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Foliar and soil N fertilization as a function of cropping behaviour of Royal Delicious apple (*Malus domestica*)

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ABSTRACT

The key factor to obtain good yield and high fruit quality in apple (*Malus domestica* Borkh.) production is tree fertilization. The present study was planned with the objective to investigate the effect of soil applied N sources through foliar Urea sprays on morphometric growth traits, yield and fruit quality of apple cv. Royal Delicious. The trial was carried out on 28-year old trees raised on Crab apple *Malus sylvestris* (L.) Mill rootstock. Soil application of N sources, viz. Urea, calcium nitrate (CN), N:P:K (19:19:19) + Urea, N:P:K (12:32:16) + Urea and CAN + foliar Urea sprays at the levels of 840, 700 and 560 g N/tree were used. The effect of soil application of N sources and levels along with foliar Urea sprays on growth, production and fruit quality of apple recorded CAN + foliar Urea at 700 g N/tree as the superior combination for optimum growth, fruit set and yield which was closely followed by CN + foliar Urea and Urea (soil) + Urea (foliar) application at 700 g N/tree. Whereas, fruit quality in terms of fruit size, weight, sugars and total soluble solids were improved with CAN + foliar Urea as well as CN + foliar Urea at 700 g N/tree.

Key words: Biochemical analysis, Foliar feeding, Yield efficiency

Apple (*Malus domestica* Borkh.) is an important temperate fruit of the north-west Himalayas, predominantly grown in Jammu and Kashmir, Himachal Pradesh and Uttarakhand covers over 90% of the total production of India. In Himachal Pradesh, total area under cultivation is 10,769 ha with production of 5,88,970 MT**.** Optimal mineral nutrition play an important role for growth, development and yield of apple trees. With increasing concern about environmental contamination by nitrate leaching from soils, foliar sprays have been recommended. Foliar spraying of Urea has been recommended because of greater efficiency of uptake and there is no risk of groundwater contamination (Weinbaum 1988, Cambardella 2002). Considerable amount of total N was lost through leaching of soil applied N, compared with foliar N applications (Fallahi *et al.* 1997). Foliar N sprays to fruit trees can have higher use efficiency, but it may adversely affect plant vigor and reduce the economic yield if relied upon solely (Weinbaum 1988). Uptake by roots will be influenced both by the root system and by its environment which, as well as directly affecting uptake, will indirectly influence it through effects on root growth. The effectiveness of foliar N sprays for fruit set, fruit quantity and quality is controversial. Some researchers have claimed that foliar Urea applied is equally or more effective than ground N applications in improving fruit set and subsequent fruit size and yield. Others have found that the effect of foliar sprays are largely confined to the sprayed leaves and do not affect fruiting or N status of the entire tree (Forshey 1963). The distribution of Urea derived N in fruits, leaves, shoots, and branches of 'Golden Delicious' apple tree was strongly influenced by the amount of Urea application and its method (soil or foliar) of applications (Fallahi *et al.* 1997). Allen (1970) and Han *et al.* (1989) found that up to 80 per cent of N spray could be absorbed by the leaves, while Ford (1968) showed that N sprays could increase leaf concentration less than 50 per cent. Combinations of soil and foliar N application might achieve optimum N use and plant production, but there have been no consistent results reported in the literature (Johnson *et al.* 2001). This experiment was carried out to find the response of plants to foliar *vs.* soil N formulations on cropping behaviour, fruit set, yield and quality of fruits.

