**

Copper (ppm)

The perusal of data presented in Table 13 reveal that leaf Cu content was influenced significantly by different pruning and nitrogen levels. The markedly highest leaf Cu content (14.56 ppm) was recorded in T_1 (20% heading back of scaffolds+500g Nitrogen) treatment. The lowest leaf Cu content (10.94 ppm) was recorded in T_9 (60% heading back of scaffolds+750g Nitrogen) treatment. In general, the leaf Cu content decreased with increasing pruning severity.

Chapter-5

DISCUSSION

The salient finding of the present investigations entitled "Rejuvenation studies on growth, fruiting and fruit quality of apricot (*Prunus armeniaca* L.) cv. New Castle presented in tables 1 to 13 (pooled data) have been discussed in the light of available literature below under appropriate headings.

5.1 TREE GROWTH AND VIGOUR

In the present study, treatment combinations of different pruning intensities and nitrogen levels were observed to have significant influence on tree growth and vigour. The treatment combination of heavy pruning severity and higher nitrogen levels increased vegetative growth in terms of annual shoot growth, tree spread, leaf area and pruning wood weight except trunk girth. The maximum growth and vigour in respect of all these parameters was observed in T_9 (60% heading back of scaffolds+750g Nitrogen), during both the years of study. However, the overall maximum increased in trunk girth (3.20 cm) was recorded in treatment T_5 (40% heading back of scaffolds+625g Nitrogen), whereas, minimum increased in trunk girth (2.12 cm) was found in control (heading back at secondary branches level+500g Nitrogen). Similar, results have been reported by Thakur (2012) and Singh (1992) who recorded the maximum trunk girth, annual shoot growth, pruning wood weight and leaf area with heavy pruning and increased dose of nitrogen. The higher increase in trunk girth in T_5 may be due to appropriate level of pruning and nitrogen for optimum extension growth, as excessive shoot growth restricts trunk girth (Table 1).

Increased levels of nitrogen application significantly affected the growth of apricot trees in terms of increase in trunk girth, annual shoot growth, tree volume, pruning wood weight and leaf area. These findings are in conformity with Suklabaidya, (2012) reported that additional (75%) N resulted in increased annual shoot growth, trunk girth, tree volume and leaf area of senile plum trees. Asma *et al*., (2007) recorded enhancement of vegetative growth with higher dose of nitrogen in Hacihaliloglu apricot. Similar result were recorded by Bussi *et al*., (2003) in Bergeron apricot. Chauhan (2008) and Sharma and Bhargava (2003) found better tree growth in plum with higher dose of nitrogen application. Tree growth in terms of height, spread, girth and shoot extension growth increased with soil application of N and P (Joolka *et al.,* 1989). Application of N has been observed to increase the trunk diameter in peach trees (Twafik *et al.,* 1974). The application of nitrogen to soil has been reported to increase vegetative growth and vigour of peach trees by many workers (Bussi *et al.,* 1991; Soing *et al.,* 1998; Lobit *et al.,* 1998 and Arora *et al.,* 1999). The possible reason for the increased growth with the increasing levels of N might have been; i) the higher availability of N content (NH_4^+, NO_3^- and total N in the soil); ii) higher N content in various parts of the tree and iii)better development of the root system of the tree. Nitrogen is associated with all vital life processes of the plant; therefore a sufficient supply of various nitrogenous compounds is required in each plant cell for its proper functioning.

The increase in growth was primarily a function of higher availability of photosynthates (Table 4) and nutrients in the heavily pruned trees (Table 12 and 13), as with the increase in severity of pruning there was proportionate reduction in the number of vegetative buds likely to develop into new shoots, thereby reducing competition for carbohydrates and other metabolites. Several workers have reported an increase in tree vigour with increased pruning severity in apricot. Szklarz *et al*., (2011) found an increase in tree spread and projection of crown with increased pruning severity in apricot. Suklabaidya (2012) recorded maximum annual shoot growth, radial growth of trunk, pruning weight and average leaf area in heavily pruned declined plum tree. Singh *et al.,* (1997) found that terminal shoot growth and leaf size increased with increase in level of pruning. Sharma, (1995) reported that with increasing pruning intensity, annual shoot extension growth increased but canopy volume decreased. The more increase in tree volume could be attributed to less removal of pruning wood from the lightly pruned trees. Improved tree growth and leaf cover by reducing number of fruiting shoots in 'Mit-Ghamr' peach trees was observed by Hassan (1990). Rathi *et al*., (2003) found longest and thickest shoot in heavily pruned peach tree.

