COMPARATIVE EFFECT OF NATURAL AND CHEMICAL FARMING SYSTEMS OF APPLE PRODUCTION ON SOIL PHYSIO-CHEMICAL PROPERTIES, LEAF MINERAL CONTENT AND FRUIT QUALITY

Abstract

The present study was conducted to compare the effects of natural and chemical farming system of apple production on soil, leaf nutrient status and fruit quality. The results indicated significant difference in primary (N, P, K) and secondary ((6.12, 0.48 dS m^{-1}) in CFS than NFS (5.77, 0.38 dS m^{-1}), while OC was reported to be higher (2.03 %) in Ca, Mg) macronutrient status of leaf and soil samples collected from the study orchards ($p<0.05$). Among micronutrients, status of Cu and Zn were recorded to be significantly different in both the farming systems whereas, Fe and Mn were recorded to be non-significant. Soil pH and EC were recorded to be higher NFS than CFS (1.78 %). Fruit length, breath, weight and TSS showed significant difference in both the farming systems. Mean fruit length, breadth, weight, and acidity was recorded to be higher (65.80 mm, 71.62 mm, 159.65 g, 0.64 %) in CFS than NFS (58.87 mm, 62.72 mm, 122.41 g, 0.48 %). While firmness and TSS were recorded to be higher (6.95 kg $inch^{-2}$, 12.27 ºBrix) in NFS than CFS (5.64 kg $inch^{-2}$, 10.91 ºBrix). It can be concluded that nutrient status of soils and leaves was higher in CFS.

Keywords: *Leaf and soil analysis, fruit quality analysis*

Introduction

As people have become more health conscious, there is a growing desire for food that is devoid of chemicals (Pillai et al., 2021). Natural farming is one of the non-chemical disease management strategies that farmers are presently utilising. Natural farming involves using only natural methods and no chemicals. For crop growth, biological fertilizers including cow dung, cow urine, jaggery and pulse flour are used in place of chemical fertilizers in this chemical-free strategy. In comparison to chemical methods, this new emerging method of farming has many advantages including an increase in soil fertility, yield and produce quality as well as protection from the negative effects of chemical methods such as magnification, pollution, and carcinogenic elements (Bishnoi and Bhati, 2017).

The chemical properties of soil change significantly when conventional farming is replaced by organic farming, which is likely to alter the processes that determine soil fertility. These modifications also alter the availability of minerals to crops, either directly by enhancing nutrient pools or inadvertently by affecting the soil environment. Studies comparing conventional and organic agricultural methods have revealed that organically farmed soils contain higher soil organic matter (SOM) and mineral levels (Herencia et al., 2008). However, the information on how various management strategies affect soil qualities is still contradictory. Gosling and Shepherd (2005) claim that the substantial overlap in management approaches makes comparing organically and conventionally managed systems challenging and complex. The present studies were conducted to know the difference in leaf and soil nutrient status and fruit quality in natural and chemical farming systems of apple production.

Materials and Methods

Orchard sites and management practices

The present study was focused on commercial apple orchards in three different blocks (Theog, Jubbal, Rohru) of Shimla district of Himachal Pradesh. The experiment took place in adjacent commercial, irrigated apple orchards, one natural and one conventional, each approximately 1.0 ha in size, to avoid any pedoclimatic impact. In total, five orchards under natural farming system (NFS) and five orchards under chemical farming system (CFS) of apple production were selected for comparison. The variety used was "Starking Delicious" grafted onto seedling rootstock. All the sampled trees were of uniform age and size. Detailed description of study orchard sites has been mentioned in Table 1. Also, the practices followed by the farmers of study orchard sites in both the farming systems has been mentioned in Table 2.

Table 1. *Description about study orchard sites*

Sites	Village/Block	Abbreviated Term	Elevation (m amsl)	GPS Co-ordinates
Site 1	Lafughati (Theog)	LG	2300	*NFS - 31°10'21.3"N 77°22'38.5"E
				**CFS - 31°10'49.5"N 77°22'31.3"E
Site 2	Sariuoon (Theog)	SR	2203	NFS - 31°7'38.7"N 77°23'4.8"E
				CFS - 31°7'48.6"N 77°23'14.2"E
Site 3	Himari (Theog)	HM	2218	NFS - 31°7'59.5"N 77°23'24.7"E
				CFS - 31°7'52.9"N 77°24'8.9"E
Site 4	Mandhol (Jubbal)	MD	1083	NFS - 31°7'50.5"N 77°42'48.5"E
				CFS - 31°7'51.3"N 77°42'49.2"E
Site 5	Sainji (Rohru)	SJ	1876	NFS - 31°12'20.6"N 77°47'24.9"E
				CFS - 31°12'10.8"N 77°47'14.3"E