Excessive crop in 'On year' deplete the nutrients needed to form new fruit buds; however there is also evidence that seed producing hormones exported from developing ovules have a direct inhibitory effect on flower development. Application of N in the form of Urea tends to increase tree N

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storage and regulate N distribution, results in healthy spurs and better flowering. N is the most important element for plant growth and development. Consequently, application of N fertilizers had the most significant effect in increasing crop production. Because of its importance in crop production, N fertilizer is often used as an 'insurance policy' to achieve maximum productivity (Sanchez *et al.* 1995). Application of N to the soil is a traditional method to supply N to plants. Soil N application usually improves plant growth and has a low recovery and high risk of losses to leaching (Dines *et al.* 2002). Several researchers have shown that applications of N to foliage (foliar N applications) have a higher recovery rate than soil applications (Rosecrance *et al.* 1998). Applying Urea in spring and/ or autumn to apple trees as a substitute or supplement to soil N dressing has been reported to increase the amount of shoot growth (Shim *et al.* 1972). However, when N status of experimental trees was high, growth responses to Urea spray was not obtained. It seems to be desirable to have some of technological intervention in the package of practice for apple growers so that we can be able to boost up the productivity and encourage the farmer to grow and earn more.

MATERIALS AND METHODS

Apple cultivar, Royal Delicious raised on Crab apple, *Malus sylvestris* (L.) Mill. seedling rootstock was established in Shimla district of Himachal Pradesh, typically a temperate zone of north-west Himalaya. The experiment was laid out for two consecutive seasons between 2015 and 2016. The experimental area experienced an annual average rainfall of about 800-1300 mm and temperature remains very low throughout the year. The commercial site representing similar rainfall and temperature pattern as well as soil types was selected. The principal objective of selecting site was to ascertain whether there was any interaction between variety and climate for productive potential of apple orchards. Trees of uniform age group (28-year) spaced at 6 m × 6 m were planted in north-south row orientation. This planting spacing resulted into a tree density of 277 trees ha^{-1} trained with the modified central leader system. Soil was sandy loam in texture with an average particle-size of sand (59.9%), silt (20.6%) and clay (18.8%). Water holding capacity and moisture content at field capacity at 15-30 cm depth were 64.80% and 22.10%, respectively. The experimental soil was towards neutral (pH 6.51) in reaction, 1.52% of soil organic carbon (SOC). The site had an initial available N (354 kg ha^{-1}), available P ($NaHCO_3$-extractable, 12.3 kg ha^{-1}) and available K (298.1 kg ha^{-1}), exchangeable Ca (24.5 mg kg^{-1}) and Mg (17.2 mg kg^{-1}). DTPA–extractable micronutrient cations in the soil were in sufficiency range, viz. zinc (Zn), manganese (Mn), iron (Fe) and copper (Cu) were 2.18, 34.2, 40.1 and 1.30 mg kg^{-1}, respectively.

The experiment was arranged as randomized completely block design (RCBD) with four replicates, three trees per treatment selected for each season. Different factor levels of NPK fertilizers in RCBD factorial matrix included as i) Urea (soil) + Urea (foliar) ii) C N + Urea iii) NPK (19:19:19 + Urea)+ Urea iv) NPK (12:32:16 + Urea)+ Urea; v) CAN + Urea. Three levels of N fertilizers (840 g $tree^{-1}$ 100% through soil + 20% as foliar application), 560 g $tree^{-1}$ 80% through soil + 20% as foliar application, and 420 g $tree^{-1}$ 60% through soil + 20% as foliar application of the blanket Recommended Dose of Fertilizers (RDF, 70:35:70) were adjusted. NPK mixture of 19:19:19 and 12:32:16 were applied during the month of December along with P, K fertilizers. NPK fertilizers sources referred were adjusted through splits of soil and foliar with Urea (46%N, 100%, 80%, 60% through soil along with 20% as foliar), CAN (25%N, 100%, 80%, 60% through soil along with 20% as foliar), calcium nitrate (CN, 15.5% N, 100%, 80%, 60% through soil along with 20% as foliar), water soluble 19:19:19+ Urea (100%, 80%, 20% through soil along with 20% as foliar) and 12:32:16+Urea (100%, 80%, 20% through soil along with 20% as foliar). The half of the dose of N, along with farm yard manure was applied fifteen days before flowering and the remaining half dose of N was applied one month after flowering, 30 cm away from the tree trunk as broadcast application, whereas, foliar application of Urea was done in two splits, first spray was applied one week after petal fall and other one after fifteen days of first spray. Besides, the fertilization management was conducted as foliar boric acid (1% w/w) at pink bud stage, and $CaCl_2$ (1% w/w) at fruit set to pea nut stage (20 mm fruit diameter) and the last stage of fruit growth (1-2 spray application at walnut stage to fruit about 80-90% of final size stage).

