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Influence of pruning time and severity on growth, fruit quality and leaf nutrient status of olive (*Olea europea*) cv Frontoio

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ABSTRACT

An experiment was conducted during the year 2008-09 and 2009-10 comprising three dates of pruning, i.e. 1 January, 15 January, 30 January and three intensities of pruning, i.e. 20%; 25%; 30% to find out the optimum time and intensity of pruning in olive (*Olea europea* L.) cv Frontoio. The results revealed that maximum increase in trunk circumference (7.18%) was found in trees pruned on 1 January with 20% pruning intensity whereas maximum shoot extension growth (11.13 cm) and leaf area (3.99 cm^2) was measured in trees pruned on 15 January with 25% pruning intensity. However, significantly higher chlorophyll content of 1.57 mg/g was found in trees pruned on 15 January with 30% pruning intensity. The maximum fruit quality characters, viz. size (1.76 cm), weight (2.41 g), volume (2.35 cc), pulp: stone ratio (3.62) and oil content (27.03%) were observed in trees pruned on 15 January with 25% pruning intensity. The highest leaf N (1.91%), P (0.243%) and K (1.99%) was found in trees pruned on 30 January with 30% pruning intensity, 1 January with 30% pruning intensity and 15 January with 30% pruning intensity, respectively. The leaf Ca (1.70%) and Mg (0.141%) were highest in trees pruned on 1 January with 20% pruning intensity.

Key words: Growth, Leaf nutrients, Oil content, Olive, Pruning, Quality

Olive (*Olea europea* L.), commonly known as *zaitoon*, is one of the world's oldest cultivated crop, considered to be the native of Asia Minor, the areas lying between Armenia, Turkestan and Pamirs (Cimato and Bartolini 1987). The olives are principally used for oil extraction all over the world, while some cultivars can also be used for pickling. The area and production under olive in the world is 9.39 million ha and 20.58 million tonnes, respectively (FAO 2012). The leading olive producing countries of the world are Spain, Italy, Greece, Portugal, Turkey, Syria, Jordan, etc. Spain is the leading producer of olive in the world.

Pruning of olive trees is aimed to stimulate a cycle of new growth round the year and to create equilibrium between vegetative growth and productivity. The other criterion for pruning of olive trees is its unique bearing behaviour, i.e. it never bears twice at the same position. Therefore, accurate and timely pruning of olive trees ensures a regular succession of new flush growth, increase the bearing surface of the tree canopy and also facilitate harvesting of the crop. The appropriate pruning of olive trees by heading back and thinning out also diminish their tendency for alternate or irregular bearing by promoting adequate number of new shoots every year. Denden *et al.* (1998) reported an increase in yield of olive trees by their rejuvenating pruning. Similarly, Metzidakis (2002) observed higher yield to the tune of 10-30%, depending upon cultivar, after 10 years of regeneration pruning in olive. Tombesi *et al.* (2002a) observed that in olives, heavy pruning altered the nature and number of productive branches; light pruning stimulated the formation of numerous shoots, of average vigour, while heavy pruning stimulated fewer, but more vigorous shoots, with lesser propensity to flower.

In view of this fact, present investigation was undertaken to determine the influence of pruning time and severity on plant growth, fruit quality and leaf nutrient status of olive cv. Frontoio.

MATERIALS AND METHODS

The present experiment was conducted during the year 2009 and 2010. The orchard located at Dharamthal (Udhampur) which is situated in the intermediate zone at 32°50′ North latitude and 74°55′ East longitude, with an altitude of 1100 meter above mean sea level. Annual precipitation is about 910 mm mostly coinciding during February to June (about 80 per cent). The mean annual

