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Short communication

Effect of fertigation and rootstocks on yield and quality of apple under high density plantation

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Apple cultivation in India is restricted to North-western Himalayan region comprising the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand and to a small extent in north-eastern states. The area and production of apple in India has increased significantly but low productivity is still a matter of concern to the farmers as well as the scientists. The low productivity has been attributed to various reason 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 in developed countries are encouraging but such information under Indian conditions is limited. Therefore, it was proposed to study the effect of different levels of fertigation and three different rootstocks on apple under high density plantation.

An experiment was carried out at Fruit Research Station, Seobagh, Kullu and Department of Pomology of Dr Y.S. Parmar, UHF Nauni, Solan to ascertain the effect of different fertigation treatments on fruit yield and quality parameters of apple under high density plantation. The experimental site represented sub-montane zone of Himachal Pradesh, situated at an elevation of 1,350 m above mean sea level and with latitude 32° 1'N and longitude 77° 2'E. The planting material consisted of six-year-old apple plants of cvs. Red Fuji and Scarlet Gala grafted on three clonal rootstocks, *viz*., EMLA-106, EMLA-7 and EMLA-111. The plants were spaced at 3 m x 3 m. Each treatment was applied to both the cultivars on every rootstock. The results are presented as mean performance of both the cultivars on individual rootstocks. There were four fertigation treatments, *viz*., full dose of N, P and K through drip, 2/3 dose of N, P and K, ½ dose of N, P and K and 1/3 dose of N, P and K, whereas, full dose of N, P and K in soil as a single application consisted the control treatment. The basic dose for one-year-old plant under high density (3 m × 3 m) was fixed to half of the dose for standard trees (Anon, 1). The actual dose for one-year-old tree was deduced to 35.0 g N, 17.5 g P_2O_5 and 35.0 g K_2O. Using this dose, the required fertilizer dose to be applied for six-year and seven-year-old plants were calculated. The fertilizer dose thus obtained (210 g N, 105 g P_2O_5 and 210 g K_2O for six-year-old plants) was divided into 10 equal parts and applied at ten days intervals starting from third week of March. The sources of NPK were CAN, DAP and DSP, respectively. Fertigation was done through a Venturi system. The observations were recorded on yield, fruit weight, size, pressure, TSS, acidity and sugars and presented separately for two years of study. The experiment was conducted in a split plot design.

It is evident from the data presented in Tables 1 & 2 that the main effects of fertigation treatment, variety and rootstock were significant for fruit yield during both the years of study. Among treatments, full dose of N, P and K through drip recorded the maximum fruit yield (12.19 and 12.62 kg/plant), whereas, the minimum (11.11 and 10.47 kg/plant) fruit yield was recorded in control. Fertigation with full, 2/3 and ½ dose of N, P and K caused increase in fruit yield over control. Earlier, Neilson *et al.* (6) and Brussi *et al.* (2) suggested that fertigation results in higher yields due to direct effect of nutrient application and its timings and a reduction of nitrate leaching. Increased yields of 4.3 to 11.4 t/ha on Golden Delicious / M-26 apple trees have also been reported by Zydlik and Pacholak (8). Red Fuji registered higher fruit yield (11.63 and 11.80 kg/plant, respectively) during both the years than Scarlet Gala. This may be attributed to higher fruit size and weight registered in the former variety. Fruit yield was maximum on rootstock EMLA-106, whereas EMLA-7 and EMLA-111 were at par with each other. These results are in conformity with those of Paul (7) who obtained higher yields on MM-106 as compared to that of EMLA-111.

The first order interactions TxV (Treatment x variety) and TxR (Treatment x rootstock) were found to be significant during both the years, whereas VxR (Variety x rootstock) interaction was significant during first year only. The second order interaction (Table

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Table 1. Effect of fertigation treatments, varieties, rootstocks and their interaction on fruit yield (kg/ plant) in apple.

Treatment	1st year						2nd year					
	Variety		Mean	Rootstock			Variety		Mean	Rootstock		
	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)
T_1 (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
T_2 (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
T_3 (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
T_4 (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
T_5 (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				

$CD_{0.05}$

	1st year	2nd year
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

Table 2. Effect of fertigation treatments, varieties, rootstocks and their interaction on fruit length (cm) in apple.