The increase in tree volume was significantly higher in lightly pruned trees than all other pruning intensities and showed decreasing trend with the increasing severity of pruning.

5.2 TOTAL CHLOROPHYLL CONTENT

Combination of different pruning intensities and nitrogen levels treatments had significant effect on the accumulation of leaf chlorophyll content (Table 4) during 2013 and 2014. The heavy pruning severity in combination with highest level of nitrogen increased the total chlorophyll content of rejuvenated 'New Castle' apricot leaves during both the years of study. The highest chlorophyll content was recorded in T_9 (60% heading back of scaffolds+750g Nitrogen) treatment while lowest in control (heading back at secondary branches level+500g Nitrogen). The increased chlorophyll accumulation with the increasing severity of pruning and N levels could possibly be due to the increased N absorption which forms a basic constituent of chlorophyll pigment.

In New Castle apricot an increase in leaf chlorophyll content was reported with increasing pruning severity and fertilizer levels by Thakur, (2012). Further, these findings get the support from the work of Suklabaidya (2012) who recorded increase in chlorophyll content in heavily pruned declined plum trees fertilized with higher dose of N. Singh, (1992) and Sharma, (1995) also observed increase in chlorophyll content in July Elberta peach leaves with increasing pruning severity and fertilizer levels. Increased chlorophyll in apple leaves has also been observed with N fertilizers by Klein *et al.,* (1989).

5.3 FRUIT SET AND YIELD

5.3.1 Fruit set

Different pruning intensities and nitrogen levels significantly influenced the fruit set during 2013, whereas, the results were inconsistent during 2014 due occurance of hail and storms at the time of flowering and fruiting.

The maximum pooled fruit set was observed in T_5 (40% heading back of scaffolds+ 750g Nitrogen) and minimum in T_7 (60% heading back of scaffolds+500g Nitrogen) treatment (Table 5). The results are in conformity with those of Thakur (2012) who recorded the similar result during the year 2011 and 2012 in rejuvenated declined apricot trees cv. New Castle. Further, Suklabaidya (2012) recorded higher fruit set in lightly pruned trees compared to heavily pruned tree of plum cv. Santa Rosa. Singh *et al.,* (1997) and Rathi *et al.,* (2003) also reported reduced fruit set with heavy pruning in peach. The reduction in fruit setting in heavy pruning may be anticipated due to loss of reserved food material through the pruning wood besides, active utilization of carbohydrates in new vegetative growth. Singh (1983), Daulta and Singh (1986), Singh (1992) and Thakur (1993) who reported reduced fruit set in peach with the increase in pruning severity.

The per cent fruit set did not show any consistent change with increasing level of N fertilizer as most of the available N was utilized for vegetative growth owing to rejuvenation pruning. These results are in line with Taylor and Van Den Ende (1970), who did not find any influence of N application on flowering performance and fruit set in Golden Queen peaches. Further, Stassen *et al.* (1981), Singh (1983), Khan *et al.* (2000) and Sharma and Bhargava (2003) have reported increased fruit set in various temperate fruits with the increasing levels of N, which was attributed to its role in the synthesis of protein nucleic acids and enzymes in plants.

5.3.2 Fruit yield

Combination of different rejuvenation pruning intensities and nitrogen levels significantly influenced the fruit yield during both the years of study (Table 5). However, the highest fruit yield in pooled data was recorded in T_7 (60% heading back of scaffolds+500g Nitrogen) treatment while, the plants with treatment T_9 (60% heading back of scaffolds+750g Nitrogen) recorded the lowest fruit yield. These results are in line with those of Szklarz *et al*., (2011) who observed maximum yield on heavily purned apricot tree and Neri and Sansavani (2004) in plum tree. In general, the lightly pruned trees produced the higher fruit yields as compared to medium and heavily pruned trees. The yield reduction in the medium and heavy pruning was due to removal of higher proportion of the fruiting wood at the time of rejuvenation pruning. Similar results were recorded by Thakur (2012) in New Castle apricot, Sharma (1995) in July Elberta peach and Suklabaidya (2012) in Santa Rosa plum.

