*Himachal Journal of Agricultural Research 33 (2):205-210, 2007*

# Effect of fertigation treatments and rootstocks on growth, cropping and yield of apple under high density plantation

**Sanjeev Kumar Banyal and A. S. Rehalia**
Department of Pomology
Dr. Y. S. Parmar University of Horticulture and Forestry, Solan- 173 230, India.

**Abstract**

**In the present investigations fertigation treatments especially full dose of N, P and K through drip increased tree growth, trunk girth and shoot extension over soil fertilization. Among rootstocks, the scion grafted on EMLA-111 grew more vigorously than those on other two rootstocks. Flowering intensity and fruit set increased with increase in the dose of nutrients applied through drip. Higher doses of nutrients through drip produced higher yields.**

## Introduction

In India, apple is mainly produced in the north-western Himalayan region comprising the states of Jammu & Kashmir, Himachal Pradesh, Uttaranchal and to a small extent in North-eastern states. Although apple production has made significant strides in Himachal Pradesh but the productivity of apple in the state is nowhere near to that of developed western countries. The low productivity has been attributed to various reasons such as sloppy lands, shallow, unirrigated and less fertile land beside inadequate nutrition and improper plant protection measures. It has necessitated the apple growers to change over to more efficient orcharding system by the use of critical inputs like water and fertilizers. The reports on fertigation under high density plantation are enthusiastic in abroad but information on this aspect is therefore proposed to study the effect of different levels of fertigation and three different rootstocks on apple under high density plantation.

## Material and Methods

The experimental site falls in the sub-mountain zone of Himachal Pradesh situated at an elevation of 1350 m amsl. The climate of the area ranges from sub-temperate to temperate with maximum temperature upto 32°C during summer and an average annual rainfall of 80-90 cm.

The experiment was laid down on six years old plants of cultivars Red Fuji and Scarlet Gala, grafted on three clonal rootstocks viz., EMLA-106, EMLA-7 and EMLA-111 spaced at 3x3 m. Five fertigation treatments viz., Full dose of N, P and K through drip, 2/3 dose of N, P and K through drip, ½ dose of N, P and K through drip, 1/3 dose of N, P and K through drip and full dose of N, P and K through soil (control) were applied for two seasons during 2002 to 2004. The full dose of N, P and K was fixed at 35 g N, 175 g $P_2O_5$ and 35 g $K_2O$ per year age of the tree. The fertigation doses were applied as ten split applications at an interval of ten days commencing from third week of March whereas, soil application was made as a single dose. The experiment was conducted according to split split plot design. The vegetative growth in terms of tree height, trunk girth and shoot extension growth was measured before and after the completion of growing season. Various cropping parameters like flowering intensity, fruit set and fruit drop were also observed during the course of study. All the fruits harvested from individual plants were weighed to deduce total yield.

## Results and Discussion

### Vegetative growth

The perusal of data presented in Table1 revealed that with the dose of N, P and K applied through drip, the tree height increased. The maximum increase (22.76 and 25.46 cm during first and second year, respectively) in tree height was found with full dose of $N_1$ P and K through Drip, whereas minimum increase was found under control. The scions grafted in EMLA-111 were found to have higher tree height that EMLA-7 and EMLA-106. The trunk girth and shoot

extension growth was also found to be maximum in the treatment that received highest does of N, P and K through drip, consistently during both the years of study. Among the rootstocks, EMLA-111 had maximum increase in trunk girth (1.28 and 1.29 cm) during first and second year respectively. Data pertaining to shoot extension growth showed that all the fertigation treatments had significantly higher shoot extension growth over control. It may be concluded that all the fertigation treatments effectively enhanced vegetative growth over soil application. This may be attributed to the fact that a continuous supply to nutrients in a solubilize form was provided to the plants at critical stages of growth under fertigation which resulted in enhanced vegetative growth. Similar results were obtained by Klein *et al.*(1998) and Hipps (1997). Fertigation has also been found to increase nutrient use efficiency by minimizing leaching losses (Albergts *et al.*1996, Yasef, 1999). The maximum vegetative growth was found on rootstock EMLA-111 which is consistent with the results obtained by Ferree and Carlxin (1987).