RESULTS AND DISCUSSION

Morphometric growth attributes

Morphometric vegetative growth traits of the trees was recorded at harvest in October month and the data depicted in Table 1 showed that maximum tree height (6.83 m) was recorded in CAN + Urea and minimum (6.10 m) in treatment (12:32:16 + Urea) + Urea. Among N levels, maximum (6.74 m) and minimum (5.95 m) tree height was recorded in soil + foliar application of 700 g N/tree and 560 g N/tree, respectively. Similarly, Urea (soil) + Urea (foliar) and CN + Urea registered maximum (6.14 m) and minimum (5.68 m) tree spread of apple trees, respectively. Among N levels, maximum (6.16 m) and minimum (5.65 m) tree spread was recorded in 700 g N/tree and 560 g N/ tree, respectively. However, among interactions, maximum (6.76 m) and minimum (5.24 m) tree spread was recorded in CAN+ Urea at 700 g N/tree and CN + Urea at 560 g/tree, respectively. The data also showed the effect of soil + foliar application of N sources and levels on tree girth was found significant. However, no difference was recorded in soil + foliar application for interactions. Among treatments, Urea (soil) + Urea (foliar) at 700 g N/tree resulted in maximum tree girth. The increase in tree girth may be attributed to increased cell size and number due to N fertilization. These findings are also supported by Fallahi *et al.* (2002). Dubey et *al* (2003) and Rathore and Chandra (2003) who

Table 1 Morphometric traits of 'Royal Delicious' apple at various soil and foliar N formulations

Fertilizer treatment (T) (Soil + Foliar)	Plant height (m)				Tree spread (m)				Tree girth (cm)				ASEG (cm)				Leaf area (cm^2)			
Rate (R)	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean
Urea + Urea	6.00	6.63	5.81	6.15	6.18	6.10	6.15	6.14	74.46	74.20	72.46	73.71	45.14	44.68	43.54	44.45	46.74	47.11	32.99	42.28
CN + Urea	6.37	7.01	5.69	6.36	5.29	6.50	5.24	5.68	71.54	72.45	70.81	71.60	51.21	54.07	50.79	52.02	47.20	50.13	45.81	47.71
(19:19:19 + Urea) + Urea	6.20	6.40	5.83	6.14	5.75	6.12	5.52	5.80	69.84	68.87	67.78	68.83	48.95	46.51	46.25	47.24	45.09	42.57	38.63	42.10
(12:32:16 + Urea) + Urea	6.05	6.33	5.91	6.10	5.89	5.33	5.92	5.71	69.59	69.55	65.57	68.24	48.64	46.39	45.78	46.94	42.89	42.81	37.75	41.15
CAN + Urea	6.66	7.32	6.51	6.83	5.71	6.76	5.44	5.97	70.56	71.91	70.21	70.89	59.59	62.30	59.72	60.54	49.10	50.63	46.62	48.78
Mean	6.26	6.74	5.95		5.76	6.16	5.65		71.20	71.40	69.37		50.71	50.79	49.22		46.20	46.65	40.36	
LSD (P=0.05)																				
T	0.32				0.22				1.93				0.89				0.90			
R	0.25				0.17				1.50				0.69				0.70			
T × R	NS				0.37				NS				1.54				1.56			

ASEG, annual shoot extension growth; NS, non-significant.

