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Effect of canopy and nutrient management on senile orchards of Indian gooseberry (*Emblica officinalis*) cv Francis

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ABSTRACT

A study was conducted on 15 years old senile orchard of Indian gooseberry (*Emblica officinalis* G.) cv Francis to convert into productive through canopy and nutrient management. The results revealed that 50% pruning of previous season growth (P_2) was statistically superior which resulted in maximum duration of flowering, fruit set and retention, yield, physical and chemical qualities of fruit and leaf as well as soil nutrient status. Further, nutrient management revealed that application of 40 kg FYM (M_1) resulted maximum fruit set, retention, yield and phosphorus content in leaves and NPK in soil and minimum fruit drop, days taken to maturity and fibre content. Similarly 100 per cent RDF (N_2) resulted in maximum fruit set (64.90 %), retention (20.51 %), yield (118 kg/tree), nitrogen and phosphorus content in leaves (2.46 and 0.44 %) as well as in soil (238.6 and 17.75 kg/ha). A critical observation of the results showed that interactions had been most effective to improve yield and quality parameters of fruits and nutrient status in leaves of aonla as well as soil than the individual application of different levels of pruning, organic manure and nutrient. Among flowering, fruiting and yield parameters, maximum duration of flowering (29 days), fruit set (74.61 %), retention (28.33 %) and yield (145 kg/tree) and minimum fruit drop (71.67 %) and days taken to fruit maturity (216 days) was found under $P_2M_2N_2$ followed by $P_2M_2N_1$. Interaction $P_2M_2N_2$ has been noticed statistically superior to enhance physical and chemical characteristics of fruit followed by $P_2M_2N_1$. This treatment has not only enhanced bearing and quality parameters in aonla but also increased the leaf nutrient status as well as soil fertility status. A significant increased yield of Indian gooseberry with application of pruning intensity, organic and inorganic nutrients was found due to vigorous vegetative growth and increased chlorophyll content, which together accelerated the photosynthesis that increased the supply of carbohydrates to plants. There is a positive correlation among nutrient doses with leaf nutrient content yield and quality of fruits. The supplemented organic manures have improved the physical, chemical and biological activities of soil which helped in better nutrient absorption by plants, resulting higher yield.

Key words: Indian gooseberry, Nutrient, Pruning, Sodic

Pruning is very effective to induce healthy current season shoot from older branches causes invigorating effect on Indian gooseberry (*Emblica officinalis* G.) plants and also increase the level of available soil nutrients that might be due to recycling of pruned debris and decrease in utilization of excessive nutrients by undesirable branches. Further, proper nutrient management is also essential to maintain soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner. Although, it is highly remunerative crop, yet the productivity and quality of fruits of senile orchards are being declining due to poor management practices as most of the cultivators do not apply manures and fertilizers that resulted in diminishing the fruit size and quality. Moreover, Francis and Banarasi are the most popular variety among aonla growers of Eastern Uttar Pradesh. Yet the old plantations of these varieties possess shy bearing tendency and produce poor fruit quality hence, they require application of rejuvenation technology to improve the productivity. Due to lack of studies on standardized practices of pruning intensity in relation to improving the bearing potential of aonla trees, So that, there is dire need to improve the health and productivity of such unproductive orchards through application of rejuvenation technology. With the foresaid objectives, an investigation on response of pruning and nutrient management on fruit yield, quality, nutrient status of soil and leaf, has been conducted during the two consecutive years.

MATERIALS AND METHODS

An experiment was conducted at Main Experiment Station, Department of Horticulture, Narendra Deva

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University of Agriculture and Technology, Kumarganj, Faizabad which is situated at $26^{0}47'$ N latitude and 82^{0} 12' E longitude at an elevation of 113 m above mean sea level. In order to analyse the leaf nutrient status and fertility levels of the soil, samples were collected up to the depth of 45 cm before initiation and after the termination of the experiment. Before experimentation, the status of N, P and K of leaf and soil were analyzed as 1.84-2.42, 0.30-0.34 and 1.00-1.50% and 229.68-233.98, 15.40-15.61 and 230.01-233.63 kg/ha, respectively. .

The experiment was laid out in a Factorial Randomized Block Design with 3 replications having 12 treatment combinations including 3 levels of pruning (un-pruned, 25% and 50% removal of one year old shoot), 2 levels of organic manure (20 kg/tree bio-pressmud and 40 kg/tree FYM) and inorganic nutrients (50% and 100% Recommended Dose of Fertilizer).