*NFS- Natural Farming System

**CFS- Chemical Farming System

Table 2. Information about the practices followed by the farmers of study orchard sites

Practices	Natural Farming System	Chemical Farming System
Mulching	Straw mulch	Straw mulch
Green manuring	Pea, rajmah, mustard, sunflower, French bean, coriander, potato, maize	nil
Farm yard manure	Applied in the form of ghanjeevamrit (4 kg $plant^{-1}$)	5-10 kg $plant^{-1}$
Chemical fertilizer	nil	Urea- 1 kg $plant^{-1}$ Calcium nitrate- 1 kg $plant^{-1}$ MOP- 1 kg $plant^{-1}$ 12:32:16 or 15:15:15 – 1 kg $plant^{-1}$ SSP – 300 g $plant^{-1}$
Jeevamrit	Once in a month as 10% foliar spray and drenching @ 8-10 L $plant^{-1}$	nil
Weed control	Manually	Manually
Pests and diseases control	➢ Buttermilk- against foliar diseases ➢ Stem paste (turmeric, linseed oil, cow urine, cow dung, soil, garlic, green chilli, walnut leaves, and asafoetida) – against soil borne diseases ➢ Bhramastra, Agniastra, Ash, Sonthastra- against insect-pests (On the onset of diseases/ insect-pests at an interval of 10-15 days)	Captan (600 g 200 L^{-1}) at green tip stage Mancozeb (600 g 200 L^{-1}) at walnut stage Carbendazim (100 g 200 L^{-1}) at pink bud stage Tebuconazole (126 ml 200 L^{-1}) at walnut stage or pre harvest Hexaconazole (100 ml 200 L^{-1}) petal fall Fenazaquin (50 ml 200 L^{-1})- against mites at fruit development Malathion (200 ml 200 L^{-1})- at pre harvest stage for aphids Chloropyriphos (400 ml 200 L^{-1}) – against woolly apple aphid

Leaf and soil sampling

From each selected orchard, ten randomly chosen trees were sampled for leaf analysis from 15th July to 15th August. Approximately 40 healthy leaves were collected from each sampled tree, at shoulder height from middle portion of terminal shoots of current year growth (Kenworthy, 1964). One composite sample of leaves per orchard was collected and placed in paper bags and transferred to the laboratory. Cleaning of leaves was done with distilled water followed by washing with 0.1N HCl and then with double distilled water. Drying of samples was done by spreading them on blotting paper in shade. After removal of external moisture, the leaves were kept in paper bags again and dried in oven at 65 ± 5°C till they attain constant weight and then grinding was done to ensure adequate mixing of plant material. Grinded samples were stored in paper bags for the estimation of leaf primary (N, P, K), secondary (Ca, Mg) macronutrients and micronutrients (Cu, Fe, Mn, Zn) status (Chapman, 1964).

Representative soil samples were collected in the month of October at a 30-cm depth according to sampling procedure zig-zag or "W" pattern (Pennock et al., 2008) using a 5 cm diameter auger after the removal of the above ground biomass. Five soil samples were collected per orchard and one composite sample was prepared. This composite sample was taken to the laboratory for estimation of physico-chemical properties (pH, EC, organic carbon), primary (N, P, K), secondary (Ca, Mg) macronutrients and micronutrients (Cu, Fe, Mn, Zn) status.

Leaf and soil analysis

For the mineral analysis, leaf samples were treated using standard procedures (as mentioned in Table 3). The contents of the plant macronutrients (N, P, K, Ca, and Mg) are expressed as the percentage of dry weight; the contents of the plant micronutrients (Cu, Fe, Zn and Mn) are expressed as ppm.

The soil samples were air-dried and ground to 2 mm prior to analysis. Estimation of soil physico-chemical properties (pH, EC, and organic carbon); macronutrients (N, P, K, Ca, and Mg) and micronutrients (Cu, Fe, Zn and Mn) content was done as per the methods mentioned in Table 4.