had also reported increase in tree girth with soil + foliar application of N. Among N sources, maximum (60.54 cm) and minimum (44.45 cm) shoot extension was recorded in CAN + Urea and Urea (soil) + Urea (foliar), respectively. Among N levels, maximum (50.79 cm) and minimum (49.22 cm) annual shoot growth was recorded in soil + foliar application of 700 g and 560 g N/tree, respectively. Among interactions, maximum (62.30 cm) annual shoot growth was recorded in soil + foliar application of CAN + Urea at 700 g N/tree and minimum (43.54 cm) in Urea (soil) + Urea (foliar) at 560 g N/tree. This increase in growth characters might be due to the fact that N is an integral part of chlorophyll which primarily absorbs light energy needed for photosynthesis, so it may be attributed to higher photosynthetic efficiency (Tisdale *et al.* 1997). The increase in tree height perhaps was brought about by an increase in the dimensions of individual cell both in pith and cortex region. These observations are also in conformity with the findings of other workers, who have also reported that N fertilization increase tree growth in citrus (Rathore and Chandra 2003). In case of cashew, also greatest plant height and mean canopy area was obtain with N application (Kumar *et al.* 2005*).* Gao *et al.* (1992), who had observed increase in shoot length of 'Fuji' apple by fertilizing the plants with nitrate in combination with ammonium N as compared to nitrate or ammonium forms alone. The effect of N sources, levels and their interactions was found significant for leaf area. Maximum (48.78 cm^2) leaf area was recorded in CAN + Urea and minimum (41.15 cm^2) in the treatment (12:32:16 + Urea) + Urea. Among N levels, maximum (46.65 cm^2) and minimum (40.36 cm^2) leaf area was recorded in soil + foliar application of 700 g N/tree and 560 g N/tree, respectively. Among the interactions, maximum (50.63 cm^2) and minimum (32.99 cm^2) leaf area was recorded in CAN + Urea at 700 g N/tree and Urea (soil) + Urea (foliar) at 560 g N/tree, respectively. Maximum leaf area was obtained with soil + foliar application of CAN + Urea at 700 g N/tree followed by CN + Urea at 700 g N/tree. This might be due to direct effect of N on leaf expansion by increasing net photosynthesis and growth of leaves. The results are in agreement with the reports of Marshner (1995) and Rackso *et al.* (2005).

Leaf chlorophylls and canopy attributes

The data depicted in Table 2 showed that total chlorophyll content was significantly affected by N sources, levels and their interactions. Between N sources, maximum (3.17 mg g^{-1}) chlorophyll content was registered in soil + foliar application of C N + Urea while, minimum (3.01 mg g^{-1}) was recorded in the treatment (12:32:16 + Urea) + Urea. Among N levels, maximum (3.13 mg g^{-1}) and minimum (3.05 mg g^{-1}) chlorophyll content was recorded in soil + foliar application of 700g N/tree and 840 g N/tree, respectively. Among interactions, maximum (3.23 mg g^{-1}) chlorophyll content was recorded in soil + foliar application of CAN + Urea at 700 g N/tree, whereas minimum (2.95 mg g^{-1}) was recorded in the treatment (12:32:16 + Urea)

Table 2 Leaf chlorophylls and canopy parameters of 'Royal Delicious' apple at various soil and foliar applied N formulations

Fertilizer treatment (T) (Soil + Foliar)	Total Chlorophylls (mg g^{-1})				TCSA (cm^2)				TCV (m^3)				CA (cm^2)			
Rate (R)	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean
Urea + Urea	3.00	3.15	3.16	3.10	441.4	438.3	418.0	432.6	132.8	116.9	115.9	121.9	119.9	116.8	118.8	118.5
CN + Urea	3.15	3.18	3.18	3.17	407.5	417.9	399.2	408.2	103.0	140.7	81.7	108.5	87.9	132.7	86.2	102.3
(19:19:19 + Urea) + Urea	3.00	3.11	3.13	3.08	388.3	377.6	365.8	377.2	111.0	122.0	93.4	108.8	103.8	117.6	95.7	105.7
(12:32:16 + Urea) + Urea	2.95	2.99	3.09	3.01	385.6	385.1	342.3	371.0	114.8	89.9	108.6	104.4	108.9	89.2	110.0	102.7
CAN + Urea	3.17	3.23	3.06	3.15	396.4	411.7	392.5	400.2	124.7	159.0	101.2	128.3	102.4	143.5	92.9	112.9
Mean	3.05	3.13	3.12		403.8	406.1	383.6		117.3	125.7	100.2		104.6	120.0	100.7	
LSD (P=0.05)																
T	0.06				0.55				2.82				0.35			
R	0.04				0.42				2.19				0.27			
T × R	0.10				0.94				4.89				0.61			

TCSA, trunk cross-sectional area; TCV, canopy volume; CA, crown area.