The higher yield in trees receiving 500g N tree^{-1} was because of higher average fruit weight (Table 7) than other N levels and also because of increased fruit set (Table 5). These results are supported by that of results of Thakur (2012) in New Castle apricot and Saini (2011) in Santa Rosa plum. Many workers have reported significant increase in the yield of stone fruits up to a certain level of nitrogen and decrease thereafter (Kanwar, 1979 and Badyal, 1980). On the contrary, Walsh *et al.* (1989) reported non-significant effect of N application on yield in Redskin peach when 45, 90 and 135 kg N ha $^{-1}$ were applied.

5.4 FRUIT QUALITY

5.4.1 Fruit weight, volume and size

Treatment combinations of different pruning intensities and nitrogen levels significantly influenced the physical fruit quality parameters during both the years of study (Tables 6 and 7). In present investigation, the highest fruit weight, fruit volume and size (in terms of length and breadth) was recorded in T_7 (60% heading back of scaffolds+500g Nitrogen) treatment. Large size fruit in terms of weight, volume, length and breadth were produced in heavy pruning and optimum N treatment combination, which may probably due to less number of fruits per tree as a result of which leaf/fruit ratio was increased and they could get more photosynthates. Similar results of increase in fruit size with increasing pruning severity and optimum N application have been reported by Thakur (2012) in New Castle apricot, Suklabaidya (2012) in Santa Rosa plum, Kaundal *et al*., (2002) in Pratap peach and Sharma (1995) in July Elberta peach. These are again supported by results of Hassani and Rezaee (2007), Hassan (1990), Singh (1992) and Thakur (1993).

The improved fruit size may possibly be attributed to more efficient nitrogen uptake because of the efficient absorption with increased levels of N which consequently resulted in more luxuriant vegetative growth at the expense of translocation of metabolites to the developing fruits. The increase in fruit size as a result of N application has also been reported by various workers Chauhan (2008), Asma *et al*., (2007), Joolka *et al*.,(1989).

5.4.2 Fruit Firmness

Treatment combination of different pruning intensities and nitrogen levels were observed to have significant influence on fruit firmness. Fruit firmness increased significantly with the combination of increasing severity of pruning and optimum dose of N but showed a declining trend with increasing levels of Nitrogen (Table 8). The maximum fruit firmness was found in fruit harvested from T_7 (60% heading back of scaffolds+500g Nitrogen) treatment and minimum in control (heading back at secondary branches level+500g nitrogen). The possible explanation for this may be that more metabolites are translocated to the fruits in heavily pruned trees. These results are in conformity to those of Thakur (2012) in New Castle apricot and Suklabaidya (2012) in Santa Rosa plum, who reported that fruit firmness increased with increased severity of pruning at optimal dose of N. These results are in line with Sharma (1995) who reported similar observations in July Elberta peach. On the contrary, Rettke *et al.* (2006) reported that the firmness of fruits was significantly reduced as the rate of applied N increased in apricot cv. Moorpark.

5.4.3 Total soluble solids and sugars

Different pruning intensities and nitrogen levels had significant effect on total soluble solids and fruit sugars during both the years of study (Tables 9 and 10). The maximum total soluble solids, total sugars, reducing sugars and non-reducing sugars were observed in T_7 (60% heading back of scaffolds+500g N) and minimum in control treatment. Higher total soluble solids and sugars as a result of increased pruning severity and optimal dose of N may be explained on the basis of increased leaf to fruit ratio and consequently more synthesis of carbohydrates and other metabolites as well as their translocation to the fruit tissues. Secondly the reduction in fruit loads with the increasing severity of pruning. These findings are in agreement with those of Thakur (2012) who reported higher total soluble solids in severe pruning and optimal dose of N treatment in New Castle apricot. Further, these finding get supported by Suklabaidya (2012) in Santa Rosa plum. These results are in line with Kumar *et al*., (2010), Hassani and Rezaee (2007), Sharma and Chauhan (2004), Rathi *et al*., (2001), who reported higher total soluble solids in severe pruning treatment in different cultivars of peach.