Table 3. *Methods followed for the analysis of leaf samples*

Sr. No.	Parameters	Method
1.	Nitrogen (%)	Microkjeldhal method (Jackson, 1973)
2.	Phosphorus (%)	Vanado-molybdate phosphoric yellow colour method (Jackson, 1973)
3.	Potassium (%)	Flame photometer (Jackson, 1973)
4.	Calcium (%)	Atomic absorption spectrophotometer (Sarma et al., 1987)
5.	Magnesium (%)	Atomic absorption spectrophotometer (Sarma et al., 1987)
6.	Copper (ppm)	Atomic absorption spectrophotometer (Sarma et al., 1987)
7.	Iron (ppm)	Atomic absorption spectrophotometer (Sarma et al., 1987)
8.	Manganese (ppm)	Atomic absorption spectrophotometer (Sarma et al., 1987)
9.	Zinc (ppm)	Atomic absorption spectrophotometer (Sarma et al., 1987)

Table 4. *Methods followed for the analysis of soil samples*

Sr. No.	Parameters	Method
1.	pH	1:2 Soil: water suspension, measured with digital pH meter (Jackson, 1973)
2.	EC	1:2 Soil: water suspension, measured with digital EC meter (Jackson, 1973)

3.	OC	Walkley and Black wet digestion method (Walkley and Black, 1934)
4.	Nitrogen (%)	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
5.	Phosphorus (%)	Olsen's method (Olsen et al., 1954)
6.	Potassium (%)	Ammonium acetate method (Merwin and Peech, 1951)
7.	Calcium [cmol(p^+) kg^{-1}]	Ammonium acetate method (Merwin and Peech, 1951)
8.	Magnesium [cmol(p^+) kg^{-1}]	Ammonium acetate method (Merwin and Peech, 1951)
9.	Copper (ppm)	Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978)
10.	Iron (ppm)	Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978)
11.	Manganese (ppm)	Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978)
12.	Zinc (ppm)	Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978)

Fruit quality analysis

Five fruits per tree were collected at the commercial harvest to access different physical and biochemical parameters. Among physical attributes, fruit dimensions were estimated with the use of a digital vernier scale (0.05 mm accuracy) and were represented in millimeters (mm). Fruit weight was measured on a top pan electronic balance. The average weight of fruits was taken and the values were expressed in grams (g). Fruit colour was determined by using Royal Horticultural Chart made by Royal Horticultural Society London. Fruit firmness was determined using Effegi Penetrometer model FT and the values were expressed in pound per square inch (kg $inch^{-2}$). Among biochemical attributes, total soluble solids were evaluated using an Erma Hand Refractometer (0-32) by squeezing a drop of fruit juice onto its prism. Refractometer was calibrated with distilled water before use. After each test, the prism plate was washed with distilled water and wiped with a soft cloth. The results were expressed in °Brix. For the estimation of titratable acidity, twenty-five grams of pulp of fruit samples was homogenized with distilled water in an electric blender and volume was made to 250 ml. The contents were filtered through Whatman No. 1 filter paper. 10 ml of the extract was taken and then titrated against 0.1 N NaOH solution using phenolphthalein indicator. The appearance of light pink colour indicated the end point. The results were expressed as per cent of fresh weight of the fruit pulp. Following formula was used to calculate the titratable acidity:

$$\text{Titratable acidity (TA, \%)} = \frac{T \times N \times V1 \times E}{V2 \times W \times 1000} \times 100$$

Where,

T = Titre value

N = Normality of NaOH

V1 = Volume made

E = Equivalent weight of acid

V2 = Volume of extract

W = Weight of sample (g)

Statistical Analysis

The data recorded was analyzed by using MS-Excel and T test was followed for the comparison (Gomez and Gomez, 1984).

Results

Effect of farming systems on leaf macronutrient status

From the perusal of data presented in Table 5, leaf nitrogen content under NFS ranged from 1.81 to 1.91 per cent whereas, under CFS it ranged from 2.07 to 2.72 per cent. Mean nitrogen content of leaves was recorded to be lower under NFS (1.86 %) as compared to CFS (2.43 %). Phosphorus content of leaves under NFS ranged from 0.11 to 0.24 per cent while, under CFS it ranged from 0.26 to 0.31 per cent. Mean phosphorus content of leaves was recorded to be lower under NFS (0.17 %) as compared to CFS (0.28 %). Potassium content of leaves under NFS and CFS ranged from 1.40 to 1.47 per cent and 1.52 to 1.81 per cent, respectively. Mean potassium content of leaves was recorded to be lower under NFS (1.43 %) as compared to CFS (1.66 %). Calcium content of leaves under NFS ranged from 1.56 to 1.63 per cent while, under CFS it ranged from 1.87 to 2.10 per cent. Mean calcium content of leaves was recorded to be lower under NFS (1.60 %) as compared to CFS (1.94 %). Magnesium content of leaves under NFS ranged from 0.22 to 0.29 per cent while, under CFS it ranged from 0.29 to 0.36 per cent. Mean magnesium content of leaves was recorded to be lower under NFS (0.26 %) than CFS (0.31 %).