+ Urea at 840 g N/tree. Highest chlorophyll content was found in the leaves which were treated with soil + foliar application of CAN + Urea at 700 g N/tree. This agreement is in line with that of Guihong Bi *et al.* (2008), who also reported increase in chlorophyll content and leaf area with Urea spray. Similarly, maximum increase in TCSA (432.6 cm^2) in Urea (soil) + Urea (foliar), TCV (128.3 m^3) in CAN + Urea and CA (118.5 cm^2) in Urea (soil) + Urea (foliar) was recorded compared to other N sources applied. Further, the maximum canopy volume increment (128.31 m^3) was registered in soil + foliar application of CAN + Urea while, minimum (104.4 m^3) was recorded in the treatment (12:32:16 + Urea) + Urea. Among N levels, maximum (125.7 m^3) and minimum (100.2 m^3) canopy volume was recorded in soil + foliar application of 700 g and 560 g N/tree, respectively. Among interactions, maximum (159.04 m^3) canopy volume was recorded in soil + foliar application of CAN + Urea at 700 g N/tree and minimum (81.70 m^3) in CN + Urea at 560 g N/tree. Bakeer (2016) documented increased tree canopy volume with increased ammonium nitrate fertilizer application.

Fruit set, yield and yield efficiency

Among different N fertilizer sources tested, the flowering attributes were markedly influenced by conjoint combinations (Table 3). Maximum (33.04%) fruit set was registered in soil + foliar application of CAN + Urea while, minimum (24.87%) was recorded in Urea (soil) + Urea (foliar). Among N levels, maximum (32.02%) and minimum (25.31%) fruit set was recorded in soil + foliar application of 700 g and 560 g N/tree, respectively. Among interactions, maximum (36.69%) and minimum (21.19%) fruit set was recorded in soil + foliar application of CAN + Urea at 700g N/tree and in the treatment (19:19:19 + Urea) + Urea at 840 g N/tree, respectively. The higher fruit set was recorded in trees treated with soil + foliar application of CAN + Urea at 700 g N/tree, which was statistically at par with CN + Urea at 700 g N/tree. They also observed more fruit set with Urea sprays as compared to soil application alone. Similarly, Delver (1966) and Quast (1979) recorded maximum fruit set in apple with Urea sprays.

Main effects of N sources, levels and their interaction showed a significant influence on fruit yield. Between N sources, maximum (115.32 kg/tree) yield was registered in soil + foliar application of CAN + Urea while, minimum (87.60 kg/tree) was recorded in the treatment (12:32:16 + Urea) + Urea. Among N levels, maximum (105.62 kg/tree) and minimum (102.50 kg/tree) fruit yield was recorded in soil + foliar application of 700 g and 840 g N/tree, respectively. Among interactions, maximum (118.75 kg/tree) fruit yield was recorded in soil + foliar application of CAN + Urea at 700 g N/tree, whereas minimum (85.91 kg/tree) was observed in the treatment (12:32:16 + Urea) + Urea at 700 g N/tree. The increase in flowering and fruiting characters might be due to better growth and development of plant which produce higher yield components, resulted in early flowering as well as higher fruit yield. This

Table 3 Fruit set, yield and yield efficiency at various soil and foliar applied N formulations in Royal Delicious apple

