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Combined Influence of Pruning Regimes and Fertilizer Application on Vegetative Growth and Photosynthetic Efficiency of Apple cv Red Delicious

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Abstract

Investigation on combined influence of pruning regimes and fertilizer application on vegetative growth and photosynthetic efficiency of apple cv Red Delicious was carried in 4 × 3 × 3 factorial randomized block design experiment with four levels of pruning and three levels of nitrogen and potassium in 2004 and 2005. Vegetative growth in terms of number of branches produced per cut, average annual extension growth, tree volume, leaf area and photosynthetic efficiency increased with increase in pruning intensity and nitrogen application. However, K recorded no significant effect on average number of branches produced per cut, average annual extension growth and leaf area. Whereas significant effect was recorded in photosynthetic efficiency at higher levels of potassium application. The interaction effect of pruning and nitrogen produced significant effect in vegetative growth and the photosynthetic efficiency of Red Delicious apple. All other interactions were found to be non-significant.

Key words : Pruning, Nitrogen, Potassium, Leaf area, Photosynthetic efficiency.

Pruning is the art of cutting or removal of unwanted plant to make it grow or behave the way it is desired. Fruit trees are pruned to restrict tree size, ensure adequate penetration of sun light into tree canopy, removal of dead, diseased and broken branches adjust crop load and maintain a balance between vegetative and reproductive growth (1). When the shoot apex is removed the hormonal status between the meristems is changed, which results in stimulation of lateral buds, induction of branching and increment in photosynthesis of basal leaves. The amount and quality of fruit produced by an apple tree are determined by the relationship between vegetative and reproductive growth. Nitrogen and potassium play an important role in the nutrition of fruit trees. Nitrogen has a greater influence on vegetative growth of fruit trees. Potassium maintains turgor pressure in the leaves and helps in opening and closing of stomata. But when the elements are severily deficient in soil, the trees needs application in right amount to over come the deficiency (2).

Methods

Twenty year old Red Delicious apple trees of uniform size and vigor were selected during 2004 and 2005 for experimentation. All the trees were maintained under similar cultural practices except the receptive pruning treatments and fertilizer application. Experiment was laid in a factorial randomized block design with three replications and two trees per treatment at plot size. The pruning and the fertilizer treatments were given as follows.

Pruning : Control (Pr_0)—Removal of dead, diseased and broken branches, removal of water sprouts, Light (Pr)—a + proper thinning + 1/3rd of the one year shoot is cut, Medium (Pr_2)—a + proper thinning + 1/2 of the one year shoot is cut, and Strong (Pr_3)—a + proper thinning + 2/3rd of the one year shoot is cut. *Nutrient supplement :* Nitrogen application. N_1—795 urea (25%less of recommended dose), N_2—1,060 g urea (recommended dose), and N_3—1,325 g urea (25% more of recommended dose). Potassium appli-

Table 1. Effect of different prunning (Pr) regimes, levels of nitrogen (N) and potassium (K) on average number of branches produced per cut of apple cv Red Delicious.