More efficient absorption of total sugar and sugars with the increased levels of N which consequently resulted in more luxuriant vegetative growth at the expense of translocation of metabolites to developing fruits. These results are in agreement with Chauhan (2008) and Asma *et al*., (2007). Further, reduction in sugar content of fruits with increasing N supply beyond 500g was observed in present study, which might be due to the utilization of these sugars in the synthesis of amino acids, amides and proteins. On the contrary Schneider *et al.* (1958) reported a significant increase in soluble solids when the rate of applied N was increased from 0.3 lb to 1.20 lb N $tree^{-1}$. Similar findings have been reported by Badyal (1980) and Joon *et al*.,(1990) in Santa Rosa plum. Such effects may be associated with the increase in the rate of photosynthesis at higher N levels and rapid translocation of synthesized photosynthates which in turn helped in sugar translocation.

5.4.4 Acidity

Treatments of different pruning intensities and different nitrogen levels had significant influence on the fruit acidity during both the years of study (Table 11). Treatment T_7 (60% heading back of scaffolds +500g Nitrogen) resulted in maximum fruit acidity during both the years of study, whereas minimum was observed with light pruning treatment T_2 (60% heading back of scaffolds +500g Nitrogen). This is in conformity with, Thakur (2012), who reported significantly higher acidity due to an increased in pruning severity and optimal dose of N in New Castle apricot. These results are again supported by Kumar *et al*., (2010), Rathi *et al*., (2001) and Sharma and Chauhan (2004), who reported significantly higher acidity due to an increase in the pruning severity in different peach varieties. On the contrary, Badiyala and Awasthi (1989) reported decrease in fruit acidity with increasing pruning severity. These results are in line with reports of Joolka *et al*., (1989), in New Castle apricot and Badyal (1980), in Santa Rosa plum fruits. The decrease in acidity might be due to increased synthesis of carbohydrates and their translocation to fruit tissues. Sharma (1995) did not observe any significant effect on titratable acidity in peach fruits by different combinations of pruning intensities and N fertilizer treatments.

5.5 LEAF NUTRIENT STATUS

5.5.1 Macro - nutrients

Treatment combination of heavy pruning along with increased dose of nitrogen influenced leaf N content significantly during both the years of study (Table 12). Highest leaf N (2.97 % in pooled data) content was recorded in T_9 (60% heading back of scaffolds+750g Nitrogen) treatment. The higher foliar N in heavily pruned trees with higher level of N may be due to low yield and less accumulation of dry matter in the leaves. These finding are in agreement with Thakur, (2012) who observed increase in foliar nitrogen content with increase in pruning intensities and nitrogen level in rejuvenated New Castle apricot trees. Similar observations were also recorded by Schneider *et al*. (1958), and Sharma, (1995) in peaches. The increase in leaf nitrogen content in response to soil application of this element has also been reported by Stembridge *et al*. (1962) and Walsh *et al*. (1989).

Minimum pruning intensity and lower dose of N in T_1 (20% heading back of scaffolds+500g Nitrogen) increased leaf P (0.247 %) content during both the years of study. However, the maximum foliar P content was recorded with the combination of lower pruning intensity and N level. Similar results were obtained by Thakur (2012) in New Castle apricot and Sharma, (1995) in July Elberta peach. This was attributed to the effect of pruning on the root system of the trees, as heavy pruning reduces the horizontal extension of the roots than the light pruning and ultimately affects the uptake of nutrients. These results are in agreement with the findings of Sharma and Singh (1982) in Sharbati cultivar of peach where P content of leaf decreased with increasing rate of N application.

Morris *et al.* (1983) reported higher P status due to heavy pruning. This may also be attributed towards the antagonism between phosphate and nitrate anions. On the other hand Sharma and Bhutani (1989) and Walsh *et al.* (1989) did not observe any consistent effect of different N levels on leaf P content. Where as, Fallahi *et al.*, (1993) observed increase in P content of leaf with increased pruning intensity in Bing sweet cherry.