Fertilizer treatment (T) (Soil + Foliar)	Fruit set (%)				Yield (Y, kg tree^{-1})				Yield efficiency															
									Y/TCSA (g m^{-2})				Y/TCV (kg m^{-3})				Y/CA (kg cm^{-2})				Y/LA (kg cm^{-2})			
Rate (R)	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean
Urea + Urea	24.82	27.65	22.15	24.87	106.20	107.59	103.93	105.91	0.241	0.245	0.249	0.245	0.800	0.92	0.897	0.872	0.89	0.92	0.88	0.897	2.27	2.28	3.15	2.57
C N + Urea	31.71	33.79	25.58	30.36	106.92	113.53	110.41	110.29	0.262	0.272	0.277	0.270	1.038	0.807	1.351	1.065	1.22	0.86	1.28	1.120	2.27	2.26	2.41	2.31
(19:19:19 + Urea) + Urea	21.19	32.30	24.23	25.91	97.40	102.31	99.59	99.77	0.251	0.271	0.272	0.265	0.877	0.839	1.066	0.927	0.94	0.87	1.04	0.950	2.16	2.4	2.58	2.38
(12:32:16 + Urea) + Urea	22.67	29.68	25.81	26.05	89.93	85.91	86.95	87.60	0.233	0.223	0.254	0.237	0.783	0.956	0.801	0.847	0.83	0.96	0.79	0.860	2.1	2.01	2.3	2.14
CAN + Urea	33.65	36.69	28.79	33.04	112.03	118.75	115.18	115.32	0.283	0.288	0.293	0.288	0.898	0.747	1.138	0.928	1.09	0.83	1.24	1.053	2.28	2.35	2.47	2.37
Mean	26.81	32.02	25.31		102.50	105.62	103.21		0.254	0.260	0.269		0.879	0.854	1.051		0.994	0.888	1.05		2.22	2.26	2.58	
LSD (P=0.05)																								
T	2.02				0.49				0.001				0.004				0.003				0.004			
R	1.56				0.38				0.001				0.003				0.002				0.003			
T × R	3.50				0.84				0.002				0.007				0.005				0.006			

TCSA, Trunk cross-sectional area; TCV, canopy volume; CA, crown area; LA, leaf area.

Table 4 Fruit quality traits at various soil and foliar applied N formulations in Royal Delicious apple

Fertilizer treatment (T) (Soil + Foliar)	Fruit dimension: Length (mm)				Fruit dimension: Width (mm)				Fruit weight (g)				Acidity (%)				TSS (°B)				Total sugars (%)			
Rate (R)	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean	840	700	560	Mean
Urea + Urea	67.24	72.90	71.48	70.54	71.38	75.75	72.32	73.15	203.5	206.4	203.9	204.6	0.24	0.22	0.21	0.22	12.43	13.21	12.64	12.76	9.20	9.09	8.86	9.05
C N + Urea	69.80	74.13	72.77	72.23	71.46	75.96	73.37	73.60	222.3	224.8	222.5	223.2	0.21	0.20	0.19	0.20	12.28	13.34	12.84	12.82	10.44	10.26	9.91	10.20
(19:19:19 + Urea) + Urea	70.51	71.41	68.20	70.04	73.91	75.20	74.58	74.56	197.1	197.6	196.5	197.1	0.25	0.22	0.20	0.23	13.19	12.04	11.73	12.32	8.95	8.88	8.86	8.90
(12:32:16 + Urea) + Urea	66.88	70.40	67.79	68.36	71.13	72.95	72.09	72.06	185.5	186.2	184.7	185.5	0.23	0.21	0.20	0.21	13.02	12.46	12.24	12.57	8.39	7.83	7.72	7.98
CAN + Urea	70.19	77.41	73.33	73.64	73.79	79.30	75.92	76.34	228.1	230.3	228.7	229.0	0.21	0.21	0.19	0.20	12.16	13.88	12.28	12.77	9.27	9.15	8.79	9.07
Mean	68.92	73.25	70.71		72.33	75.83	73.66		207.3	209.1	207.2		0.23	0.22	0.20		12.62	12.99	12.35		9.25	9.04	8.83	
LSD (P=0.05)																								
T	2.57				2.12				4.14				0.01				NS				0.13			
R	1.99				1.64				NS				N/S				0.37				0.10			
T × R	NS				NS				NS				0.02				0.84				0.22			