Table 5. *Comparison of primary and secondary macronutrient status of leaves under natural and chemical farming systems of apple production*

	NFS					CFS				
Parameter / Location	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
LG	1.89	0.17	1.40	1.61	0.24	2.07	0.27	1.61	1.91	0.31
SR	1.91	0.13	1.41	1.58	0.22	2.41	0.31	1.63	1.87	0.29
HM	1.87	0.11	1.44	1.63	0.27	2.35	0.26	1.52	2.10	0.33
MD	1.81	0.24	1.47	1.56	0.29	2.63	0.28	1.73	1.95	0.36
SJ	1.83	0.21	1.45	1.62	0.29	2.72	0.29	1.81	1.89	0.30
Range	1.81-1.91	0.11-0.24	1.40-1.47	1.56-1.63	0.22-0.29	2.07-2.72	0.26-0.31	1.52-1.81	1.87-2.10	0.29-0.36
Mean	1.86	0.17	1.43	1.60	0.26	2.43	0.28	1.66	1.94	0.31
CV	2.23	31.42	2.01	1.82	11.89	10.47	6.82	6.76	4.74	8.73

SE	0.02	0.02	0.01	0.01	0.01	0.11	0.01	0.05	0.04	0.01
t	4.96	4.28	4.36	7.96	3.00					
P	0.007	0.002	0.007	0.0005	0.017					

Effect of farming systems on leaf micronutrient status

Micronutrient (Cu, Fe, Zn, Mn) status of leaves collected from the study orchards was estimated and presented in Table 6. Copper content of leaves under NFS ranged from 11.20 to 13.20 ppm while, under CFS it ranged from 13.70 to 16.90 ppm. Mean copper content in leaves was recorded to be lower under NFS (12.30 ppm) as compared to CFS (15.28 ppm). Leaf iron content under NFS ranged from 104 to 117 ppm and under CFS it ranged from 136 to 154 ppm. Mean iron content was recorded to be lower under NFS (110.40 ppm) as compared to CFS (146.80 ppm). Zinc content of leaves under NFS ranged from 23.60 to 39.09 ppm while, under CFS ranged from 29.40 to 49.80 ppm. Mean leaf zinc content was recorded to be lower under NFS (31.70 ppm) as compared to CFS (42.27 ppm). Manganese content of leaves under NFS ranged from 28.80 to 91.20 ppm and under CFS it ranged from 31.60 to 94.30 ppm. Mean manganese content was recorded to be lower under NFS (47.02 ppm) as compared to CFS (53.66 ppm).

Table 6. *Comparison of micronutrient status of leaves under natural and chemical farming systems of apple production*

	NFS				**CFS**			
Parameter / Location	**Cu (ppm)**	**Fe (ppm)**	**Zn (ppm)**	**Mn (ppm)**	**Cu (ppm)**	**Fe (ppm)**	**Zn (ppm)**	**Mn (ppm)**
LG	12.30	104.00	37.03	29.70	16.90	144.00	49.83	31.60
SR	11.70	114.00	39.09	28.80	13.70	149.00	48.03	35.30
HM	13.10	107.00	31.07	30.30	15.20	154.00	41.02	47.20
MD	11.20	110.00	23.62	55.10	14.00	136.00	29.41	59.90
SJ	13.20	117.00	27.73	91.20	16.60	151.00	44.27	94.30
Range	11.20-13.20	104.00-117.00	23.60-39.09	28.80-91.20	13.70-16.90	136.00-154.00	29.40-49.80	31.60-94.30
Mean	12.30	110.40	31.70	47.02	15.28	146.80	42.27	53.66
CV	7.06	4.73	20.22	57.55	9.54	4.80	19.00	47.11
SE	0.39	2.34	2.87	12.10	0.65	3.15	3.61	11.30
t	3.92	9.27	2.34	0.4				