**Cropping**

The data pertaining to flowering intensity (Table1), reveal that only full dose of N, P and K and 2/3 dose of N, P and K through drip produced significantly higher (28.27 and 27.11 clusters/m respectively) flowering intensity over control, during the first year of study. During the second year, the maximum flowering intensity (33.95 cluster/m) was found in treatment $T_1$(full dose of N, P and K through drip) and minimum in treatment $T_5$(control). The rootstocks did not show any significant difference for flowering intensity during any of the year. Treatment $T_1$(Full dose of N, P and K through drip) had the highest (41.07 and 43.8 % during first and second year, respectively) fruit set which was statistically at par with treatment $T_2$ (2/3 dose of N, P and K through drip). The fruit set was maximum on EMLA-106 during the first year, whereas it was non-significant during the second year of study. Fruit drop was maximum (12.38%) in treatment $T_5$(control) and minimum (7.82%) in treatment $T_1$ (Full dose of N, P and K through drip) during the first year and Non-significant during second year.

The fertigation treatments enhanced flowering intensity and fruit set over control and reduced fruit drop. This may be due to better availability of nutrients under fertigation. Fertigation was found to enhance flower bud number by Tromp and Bolding (1987), flower bud in cluster (Westerlaken, 1986) and flowers/m shoot growth than the trees which were not fertigated (Delver, 1984). Hipps (1992) also reported an increase in fruit set by application of higher dose of N through irrigation water.

**Fruit yield**

Fruit yield (Table 3) was significantly enhanced over control with full dose, 2/3 dose and ½ dose of N, P and K through drip. Significantly higher yields under fertigation may be attributed to the improved tree vigour, higher flowering intensity and fruit set, lower fruit drop and larger size of fruits. The treatment $T_1$(full dose of N, P and K through drip) recorded maximum (12.19 and 12.62 kg/plant during first and second year, respectively) fruit yield, whereas the minimum (11.11 and 10.47 kg/plant) fruit yield was observed under control.

Higher yields obtained under fertigation may be explained in the light of hypothesis formulated by Bussi *et al* (1991) who suggested that fertigation results in higher yield due to the direct effect of nutrient fertilizers application timings and a reduction in nitrate leaching. Furthermore, fertigation was particularly suitable because of fractionated supplies which very well met the nutrient requirement of crops at different stages of growth. Increased yields of 4.3 to 11.4 t/ha on Golden Delicious/M.26 apples under fertigation has also been reported by Zydlik and Pacholak (1998). Similar results were obtained by Kodder *et al.* (1992) who reported increased yield of 10.3 kg/tree in Cox Orange Pippin and 19.7 kg/tree in Jonagold apples trees with fertigation. Among the rootstocks, the fruit yield was maximum on EMLA-106, whereas the other two rootstocks were at par with each other. The results are in conformity with Paul James (1997), who obtained higher yields on MM–106 as compared to that on EMLA-111.