The full dose of phosphorus, potassium, FYM and bio-pressmud were applied as a basal dose in the month of February, while nitrogen was applied in two split doses, one with basal dose and another after fruit bud bursting in the month of September. Plants were pruned in the month of February at an intensity of 25 % and 50 %. Plants were left un-pruned under control. The observations were recorded on per cent fruit set, days taken to fruit maturity and yield, physico-chemical characteristics of fruits, leaf nutrient status (%) and available N, P and K (kg/ha) in soil. The physico-chemical properties of fruits were analysed by the standard methods of AOAC (1990), N, P, K status in leaves were analyzed by Linder (1944) and Richards (1968), organic carbon and available soil N, P and K was analyzed by Baruah and Borthakur (1998), and soil pH is analyzed by Singh *et al.* (1999) whereas soil calcium and magnesium is calculated by the method described by Chopra and Kanwar (1999). The data recorded in both the years, i.e. 2007 and 2008 were analyzed in factorial RBD and pooled data are presented in respective tables.

RESULTS AND DISCUSSION

Yield parameters

The perusal of data presented in Table 1 and 2 related to response of pruning intensity on duration of flowering, % fruit set, fruit retention, fruit drop and days taken to fruit maturity showed significant effect. The maximum duration of flowering, fruit set and fruit retention was recorded in P_2 (26.0, 70.54 and 23.38 days) and minimum in P_0 (20.70, 57.72 and 16.24 days). Minimum fruit drop occurred in P_2 (76.62 %) followed by P_1 (81.65 %) whereas, maximum fruit drop occurred in un-pruned trees (83.76 %). Significantly maximum yield was found under P_2 (130 kg/tree) and minimum under P_0 (100 kg/tree). The individual response of manures and nutrients on flowering and fruiting characteristics was significant. Similarly, significantly maximum fruit set was noticed in M_2 (65.95%) and N_2 (64.50 %). Due to application of organic manures maximum fruit retention was noticed in M_2 (21.38 %) as compared to M_1 (17.26 %). Fruit drop was significantly reduced by application of organic manure and inorganic fertilizers. Fruit yield was found to be maximum (119 and 118 kg/tree) under M_2 and N_2 and minimum in M_1 (110 kg/tree) and N_1 (111 kg/tree).

Interaction effect of P×M, P×N, M×N and P×M×N was also significantly affected the flowering and fruiting behavior. The maximum fruit retention was noticed in $P_2M_2N_2$ (28.33 %) followed by $P_2M_2N_1$ (24.35 %) and minimum in $P_0M_1N_1$ (13.70 %). The minimum fruit drop (73.66, 75.25 and 76.98 %) under P_2M_2, P_2N_2 and M_2N_2 and maximum (85.40, 84.78, 83.48 %) under P_0M_1, P_0N_1 and M_1N_1 has been recorded, respectively. It was found minimum in $P_2M_2N_2$ (71.67 %) followed by $P_2M_2N_1$ (75.65 %) as compared to other treatments. The fruits matured in minimum 217 days under P_2M_2, 216 days under P_2N_2 and 222 days under M_2N_2 and M_1N_2 whereas, it took maximum 231 days under P_0M_1, 232 days under P_0N_1 and 229 days under M_1N_1, respectively. It was minimum under $P_2M_2N_2$ (216 days) followed by $P_2M_1N_2$ (216 days) and $P_2M_2N_1$ (218 days) and maximum under $P_0M_1N_1$ (237 days). Maximum (145 kg/tree) has been obtained in $P_2M_2N_2$ which was at par with $P_2M_1N_2$ and $P_2M_1N_2$ (127 and 125 kg/tree) and minimum yield (89 kg/tree) was obtained under $P_0M_1N_1$. Since flowering in Indian gooseberry occurs on new determinate shoots therefore, pruning helps in getting new fruiting units and thus increases the number of flowers per shoot. Similar findings were also observed by Dhaliwal *et al.* (2000), Dalal *et al.* (2000) and Singh (2005).

A significant increase in yield and yield parameters in Indian gooseberry with nutrient application would have been due to vigorous vegetative growth and increased chlorophyll content, which together accelerated the photosynthesis that increased the supply of carbohydrates to plants. In addition, it may also be due to more number of female flowers/shoot and higher fruit retention and reduced fruit drop. The beneficial role of supplemented organic manures in improving soil physical, chemical and biological activities is well known, that helped in better nutrient absorption by plants, resulting higher yield (Prabu *et al.*, 2002). However, other factors like cultural practices and nutrition of the plants also influenced flowering characters to an appreciable extent (Tripathi and Maity 2007). The significant interactive effect as a consequence of organic sources and fertilizers are attributed to the favourable nutritional status of the soil resulting into increased biomass production of the crop. The results of the present study are in conformity with Totawat *et al.* (2001), Singh and Swaroop (2000) and Swarup and Wanjari (2000).