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maximum and minimum temperature are 21.72°C and 12.57°C, respectively. Soil of the experimental orchard was clay loam having pH of 6.4; electrical conductivity 0.24; organic carbon 0.84%; available N 283 kg/ha; phosphorus 73 kg/ha and potassium 188 kg/ha. Uniform and healthy, 15 years old olive trees spaced 8 m × 5 m apart were selected for the investigations using 10 treatment combinations, viz. T_1: D_1I_1; T_2: D_1I_2; T_3: D_1I_3; T_4: D_2I_1; T_5: D_2I_2; T_6: D_2I_3; T_7: D_3I_1; T_8: D_3I_2; T_9: D_3I_3 and T_{10}: Control (no pruning), where, D_1, D_2 and D_3 are different dates of pruning, i.e. 1 January; 15 January and 30 January, respectively and I_1, I_2 and I_3 are different intensities of pruning, i.e. 20%; 25%; and 30%, respectively. Each treatment was replicated thrice in a randomized block design. All cultural management practices were followed as per the package of practices of SKUAST-J. Trunk diameter of olive trees was measured at 15 cm above the ground with the help of digital vernier callipers (Mitutoyo, Japan) and expressed in centimeters (cm). Trunk circumference was calculated using formula $2\pi r$ (r = radius of tree trunk) and the data is presented in terms of per cent increase in trunk circumference over their initial values recorded at the beginning of the experiment. For measuring shoot extension growth, twenty uniform and healthy shoots were randomly selected all over the tree canopy in all directions. The length of each shoot was measured at the beginning and end of growing season between the points of initiation of new growth to the extremity of the shoot tip and expressed in centimetres. Leaf chlorophyll content was estimated by the procedure given by Arnon (1949) and the total chlorophyll content was calculated using following formula:

$$\text{Total chlorophyll (mg/g)} = 20.2\ (A_{645}) + 8.02\ (A_{663}) \times \frac{V}{1000 \times W}$$

where, A_{645}, Absorbance at 645 nm, A_{663}, Absorbance at 663 nm, V, volume of aliquot made; W, weight of the leaf tissue taken (g).

For measurement of physical parameters of fruits, one hundred healthy fruits were randomly selected from each treatment. Fruit size (cm) was calculated by using a digital vernier calliper on the basis of length and diameter. Fruit weight (g) was recorded on a top pan electrical balance with an accuracy of $\pm$ 0.5 g. Fruit volume (cc) was estimated by water displacement method using a graduated glass cylinder. For estimation of pulp: stone ratio, the fruit flesh was separated from the stone and the ratio between weights of pulp and stone was worked out for all the treatments. Oil content of fruit pulp was estimated by Soxhlet extraction method using hexane as a solvent (AOAC 1980) and expressed in per cent on fresh weight basis.

For the estimation of macro-nutrient status of experimental trees, one hundred fully expanded leaves along with petioles were sampled from the middle portion of the previous season's shoots situated all around the canopy of the tree as recommended by Chapman (1964). Cleaning, drying, grinding and storing of samples were carried out in accordance with the procedures outlined by Kenworthy (1964). The methods described by Jackson (1973) and micro Kjeldahl method (AOAC 1980) used for the estimation of N. For the estimation of P, K, Ca and Mg digestion was done in triacid mixture. All precautions as suggested by Piper (1966) for wet digestion of leaf samples were taken. Total P was determined by Vanadomolybdo phosphoric yellow colour method as described by Jackson (1973), while total K in the plant sample was estimated with the help of Corning 410 digital Flame photometer. Calcium and magnesium were determined on Atomic Absorption Spectrophotometer. The data was analyzed statistically as per procedure described by Panse and Sukhatme (2000).

RESULTS AND DISCUSSION

Trunk circumference

The perusal of data shows that there was a decrease in trunk circumference with the increase in pruning intensity (Table 1). During the year 2008-09, highest increase in trunk circumference (6.64%) was recorded in trees pruned on 1 January with 20% intensity of pruning followed by trees pruned on 15 January with 20% pruning intensity,

Table 1 Effect of time and severity of pruning on increase in trunk circumference, shoot extension growth and chlorophyll content of olive cv. Frontoio.

Treatment	Increase in trunk circumference (%)			Shoot extension growth (cm)			Leaf area (cm^2)			Chlorophyll content (mg/g)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
T_1	6.64	7.72	7.18	8.43	6.82	7.63	2.81	2.93	2.87	1.15	1.09	1.12
T_2	5.92	7.11	6.51	9.17	6.25	7.71	3.12	3.34	3.23	1.24	1.12	1.18
T_3	5.38	6.41	5.89	9.78	7.47	8.63	3.03	3.12	3.08	1.30	1.27	1.29
T_4	6.43	7.49	6.96	10.10	8.73	9.41	3.37	3.36	3.36	1.20	1.14	1.17
T_5	5.71	6.50	6.11	11.05	11.22	11.13	3.93	4.05	3.99	1.52	1.38	1.45
T_6	5.50	6.21	5.85	9.40	10.39	9.89	3.88	3.92	3.89	1.64	1.50	1.57
T_7	6.34	6.92	6.63	8.90	9.69	9.29	3.20	3.63	3.41	1.07	1.01	1.04
T_8	5.45	6.31	5.88	8.35	8.31	8.33	3.03	3.25	3.14	1.28	1.21	1.25
T_9	5.38	6.27	5.82	7.92	8.08	8.00	3.03	3.25	3.14	1.38	1.32	1.35
T_{10}	6.26	7.19	6.72	6.78	6.76	6.77	2.85	2.98	2.92	1.02	0.91	0.97
CD(P=0.05)	0.65	NS	0.67	0.68	0.84	0.52	0.18	0.24	0.15	0.11	0.14	0.09