**Table 1. Effect of fertigation treatments and rootstocks on vegetative growth in apple**

| Treatments | Flowering intensity (Flower clusters/m) | | | | | | | | Fruit set (%) | | | | | | | | Fruit drop (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Year | | | | 2nd Year | | | | 1st Year | | | | 2nd Year | | | | 1st Year | | | | 2nd Year | | | |
| | EMLA-106 | EMLA-7 | EMLA-111 | Mean | EMLA-106 | EMLA-7 | EMLA-111 | Mean | EMLA-106 | EMLA-7 | EMLA-111 | Mean | EMLA-106 | EMLA-7 | EMLA-111 | Mean | EMLA-106 | EMLA-7 | EMLA-111 | Mean | EMLA-106 | EMLA-7 | EMLA-111 | Mean |
| Full dose of NPK | 28.30 | 28.22 | 28.29 | 28.27 | 33.87 | 34.03 | 33.95 | 33.95 | 41.46 (40.08) | 40.82 (39.71) | 40.94 (39.78) | 41.07 (39.85) | 44.12 (41.62) | 43.72 (41.39) | 43.68 (41.37) | 43.80 (41.44) | 7.21 (2.68) | 8.14 (2.85) | 8.11 (2.84) | 7.82 (2.79) | 6.36 (2.52) | 6.45 (2.53) | 6.45 (2.53) | 6.42 (2.53) |
| 2/3 dose of NPK | 27.06 | 27.37 | 26.88 | 27.11 | 32.36 | 32.43 | 32.38 | 32.39 | 38.99 (38.64) | 38.25 (38.20) | 38.41 (38.30) | 38.55 (38.38) | 41.54 (40.13) | 41.20 (39.93) | 41.07 (39.85) | 41.27 (39.97) | 7.48 (2.73) | 8.49 (2.91) | 8.46 (2.90) | 8.14 (2.85) | 6.77 (2.60) | 6.91 (2.62) | 6.93 (2.63) | 6.87 (2.62) |
| 1/2 dose of NPK | 26.60 | 26.55 | 27.32 | 26.82 | 31.04 | 31.12 | 31.08 | 31.09 | 36.54 (37.19) | 35.62 (36.64) | 35.62 (36.64) | 35.93 (36.82) | 39.08 (38.69) | 38.82 (38.54) | 38.77 (38.51) | 38.89 (38.58) | 9.00 (3.00) | 9.51 (3.08) | 9.49 (3.08) | 9.33 (3.05) | 7.21 (2.68) | 7.39 (2.71) | 7.45 (2.72) | 7.35 (2.71) |
| 1/3 dose of NPK | 26.20 | 26.18 | 26.41 | 26.26 | 30.41 | 30.43 | 30.36 | 30.40 | 34.49 (35.96) | 33.57 (33.57) | 33.79 (35.54) | 33.95 (35.63) | 36.81 (37.35) | 36.17 (36.97) | 36.13 (36.94) | 36.37 (37.09) | 10.41 (3.22) | 10.14 (3.18) | 11.12 (3.33) | 10.56 (3.24) | 7.60 (2.75) | 7.61 (2.75) | 7.71 (2.77) | 7.66 (2.75) |
| Full dose of NPK in soil (Control) | 25.99 | 25.04 | 25.91 | 25.65 | 29.49 | 29.46 | 29.43 | 29.46 | 31.55 (34.17) | 30.80 (33.71) | 30.80 (33.71) | 31.05 (33.86) | 35.26 (36.42) | 34.40 (36.09) | 34.62 (36.04) | 34.86 (36.18) | 11.26 (3.35) | 12.97 (3.60) | 12.91 (3.59) | 12.38 (3.57) | 8.22 (2.86) | 8.28 (2.87) | 8.34 (2.88) | 8.28 (2.87) |
| *Mean* | 26.83 | 26.67 | 26.96 | | 31.43 | 31.18 | 31.44 | | 36.60 (37.22) | 35.81 (36.75) | 35.91 (36.81) | | 39.36 (38.85) | 38.90 (35.58) | 38.85 (38.55) | | 9.07 (3.01) | 9.85 (3.13) | 10.02 (3.16) | | 7.23 (2.68) | 7.32 (2.70) | 7.38 (2.71) | |

| $CD_0$ (P=0.05) | 1st year | 2nd year | 1st year | 2nd year | 1st year | 2rd year |
|---|---|---|---|---|---|---|
| Treatment (T) | 1.50 | 1.32 | 2.12 | 2.87 | 0.36 | NS |
| | NS | NS | 0.44 | NS | NS | NS |
| *Rootstock (R)* | | | | | | |
| TxR | 1.51 | 2.53 | 4.69 | 4.14 | 0.64 | NS |

Figures in parentheses for fruit set are arc sine and for fruit drop square root transformed values