Physical characteristics of the fruits

Different level of pruning intensity significantly influenced equatorial diameter, polar length, weight, volume, pulp stone ratio and fibre content of Indian gooseberry fruit. Effect of P×M×N shows that the application of $P_2M_2N_2$ produced significantly larger equatorial diameter (4.69 cm) of fruit followed by $P_2M_1N_1$ (4.54 cm) whereas, the minimum equatorial fruit diameter was recorded under

Table 1 Effect of the pruning intensity and nutrient management on duration of flowering, fruit set and fruit retention

Treatment	Duration of flowering (days)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	20.4	21.0	18.9	22.5	18.7	22.0	19.0	23.0	20.7
P_1	23.5	28.0	25.0	26.5	24.0	23.0	26.0	30.0	25.8
P_2	26.0	26.0	24.0	28.0	25.0	27.0	23.0	29.0	26.0
Mean	23.3	25.0	22.6	25.7	22.6	24.0	22.7	27.3	24.2

Treatment	Fruit Set (%)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	53.79	61.65	56.43	59.01	53.18	54.39	59.67	63.63	57.72
P_1	58.65	62.90	58.14	63.41	55.81	61.48	60.46	65.34	60.78
P_2	67.77	73.31	69.99	71.09	67.98	67.56	72.00	74.61	70.54
Mean	60.07	65.95	61.52	64.50	58.99	61.14	64.04	67.86	63.01

Treatment	Fruit Retention (%)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	14.60	17.88	15.23	17.25	13.70	15.50	16.75	19.00	16.24
P_1	16.78	19.93	17.17	19.53	16.20	17.33	18.13	21.73	18.35
P_2	20.42	26.34	22.01	24.75	19.67	21.17	24.35	28.33	23.38
Mean	17.26	21.38	18.13	20.51	16.52	18.00	19.74	23.02	19.32

	Duration of flowering (days)		Fruit Set (%)		Fruit Retention (%)	
	SEm ±	*CD (P = 0.05)*	*SEm* ±	*CD (P = 0.05)*	*SEm* ±	*CD (P = 0.05)*
Pruning intensity (P)	0.49	1.42	0.850	2.487	0.358	1.048
Manure (M)	0.41	1.16	0.694	2.031	0.293	0.856
Nutrients (N)	0.41	1.16	0.694	2.031	0.293	0.856
P×M	0.69	2.02	1.202	3.517	0.507	1.482
P×N	0.69	2.02	1.202	3.517	0.507	1.482
M×N	0.56	1.65	0.982	2.872	0.414	1.210
P×M×N	0.97	2.85	1.700	4.974	0.717	2.096

Table 2 Effect of the pruning intensity and nutrient management on fruit drop, days taken to fruit maturity and fruit yield

Treatment	Fruit drop (%)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	85.40	82.13	84.78	82.75	86.30	84.50	83.25	81.00	83.76
P_1	83.24	82.07	82.84	80.47	83.80	82.67	81.87	78.27	81.65
P_2	79.58	73.66	77.99	75.25	80.33	78.83	75.65	71.67	76.62
Mean	82.74	78.62	81.87	79.49	83.48	82.00	80.26	76.98	80.68

Treatment	Days taken to fruit maturity (%)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	231‘	228	232	227	237	225	227	228	229
P_1	226	223	225	223	227	224	223	222	224
P_2	220	217	221	216	224	216	218	216	218
Mean	226	222	226	222	229	222	223	222	224

Treatment	Fruit yield (kg/tree)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	94	107	97	103	89	98	105	108	100
P_1	113	115	112	116	110	115	113	116	114
P_2	124	135	123	136	121	127	125	145	130
Mean	110	119	111	118	107	113	114	123	115

	Fruit drop (%)		Days taken to fruit maturity (%)		Fruit yield (kg/tree)	
	SEm ±	*CD (P = 0.05)*	*SEm* ±	*CD (P = 0.05)*	*SEm* ±	*CD (P = 0.05)*
Pruning intensity (P)	0.358	1.048	0.399	1.166	1.384	4.050
Manure (M)	0.293	0.856	0.325	0.952	1.130	3.306
Nutrients (N)	0.293	0.856	0.325	0.952	1.130	3.306
P×M	0.507	1.482	0.564	1.649	1.958	5.727
P×N	0.507	1.482	0.564	1.649	1.958	5.727
M×N	0.414	1.210	0.460	1.347	1.598	4.676
P×M×N	0.717	2.096	0.797	2.332	2.768	8.099

Table 3 Effect of the pruning intensity and nutrient management on equatorial diameter, polar length and fruit weight

Treatment	Equatorial diameter of fruit (cm)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	3.07	4.01	3.39	3.68	3.00	3.13	3.77	4.24	3.54
P_1	4.35	3.91	4.28	3.97	4.31	4.38	4.25	3.57	4.13
P_2	4.34	4.50	4.43	4.41	4.54	4.14	4.31	4.69	4.42
Mean	3.92	4.14	4.03	4.02	3.95	3.88	4.11	4.17	4.03

Treatment	Polar length of fruit (cm)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	3.24	3.50	3.22	3.52	3.20	3.28	3.24	3.75	3.37
P_1	3.83	3.48	3.82	3.49	3.70	3.95	3.94	3.02	3.66
P_2	4.08	4.38	4.15	4.31	4.12	4.04	4.17	4.58	4.23
Mean	3.72	3.79	3.73	3.77	3.67	3.76	3.78	3.78	3.75