Different rejuvenation treatments had significant effect on per cent K content of leaves during both the years of study. Heavy pruning treatment with lowest level of N (Table 12) resulted in the maximum leaf K content and minimum in control (heading back at secondary branches level+500g Nitrogen). The higher foliar K in the heavily pruned trees was due to the less accumulation of dry matter and vigorous growth which caused increased uptake of K. Similar results have been observed by Thakur (2012) in New Castle apricot and Singh (1992) and Sharma (1995) in different cultivars of peach. The foliar K was in optimum range in all the pruning treatments during both years of study. The results are in conformity with Sharma and Singh (1982) and Sharma and Bhutani (1989) in different cultivars of peach, where in K concentration in leaves decreased with the increase in rate of N application. Such a relationship has also been found in other fruit trees by Badyal (1980) in peach and Chandel (1985) in apricot. These observations get support from that of Fallahi *et al.*, (1993) in sweet cheery and Singh *et al.*, (1997) in peach observed increase in foliar K with increased pruning intensities and decreased N levels.

Different treatments influenced the leaf Ca content significantly. The increasing levels of pruning and nitrogen resulted in decreased foliar Ca content in apricot (Table 12). These results are in agreement with the findings of Thakur (2012) in New Castle apricot, Fallahi *et al.*, (1993) in sweet cherry, Singh *et al.*, (1997) in peach and Tawfik and Abdel-Aziz (1972) in peach. The decrease in leaf Ca with increasing pruning intensity could be attributed to higher K levels in the leaves of heavily pruned trees. The higher amount of dry matter in the lightly pruned trees also favoured more Ca accumulation. The failure of N application to increase Ca level in leaves may be related to the slow mobility of Ca in plant tissue (Norton and Wittwer, 1963). Kanwar (1979), Singh (1992) and Sharma

(1995) also reported decrease in leaf Ca with increase in severity of pruning and fertilizer treatments.

Different treatment combinations had significant influence on the leaf Mg content. The maximum leaf Mg was recorded in T_1 (20% heading back of scaffolds+500g Nitrogen) and minimum in T_9 (60% heading back of scaffolds+750g Nitrogen) treatment (Table 12). The results are on accordance with Sharma, (1995) who recorded higher foliar Mg content under light pruning intensity and lower levels of N and K fertilizers in July Elberta peach. Similar decreasing trend in leaf Mg was observed by Singh (1992) in different cultivars of peach. Leece (1976) also reported that application of N fertilizers to peach trees resulted decrease in leaf Mg.

5.5.2 Micro - Nutrients

Iron content of the leaves increased significantly with increasing severity of pruning and N levels (T_9-60% heading back of scaffolds+750g Nitrogen) (Table 13). The results are in conformity with the findings of Thakur, (2012) in apricot and Sharma, (1995) who recorded higher foliar Fe content under heavy pruning intensity and higher levels of N and K fertilizers in July Elberta peach. The higher Fe in heavily pruned trees may be due to pruning effects on growth as heavy pruning induces vigorous growth that ultimately increases nutrient uptake through transpiration pull (Kanwar, 1979). These results again get supports from that of Fallahi *et al*., (1993) in sweet cheery and Singh *et al*., (1997) in peach.

The increased severity of pruning and N levels increased foliar Mn content of apricot leaves. The higher Mn content in treatment combinations of heavy pruning and higher dose of N could be attributed to pruning effects on growth as heavy pruning induces vigorous growth. Higher leaf Mn in heavily pruned trees may also be due to synergistic effect of N. The results are in line with the findings of Thakur, (2012) in apricot and Sharma, (1995) who recorded higher foliar Mn content under heavy pruning intensity and higher levels of N and K fertilizers in July Elberta peach. The increase in leaf Mn in the present study is supported by the findings of Fallahi *et al*., (1993) in sweet cheery and Singh *et al*., (1997) in peach.

The Foliar status of Zn was affected significantly by different pruning severities and N treatment combinations during both the years of study. The leaf Zn content increased with increasing level of pruning and nitrogen. The higher Zn content in heavily pruned trees along with higher dose of nitrogen could be attributed to pruning effects on growth, as heavy pruning induces vigorous growth or it may be due to the antagonistic effect of P on the Zn, as leaf P decreased with the increasing levels of N (Table 12). These finding are in agreement with Thakur, (2012) who observed increase in foliar Zn content with increase in pruning intensities and nitrogen level in New Castle apricot. Fallahi *et al*., (1993) support these findings in sweet cherry. Singh *et al*., (1997) in peach and observed that pruning had no significant effect on leaf Zn content.