P	0.004	1.483	0.047	0.698				

Effect of farming systems on soil physio-chemical properties

Soil pH under NFS and CFS ranged from 5.33 to 6.41 and 5.73 to 6.62, respectively (Table 7). EC ranged from 0.22 to 0.51 dS m^{-1} under NFS while under CFS it ranged from 0.42 to 0.57 dS m^{-1}. EC was recorded to be more under CFS (0.48 dS m^{-1}) as compared to NFS (0.38 dS m^{-1}). Soil OC in the study orchard sites under NFS and CFS ranged from 1.85 to 2.15 per cent and 1.51 to 1.94 per cent, respectively. Mean soil OC was recorded to be higher under NFS (2.03 %) than CFS (1.77 %).

Table 7 *Comparison of physio-chemical properties of soils under natural and chemical farming systems of apple production*

	NFS			CFS		
Parameter / Location	**pH**	**EC (dS m^{-1})**	**OC (%)**	**pH**	**EC (dS m^{-1})**	**OC (%)**
LG	5.33	0.22	2.14	5.73	0.43	1.91
SR	5.61	0.47	2.15	6.11	0.51	1.94
HM	6.41	0.30	1.98	6.62	0.46	1.79
MD	5.76	0.39	1.85	6.32	0.42	1.51
SJ	5.76	0.51	2.04	5.83	0.57	1.74
Range	5.33-6.41	0.22-0.51	1.85-2.15	5.73-6.62	0.42-0.57	1.51-1.94
Mean	5.77	0.38	2.03	6.12	0.48	1.78
CV	6.87	31.60	6.10	5.92	13.01	9.62
SE	0.18	0.05	0.06	0.16	0.03	0.08
t	1.44	1.66	2.68			
P	0.19	0.14	0.02			

Effect of farming systems on soil macronutrient status

Soil primary (N, P, K) and secondary (Ca, Mg) macronutrient status was estimated and compared for both the systems (Table 8). Nitrogen status of soils under NFS ranged from 342 to 391 kg ha^{-1}, while under CFS it ranged from 379 to 414 kg ha^{-1}. Mean nitrogen content of soil was recorded to be lower under NFS (368 kg ha^{-1}) as compared to CFS (397 kg ha^{-1}). Phosphorus content of soils under NFS ranged from 59.80 to 67.78 kg ha^{-1}, while under CFS it ranged from 61.80 to 81.70 kg ha^{-1}. Mean phosphorus content of soil was recorded to be lower under NFS (64.28 kg ha^{-1}) as compared to CFS (73.00 kg ha^{-1}). Potassium content of soils under NFS ranged from 312 to 418 kg ha^{-1}, while under CFS it ranged from 377 to 523 kg ha^{-1}. Mean potassium content of soil was recorded to be lower under NFS (355.80 kg ha^{-1})

as compared to CFS (428 kg ha^{-1}). Calcium content of soils under NFS ranged from 3.11 to 3.92 cmol(p^+) kg^{-1}, while under CFS it ranged from 4.11 to 4.92 cmol(p^+) kg^{-1}. Mean calcium content of soil was recorded to be lower under NFS [3.53 cmol(p^+) kg^{-1}] as compared to CFS [4.53 cmol(p^+) kg^{-1}]. Magnesium content of soils under NFS ranged from 1.47 to 1.95 cmol(p^+) kg^{-1}, while under CFS it ranged from 2.03 to 3.07 cmol(p^+) kg^{-1}. Mean magnesium content of soil was recorded to be lower under NFS 1.74 cmol(p^+) kg^{-1} as compared to CFS 2.57 cmol(p^+) kg^{-1}.

Table 8. Comparison of primary and secondary macronutrient status of soils under natural and chemical farming systems of apple production