Treatment	1st year						2nd year					
	Variety			Rootstock			Variety			Rootstock		
	V_1 (Red Fuji)	V_2 (Scarlet Gala)	Mean	R_1 (EMLA-106)	R_2 (EMLA-7)	R_3 (EMLA-111)	V_1 (Red Fuji)	V_2 (Scarlet Gala)	Mean	R_1 (EMLA-106)	R_2 (EMLA-7)	R_3 (EMLA-111)
T_1 (Full dose of NPK)	6.72	6.86	6.79	7.45	7.16	5.76	6.32	6.73	6.53	6.58	6.55	6.46
T_2 (2/3 dose of NPK)	6.07	6.32	6.20	6.07	6.27	6.25	5.83	6.32	6.08	6.21	6.01	6.04
T_3 (1/2 dose of NPK)	5.53	5.88	5.71	5.52	5.82	5.80	5.67	6.06	5.87	5.98	5.83	5.80
T_4 (1/3 dose of NPK)	5.22	5.46	5.35	5.48	5.30	5.28	4.93	5.73	5.33	5.47	5.29	5.23
T_5 (Control)	4.74	5.07	4.90	5.08	4.70	4.95	4.28	5.06	4.67	4.79	4.60	4.62
Mean	5.66	5.92		5.92	5.85	5.61	5.04	5.98		5.81	5.66	5.63
R_1 (EMLA-106)	5.78	6.06					5.72	5.90				
R_2 (EMLA-7)	5.72	5.99					5.73	5.59				
R_3 (EMLA-111)	5.50	5.72					5.70	5.56				

$CD_{0.05}$

	1st year	2nd year
T	1.13	0.98
V	0.23	0.17
R	0.26	0.49
TxV	1.21	1.31
TxR	1.95	1.53
VxR	NS	NS
TxVxR	NS	NS

Table 3. Effect of fertigation treatments, varieties, rootstocks and their interaction on fruit diameter (cm) in apple.

Treatment	1st year						2nd year					
	Variety			Rootstock			Variety			Rootstock		
	V_1 (Red Fuji)	V_2 (Scarlet Gala)	Mean	R_1 (EMLA-106)	R_2 (EMLA-7)	R_3 (EMLA-111)	V_1 (Red Fuji)	V_2 (Scarlet Gala)	Mean	R_1 (EMLA-106)	R_2 (EMLA-7)	R_3 (EMLA-111)
T_1 (Full dose of NPK)	8.32	6.33	7.33	7.48	7.22	7.28	8.42	7.98	8.20	8.39	8.12	8.08
T_2 (2/3 dose of NPK)	8.26	6.41	7.34	7.69	7.27	7.12	7.97	7.12	7.45	8.06	7.92	6.97
T_3 (1/2 dose of NPK)	7.65	6.17	6.61	7.07	6.38	6.39	7.21	6.78	6.99	7.11	6.94	6.92
T_4 (1/3 dose of NPK)	6.81	6.30	6.55	7.35	6.55	5.77	6.29	6.03	6.16	6.30	6.10	6.08
T_5 (Control)	6.42	6.05	6.24	6.77	6.28	5.66	5.17	5.61	5.39	5.88	5.74	5.76
Mean	7.43	6.25		7.26	6.74	6.44	7.17	6.70		7.15	6.96	6.76
R_1 (EMLA-106)	7.90	6.61					7.24	7.06				
R_2 (EMLA-7)	7.32	6.15					7.07	6.85				
R_3 (EMLA-111)	6.84	5.99					6.80	6.62				

$CD_{0.05}$

	1st year	2nd year
T	1.06	1.72
V	0.59	0.42
R	0.42	0.21
TxV	1.23	1.87
TxR	1.62	1.54
VxR	1.10	NS
TxVxR	NS	NS

Table 4. Effect of fertigation treatments, varieties, rootstocks and their interaction on average fruit weight (g) in apple.