Treatment	2004					2005				
	Pr_0	Pr_1	Pr_2	Pr_3	Mean	Pr_0	Pr_1	Pr_2	Pr_3	Mean
N_1	1.95	3.43	3.47	4.61	3.36	1.94	2.26	3.98	4.15	3.09
N_2	2.84	3.51	5.23	5.17	4.18	2.25	3.19	5.41	6.35	3.55
N_3	3.42	3.76	5.40	5.42	4.50	2.53	3.26	5.58	6.20	4.39
K_1	3.02	3.50	5.12	5.44	4.27	2.52	3.06	5.28	6.13	4.24
K_2	2.65	3.81	4.60	4.96	4.00	2.25	2.95	4.98	5.42	3.90
K_3	2.53	3.40	4.40	4.77	3.77	1.95	2.71	4.71	5.15	3.63
N_1K_1	2.65	3.36	3.53	4.26	3.45	2.16	2.26	3.90	4.80	3.28
N_1K_2	1.67	3.60	3.50	4.50	3.31	1.96	2.23	4.13	3.63	2.99
N_1K_3	1.53	3.33	3.40	5.06	3.33	1.70	2.30	3.93	4.03	2.99
N_2K_1	2.90	3.93	5.90	5.70	4.60	2.40	3.28	5.93	6.63	4.56
N_2K_2	2.63	3.96	5.13	5.13	4.21	2.43	3.26	5.26	6.26	4.30
N_2K_3	3.00	3.63	4.66	4.70	4.00	1.93	3.03	5.03	6.16	4.04
N_3K_1	3.53	4.20	5.93	6.36	5.00	3.00	3.63	6.03	6.96	4.90
N_3K_2	3.66	3.86	5.16	5.26	4.49	2.36	3.36	5.56	6.36	4.41
N_3K_3	3.06	3.23	5.13	4.56	4.00	2.23	2.80	5.16	5.26	3.86
Mean	2.73	3.56	4.70	5.06		2.24	2.90	4.99	5.57	
CD (P=0.05)										
Pruning (Pr) =		0.64					0.73			
Nitrogen (N) =		0.55					0.64			
Potassium (K) =		NS					NS			
Pr × N =		1.12					1.28			
Pr × K =		NS					NS			
N × K =		NS					NS			
Pr × N × K =		NS					NS			

cation : K_1—1,125 g MOP (25% less of recommended dose), K_2—1,500 g MOP (recommended dose), and K_3—1,875 g MOP (25% more of recommended dose). Phosphorus application was same for all trees as 650 g tree as DAP.

The pruning treatments were given in December, nitrogen was supplied in two split doses. First half of nitrogen along with full dose of potassium was supplied 3 weeks before expected bloom. Second dose of nitrogen was applied 3 weeks after fruit set.

The observations on vegetative growth and tree, volume, were recorded after leaf fall. Average leaf area was measured in July with the help of automatic leaf area meter. Photosynthetic efficiency on dry weight basis for comparative study of different treatments was done in accordance with the procedures sug-

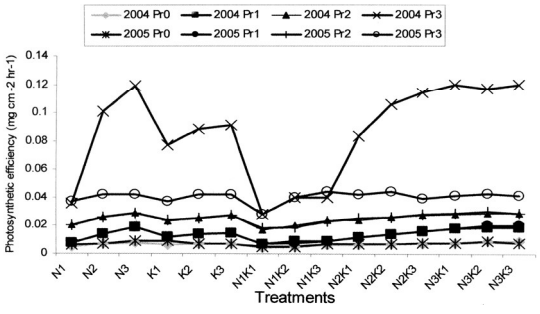

Figure 1. Effect of different pruning (Pr) regimes, levels of nitrogen (N) and potassium (K) on average leaf area (cm^2) of apple cv Red Delicious.

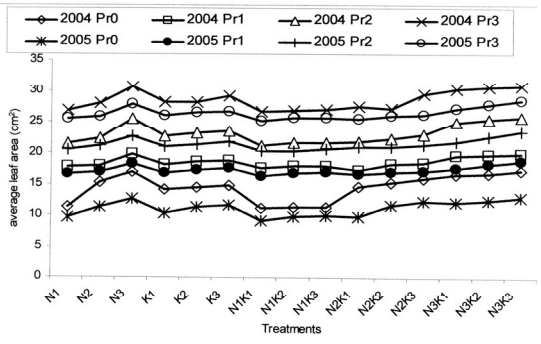

Figure 2. Effect of different pruning (Pr) regimes, levels of nitrogen (N) and potassium (K) on photosynthetic efficiency ($mg/cm^2/hr$) of apple cv Red Delicious.

Table 2. Effect of different pruning (Pr) regimes, levels of nitrogen (N) and potassium (K) on average annual extension growth (cm) of apple cv Red Delicious.