Parameter / Location	NFS					CFS				
	N ($kg\ ha^{-1}$)	P ($kg\ ha^{-1}$)	K ($kg\ ha^{-1}$)	Ca [$cmol(p^+)\ kg^{-1}$]	Mg [$cmol(p^+)\ kg^{-1}$]	N ($kg\ ha^{-1}$)	P ($kg\ ha^{-1}$)	K ($kg\ ha^{-1}$)	Ca [$cmol(p^+)\ kg^{-1}$]	Mg [$cmol(p^+)\ kg^{-1}$]
LG	349.00	66.02	343.00	3.51	1.76	379.00	76.10	377.00	4.72	2.36
SR	342.00	63.67	339.00	3.11	1.95	390.00	72.30	399.00	4.32	3.07
HM	377.00	67.78	312.00	3.44	1.85	398.00	81.70	523.00	4.62	2.62
MD	381.00	64.13	418.00	3.67	1.47	404.00	73.10	438.00	4.11	2.03
SJ	391.00	59.80	367.00	3.92	1.69	414.00	61.80	403.00	4.92	2.77
Range	342-391	59.8-67.78	312-418	3.11-3.92	1.47-1.95	379-414	61.8-81.70	377-523	4.11-4.92	2.03-3.07
Mean	368.00	64.28	355.80	3.53	1.74	397.00	73.00	428.00	4.53	2.57
CV	5.79	4.65	11.21	8.46	10.41	3.36	9.95	13.42	7.11	15.42
SE	9.53	1.34	17.83	0.13	0.08	5.97	3.25	25.68	0.14	0.18
t	2.57	2.48	2.3	5.12	4.23					
P	0.032	0.038	0.049	0.0008	0.002					

Effect of farming systems on soil micronutrient status

Micronutrient (Cu, Fe, Zn and Mn) status of the collected soil samples was also estimated and presented in Table 9. Copper content of soils under NFS ranged from 3.96 to 5.10 ppm, while under CFS it ranged from 4.90 to 6.32 ppm. Mean copper content of soil was recorded to be lower under NFS (4.71 ppm) as compared to CFS (5.50 ppm). Iron content of soils under NFS ranged from 25.30 to 49.60 ppm, while under CFS it ranged from 36.20 to 51.30 ppm. Iron content of soil was recorded to be lower under NFS (36.22 ppm) as compared to CFS (44.12 ppm). Zinc content of soils under NFS ranged from 3.11 to 3.82 ppm, while under CFS it ranged from 3.89 to 5.11 ppm. Mean zinc content of soil was recorded to be lower under NFS (3.58 ppm) as compared to CFS (4.38 ppm). Manganese content of soils under NFS ranged from 17.30 to 39.90 ppm, while under CFS it ranged from 24.10 to 41.70 ppm. Mean manganese content of soil was recorded to be lower under NFS (25.84 ppm) as compared to CFS (31.74 ppm).

Table 9 *Comparison of micronutrient status of soils under natural and chemical farming systems of apple production*

Parameter / Location	NFS				CFS			
	Cu (ppm)	**Fe (ppm)**	**Zn (ppm)**	**Mn (ppm)**	**Cu (ppm)**	**Fe (ppm)**	**Zn (ppm)**	**Mn (ppm)**
LG	3.96	33.70	3.71	25.60	4.90	37.90	3.99	27.70
SR	4.77	49.60	3.82	23.10	5.71	51.30	3.89	24.10
HM	4.92	35.20	3.65	17.30	6.32	45.70	4.12	33.10
MD	5.10	25.30	3.11	39.90	5.63	36.20	4.81	41.70
SJ	4.80	37.30	3.61	23.30	4.97	49.50	5.11	32.10
Range	3.96-5.10	25.30-49.60	3.11-3.82	17.30-39.90	4.90-6.32	36.20-51.30	3.89-5.11	24.10-41.70
Mean	4.71	36.22	3.58	25.84	5.50	44.12	4.38	31.74
CV	9.32	24.18	7.67	32.65	10.65	15.40	12.38	20.89
SE	0.20	3.92	0.12	3.77	0.26	3.04	0.24	2.97
t	2.43	1.59	2.95	1.22				
P	0.04	0.14	0.01	0.25				

Effect of farming systems on fruit quality

Fruit quality parameters like fruit length, breadth, weight, firmness, total sugar solids (TSS), titratable acidity and colour were evaluated for both the farming systems and compared (Table 10). Fruit length, breadth, and weight under NFS ranged from 52.92 to 62.56 mm, 55.0 to 68.70 mm, and 98.00 to 143.05 g, whereas under CFS these parameters ranged from 61.07 to 73.44 mm, 66.60 to 77.50 mm and 119.80 to 191.80 g. All these parameters were recorded to be comparatively lower under NFS (58.87 mm, 62.72 mm, 122.41 g) than CFS (65.80 mm, 71.62 mm, 159.65 g). Overall, per cent decrease over CFS for length, breadth and weight was found to be -11.85, -14.36 and -31.10 per cent, respectively. Fruit firmness under NFS ranged from 5.90 to 8.40 kg inch^{-2}, while under CFS it ranged from 3.20 to 8.40 kg inch^{-2}. Mean firmness was recorded to be higher under NFS (6.95 kg inch^{-2}) as compared to under CFS (5.64 kg inch^{-2}). Total soluble solids of fruits under NFS ranged from 11.40 to 13.20 °Brix, while under CFS it ranged from 9.90 to 11.95 °Brix. Mean total soluble solids of fruits was recorded to be higher under NFS (12.27 °Brix) as compared to CFS (10.91 °Brix). Titratable acidity of fruits under NFS ranged from 0.40 to 0.53 per cent, while under CFS it ranged from 0.44 to 0.83 per cent. Mean titratable acidity of fruits was recorded to be lower under NFS (0.48 %) as compared to CFS (0.64 %).