Significant reduction in the leaf Cu content was observed during the course of investigation with increased levels of pruning and nitrogen (Table 13). This could also be attributed to the interaction of this element with Zn and N. The leaf Cu content decreased with increased rate of N. This could be because of negative correlation of Cu with N and Zn. These finding are in agreement with Thakur, (2012) who observed decreased in foliar Cu content with increase in pruning intensities and nitrogen level in New Castle apricot Fallahi *et al*., (1993) in sweet cherry and Singh *et al*., (1997) in peach.

Chapter-6

SUMMARY AND CONCLUSION

The present investigations entitled "Rejuvenation studies on growth, fruiting and fruit quality of apricot (*Prunus armeniaca* L.) cv. New Castle" was carried out in the experimental orchard of department of Fruit Science, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan, Nauni, (H.P.) during the year 2013 and 2014 as a continuation of the experiment conducted during 2011 and 2012 in which trees were given rejuvenation treatments (combination of 3 pruning severities and 3 levels of nitrogen) in the year 2011 and therefore standard pruning was practiced with same combination of nitrogen levels to ascertain the effect of these rejuvenation treatments on tree vigour, fruiting and productivity of declining apricot trees. The two year data pooled results obtained are summarized as under:

6.1 Heavy pruning along with the highest dose of nitrogen produced significantly more growth than other pruning and nitrogen treatment combinations in both the years of study. The maximum pooled annual shoot growth (167.06 cm), tree spread (4.63m), pruning wood weight (9.19 kg/tree) and leaf area (36.15 cm^2) was obtained with treatment T_9 (60% heading back of scaffolds+750g Nitrogen) during both the years of investigation. However, the maximum pooled tree volume (32.45 m^3) was recorded under combination of lower intensity of pruning and highest N level i.e. in T_3 (20% heading back of scaffolds+750g Nitrogen) treatment.

6.2 The chlorophyll content of the leaves was significantly increased with the increasing pruning severity and nitrogen levels. Heavy pruning with highest nitrogen fertilizer combination resulted in maximum chlorophyll content. The treatment T_9 (60% heading back of scaffolds+750g Nitrogen) accumulated highest chlorophyll content (2.62 mg/100g in pooled data) than all other treatments.

6.3 Different pruning intensities and nitrogen levels had significant effect on per cent fruit set during both the years of study. Medium pruning with medium nitrogen fertilizer combination resulted in maximum fruit set. The highest pooled fruit set (47.85 %) was recorded with T_5 (40% heading back of scaffolds+625g Nitrogen) treatment.

6.4 Different combinations of rejuvenation pruning and nitrogen treatments had significant effect on fruit yield per tree after 3rd and 4th year of rejuvenation treatments. Maximum fruit yield 22.64 kg was recorded in T_7 (60% heading back of scaffolds+500g Nitrogen) during both the year.

6.5 Heavy pruning in combination with standard dose of N produced significantly heavier and larger fruits than all the other treatments. The highest pooled fruit weight (26.59 g), volume (22.91 cc) and fruit size (33.87 mm and 33.97 mm) in terms of length and breadth respectively was recorded in T_7 (60% heading back of scaffolds+500g Nitrogen) treatment during the course of studies. In both the years, the smallest fruits were produced with control (heading back at secondary branches level+500g Nitrogen).

6.6 Various physico-chemical fruit parameters were significantly influenced by heavy pruning in combination with lower level of nitrogen. The total soluble solids, total sugars, reducing sugars and non-reducing sugars were increased with the combination of increasing severity of pruning and decreased level of N. The maximum of these quality parameters were observed in T_7 (60% heading back of scaffolds+500g Nitrogen) and minimum in control (heading back at secondary branches level+500g Nitrogen) treatment.

6.7 Pruning intensities and different nitrogen levels had significant influence on the fruit acidity during both the years of study. Maximum pooled acidity (1.91 %) was obtained with the treatment combination of heavy pruning severity and lower level of nitrogen T_7 (60% heading back of scaffolds+500g Nitrogen).