Treatment	1st year						2nd year					
	Variety			Rootstock			Variety			Rootstock		
	V_1 (Red Fuji)	V_2 (Scarlet Gala)	Mean	R_1 (EMLA-106)	R_2 (EMLA-7)	R_3 (EMLA-111)	V_1 (Red Fuji)	V_2 (Scarlet Gala)	Mean	R_1 (EMLA-106)	R_2 (EMLA-7)	R_3 (EMLA-111)
T_1 (Full dose of NPK)	115.70	95.33	105.52	110.0	106.7	99.87	119.12	107.76	111.44	114.13	110.20	109.11
T_2 (2/3 dose of NPK)	108.10	87.75	97.92	101.60	103.40	88.75	112.19	98.33	105.26	113.17	100.21	102.03
T_3 (1/2 dose of NPK)	96.00	76.00	86.00	89.25	87.25	81.50	102.76	81.81	92.29	95.04	92.13	89.10
T_4 (1/3 dose of NPK)	87.25	77.00	82.12	82.00	87.25	77.12	94.63	84.14	88.29	93.81	89.51	83.05
T_5 (Control)	80.83	71.50	76.17	75.25	78.37	74.87	87.71	76.39	82.05	88.27	80.42	78.35
Mean	97.58	81.52		91.62	92.60	84.42	103.28	89.29		100.88	94.49	92.35
R_1 (EMLA-106)	100.10	83.10					103.65	98.10				
R_2 (EMLA-7)	102.90	82.30					98.40	90.58				
R_3 (EMLA-111)	89.70	79.15					96.81	87.89				

$CD_{0.05}$

	1st year	2nd year
T	5.20	4.10
V	5.13	4.78
R	4.49	4.08
TxV	18.24	15.87
TxR	11.57	13.91
VxR	15.61	11.90

2) (TxVxR) was maximum in $T_2V_2R_1$ (12.58 kg/plant) during the first year and in the interaction $T_2V_1R_1$ (12.24 kg/plant) during the next year.

The data pertaining to fruit length, diameter and weight (Table 3) showed that all fertigation treatments except 1/3 dose of N, P and K through drip enhanced fruit size and weight over control. The maximum fruit length (4.90 and 6.53 cm during the two years respectively) was recorded in the treatment T_1 (full dose of N, P and K through drip) and was statistically at par with treatment T_2 (2/3 dose of N, P and K). The minimum fruit size was noticed under control which was at par with treatment T_4 (1/3 dose of N, P and K). Similar results were obtained for fruit diameter. Maximum fruit weight (105.52 g) was recorded in the treatment T_1 (full dose of N, P and K through drip) and minimum (76.17 g) under control. Similar trend was observed during the subsequent year. The uniform distribution of nutrients, coupled with its confinement to root zone, might have increased the nutrient uptake under fertigation treatments, which resulted in better fruit size and weight. Hipps (4), also observed better size of fruits under fertigation. Higher N dose has also been found to affect fruit size of apples (Klein *et al*., 5).

Among rootstocks, the largest fruits were obtained on EMLA-106, whereas, EMLA-7 and EMLA-111 were at par with each other. The fruit diameter was also found to be maximum on rootstock EMLA-106 during both the years, respectively. The fruits borne on rootstocks EMLA-7 and EMLA-111 had the maximum weight (92.6 and 100.8 g) during both years of study. The data pertaining to fruit firmness (Table 4) showed that the main effects of fertigation treatments were found to be non-significant, whereas that of rootstocks were significant during both the years of investigations. A non-significant effect of fertigation treatments was also noted on total soluble solids (TSS) content. Similar trend was noted for total sugars content where none of the fertigation treatments could cause any significant effect. The effect of rootstocks on total sugars content was significant during the first year. Rootstock EMLA-106 recorded the maximum total sugars content (7.28%), which was statistically at par with rootstock EMLA-7. The treatment x rootstock interaction was also found to be significant during the first year of study.

All fertigation treatments failed to induce significant influence on the quality parameters (firmness, TSS and sugars) during both the years. These results are in line with those obtained by Dolega and Link (3) who reported that no appreciable differences in firmness, sugar and acid contents between control and fertigated trees.

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