trees pruned on 30 January with 20% pruning intensity and un-pruned trees registered trunk circumference of 6.43, 6.34, and 6.26 percent, respectively whereas, lowest increase in trunk circumference (5.38%) was recorded in trees pruned on 1 January with 30% pruning intensity and those pruned on 30 January with 30% pruning intensity. During the second year of experimentation, trunk circumference was not significantly affected by time and severity of pruning where as, increase in trunk circumference ranged from 6.21 to 7.72 percent for all the tried treatments. However, significant effect of different time and severity of pruning on increase in trunk circumference was observed in the pooled data. Highest increase in trunk circumference (7.18%) was found in trees pruned on 1 January with 20% pruning intensity followed by trees pruned on 15 January with 20% pruning intensity, un-pruned trees, trees pruned on 30 January with 20% pruning intensity and 1 January with 25% pruning intensity registered values of 6.96, 6.72, 6.63 and 6.51 percent, respectively whereas, lowest increase in trunk circumference (5.82%) was observed in trees pruned on 30 January with 30% pruning intensity. These results are in conformity with those of Mika (1986) and Tombesi *et al*. (2002b).

Shoot extension growth

Shoot extension growth was significantly affected by different time and severity of pruning during both the years of investigation (Table 1). Significantly higher shoot extension growth (11.05 cm) was recorded in trees pruned on 15 January with 25% pruning intensity as compared to all other treatments tried during 2008-09 whereas, minimum shoot extension growth (6.78 cm) was observed in untreated trees. During 2009-10, maximum shoot extension growth (11.22 cm) was recorded in trees pruned on 15 January with 25% pruning intensity whereas, minimum shoot extension growth (6.25 cm) was recorded in trees pruned on 1 January with 25% pruning intensity followed by untreated trees, and trees pruned on 1 January with 20% pruning intensity registered shoot extension growth of 6.76 and 6.82 cm, respectively. It is evident from the pooled data that maximum shoot extension growth (11.13 cm) was measured in trees pruned on 15 January with 25% pruning intensity and was significantly higher than the shoot extension growth recorded in all other treatments. Lowest shoot extension growth (6.77 cm) was measured in untreated trees. Increase in shoot growth with the increase in pruning intensity as observed in the present studies has also been reported in ber by Kanwar and Nijjar (1983) and Bharad and Tayde (1998) who stated that the better growth rate may be due to lesser number of shoots on the pruned tree and therefore, more nutrients were available to each shoot.

Leaf area

The data presented in Table 1 revealed that during first year of experimentation, maximum leaf area (3.93 cm^2) was recorded in trees pruned on 15 January with 25% pruning intensity followed by trees pruned on 15 January with 30% pruning intensity (3.88 cm^2). In the second year (2009-10) of experiment, maximum leaf area (4.05 cm^2) was recorded in trees pruned on 15 January with 25% pruning intensity followed by trees pruned on 15 January with 30% pruning intensity (3.92 cm^2). In pooled data significantly maximum leaf area (3.99 cm^2) was recorded in trees pruned on 15 January with 25% pruning intensity which was at par with leaf area measured in trees pruned on 15 January with 30% pruning intensity (3.89 cm^2). However, minimum leaf area (2.87 cm^2) was measured in trees pruned on 1 January with 20% pruning intensity and was at par with leaf area recorded in untreated trees (2.92 cm^2). The increased leaf area as a result of different pruning severity and time in the present studies might be because of the fact that heavy pruning proportionately reduced the number of vegetative buds which were likely to develop into new shoots, thereby, reduced the competition for carbohydrates and other metabolites and resulted in increased leaf size (Kalabekova 1974). The present findings are in consonance with those of Nanthakumar and Balakrishnan (1999) in ber.