Table 10. *Comparison of fruit quality parameters under natural and chemical farming systems of apple production*

Parameter / Location	NFS							CFS							Per cent decrease over CFS		
	Length (mm)	**Breadth (mm)**	**Weight (g)**	**Firmness (Kg inch^{-2})**	**TSS (°Brix)**	**Acidity (%)**	**Colour**	**Length (mm)**	**Breadth (mm)**	**Weight (g)**	**Firmness (Kg inch^{-2})**	**TSS (°Brix)**	**Acidity (%)**	**Colour**	**Length**	**Breadth**	**Weight**
LG	57.60	59.90	98.00	5.90	13.20	0.40	Red Group 46 A	61.07	67.10	119.80	3.20	11.50	0.44	Red Group 45 C	-6.03	-12.05	-22.24
SR	62.56	67.80	143.05	6.20	12.25	0.50	Red Group 46 A	67.84	77.20	161.67	3.90	11.95	0.83	Red Group 45 C	-8.45	-13.94	-13.01
HM	60.70	55.00	126.30	7.60	12.25	0.45	Red Group 46 A	65.18	66.60	173.80	5.10	9.90	0.51	Red Group 44 B	-7.38	-21.13	-37.61
MD	52.92	62.20	102.00	8.40	11.40	0.50	Red Group 46 A	61.48	69.70	151.20	7.60	10.10	0.63	Red Group 44A	-16.18	-11.96	-48.24
SJ	60.60	68.70	142.70	6.66	12.27	0.53	Red Group 44C	73.44	77.50	191.80	8.40	11.10	0.80	Red Group 44C	-21.20	-12.71	-34.41
Range	52.92-62.56	55.0-68.7	98.0-143.05	5.90-8.40	11.40-13.20	0.40-0.53		61.07-73.44	66.6-77.5	119.80-191.8	3.20-8.40	9.90-11.95	0.44-0.83				
Mean	58.87	62.72	122.41	6.95	12.27	0.48		65.80	71.62	159.65	5.64	10.91	0.64		-11.85	-14.36	-31.10
CV	6.41	9.07	19.60	14.87	5.19	10.95		7.75	7.47	16.52	40.37	8.12	26.83				
SE	1.69	2.54	10.59	0.46	0.28	0.02		2.28	2.39	11.88	1.02	0.40	0.08				
t	2.44	2.54	2.51	1.17	2.79	2.05											
P	0.04	0.03	0.036	0.27	0.023	0.074											

Discussion

Significant difference was found between the primary (N, P, K) and secondary (Ca, Mg) macronutrient status of leaves in natural and conventional farming systems of apple. These findings are in conformity with those of Kumar et al. (2020). They analyzed leaves of turmeric and sorghum and found that amount of mean N, P, K, Ca, Mg, Fe, Mn, Cu and Zn in leaves was more under CFS as compared to NFS. While in paddy, higher micronutrients (Fe, Mn, Cu and Zn) were observed in CFS as compared to NFS. However, in some cases, reverse results were also obtained for micronutrients.

