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Effect of Inorganic and Organic Fertilisers on Yield and Soil Nutrient Status of Walnut Orchard

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was aimed to determine the effect of integrated application of inorganic and organic fertilisers on nut yield and soil nutrient status of walnut orchard under temperate region of India (Kashmir) during year 2011 and 2012. The experiment consisted of four selections [SKAU/002 (S_1), SKAU/008 (S_2), SKAU/024 (S_3) and SKAU/040 (S_4)] of walnut and six mineral treatments [T_1 (100% NPK recommended as per package of practices), T_2 {100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)}, T_3 (75% NPK inorganic fertilizers + 25% FYM), T_4 (75% NPK inorganic fertilizers + 25% vermicompost), T_5 (75% NPK inorganic fertilizers + 25% poultry manure) and T_6 {75% NPK inorganic fertilizers + 25% manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure)} replicated five times and three trees in each replication in Factorial Randomized Block Design. All fertilizers and manures were applied in the first week of December beneath the tree canopy and mixed well with soil. Maximum yield 6.82 kg/tree and nut weight, 13.66 g in selection SKAU/024 were obtained with the application of 75% NPK through inorganic fertilizers + 25% through vermicompost .Combined application improved soil nutrient status. Highest available nitrogen (338.59 kg/ha), phosphorus (20.80 kg/ha) and calcium (1312.25ppm), available zinc (1.19 ppm), manganese (66.66 ppm), iron (55.95 ppm) and copper content (2.74 ppm) was found in treatment 75% NPK through inorganic fertilizers + 25% through

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vermicompost, whereas, maximum available potassium (259.27 kg/ha) and magnesium (268.86 ppm) was observed in treatment {100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)}. The application of 75% fertilizer through inorganic coupled with 25% vermicompost enhanced yield as well as soil nutrient status followed by treatment 75% fertilizer through inorganic coupled with 25% poultry manure.

Keywords: Chemical fertilizers; organic manure; nutrients; soil; walnut.

1. INTRODUCTION

Jammu and Kashmir state has created a special place in the international trade of walnuts. The entire export of the country comes from Jammu and Kashmir state. In Jammu and Kashmir state walnut is grown on an area of about 89788 ha with annual production of about 163745 metric tons [1] with the productivity of 1.823 metric tons per hectare. It produces about 98 per cent of the total production in India.

The demand of quality walnuts is increasing day by day in the national and international market, but production of walnut is still low as compared to China, USA, France and other developed countries. Production of horticultural crops has undergone enormous changes in the recent years due to the development of innovative technologies including nutrient management practice. The nutrient management of walnut is one of the important factors to boost the yield and improve the quality of nuts. The application of fertilizers to add N, P and K have influenced the growth of tree and production of fruits like chestnut, grapes, pears, figs and walnut trees [2,3,4]. Fertilization treatments have the potential for increasing growth and nut production of walnuts [5]. Though the chemical farming helped the farmers to accomplish new strides in horticulture, but their indiscriminate and unscrupulous use in horticulture/agriculture has led to deterioration of soil health. The increased use of fertilizers in non-judicious manner, has led to diminishing soil productivity and multiple nutrient deficiencies. The gravity of environmental degradation caused by the faulty cultivation practices has led to focus on ecologically sound, viable and sustainable farming systems.

Minimizing use of chemical fertilizers in fruit growing is a goal of integrated fruit production [6,7]. Recently, environmental aspects of plant nutrient application have received much interest. The organic manures, when applied to soil increases the fertility status of soil and favourably influence the crop yield for several years. It has been reported that farm yard manure, vermicompost and poultry manure have increased growth, yield and quality in different crops [8,9,10]. Application of vermicompost along with mineral fertilizers has given encouraging results in terms of crop productivity and maintenance of soil health [11]. Korwar et al. [12] also reported that, the application of vermicompost and FYM, along with chemical fertilizers resulted in the maintenance of the physical, chemical and biological properties of soil. Thus it has been realised that use of chemical fertilisers must be integrated through more economic and eco-friendly organic manures in order to achieve the substantial productivity with minimum deleterious effect of chemical fertilisers on soil health and environment. Therefore the main objective of this study was to study the influence of conjoint application of both inorganic and organic fertilisers on walnut yield and available soil nutrient status of the orchard.