Treatment	2004					2005				
	Pr_0	Pr_1	Pr_2	Pr_3	Mean	Pr_0	Pr_1	Pr_2	Pr_3	Mean
N_1	27.96	29.87	36.22	38.23	33.07	41.30	44.60	45.92	55.09	46.73
N_2	27.51	34.03	40.59	40.36	35.62	42.83	47.88	49.31	56.47	49.05
N_3	27.02	33.92	46.84	42.11	36.72	45.01	45.41	53.80	53.89	49.53
K_1	27.74	34.39	40.94	40.62	35.92	43.05	45.58	49.64	55.82	48.27
K_2	28.02	32.22	40.34	40.57	35.29	43.80	46.64	50.42	55.88	49.18
K_3	26.72	31.22	39.36	39.50	34.20	42.30	45.68	48.98	54.45	47.85
N_1K_1	27.62	28.25	36.50	38.24	32.65	38.38	41.46	44.77	54.26	44.72
N_1K_2	29.21	31.20	36.49	39.02	33.98	43.09	46.36	47.15	55.91	48.13
N_1K_3	27.05	30.17	35.67	37.42	32.58	42.43	46.00	45.85	55.10	47.34
N_2K_1	28.29	38.16	42.33	40.56	37.33	44.16	49.52	50.67	56.03	50.09
N_2K_2	27.82	32.08	40.33	40.46	35.17	43.11	47.34	49.18	57.42	49.26
N_2K_3	26.43	31.84	39.11	40.05	34.36	41.22	46.79	48.08	55.07	47.79
N_3K_1	27.32	36.75	44.00	43.06	37.78	46.59	45.76	53.48	54.16	50.00
N_3K_2	27.03	33.38	44.22	42.23	36.71	45.20	46.21	54.91	54.32	50.16
N_3K_3	26.69	31.64	43.30	41.03	35.67	43.24	44.26	53.00	53.18	48.42
Mean	27.50	32.61	40.21	40.23		43.05	45.97	49.68	55.05	
CD (P=0.05)										
Pruning (Pr) =		1.24					1.48			
Nitrogen (N) =		1.07					1.28			
Potassium (K) =		NS					NS			
Pr × N =		2.15					2.56			
Pr × K =		NS					NS			
N × K =		NS					NS			
Pr × N × K =		NS					NS			

gested by Westwood (3).

Results and Discussion

The data for vegetative characters of apple cv Red Delicious in response to various levels of pruning and fertilizer applications are presented in Tables 1 to 3 and Figure 1 to 2. All the pruning levels and fertilizer applications were found to exert a significant influence on tree growth and vigor. However, their interactions were not significant. Increasing pruning severity increased the vegetative growth in terms of annual shoot growth, shoot number, tree volume and leaf area. The maximum growth in respect of all these parameters was observed in strong pruning and minimum in control. The increase in growth was primarily a function of greater availability of photosynthesis and the nutrients in the heavily pruned trees as with the increase in severity of pruning, there was proportionate reduction in the number of vegetative buds like to develop into new shoots, thereby reducing competition for carbohydrates and other metabolites. When the shoots are shortened to different lengths, the new terminals became longer with increasing shoot shortening (4). Growth response of pruning can be attributed to certain physiological changes particularly altered hormonal and nutritional translocation pattern in the trees as auxin and cytokinin activity increases with pruning. Increased uptake of N, P and K was observed in the present study, which might be one of the contributory factors towards increased shoot growth in heavily pruned trees. The present findings are similar to those obtained by Mika (5) and Singh (6). The increase in the tree volume was highest in strongly pruned trees which decreased with decrease in pruning severity. These results are in line with Abbott (7).

Increased levels of nitrogen application significantly increased the growth of apple trees in terms of shoot growth and tree volume. Several workers have reported an increase in tree vigor due to N fertilization in fruit trees (8). The possible reason for the increased growth with increasing levels of nitrogen might be higher availability of N content (NH_4+ $NO3^-$

Table 3. Effect of different pruning (Pr) regimes, levels of nitrogen (N) and potassium (K) on average tree volume (m^3) of apple cv Red Delicious.