Chlorophyll content

A cursory glance of the data given in Table 1 showed that total chlorophyll content was significantly increased with different time and severity of pruning as compared to control. During the year 2008-09, highest chlorophyll content (1.64 mg/g) was recorded in trees pruned on 15 January with 30% pruning intensity and was significantly higher than all other treatments tried in the present investigation whereas, lowest chlorophyll content (1.02 mg/g) was recorded in un-pruned trees. During the year 2009-10 also, the trees pruned on 15 January with 30% pruning intensity recorded highest chlorophyll content (1.50 mg/g) followed by trees pruned on 15 January with 25% pruning intensity (1.38 mg/g), whereas minimum chlorophyll content (0.91 mg/g) was observed in un-pruned trees. The pooled data showed that chlorophyll content was significantly higher (1.57 mg/g) in trees pruned on 15 January with 30% pruning intensity whereas, lowest chlorophyll content (0.97 mg/g) was recorded in control. The increase in chlorophyll content with increasing pruning intensity in the present study is in consonance with the findings of Singh *et al*. (2010) where in they found that severely pruned trees of Dashehari mango exhibited improved chlorophyll content, whereas shoot heading seemed to delay leaf senescence, as shown by Satoh *et al*. (1977) in pruning experiments with mulberry trees.

Fruit size

The fruit size was significantly affected by time and severity of pruning during both the years of investigation (Table 2). During the year 2008-09, maximum fruit size (1.73 cm) was observed in trees pruned on 15 January with 25% pruning intensity whereas, minimum (1.28 cm) was recorded in un-pruned trees and those pruned on 30 January with 30% pruning intensity. During second year of experimentation, significantly higher fruit size of 1.80 cm was obtained in trees pruned on 15 January with 25% pruning intensity whereas, minimum (1.25 cm) was recorded in un-pruned trees of olive. The pooled data regarding fruit size showed that there was a significant increase in fruit size of pruned trees as compared to un-pruned trees. The maximum fruit size (1.76 cm) was measured in trees pruned on 15 January with a pruning intensity of 25%. However, minimum fruit size (1.26 cm) was found in control. Thus, moderate pruning proved best for increasing fruit size of olive. A similar effect of pruning on fruit size has also been reported in ber by Syamal and Rajput (1989) and Gupta *et al.* (1990) and in apple (Bound and Summers 2001).

Fruit weight

The fruit weight was significantly influenced by time and severity of pruning during both the years of study (Table 2). During the year 2008-09, maximum fruit weight (2.42 g) was recorded in trees pruned on 15 January with 25% pruning intensity and minimum (1.09 g) in un-pruned trees. During second year of experimentation, similar results as obtained during the first year were observed. As evident from the pooled data, maximum fruit weight (2.41 g) was measured in the trees pruned on 15 January with 25% pruning severity whereas, minimum fruit weight (1.12 g) was observed in un-pruned trees. Similar improvement in fruit weight with increasing pruning severity has been reported in olive (Tan 1997 and Metzidakis 2002), ber (Bajwa *et al.* 1987, Syamal and Rajput 1989) and in apricot (Sharma *et al.* 1997). The decrease of fruit weight in pruned trees after 15 January might be because of the prolonged vegetative growth, hence more utilization of assimilates for vegetative growth (Metzidakis 2002).

Fruit volume

Fruit volume was increased with different time and severity of pruning as compared to control (Table 2). Maximum fruit volume (2.35 cc) was recorded in trees pruned on 15 January with 25% pruning intensity whereas, minimum (1.29 cc) was observed in untreated trees during the first year of experimentation. During the year 2009-10 trees pruned on 15 January with 25% pruning intensity, resulted in maximum fruit volume of 2.35 cc, whereas lowest fruit volume (1.28 cc)

Table 2 Effect of time and severity of pruning on fruit size, fruit weight, fruit volume, pulp: stone ratio and oil content of olive cv. Frontoio