Treatment	Fruit weight (g)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	41.74	41.67	40.93	42.48	40.33	43.15	41.53	41.80	41.70
P_1	45.13	45.01	44.54	45.60	46.33	43.93	42.75	47.26	45.07
P_2	47.14	58.59	53.34	52.39	51.67	42.60	55.00	62.18	52.86
Mean	44.67	48.42	46.27	46.82	46.11	43.23	46.43	50.41	46.54

	Equatorial diameter *SEm* ±	Equatorial diameter *CD (P = 0.05)*	Polar length *SEm* ±	Polar length *CD (P = 0.05)*	Fruit weight *SEm* ±	Fruit weight *CD (P = 0.05)*
Pruning intensity (P)	0.144	0.422	0.105	0.307	1.177	3.443
Manure (M)	0.118	NS	0.086	NS	0.961	2.811
Nutrients (N)	0.118	NS	0.086	NS	0.961	NS
P×M	0.204	0.596	0.149	0.435	1.665	4.871
P×N	0.204	0.596	0.149	0.435	1.665	4.871
M×N	0.166	NS	0.121	NS	1.359	NS
P×M×N	0.288	0.843	0.210	0.615	2.354	6.887

Table 4 Effect of the pruning intensity and nutrient management on fruit volume, pulp stone ratio and fibre content

Treatment	Fruit volume (cc)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	40.04	39.27	39.12	40.19	38.50	41.57	39.73	38.8	39.65
P_1	43.31	43.38	43.10	43.60	44.76	41.86	41.43	45.33	43.35
P_2	45.19	56.56	51.50	50.25	49.79	40.59	53.20	59.91	50.88
Mean	42.85	46.41	44.57	44.68	44.35	41.34	44.79	48.01	44.63

Treatment	Pulp stone ratio								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	17.4:1	17.3:1	17.2:1	17.5:1	17.0:1	17.7:1	17.3:1	17.2:1	17.3:1
P_1	18.5:1	18.3:1	18.2:1	18.6:1	18.9:1	18.2:1	17.6:1	19.0:1	18.4:1
P_2	19.5:1	23.1:1	21.3:1	21.2:1	20.9:1	18.0:1	21.7:1	24.4:1	21.3:1
Mean	18.5:1	19.5:1	18.9:1	19.1:1	18.9:1	18.0:1	18.9:1	20.2:1	19.0:1

Treatment	Fibre content (%)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	0.035	0.031	0.034	0.033	0.036	0.034	0.031	0.031	0.033
P_1	0.026	0.022	0.025	0.023	0.027	0.024	0.022	0.021	0.024
P_2	0.019	0.011	0.015	0.015	0.018	0.019	0.011	0.011	0.015
Mean	0.026	0.021	0.025	0.023	0.027	0.026	0.021	0.021	0.024

	Fruit volume *SEm* ±	Fruit volume *CD (P = 0.05)*	Pulp stone ratio *SEm* ±	Pulp stone ratio *CD (P = 0.05)*	Fibre content *SEm* ±	Fibre content *CD (P = 0.05)*
Pruning intensity (P)	1.220	3.569	0.373	1.091	0.001	0.003
Manure (M)	0.996	2.914	0.304	0.891	0.001	0.003
Nutrients (N)	0.996	NS	0.304	NS	0.001	0.003
P×M	1.725	5.048	0.527	1.542	0.002	0.004
P×N	1.725	5.048	0.527	1.542	0.002	0.004
M×N	1.409	4.121	0.430	1.261	0.001	0.003
P×M×N	2.440	7.139	0.746	2.182	0.002	0.006

Table 5 Effect of the pruning intensity and nutrient management on TSS and Vitamin C

Treat-ment	Total soluble solids (⁰ Brix)									Vitamin C (mg/100 g pulp)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	11.28	11.62	11.42	11.48	11.83	10.73	11.00	12.23	11.45	443.2	461.0	446.7	457.5	433.3	453.0	460.0	462.0	452.1
P_1	12.44	12.43	12.40	12.47	12.47	12.40	12.33	12.53	12.43	481.8	489.0	485.0	485.8	488.0	475.7	482.0	496.0	485.4
P_2	13.32	13.85	13.37	13.82	13.00	13.67	13.74	13.97	13.59	478.7	486.8	477.5	487.9	478.7	478.7	476.3	497.2	482.7
Mean	12.35	12.63	12.41	12.59	12.43	12.27	12.36	12.91	12.49	467.9	478.9	469.7	477.1	466.7	469.1	472.8	485.1	473.4

	SEm ±	CD (P = 0.05)	SEm ±	CD (P = 0.05)
Pruning intensity (P)	0.213	0.623	1.776	5.195
Manure (M)	0.174	NS	1.451	4.241
Nutrients (N)	0.174	NS	1.451	4.241
PxM	0.301	0.881	2.511	7.346
PxN	0.301	0.881	2.511	7.346
MxN	0.246	NS	2.050	5.998
PxMxN	0.426	1.245	3.551	10.389