**Table 2. Effect of fertigation treatments and rootstocks on vegetative growth in apple**

| Treatments | Increase in tree height (cm) | | | | | | | | Increase in trunk girth (cm) | | | | | | | | Extension growth (cm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st Year | | | | 2nd Year | | | | 1st Year | | | | 2nd Year | | | | 1st Year | | | | 2nd Year | | | |
| | EMLA -106 | EMLA -7 | EMLA -111 | Mean | EMLA -106 | EMLA -7 | EMLA -111 | Mean | EMLA -106 | EMLA -7 | EMLA -111 | Mean | EMLA -106 | EMLA -7 | EMLA -111 | Mean | EMLA -106 | EMLA -7 | EMLA -111 | Mean | EMLA -106 | EMLA -7 | EMLA -111 | Mean |
| Full dose of NPK | 20.62 | 21.50 | 26.12 | 22.76 | 26.12 | 23.01 | 27.25 | 25.46 | 1.06 | 0.99 | 1.40 | 1.15 | 1.05 | 1.07 | 1.35 | 1.16 | 27.87 | 25.00 | 31.25 | 28.04 | 32.62 | 31.12 | 39.80 | 34.46 |
| 2/3 dose of NPK | 20.02 | 20.62 | 24.75 | 21.79 | 25.50 | 20.75 | 26.12 | 24.12 | 0.95 | 0.86 | 1.31 | 1.04 | 0.96 | 0.95 | 1.34 | 1.08 | 24.37 | 21.62 | 27.01 | 24.33 | 27.87 | 29.12 | 33.37 | 30.12 |
| 1/2 dose of NPK | 17.87 | 19.50 | 22.25 | 19.87 | 21.50 | 20.25 | 24.13 | 21.96 | 0.84 | 0.76 | 1.27 | 0.96 | 0.86 | 0.87 | 1.30 | 1.01 | 22.35 | 19.12 | 22.75 | 21.42 | 24.25 | 23.27 | 25.87 | 24.46 |
| 1/3 dose of NPK | 16.87 | 17.82 | 19.62 | 17.96 | 19.53 | 17.27 | 20.49 | 19.08 | 0.75 | 0.76 | 1.21 | 0.92 | 0.77 | 0.82 | 1.24 | 0.95 | 19.50 | 19.25 | 19.52 | 19.41 | 21.02 | 21.24 | 22.62 | 21.62 |
| Full dose of NPK in soil (Control) | 15.37 | 14.75 | 18.37 | 16.17 | 17.09 | 15.02 | 18.51 | 16.88 | 0.73 | 0.66 | 1.20 | 0.86 | 0.73 | 0.78 | 1.22 | 0.91 | 17.11 | 17.13 | 16.75 | 16.99 | 16.50 | 18.01 | 19.60 | 17.37 |
| *Mean* | 18.05 | 18.85 | 22.23 | | 21.95 | 19.25 | 23.30 | | 0.87 | 0.79 | 1.28 | | 0.87 | 0.90 | 1.29 | | 22.25 | 20.42 | 23.45 | | 24.45 | 24.55 | | |

| CD (P=0.05) | | 1st year | 2nd year | 1st year | 2nd year | 1st year | 2nd year |
|---|---|---|---|---|---|---|---|
| | Treatment (T) | 1.15 | 1.49 | 0.09 | 0.11 | 1.31 | 1.79 |
| | Rootstock (R) | 1.27 | 0.95 | 0.30 | 0.21 | 1.12 | 1.09 |
| | TxR | 4.39 | 3.98 | 0.49 | 0.56 | 6.22 | 7.59 |

VIR OF ICH

**Table 3. Effect of fertigation treatments, varieties, rootstocks and their interaction on fruit yield (kg/ plant) in apple**