Treatment	Fruit size (cm)			Fruit weight (g)			Fruit volume (cc)			Pulp: stone ratio			Oil content (%)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
T_1	1.43	1.47	1.45	1.72	1.87	1.80	1.92	2.03	1.97	2.95	2.84	2.89	23.42 (4.94)	23.52 (4.95)	23.4 (4.95)
T_2	1.52	1.56	1.54	1.73	1.93	1.83	2.05	2.11	2.08	3.31	3.05	3.18	23.09 (4.91)	23.23 (4.92)	23.16 (4.91)
T_3	1.53	1.53	1.53	1.70	1.90	1.80	1.88	1.93	1.90	3.17	3.13	3.15	23.22 (4.92)	23.63 (4.96)	23.42 (4.94)
T_4	1.52	1.61	1.56	2.13	2.06	2.09	2.14	2.17	2.16	3.41	3.41	3.41	25.04 (5.10)	25.68 (5.16)	25.36 (5.13)
T_5	1.73	1.80	1.76	2.42	2.40	2.41	2.35	2.35	2.35	3.64	3.61	3.62	27.06 (5.29)	26.99 (5.29)	27.03 (5.29)
T_6	1.52	1.67	1.59	1.72	2.03	1.87	1.75	2.07	1.91	2.93	3.39	3.16	24.74 (5.07)	25.17 (5.12)	24.96 (5.09)
T_7	1.49	1.52	1.51	1.52	1.70	1.61	1.55	1.86	1.70	2.75	3.08	2.91	23.88 (4.99)	23.87 (4.99)	23.87 (4.99)
T_8	1.27	1.42	1.35	1.40	1.55	1.47	1.35	1.65	1.50	2.55	2.79	2.67	22.52 (4.85)	21.99 (4.79)	22.26 (4.82)
T_9	1.28	1.34	1.31	1.13	1.24	1.19	1.30	1.45	1.37	2.36	2.63	2.50	22.31 (4.83)	21.82 (4.78)	22.06 (4.80)
T_{10}	1.28	1.25	1.26	1.09	1.15	1.12	1.29	1.28	1.28	2.24	2.33	2.29 (4.65)	20.66 (4.68)	20.93 (4.67)	20.79
CD(P=0.05)	0.12	0.06	0.06	0.14	0.14	0.09	0.12	0.13	0.08	0.15	0.10	0.09	0.13	0.13	0.09

Figures in the parentheses are transformed means.

was obtained in un-pruned trees. The pooled data on fruit volume showed that maximum fruit volume (2.35 cc) was obtained in trees pruned on 15 January with 25% pruning intensity, and the minimum fruit volume (1.28 cc) was found in un-pruned trees. Awasthi and Misra (1969) also obtained similar increase in fruit volume with progressive increase in pruning severity in ber.

Pulp: stone ratio

The perusal of data from Table 2 shows that pulp: stone ratio was also significantly improved with different time and severity of pruning during both the years of study. Significantly higher pulp: stone ratio of 3.64 and 3.61 was recorded during the year 2008-09 and 2009-10, respectively in trees pruned on 15 January with 25% pruning intensity, whereas minimum pulp: stone ratio of 2.24 and 2.33 for respective years was obtained in un-pruned trees. The pooled data also revealed significant effect of time and severity of pruning on pulp: stone ratio. The highest pulp: stone ratio (3.62) was recorded in trees pruned on 15 January with 25% pruning intensity, however, minimum pulp: stone ratio (2.29) was recorded in un-pruned trees. These observations are in consonance with the findings of Bajwa *et al.* (1987) in ber and Tan (1997) and Metzidakis (2002) in olive.

Oil content

The oil content of olive cv. Frontoio increased significantly with time and severity of pruning as compared to un-pruned trees (Table 2). Highest oil content (27.06%) was recorded in trees pruned on 15 January with 25% pruning intensity whereas, lowest (20.66%) was recorded in un-pruned trees of olive during 2008-09. Similarly in 2009-10, trees pruned on 15 January with 25% pruning intensity recorded highest oil content of 26.99 percent whereas, un-pruned trees resulted in lowest oil content. It is evident from the pooled data that significantly higher oil content (27.03%) was recorded in trees pruned on 15 January with 25% pruning intensity whereas, lowest oil content (20.79%) was recorded in un-pruned trees. The improved pulp: stone ratio might be responsible for increased oil content of olive fruits, as pulp contains more oil than the pit of olive. Higher flesh: pit ratio and oil content has also been reported following regeneration pruning in olive (Metzidakis 2002).

Table 3 Effect of time and severity of pruning on total leaf N, P, K, Ca and Mg content of olive cv. Frontoio.