Table 6 Effect of the pruning intensity and nutrient management on total sugars and reducing sugar

Treat-ment	Total sugars (%)									Reducing sugar (%)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	4.53	4.63	4.60	4.55	4.50	4.55	4.60	4.65	4.58	2.36	2.34	2.36	2.34	2.33	2.39	2.39	2.28	2.35
P_1	4.72	4.82	4.74	4.79	4.75	4.69	4.84	4.79	4.77	2.41	2.40	2.39	2.42	2.40	2.41	2.38	2.42	2.40
P_2	4.83	4.91	4.86	4.87	4.85	4.80	4.90	4.92	4.87	2.47	2.47	2.51	2.44	2.51	2.45	2.51	2.42	2.48
Mean	4.69	4.78	4.73	4.74	4.70	4.68	4.78	4.79	4.74	2.41	2.41	2.42	2.40	2.41	2.41	2.43	2.37	2.41

	SEm ±	*CD (P = 0.05)*	*SEm ±*	*CD (P = 0.05)*
Pruning intensity (P)	0.006	0.016	0.024	0.071
Manure (M)	0.005	0.013	0.021	NS
Nutrients (N)	0.005	NS	0.021	NS
P×M	0.008	0.023	0.034	0.101
P×N	0.008	0.023	0.034	0.101
M×N	0.006	0.019	0.028	NS
P×M×N	0.011	0.033	0.049	0.143

Po, No pruning, P1, 25% removal of one year old shoot, P2, 50% removal of one year old shoot, M1, 20 kg/tree bio-pressmud, M2, 40 kg FYM /tree, N1, 50% of RDF, N_2, 100% of RDF

treatment $P_0M_1N_1$ (3.0 cm). The maximum polar fruit length (4.58 cm) was recorded under $P_2M_2N_2$ followed by $P_2M_2N_1$ (4.17 cm). While, minimum polar length (3.20 cm) was found under $P_1M_1N_1$. Under interaction of P×M×N maximum fruit weight (62.18 g) in $P_2M_2N_2$ followed by $P_2M_2N_1$ (55.00 g) and minimum (40.33 g) under $P_0M_1N_1$ was recorded. The effect of P×M, P×N, M×N and P×M×N on fruit volume, pulp stone ratio and fibre content was found significant. The maximum fruit volume (59.91 cc) was observed under the treatment $P_2M_2N_2$ followed by $P_2M_2N_1$ (53.20 cc) as compared to other treatments and minimum fruit volume was obtained under the treatment $P_0M_1N_1$ (38.50 cc). Similarly, it was found maximum (24.4:1) under $P_2M_2N_2$ and minimum (17.0:1) under $P_0M_1N_1$ (Table 4). The results are in accordance with findings of Dhaliwal *et al.* (2000) and Shaaban *et al.* (2006). Use of organic sources leaves better effect on physico-chemical properties of the soil that helps in improvement of soil structure for favorable root growth which caused better plant growth and fruit bearing as compared to chemical fertilizers. These results are in conformity with findings of Ghuge *et al.* (2007).

A synergistic interaction between organic manures and inorganic fertilizers has resulted in enhanced production of growth promoting substances like gibberellic acid, indole acetic acid and dihydrozeatin. They have positive influence on the physiological activity of the plants that enhanced fruit length and diameter, which ultimately increased the average fruit weight. Combined application of organic manures along with fertilizers might have helped in strengthening process in the nucleic acid and metabolism. Obviously, it has increased utilization of native N and P due to organic acids produced during decomposition and induced chelating effects on micronutrients which probably enhanced the availability of N, P and K along with solubilizing the availability of micronutrients. Thus, application of organic manures and fertilizers resulted in an overall significant increase in N, P and K in plants at lesser cost but longer in durability. The combined use of pruning, organic manures and fertilizers has been found effective not only in maintaining higher productivity but also in providing stable crop yield for sustainable crop production through integrated

Table 7 Effect of the pruning intensity and nutrient management on nitrogen, phosphorus and potassium content in branchlet

Treatment	Nitrogen content in branchlet (%)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	2.18	2.14	1.93	2.39	1.94	2.41	1.91	2.37	2.16
P_1	2.34	2.43	2.29	2.47	2.24	2.43	2.34	2.51	2.38
P_2	2.43	2.47	2.38	2.52	2.35	2.50	2.41	2.53	2.45
Mean	2.31	2.34	2.20	2.46	2.18	2.45	2.22	2.47	2.33
				SEm ±				*CD (P = 0.05)*	
Pruning intensity (P)				0.019				0.054	
Manure (M)				0.015				NS	
Nutrients (N)				0.015				0.044	
P×M				0.026				0.077	
P×N				0.026				0.077	
M×N				0.021				0.063	
P×M×N				0.037				0.109	