| Treatments | 2002 | | | | | | 2004 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Varieties | | Mean | Rootstocks | | | Varieties | | Mean | Rootstocks | | |
| | $V_1$ (Red Fuji) | $V_2$ (Scarlet Gala) | | $R_1$ (EMLA-106) | $R_2$ (EMLA-7) | $R_3$ (EMLA-111) | $V_1$ (Red Fuji) | $V_2$ (Scarlet Gala) | | $R_1$ (EMLA-106) | $R_2$ (EMLA-7) | $R_3$ (EMLA-111) |
| (Full dose of NPK) | 12.21 | 12.17 | 12.19 | 12.34 | 12.13 | 12.10 | 12.76 | 12.47 | 12.62 | 12.74 | 12.58 | 12.54 |
| (2/3 dose of NPK) | 12.03 | 11.85 | 11.94 | 12.07 | 11.88 | 11.86 | 12.28 | 12.10 | 12.20 | 12.34 | 12.13 | 12.13 |
| (1/2 dose of NPK) | 11.61 | 11.45 | 11.53 | 11.69 | 12.61 | 11.59 | 11.97 | 11.28 | 11.63 | 11.71 | 11.61 | 11.57 |
| (1/3 dose of NPK) | 11.33 | 11.11 | 11.22 | 11.34 | 11.17 | 11.15 | 11.33 | 10.78 | 11.05 | 11.21 | 10.98 | 10.95 |
| (Control) | 10.75 | 11.46 | 11.11 | 11.25 | 11.05 | 11.03 | 10.68 | 10.26 | 10.47 | 10.63 | 10.41 | 10.37 |
| *Mean* | 11.63 | 10.41 | | 11.74 | 11.57 | 11.54 | 11.80 | 11.38 | | 11.73 | 11.54 | 11.50 |
| $R_1$ (EMLA-106) | 11.91 | 11.57 | | | | | 11.79 | 11.67 | | | | |
| $R_2$ (EMLA-7) | 11.66 | 11.48 | | | | | 11.66 | 11.42 | | | | |
| $R_3$ (EMLA-111) | 11.67 | 11.41 | | | | | 11.63 | 11.37 | | | | |

CD (P=0.05)

| | 2002 | 2004 |
|---|---|---|
| T | 0.22 | 0.52 |
| V | 0.18 | 0.20 |
| R | 0.10 | 0.31 |
| TxV | 0.72 | 1.13 |
| TxR | 0.49 | 1.29 |
| VxR | 0.23 | NS |

## References


Albregts E, George JH, Craig KC, Cornell J and Harrison J 1996. Potassium fertigation requirements of drip irrigated strawberries. J. Amer. Soc. Hortic. Sci. **121** (1): 164-168.

Bussi C, Huguet JG and Defrance H 1991. Fertilization scheduling in peach orchard under trickle irrigation. J. Hortic. Sci. **66** (4): 487-493.

Delver P 1984. Efficient drip irrigation of young trees. Fruitteelt. **74**: 556-557.

Ferree DC and Carlson RF 1987. Apple rootstocks. **In**: *Rootstocks for Fruit Crops*, eds Rom RC and Carlson RF. Wiley and Sons, New York. pp 107-144.

Hipps NA 1992. Fertigation of newly planted apple trees: Establishment, early growth and precocity of cropping. J. Hortic. Sci. **67** (1): 25-32.

Hipps NA 1997. Effect of nitrogen, phosphorus, water and preplanting soil sterilization on growth and yield of Cox Orange/M9 apple trees. Acta Hort. **448**: 125-131.

Klein I, Levin B, Bar-Yosef B, Assaf R and Berkovitz A 1998. Drip nitrogen fertigation of 'Starking Delicious' apple trees. Pl. and Soil **119**: 305-314.

Kodde K, Mass R, Bolding P and Vandev-Maas R 1992. Fertigation proves itself also in later years. Fruitteelt-Den-Haag. **82** (10): 14-15.

Paul James 1997. Performance of 3 apple cultivars on 6 rootstocks during the first 6 seasons, at Lenswood, South Australia. Acta Hort. **451**: 163-169.

Tromp J and Bolding PJ 1987. Spotlight on fertigation again. Fruitteelt. **78** (1): 15-17.

Westerlaken J 1986. Experiences with fertigation in newly planted apples. Fruitteelt. **76** (13): 393-395.

Zydlik Z and Pacholak E 1998. Effect of fertigation on the yield and storage capability of apple cultivar Golden Delicious. Prace Zakresu Nauk Rolniczych. **85**: 121-128.

Yosef BB 1999. Advances in fertigation. Adv. Agron. **65**: 1-77.


VIR SOFTECH