Soil pH was recorded to be lower under NFS (5.77) as compared to CFS (6.12). Soil pH was found slightly acidic to near neutral in study orchard sites. Under NFS, soil pH was comparatively more acidic than CFS because of the soil application of jeevamrit which is acidic in nature. Also, application of jeevamrit increases the soil microbial activity ultimately increasing the biochemical reactions in soil and thus making the soil more acidic (Kaur 2020). Electrical conductivity (EC) values in apple orchards ranged between 0.11 and 0.86 dS m^{-1} and safe limits suitable for EC should be less than 0.8 dS m^{-1} for all crops (Sharma and Sood 2020). EC can be used as an indicator of the extended use of fertilizers in soil. An increase in the EC in conventionally managed soils could be due to the higher input of salts (in the form of chemical fertilizers and/or pesticides). Mean soil OC was recorded to be higher under NFS than CFS. These results are consistent with those of Rana (2018) who examined the impact of organic nutrient sources on the production and quality of French beans. He reported that the application of soil organic amendments such as panchgavya and jeevamrit increases soil organic carbon. Mulching practices done under NFS has been reported to significantly increase the soil organic carbon (Smith et al. 2020). On the contrary, opposite results have been reported by Sanchez et al. (2007), who found low SOM (< 2 %) in the topsoil under an organic fruit production system.

Significant difference was found between the primary (N, P, K) and secondary (Ca, Mg) macronutrient status of soils in natural and conventional farming systems of apple. The available K and Ca values in the conventionally managed soil was higher than those in the organically managed soils due to the application of mineral fertilizers (Gasparatos et al., 2011). Numerous studies have shown a K deficiency in the organic farms due to the lower input of nutrients (Stockdale et al., 2001; Berry et al., 2003; Gosling and Shepherd, 2005).

All the nutrients were found to be higher under CFS than NFS because under CFS chemical fertilizers are applied from past many years which may have resulted in increased nutrient content of the chemical orchards. While, there is slow release of nutrients from natural formulations applied in the initial years under NFS resulting in less nutrients (Pathania, 2020). The application of various agrochemicals, such as pesticides (Cu containing fungicides) and synthetic fertilizers (containing Cu and Zn), could account for the increased concentration of Cu and Zn in the chemical farming system.

The effects of conventional and organic management systems on soil chemical properties and leaf nutrients under Mediterranean conditions were studied over a two-year period on adjacent commercial apple orchards in Southern Greece. The results indicated no significant differences in soil chemical properties between the different management systems, including soil organic matter, pH, CEC, and C/N ratio. However, soil samples from the conventional orchards established significantly higher concentrations of K, Ca, Na, Cu and Zn, which were likely the result of chemical fertilizer application. Also, leaf analysis revealed higher concentration of Zn in conventionally grown trees (Gasparatos et al., 2011).

Significant difference was found in length, breath, weight and TSS of fruits from both the farming systems. Mean fruit length, breadth, weight, and acidity was recorded to be higher in CFS than NFS. While firmness and TSS was recorded to be higher in NFS than CFS. Similar results were also reported by Jan and Davide (2017). They reported that fruits from organic farming were 5.46 per cent smaller and 16.23 per cent lighter than fruits from conventional production. The large fruit size in the conventional farming system may be due to the good availability of soil nutrients that produced vigorous plants with higher yield and larger fruits. But large sized fruits were also observed with the use of high amount of organic matter which may be due to improvement in the physical and chemical properties of the soil (Zahra, 2016). Amarante et al. (2008) reported that the yield and tree size of organic apples were smaller than the conventional ones. The difference between organic and conventional systems in terms of mean fruit weight of cultivar was reported to be non-significant in strawberry (Macit et al., 2007). Maher et al. (2020) reported that perlite (75 %) + cocopeat (25 %) + jeevamrit (5 %) resulted in good quality fruits of strawberry under polyhouse conditions. The improvement in quality characteristics of fruits could be ascribed to improved soil physical properties such as decrease in bulk density, water holding capacity, porosity, and chemical properties (tendency of soil pH towards neutral) and incremental growth of microorganisms like bacteria, fungi, actinomycetes in soil. Better growth of plants and porous soil might have favoured accumulation of higher sugars and less acidity. The tree received dual vermi-compost and FYM which produced better quality attributes (increase in TSS and less acidity). No significant differences were found between conventional, certified organic and organic samples for titratable acidity (de Castro et al., 2014). According to Amarante et al. (2008), apples from organic orchards had lower titratable acidity than fruits from conventional orchards.

Conclusion

The nutrient status was found to be higher in leaf and soil samples collected from orchards under chemical farming system of apple production. Fruit length, breath, weight and TSS showed significant difference in both the farming systems. Mean fruit length, breadth, weight, and acidity was recorded to be higher in CFS than NFS. While, firmness and TSS were recorded to be higher in NFS than CFS. This may be due to small sample size studied and being a new concept, farmers selected were practicing natural farming from last four years only.

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Data Availability

All data generated or analyzed during the study are included in this article.

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