Treatment	Phosphorus content in branchlet (%)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	0.38	0.40	0.39	0.39	0.38	0.38	0.40	0.39	0.39
P_1	0.42	0.43	0.39	0.46	0.39	0.44	0.39	0.47	0.42
P_2	0.43	0.48	0.42	0.49	0.38	0.47	0.45	0.50	0.45
Mean	0.41	0.43	0.40	0.44	0.38	0.43	0.41	0.45	0.42
			SEm ±				*CD (P = 0.05)*		
Pruning intensity (P)			0.019				0.054		
Manure (M)			0.015				NS		
Nutrients (N)			0.015				0.044		
P×M			0.026				0.077		
P×N			0.026				0.077		
M×N			0.021				0.063		
P×M×N			0.037				0.109		

Treatment	Potassium content in branchlet (%)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	1.14	1.33	1.24	1.23	1.07	1.20	1.41	1.25	1.23
P_1	1.37	1.49	1.34	1.52	1.24	1.50	1.44	1.54	1.43
P_2	1.82	1.56	1.58	1.80	1.77	1.87	1.39	1.72	1.69
Mean	1.44	1.46	1.38	1.51	1.36	1.52	1.41	1.50	1.45
		SEm ±				*CD (P = 0.05)*			
Pruning intensity (P)		0.099				0.289			
Manure (M)		0.081				NS			
Nutrients (N)		0.081				NS			
P×M		0.141				0.409			
P×N		0.141				0.409			
M×N		0.114				NS			
P×M×N		0.198				0.578			

Table 8 Effect of the pruning intensity and nutrient management on nitrogen and phosphorus content in soil (kg/ha)

Treatment	Nitrogen content in soil (kg/ha)									Phosphorus content in soil (kg/ha)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	234.9	237.5	235.4	237.0	233.9	235.9	236.9	238.2	236.2	16.82	17.34	16.97	17.19	16.72	16.92	17.22	17.45	17.08
P_1	235.0	238.4	235.6	237.9	234.1	235.9	237.1	239.8	236.7	17.02	17.39	17.10	17.31	16.95	17.09	17.25	17.52	17.20
P_2	240.0	240.8	239.8	241.0	239.1	240.9	240.5	241.1	240.4	18.21	18.96	18.41	18.76	17.85	17.56	18.96	18.96	18.58
Mean	236.6	238.9	236.9	238.6	235.7	237.6	238.2	239.7	237.8	17.35	17.89	17.49	17.75	17.17	17.19	17.81	17.98	17.62
			SEm ±				*CD (P = 0.05)*				*SEm* ±				*CD (P = 0.05)*			
Pruning intensity (P)			0.463				1.355				0.026				0.075			
Manure (M)			0.378				1.106				0.021				0.061			
Nutrients (N)			0.378				1.106				0.021				0.061			
P×M			0.655				1.916				0.036				0.106			
P×N			0.655				1.916				0.036				0.106			
M×N			0.535				1.564				0.031				0.087			
P×M×N			0.926				2.709				0.051				0.150			

Po, No pruning, P_1, 25% removal of one year old shoot, P_2, 50% removal of one year old shoot, M_1, 20 kg/tree bio-pressmud, M_2, 40 kg FYM /tree, N_1, 50% of RDF, N_2, 100% of RDF

Table 9 Effect of the pruning intensity and nutrient management on potassium content in soil and organic carbon in soil

Treat-ment	Potassium content in soil (kg/ha)									Organic carbon in soil (%).								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	237.8	240.8	238.6	240.1	237.5	238.2	239.7	241.9	239.3	0.38	0.39	0.38	0.38	0.38	0.37	0.38	0.39	0.38
P_1	240.7	243.4	241.1	243.0	239.6	241.9	242.5	244.2	242.0	0.40	0.42	0.39	0.43	0.39	0.41	0.39	0.44	0.41
P_2	243.8	246.0	244.4	245.5	242.9	244.8	245.9	246.2	244.9	0.43	0.47	0.45	0.45	0.44	0.42	0.47	0.47	0.45
Mean	240.8	243.4	241.3	242.8	240.0	241.6	242.7	244.1	242.1	0.40	0.42	0.40	0.42	0.40	0.40	0.41	0.43	0.41

	SEm ±	*CD (P = 0.05)*	*SEm ±*	*CD (P = 0.05)*
Pruning intensity (P)	0.563	1.647	0.012	0.035
Manure (M)	0.461	1.345	0.011	NS
Nutrients (N)	0.461	1.345	0.011	NS
P×M	0.796	2.331	0.017	0.050
P×N	0.796	2.331	0.017	0.050
M×N	0.650	1.902	0.014	NS
P×M×N	1.126	3.295	0.024	0.071

nutrient use. The improvement in physical characteristics of the fruit would have been due to remarkable improvement in N, P and K content of plant under the influence of combined application of nutrients through integrated use resulting greater availability of these nutrients in the soil. Besides, greater availability of nutrients, better development of fruit was due to more absorption of nutrients from soil and their efficient translocation in plant system (Jaggi 2007).