TSS, total soluble solids; NS, non-significant.

observation is in agreement with that of Badyal (1980), who also observed that the Urea sprays applied in addition to soil dressing to Santa Rosa plum trees increased fruit yield. Similarly, Fisher and Cook (1950) found that foliar Urea sprays in apple increased fruit set and yield. These observations indicate that foliar Urea sprays may increase yields more efficiently than soil N applications. The foliar Urea applications increased both fruit number and yield in apple (Cheng *et al.* 2002). To examine the performance of the apple trees onto N fertilizers application independently of tree spacing, the yield efficiencies were also computed. The yield bearing surface per hectare described by the TCSA, TCV, CA and leaf area (LA), i.e. the rate of area covered by the bearing surface. The best YE (yield/TCSA) was noticed in CAN + Urea (0.288 m^{-2}), yield/TCV (1.065 m^{-3}) in CN + Urea, yield/CA (1.120 cm^{-2}) in C N + Urea, and it was significantly differ from all other N fertilizer sources (Table 4). The YE (yield/LA) was lowest in treatment (12:32:16 + Urea) + Urea (2.14 kg cm^{-2}).

Fruit quality characteristics

The fruit physical-biochemical traits were also significantly influenced with various N fertilizer inputs (Table 4). Main effects of N sources and levels showed significant influence on fruit length, whereas, the effect of interactions was found to be non-significant. Maximum (76.34 mm) and minimum (72.06 mm) fruit width was recorded in soil + foliar application of CAN + Urea and in (12:32:16 + Urea) + Urea, respectively. Among N levels, maximum (75.83 mm) and minimum (72.33 mm) fruit diameter was recorded in soil + foliar application of 700 g and 840 g N/tree, respectively. The highest fruit size and weight was found in trees treated with soil + foliar application of CAN + Urea at 700 g N/tree followed by C N + Urea at 700 g N/tree. The possible reason for increase in fruit size and weight by calcium might be due to faster mobilization of metabolites in the fruits and involvement in cell division and cell expansion as well as increase in the volume of intercellular space in mesocarpic cells. In general this observation is in agreement with those of Dong *et al.* (2005) and Kundu *et al.* (2007), who also observed foliar N applied as Urea increased the size of apples and guava, respectively. Soluble solids content in fruit is a good indicator sugar content of apples and presumably of sweetness (Hochn *et al.* 2003). Maximum increase in total soluble solids was recorded in soil + foliar application of CAN + Urea at 700 g N/tree. The effect of N sources and interactions on fruit acidity was found significant, whereas effect of N level was found non-significant. Between N sources, maximum (0.23%) titratable acidity was registered in (19:19:19 + Urea) + Urea and Urea (soil) + Urea (foliar) while, minimum (0.20%) was recorded in CN + Urea and CAN + Urea. Among interactions, maximum (0.25%) titratable acidity was recorded in soil + foliar application of 19:19:19 + Urea at 840 g N/tree, whereas minimum (0.19 %) was observed in CAN + Urea at 560 g N/tree and C N + Urea at 560 g N/tree. Between N sources, a maximum

(10.2%) total sugar was registered in soil + foliar application of CN + Urea while, minimum (7.98%) was recorded in treatment (12:32:16 + Urea) + Urea. Among N levels, maximum (9.25%) and minimum (8.83%) total sugar was recorded in soil + foliar application of 840g and 560 g N/ tree, respectively. Among interaction between N sources and levels, maximum (10.44%) total sugar was recorded in soil + foliar application of CN + Urea at 840 g N/tree and minimum (7.72%) in treatment (12:32:16 + Urea) + Urea at 560 g N/tree. Stamper *et al.* (2002) also recorded increase in total soluble solids, total sugars, firmness and malic acid with foliar application of N on apple.

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