6.8 Different pruning and nitrogen treatments exerted a significant influence on fruit firmness. Fruit firmness was found to be increased significantly with increasing severity of pruning but showed a declining trend with increasing levels of Nitrogen. The maximum pooled (5.40 kg/cm^2) fruit firmness was found in T_7 (60% heading back of scaffolds+500g Nitrogen) treatment and minimum in control (heading back at secondary branches level+500g nitrogen).

6.9 The foliar nutrient content N, Fe, Mn and Zn increased with the heavy pruning treatment along with increasing levels of nitrogen, while P, Ca, Mg and Cu showed declining trends with the increasing pruning severity and nitrogen levels.

On the basis of the result obtained during the present investigation, it can be concluded that annual shoot growth, tree spread, pruning wood weight, leaf area , leaf chlorophyll contents and foliar N, Fe, Mn and Zn nutrient contents were higher in T_9 (60% heading back of scaffolds+750g Nitrogen). The various physico-chemical parameters such as fruit weight, fruit volume, TSS, total sugar, reducing sugar, non-reducing sugar, acidity and fruit firmness were highest in T_7 (60% heading back of scaffolds+500g Nitrogen). However, these treatments need further evaluation prior to recommendation to the farmers.

Chapter-7

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Department of Fruit Science

Title of Thesis	**:**	**Rejuvenation studies on growth, fruiting and fruit quality of apricot (*Prunus armeniaca* L.) cv. New Castle**
Name of the student	**:**	Rocky Thokchom
Admission Number	**:**	H- 2012- 26- M
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Major Field	**:**	Fruit Science
Minor Field(s)	**:**	Plant Physiology
Degree Awarded	**:**	M. Sc. (Fruit Science)
Year of Award of Degree	**:**	2014
No. of pages in Thesis	**:**	82+III
No. of words in Abstract	**:**	297

ABSTRACT

The study entitled "Rejuvenation studies on growth, fruiting and fruit quality of apricot (*Prunus armeniaca* L.) cv. New Castle" was conducted on 25- years old rejuvenated trees of New Castle apricot in the experimental orchard of the Department of Fruit Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during 2013 and 2014. These experimental trees were given rejuvenation treatments (combination of 3 pruning severities and 3 levels of nitrogen) in the year 2011. The standard pruning was practiced afterwards but the combinations of different level of nitrogen in the experimental trees were applied. To ascertain the effect of rejuvenation treatment on tree vigour, fruiting, and productivity the study was further continued for another 2 years i.e. 2013 and 2014. The experiment was laid out using Randomized Block Design consisting of 10 treatments replicated thrice. The experiment comprised factorial combination of pruning severities (20%, 40%, 60% and heading back of main scaffolds) and, three levels of nitrogen (500, 625 and 750 g/tree). In all there were nine combinations of pruning intensities and nitrogen level treatments which were compared with control. The results revealed that maximum annual shoot growth (167.06 cm), tree spread (4.63cm), pruning wood weight (9.19kg/tree), leaf area (36.15cm^2), leaf chlorophyll contents (2.62mg/100g) and foliar N (2.97%), Fe (248.26ppm), Mn (158.19ppm) and Zn (11.77ppm) contents were higher in T_9 (60% heading back of scaffolds+750g Nitrogen). The various physico-chemical parameters such as fruit weight (26.59g), fruit volume (22.91cc), TSS (15.99^{0}B), total sugar (9.84%), reducing sugar (3.70%), non-reducing sugar (6.61%), acidity (1.91%) and fruit firmness (5.40kg/cm^2) were highest in T_7 (60% heading back of scaffolds+500g Nitrogen), while foliar P (0.247%), Ca (3.07%), Mg (0.92%) and Cu (14.56ppm) contents were higher in T_1 (20% heading back of scaffolds+500g Nitrogen) in New Castle apricot under study.