Chemical characteristics of fruits

The data on total soluble solids and vitamin C are presented in Table 5 showed significant effect on enhancement of TSS and vitamin C. The highest value (13.59° Brix) under P_2 and lowest (11.45° Brix) under P_0 was recorded. The vitamin C was found maximum (485.4 mg/100g pulp) under P_1 and minimum (452.1 mg/100g pulp) under P_0. The observations on total sugars and reducing sugar content of Indian gooseberry are presented in Table 6. Significant influence is seen by different levels of pruning. Highest total sugar and (4.87 and 2.48%) in P_2 and lowest (4.58 and 2.35%) in P_0 has been recorded. However, organic manures and nutrients significantly influenced the vitamin C content of fruit. However, application of fertilizers alone has non-significant effect on total sugars. Interaction effect of P×M, P×N and P×M×N on TSS was found to be significant but effect of M×N was non-significant. Maximum TSS was found under $P_2M_2N_2$ (13.97° Brix) and minimum under $P_0M_1N_2$ (10.73° Brix). Effect of P×M, P×N, M×N and P×M×N on ascorbic acid was found to be significant. Maximum value (489.0, 487.9, 485.1 and 497.2 mg/100g pulp) was recorded with P_1M_2, P_2N_2, M_2N_2 and $P_2M_2N_2$ while, minimum vitamin C content was recorded with P_0M_1, P_0N_1, M_1N_1 and $P_0M_1N_1$ (443.2, 446.7, 446.7 and 433.3 mg/100g pulp), respectively. In the same way, maximum total sugar (4.92 %) was obtained under $P_2M_2N_2$ followed by 4.90 % under $P_2M_2N_1$. Beneficial effect of pruning on quality parameters of Indian gooseberry are in conformity with findings of Dhaliwal *et al*. (2000).

Nutrient status of branchlet

A perusal of pooled data presented in Table 7 reveal that application of pruning intensity has significant influence on nitrogen, phosphorus and potassium content in branchlet of Indian gooseberry during experimentation. Due to interactions P×M, P×N, M×N and P×M×N maximum nitrogen (2.47, 2.52 and 2.47 %) under P_2M_2, P_2N_2, M_2N_2 and minimum (2.14, 1.93 and 2.18 %) under P_0M_2, P_0N_1 and M_2N_2 is seen. Further, it is maximum (2.50 %) under $P_2M_1N_2$.

The effect of P×M, P×N, M×N and P×M×N was found significant where maximum phosphorus (0.48, 0.49, 0.45 and 0.50 %) was found due to P_2M_2, P_2N_2, M_2N_2 and $P_2M_2N_2$ and minimum (0.38, 0.39, 0.38 and 0.38 %) due to P_0M_1, (P_0N_1, P_0N_2 and P_1N_1), M_1N_1 and $P_0M_1N_1$ and $P_0M_1N_2$ respectively.

Maximum potassium content in branchlet (1.82, 1.80 and 1.87 %) under P_2M_1, P_2N_2 and $P_2M_1N_2$ and minimum (1.14, 1.23 and 1.07 %) under P_0M_1, P_0N_2 and $P_0M_1N_1$ was recorded. Increase in the nutrient status of the leaves would have been due to enhanced invigorating effect of pruning severity on the absorption of mineral content by the plants which could have increased the leaf nutrient status of the plant. Results are in line with Naik and Babu (2005).

Soil nutrient status of the orchard

Post analysis of soil samples were done to compute the status of N, P and K to verify the effect of treatments. The values recorded under Table 8 reveal that pruning levels significantly improved available nitrogen (240.4 kg/ha) in soil under P_2 with respect to P_0 (236.2 kg/ha). Again significantly highest phosphorus value (18.58 kg/ha) in P_2 and minimum (17.08 kg/ha) in P_0 was found. As evident from the pooled data on available potassium and organic carbon in soil presented in Table 9 wherein, maximum potassium value (244.9 kg/ha) and organic carbon (0.45 %) under P_2 and minimum K value (239.3 kg/ha) and organic carbon (0.38 %) under P_0, respectively was recorded. However, pruning effect enhanced calcium and magnesium

Table 10 Effect of the pruning intensity and nutrient management on calcium and magnesium content in soil

Treat-ment	Calcium content in soil (m.e./100 g)									Magnesium content in soil (m.e./100 g)								
	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean	M_1	M_2	N_1	N_2	M_1N_1	M_1N_2	M_2N_1	M_2N_2	Mean
P_0	3.88	3.90	3.88	3.90	3.87	3.88	3.89	3.91	3.89	5.80	5.87	5.80	5.86	5.74	5.85	5.87	5.88	5.83
P_1	3.94	3.97	3.94	3.97	3.92	3.96	3.95	3.98	3.95	5.89	5.91	5.90	5.90	5.89	5.89	5.90	5.91	5.90
P_2	3.98	3.99	3.98	3.99	3.98	3.98	3.98	3.99	3.98	5.94	5.97	5.95	5.97	5.93	5.95	5.96	5.98	5.96
Mean	3.93	3.95	3.93	3.95	3.92	3.94	3.94	3.96	3.94	5.87	5.92	5.88	5.91	5.85	5.91	5.91	5.92	5.91