Treatment	N (%)			P (%)			K (%)			Ca (%)			Mg (%)		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
T_1	1.64	1.40	1.52	0.214	0.193	0.203	1.67	1.47	1.57	1.81	1.59	1.70	0.153	0.130	0.141
	(1.63)	(1.55)	(1.59)	(1.10)	(1.10)	(1.10)	(1.63)	(1.57)	(1.60)	(1.68)	(1.61)	(1.64)	(1.074)	(1.063)	(1.068)
T_2	1.74	1.54	1.64	0.234	0.213	0.224	1.87	1.67	1.77	1.55	1.35	1.45	0.131	0.112	0.121
	(1.66)	(1.59)	(1.62)	(1.11)	(1.10)	(1.11)	(1.69)	(1.63)	(1.67)	(1.60)	(1.53)	(1.56)	(1.063)	(1.054)	(1.059)
T_3	1.85	1.65	1.75	0.253	0.233	0.243	1.98	1.77	1.87	1.44	1.23	1.34	0.120	0.105	0.113
	(1.69)	(1.63)	(1.66)	(1.12)	(1.11)	(1.12)	(1.73)	(1.66)	(1.69)	(1.56)	(1.49)	(1.53)	(1.058)	(1.051)	(1.055)
T_4	1.69	1.47	1.58	0.207	0.185	0.196	1.65	1.46	1.56	1.79	1.56	1.68	0.149	0.128	0.138
	(1.64)	(1.57)	(1.61)	(1.10)	(1.10)	(1.10)	(1.63)	(1.57)	(1.60)	(1.67)	(1.60)	(1.64)	(1.071)	(1.062)	(1.067)
T_5	1.89	1.68	1.78	0.229	0.208	0.218	1.93	1.71	1.82	1.57	1.31	1.44	0.127	0.109	0.118
	(1.70)	(1.64)	(1.67)	(1.11)	(1.10)	(1.10)	(1.71)	(1.65)	(1.68)	(1.60)	(1.52)	(1.56)	(1.062)	(1.053)	(1.057)
T_6	1.99	1.73	1.86	0.249	0.229	0.239	2.09	1.88	1.99	1.45	1.21	1.33	0.113	0.100	0.106
	(1.73)	(1.65)	(1.69)	(1.12)	(1.11)	(1.11)	(1.76)	(1.70)	(1.73)	(1.57)	(1.49)	(1.53)	(1.055)	(1.049)	(1.052)
T_7	1.67	1.46	1.57	0.202	0.180	0.191	1.64	1.43	1.53	1.76	1.52	1.64	0.147	0.128	0.138
	(1.63)	(1.57)	(1.60)	(1.10)	(1.10)	(1.09)	(1.62)	(1.56)	(1.59)	(1.66)	(1.59)	(1.62)	(1.071)	(1.062)	(1.062)
T_8	1.87	1.66	1.77	0.223	0.201	0.212	1.84	1.63	1.74	1.54	1.31	1.42	0.136	0.116	0.126
	(1.69)	(1.63)	(1.66)	(1.11)	(1.10)	(1.10)	(1.69)	(1.62)	(1.65)	(1.59)	(1.52)	(1.56)	(1.066)	(1.056)	(1.061)
T_9	2.01	1.81	1.91	0.235	0.215	0.225	1.95	1.73	1.84	1.44	1.22	1.33	0.129	0.109	0.119
	(1.74)	(1.67)	(1.70)	(1.11)	(1.10)	(1.11)	(1.72)	(1.65)	(1.69)	(1.56)	(1.49)	(1.53)	(1.063)	(1.053)	(1.058)
T_{10}	1.55	1.33	1.44	0.188	0.165	0.176	1.51	1.30	1.40	1.42	1.22	1.32	0.131	0.107	0.119
	(1.60)	(1.53)	(1.56)	(1.10)	(1.08)	(1.10)	(1.58)	(1.52)	(1.55)	(1.56)	(1.49)	(1.52)	(1.063)	(1.052)	(1.058)
CD(P=0.05)	0.04	0.05	0.03	0.01	0.01	0.007	0.02	0.02	0.02	0.02	0.02	0.01	0.005	0.004	0.003

Leaf N, P, K, Ca and Mg

The data regarding effect of different time and severity of pruning on leaf N, P, K, Ca and Mg is presented in Table 3. The perusal of the data showed that leaf N was significantly affected by different time and severity of pruning during both the years of investigation. There was a progressive increase in leaf N with increasing severity of pruning. During the year 2008-09, highest leaf N (2.01%) was recorded in trees pruned on 30 January with 30% pruning intensity and it was at par with trees pruned on 15 January with 30% pruning intensity. The lowest leaf N (1.55%) was recorded in un-pruned trees. During the second year of investigation, highest leaf N (1.81%) was recorded in trees pruned on 30 January with 30% pruning intensity and lowest (1.33%) in un-pruned trees. The pooled data showed that highest leaf N (1.91%) was found in trees pruned on 30 January with pruning intensity of 30% whereas, lowest leaf N (1.44%) was observed in the un-pruned trees.