Signature of Major Advisor **Signature of student**

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APPENDIX – I

ANOVA TABLE: 1: Mean sum of square for tree growth and vigour characteristics of apricot cv. New Castle

Source of variation	df	Mean sum of square												
		Trunk girth (cm)	Annual shoot growth (cm)			Tree height (m)			Tree spread (m)			Tree volume (m^3)		
		2013-2014	2013	2014	pooled	2013	2014	pooled	2013	2014	pooled	2013	2014	pooled
Replication	2	0.032	0.001	3.312	1.6565	0.007	0.006	0.0065	0.000	0.001	0.0005	0.041	0.021	0.031
Treatment	9	0.385	41.699	50.163	45.931	0.738	0.625	0.6815	0.141	0.210	0.1755	0.776	0.701	0.7385
Error	18	0.042	1.080	2.536	1.808	0.003	0.001	0.002	0.000	0.001	0.0005	0.041	0.022	0.0315
Total	29													

ANOVA TABLE: 2: Mean sum of square for pruning wood weight, leaf area, chlorophyll content and fruit set of apricot cv. New Castle

Source of variation	df	Mean sum of square											
		Pruning wood weight (kg/tree)			Leaf area (cm^2)			Chlorophyll content (mg/100g)			Fruit set (%)		
		2013	2014	pooled	2013	2014	pooled	2013	2014	pooled	2013	2014	pooled
Replication	2	0.820	0.065	0.4425	0.149	0.519	0.334	0.000	0.000	0	2.220	1.277	1.7485
Treatment	9	7.389	4.780	6.0845	9.131	9.283	9.207	0.029	0.174	0.1015	6.427	9.023	7.725
Error	18	0.305	0.171	0.238	0.171	0.359	0.265	0.000	0.001	0.0005	2.61	1.036	1.823
Total	29												

ANOVA: 3: Mean sum of square of fruit yield and physico-chemical characteristics of apricot cv. New Castle

Source of variation	df	Mean sum of square											
		Fruit yield (kg/tree)			Fruit size (cm)						Fruit weight (g)		
					Fruit length (cm)			Fruit width (cm)					
		2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Replication	2	1.639	0.009	0.824	0.499	0.383	0.441	0.128	0.174	0.151	2.386	.178	1.282
Treatment	9	0.995	0.799	0.897	4.876	3.479	4.1775	3.900	2.958	3.429	17.239	16.375	16.807
Error	18	1.465	0.730	1.0975	0.649	0.290	0.4695	0.393	0.147	0.27	2.894	0.206	1.55
Total	29												

ANOVA: 4: Mean sum of square of physico-chemical characteristics of apricot cv. New Castle

Source of variation	df	Mean sum of square											
		Fruit volume (cc)			Total soluble solids (^{0}B)			Total sugar (%)			Reducing sugar (%)		
		2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Replication	2	0.346	0.090	0.218	0.118	0.108	0.113	0.027	0.002	0.0145	0.016	0.045	0.0305
Treatment	9	16.481	12.609	14.545	1.274	0.909	1.0915	5.850	4.749	5.2995	0.839	0.743	0.791
Error	18	0.158	0.394	0.276	0.148	0.070	0.109	0.006	0.036	0.021	0.020	0.045	0.0325
Total	29												

ANOVA: 5: Mean sum of square of physico-chemical characteristics of apricot cv. New Castle

Source of variation	df	Mean sum of square											
		Non-reducing sugar (%)			Acidity (%)			Ascorbic acid (mg/100g)			Fruit firmness (kg/cm^2)		
		2013	2014	Pooled	2013	2014	Pooled	2013	2014	pooled	2013	2014	Pooled
Replication	2	0.005	0.009	0.007	0.0002	0.055	0.0276	0.054	0.055	0.0545	0.004	0.485	0.2445
Treatment	9	3.078	2.606	2.842	0.195	0.088	0.1415	19.697	19.697	19.697	0.537	1.302	0.9195
Error	18	0.047	0.084	0.0655	0.028	0.003	0.0155	0.069	0.069	0.069	0.069	0.089	0.079
Total	29												

ANOVA: 6: Mean sum of square of leaf nutrient status of apricot cv. New Castle

Source of variation	df	Mean sum of square								
		Leaf nutrient content (macro and micro nutrient)								
		Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)	Iron (ppm)	Manganese (ppm)	Zinc (ppm)	Copper (ppm)
		2104	2104	2104	2104	2104	2104	2104	2104	2104
Replication	2	0.002	0.002	0.004	0.003	0.151	0.432	0.456	0.232	0.234
Treatment	9	0.016	0.001	0.125	0.100	0.063	0.123	0.093	0.110	0.012
Error	18	0.004	0.002	0.001	0.000	0.007	0.321	0.122	0.001	0.016
Total	29									

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