	SEm ±	*CD (P = 0.05)*	*SEm ±*	*CD (P = 0.05)*
Pruning intensity (P)	0.008	0.023	0.017	0.051
Manure (M)	0.007	0.019	0.014	0.041
Nutrients (N)	0.007	0.019	0.014	NS
P×M	0.011	0.033	0.024	0.071
P×N	0.011	0.033	0.024	0.071
M×N	0.009	0.027	0.021	0.058
P×M×N	0.016	0.047	0.035	0.101

availability in soil significantly. Under pruning maximum calcium (3.98 m.e./100 g) in P_2 and minimum (3.89 m.e./ 100 g) in P_0 was found. Similarly, maximum magnesium content (5.96 m.e./100 g) was found under P_2 and minimum (5.83 m.e./100 g) under P_0 was found. Application of organic manure and inorganic fertilizers has also significant effect on improvement of available nitrogen and phosphorus. Data presented in Table 9 showed significant effect due to application of organic manure and fertilizers on potassium and organic carbon where maximum potassium (243.4 kg/ ha) and organic carbon (0.42 %) in M_2 and minimum (240.8 kg/ha) and organic carbon (0.40 %) in M_1, respectively.

A perusal of data presented in Table 10 reveal that under application of organic manure, maximum calcium content (3.95 m.e./100 g) in M_2 and minimum (3.93 m.e./ 100 g) in M_1 was found due to interactions P×M, P×N, M×N and P×M×N phosphorus content is significant. Due to P×M, P×N, M×N and P×M×N potassium content, organic carbon, Calcium and magnesium content of soil improved significantly. Balanced use of fertilizer and integrated approach would have been attributed in enhanced rhizospheric effect and soil biological activity, providing congenial physical condition to soil that conserved the soil NPK and increased the availability of other nutrients being its constituents. Increase in the level of available soil nutrients might be due to recycling of pruned debris and decrease in utilization of excessive nutrients by undesirable branches. The present findings are in conformity with Ray *et al*. (2005).

CONCLUSION

The results on present investigation revealed that among different pruning intensity, 50% pruning of previous season growth (P_2) was statistically superior which resulted maximum plant height, spread, duration of flowering, fruit set and retention, yield, physical and chemical qualities of fruit and leaf as well as soil nutrient status. Further, nutrient management revealed that application of 40 kg FYM (M_1) resulted maximum fruit set, retention, yield and phosphorus content in leaves and NPK in soil and minimum fruit drop, days taken to maturity and fibre content. Similarly 100 % Recommended Dose of Fertilizer (N_1) resulted maximum fruit set, retention, yield, nitrogen and phosphorus content in leaves as well as in soil.

Among the interactions, P_2M_2, P_2N_2 and M_2N_2 was found superior over others in improving the vegetative and reproductive plant growth beside physical and chemical quality of fruits along with nutrient status of branchlet and soil. A critical observation of the results, it is concluded that interactions had been most effective to improve the vegetative and reproductive characteristics, quality parameters of fruits and nutrient status in leaves of aonla as well as soil than the individual application of different levels of pruning, organic manure and nutrient. Plant height and spread was maximum due to the interaction $P_2M_2N_2$ (50% pruning intensity + 40 kg FYM + 100 % Recommended Dose of Fertilizer) followed by $P_2M_2N_1$. Among flowering, fruiting and yield parameters, maximum duration of flowering, fruit set, retention and yield and minimum fruit drop and days taken to fruit maturity was found under $P_2M_2N_2$ followed by $P_2M_2N_1$. Interaction $P_2M_2N_2$ has been noticed statistically superior to enhance physical and chemical characteristics of fruit followed by $P_2M_2N_1$. This treatment has not only enhanced bearing and quality parameters in aonla but also increased the leaf nutrient status as well as soil fertility status.

The analysis indicated that highest net return and cost benefit ratio was estimated in the plants that received 50% pruning intensity + 40 kg FYM + 100 % RDF followed by $P_2M_2N_1$ (50% pruning intensity + 40 kg FYM + 50 % RDF). Therefore, 50% pruning intensity along with nutrient management by use of organic manure (40 kg/tree FYM) and inorganic fertilizers (1000:500:1000 g/plant NPK) is recommended for sustainable higher fruit yield and quality of aonla while the interaction of 50% pruning intensity along with 40 kg/tree FYM and 50 % RDF is recommended for at par net return and cost benefit ratio with best treatment on less cost of production.

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