Leaf P increased with the increasing intensity of pruning. During the year 2008-09, highest leaf P (0.253%) was recorded in trees pruned on 1 January with 30% pruning intensity whereas, lowest leaf P (0.188%) was observed in un-pruned trees. In the second year of experimentation (2009-10), highest value was recorded in trees pruned on 1 January with 30% pruning intensity and lowest in un-pruned trees. The perusal of the pooled data revealed highest leaf P (0.243%) in trees pruned on 1 January with 30% pruning intensity and lowest (0.176) was in un-pruned trees.

Leaf K was significantly influenced by time and severity of pruning during both the years of study and K improved significantly at higher pruning intensities. In the first year of experimentation (2008-09), highest leaf K (2.09%) was recorded in trees pruned on 15 January with 30% pruning intensity whereas, lowest value of leaf K was found in un-pruned trees. Similarly, during 2009-10, highest (1.88%) leaf K was recorded in trees pruned on 15 January with 30% pruning intensity whereas, it was lowest (1.30%) in un-pruned trees. It is evident from the pooled data that highest leaf K (1.99%) was recorded from the trees pruned on 15 January with 30% pruning intensity, whereas lowest leaf K (1.40%) was observed in trees that were not pruned.

A progressive decrease in leaf Ca was observed with the increasing intensities of pruning in the present investigations. The trees pruned on 1 January with 20% pruning intensity recorded significantly higher leaf Ca of 1.81 and 1.59 percent during the year 2008-09 and 2009-10, respectively. The lowest leaf Ca of 1.42 percent was observed in un-pruned trees during the year 2008-09 and 1.21 percent was recorded in trees pruned on 15 January with 30% pruning intensity during 2009-10. The pooled data revealed that leaf Ca (1.70%) was highest in trees pruned on 1 January with 20% pruning intensity, whereas it was lowest (1.32%) in un-pruned trees.

Leaf Mg decreased with the increasing intensity of pruning. During the year 2008-09, highest leaf Mg (0.153%) was recorded in trees pruned on 1 January with 20% pruning intensity and it was at par with trees pruned on 15 January with 20% pruning intensity. However, lowest leaf Mg (0.113%) was recorded in trees pruned on 15 January with 30% pruning intensity. In the second year of experimentation (2009-10), highest leaf Mg (0.130%) was recorded in trees pruned on 1 January with 20% pruning intensity which was at par with leaf Mg recorded in trees pruned on 15 January with 20% pruning intensity and trees pruned on 30 January with 20% pruning intensity wherein 1.28 percent leaf Mg was observed. The lowest leaf Mg (0.100%) was obtained in trees pruned on 15 January with 30% pruning intensity. Similarly, from the pooled data it could be concluded that highest leaf Mg (0.141%) was recorded from the trees pruned on 1 January with 20% pruning intensity which was at par with leaf Mg observed in trees pruned on 15 January with 20% pruning intensity and trees pruned on 30 January with 20% pruning intensity exhibiting leaf Mg of 0.138 percent whereas, lowest leaf Mg (0.106%) was found in trees pruned on 15 January with 30% pruning intensity.

There was an improvement in leaf N, P and K content with the increasing severity of pruning, whereas, leaf Ca and Mg content decreased in response to pruning severity. Similar findings have been reported in apple (Ibrahem-Ahmed *et al.* 1983) and peach (Singh 1982). Probably the severe heading back of older branches tended to stimulate vegetative growth on such shoots and majority of metabolites and minerals translocated to such shoots were mostly utilized by the growing shoot apices and hence leaves on such shoots had relatively higher values of leaf N, P and K. Since Ca and Mg can be easily attracted and withdrawn from the available pool by actively growing shoot tips of pruned trees, hence, lower levels of these elements are found in the leaves of severely pruned trees (Mika 1986) and the results obtained are in total agreement with the above observation.

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