Treatment	2004					2005				
	Pr_0	Pr_1	Pr_2	Pr_3	Mean	Pr_0	Pr_1	Pr_2	Pr_3	Mean
N_1	15.57	16.00	19.19	18.84	17.40	13.73	14.44	15.21	19.28	15.67
N_2	16.75	17.05	21.00	20.25	18.79	14.53	16.70	16.38	21.60	17.30
N_3	17.72	18.32	22.18	23.32	20.38	17.27	17.49	17.68	24.21	19.16
K_1	16.18	16.52	19.98	20.03	18.18	14.90	15.66	16.01	20.96	16.88
K_2	16.67	17.03	20.75	20.88	18.83	15.03	16.34	16.29	21.45	17.28
K_3	17.20	17.83	21.73	21.50	19.56	15.60	16.62	16.96	22.66	17.96
N_1K_1	15.16	15.35	18.16	18.63	16.83	13.60	13.70	14.90	18.73	15.23
N_1K_2	15.50	16.00	19.25	18.98	17.44	13.80	14.46	14.94	19.33	15.63
N_1K_3	16.00	16.65	20.16	18.90	17.93	13.80	15.16	15.80	19.76	16.13
N_2K_1	15.90	16.36	20.13	19.13	17.88	14.40	16.20	16.13	20.56	16.82
N_2K_2	16.85	17.16	20.83	20.23	18.77	14.20	16.90	16.30	21.50	17.22
N_2K_3	17.50	17.63	22.33	21.40	19.71	15.00	17.00	16.70	22.73	17.86
N_3K_1	17.47	17.83	21.66	22.33	19.82	16.70	17.10	17.00	23.60	18.60
N_3K_2	17.60	17.93	22.16	23.43	20.28	17.10	17.66	17.63	23.53	18.98
N_3K_3	18.10	19.20	22.70	24.20	21.05	18.01	17.70	18.40	25.50	19.90
Mean	16.68	17.12	20.80	20.83		15.18	16.21	16.24	21.70	
CD (P=0.05)										
Pruning (Pr) =		0.45					0.49			
Nitrogen (N) =		0.39					0.43			
Potassium (K) =		0.39					0.43			
Pr × N =		0.78					0.86			
Pr × K =		NS					NS			
N × K =		NS					NS			
Pr × N × K =		NS					NS			

and total N in the soil; and better development of root system of the tree. Nitrogen is associated with all vital processes of the plant, therefore a sufficient supply of various nitrogenous compounds is required in each plant cell for its proper functioning.

Increase in tree growth and volume with the increase in K fertilization levels was recorded during both the years. Increase in tree volume with increase in K application have also been reported by Kaith and Awasthi (9). K is involved in meristematic growth. The growth process is initiated by a plassmalemma located ATPase which pumps H^+ ion out of cytoplasm into the apoplast the acidification of apoplast results in loosening of cell wall material and inactivation of hydrolyzing enzymes (10). This loosening of cell wall material is a prerequisite for cell expansion. The release of H^+ ion depends much on the presence of K^+ in the apopolast. Phytoharmones like IAA and cytokinin which are involved in growth of meristematic tissues are enhanced by K (11). K is indispensable for obtaining optimum cell turgor which is required for cell expansion.

The interaction effect of pruning and nitrogen and pruning and potassium treatments on increase in tree growth was significant during both the years. This may be due to increased availability of nutrients and photosynthates to the growing shoots. The results are in agreement with Zeiger (11) and Singh (12).

Leaf Area and Photosynthesis

Increasing severity of pruning increased the leaf area and photosynthetic efficiency (biomass) of apple leaves during both the years. Significantly maximum leaf area (28.50 and 26.40 cm^2) and photosynthetic efficiency (0.085 and 0.040 mg/cm^2) averaged over various levels of nitrogen and potassium were recoded in strong pruning, which was significantly followed by medium pruning 23.12 and 21.42 cm^2 and 0.025 mg/cm^2 in both years, respectively. This may be because of light appears to be of primary importance and strong leaves are found in areas of canopy with relative high light levels (14). Similar results have been noticed by Bound and Summers (15).

Nitrogen levels significantly increased the leaf area and photosynthetic efficiency of leaves. Maximum leaf area and photosynthetic efficiency was found in high nitrogen (23.33 and 20.35 cm^2 and 0.40 cm-2 0.025 mg/cm^2) in both years, respectively. Potassium produced non-significant effect on leaf area in 2004, however significant difference was recorded in 2005. Maximum leaf area (21.57 and 19.51 cm^2) was recorded in K_3 treatment followed by K_2 treatment (21.57 and 9.14 cm^2) in both years. Different potassium levels also had a significant influence on photosynthetic efficiency of apple leaves. Maximum photosynthetic efficiency (0.035 and 0.023 mg/cm^2) was observed in K_3 and the minimum (0.033 and 0.020 mg/cm^2) in K_1 in 2004 and 2005, respectively. The increase in leaf area and photosynthetic efficiency due to nitrogen may be due to increase in chlorophyll content of leaves, vegetative growth and photosynthesis of trees. The difference in efficiency of dry weight accumulation may be related to a change in partitioning of potential dry matter into the constituents of dry weight (16). Increase in leaf area and photosynthetic efficiency due to potassium application may be due to more water absorption capacity and more water translocation of nutrients to leaves.

References

1. Mika A. 1986. Physiological responses of fruit trees to pruning. Hort. Rev. 8 : 337—379.
2. Bose T. K., S. K. Mitra and M. K. Sadhu. 1988. Mineral nutrition of fruit crops. Naya Prakash, Calcutta, India.
3. Westwood M. N. 1978. Plant efficiency. Growth and yield measurements. Pages 119—120 *in* Temperate zone pomology. W. H. F. Freeman and Co., San Franscisco.
4. Jonkers H. 1982. Testing koopmanns rules of apple tree pruning. Scientific Hort. 16 : 209—215.
5. Mika A. 1992. The mechanism of fruiting inhibition caused by pruning in young apple tree. Acta Horticlturae 322 : 265.
6. Singh D. 1992. Effect of pruning intensities under different levels of nitrogen on growth, yield and quality of peach (*Prunus persica* Batsch.) cv July Elberta. Doctoral thesis, Dr Y. S. Parmar Univ. Hort. and For., Solan, India.
7. Abbott D. L. 1984. The apple tree, physiology and management. Grower Books, London, UK.
8. Kanwar J. S. 1979. Investigation on pruning and fertilization requirement of peach (*Prunus persica* Batsh.) cv Flordasum. Doctoral thesis, Punjab Agric. Univ., Ludhiana India.
9. Kaith N. S. and R. P. Awasthi. 1998. Effect of K on growth, yield, fruit quality and leaf nutrient status of apple Starking Delicious. Indian J. Hort. 55 : 10—15.
10. Hager A., H. Menzel and A. Krauss. 1971. Experiments and hypothesis of the primary effect of auxins on expansion growth. Planta 100 : 47—75.
11. Greene D. W. and W. J. Lord. 1978. Effect of dormant pruning, scoring and growth regulators on growth, yield and fruit quality of Delicious and Cortland apple trees. J. Am. Soc. for Hort. Sci. 108 : 590—595.
12. Zeiger D. C. 1978. Nitrogen fertilization and pruning of apple trees as they affect yield, fruit quality and tree growth in north Carolina. Tech. Bull. North Carolina Agric. Exp. Stat. 254 : 36.
13. Singh N. P. 1982. The studies on the nutrition of peach (*Prunus persica* Batsch.) cv Flordasum in relation to pruning. M. Sc. thesis, Himachal Pradesh Krishi Vishwa Vidhyalaya, Palampur, India.
14. Barritt B. H., C. R. Rom, K. R. Guelich, S. R. Drake and M. A. Dilley. 1987. Canopy position and light effects on spur, leaf and fruit characteristics of Delicious apple. Hort. Sci. 22 : 402—405.
15. Bound S. A. and C. R. Summers. 2001. The effect of pruning level and timing on fruit quality in Red Fuji apple. *Acta Horticulturae* 557 : 295—302.
16. Taylor B. H. and D. C. Ferree. 1981. The influence of summer pruning on photosynthesis, transpiration, leaf abscission and dry weight accumulation of young apple trees. J. Am. Soc. for Hort. Sci. 106 : 389—393.