2. MATERIALS AND METHODS

The experimental orchard is located at Ambri Apple Research Station Pahnoo Shopian, India. This experimental farm is located at 33.72°N latitude and 74.83°E longitudes, at an elevation of 2057 m above msl, representing high hill zone of the state. The climate of the area is typically temperate. Before application of manures and chemical fertilisers a composite soil sample of the experimental orchard was drawn and analysed soil sample of the orchard contained available nitrogen (308 Kg/ha), phosphorus (17.5 Kg/ha), potassium (230 Kg/ha), exchange calcium (1197.45 ppm), magnesium (160.23 ppm), iron (48.90), zinc (0.98 ppm), copper (2.58 ppm), manganese (64.20 ppm) and organic carbon (0.98) with pH of 6.82. The studies were conducted on 9 years old four bearing selections {SKAU/002 (S_1), SKAU/008 (S_2), SKAU/024 (S_3), SKAU/040 (S_4), of walnut grafted on seedling rootstock during year 2011 and 2012. For the conduct of experiment, trees with uniform age and vigour, placed at 6 m × 6 m were selected. The treatments were laid out in Randomised

complete block design (Factorial), containing five replications of three tree each. The details of treatment are T_1 (100% NPK recommended as per package of practices through inorganic fertilizers), T_2, T_3 (75% NPK through inorganic fertilizers + 25% through manure (FYM), T_4 (75% NPK through inorganic fertilizers + 25% through manure (vermicompost), T_5 (75% NPK through inorganic fertilizers + 25% through manure (poultry manure) and T_6 (75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM+ 1/3 Vermicompost +1/3 poultry manure). The recommended dose during first year is 200 g N, 50 g P and 200 g K and during second year 250 g N, 60 g P and 250 g K using urea, DAP and MOP as inorganic fertilizer source. There were 24 treatment combinations. Farm yard manure, vermicompost; poultry manure and inorganic fertilizer were applied to each replication as per the treatment details. All fertilizers and manures were applied in the first week of December beneath the tree canopy and mixed well with soil up to 10 cm depth. Chemical composition of organic fertilizers used for the experiment is given in Table 1.

After harvesting, the nuts from each tree were dehulled, dried, weighed and expressed in kg per tree. The weight of ten nuts randomly selected was recorded using an electronic balance and the average nut weight was expressed in grams (g). Soil samples before implementation of the experiment and after harvest of crop were collected at a depth of 0-50cm for analysis of macro and micronutrients. Soil samples were oven dried at 60℃ for 48 hours and ground to pass through a 40 mesh screen. Available nitrogen was estimated by alkaline potassium permanganate distillation method [13]. Available phosphorus content of soil was determined by Olsen's extractant (0.5N $NaHCO_3$ at pH 8.5) and colour was developed by using ammonium molybdate and $SnCl_2$. The colour intensity was measured on spectrophotometer at 660 nm wavelength [14]. Available potassium, calcium and magnesium were determined photometrically, after extracting with neutral normal ammonium acetate as described by Jackson [14]. Micro-nutrients cations (zinc, manganese, iron and copper) were extracted in the soil by DTPA (0.005MDTPA+ 0.1M $CaCl_2$+ 0.1 M TEA at pH 7.3) extraction procedure [15]. The quantitative measurement was carried out on an atomic absorption spectrophotometer. The organic carbon content (%) of a finely ground soil sample was determined as per procedure given by Walkley and Black's [16]. The pH of soil samples was determined with the help of Systronics glass electrode pH meter in 1:2 soil water suspensions [14]. Statistical analyses were conducted using the SAS and means were compared by critical difference (C.D) at 0.05 probability level.

3. RESULTS AND DISCUSSION

Highest fruit yield (5.87 kg/tree) was found in (75% NPK through inorganic fertilizers + 25% through vermicompost) followed by (75% NPK through inorganic fertilizers + 25% through poultry manure) (5.30 kg/tree) and {75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure)} (4.92 kg/tree). Maximum nut weight in selection SKAU/008 (12.56 g) followed by selection SKAU/040 (12.48 g) and least nut weight (11.97) was observed in selection SKAU/002 while as among treatments maximum nut weight (13.16 g) was found in 75% NPK through inorganic fertilizers + 25% through manure vermicompost and minimum nut weight (11.68 g) in {100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)}. This increase in nut parameter with combined application of vermicompost and inorganic fertilisers might be due to the fact that vermicompost might have improved the soil texture and provided micronutrients such as zinc, iron, copper, manganese etc. and better microbial establishment in the soil. The biological activity of the micro-organism would have helped the soil to become ready to serve as zone for essential nutrients to plant root system. Zinc is involved in the biochemical synthesis of the most important phytohormone IAA through the pathways of conversion of tryptophan to IAA. Iron is involved in the chlorophyll synthesis besides being part of co-enzymes of respiratory of respiratory chain reaction. Copper and manganese are important activators of co-enzymes. Organic manures in combination with inorganic fertilisers must have helped in metabolic changes through the supply of such important micro-nutrients and enzyme activation which ultimately must have improved nut parameters [17]. The increase in fruit parameters have been reported by different workers in several crops, Khan et al. [18] in peach, Kumar et al. [19] in plum, and Raina et al. [20] in apple.

Table 1. Chemical composition of organic fertilizers used for the experiment

Parameter / Manure	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Organic carbon (%)
FYM	0.68	0.32	0.73	0.72	0.18	144.20	62.24	15.30	2.4	10.22
Vermicompost	2.48	0.89	1.67	0.82	0.17	162.15	71.50	22.00	3.72	17.85
Poultry manure	2.97	0.95	1.19	1.84	0.41	202.81	52.50	18.00	2.93	14.55

Table 2. Effect of integrated nutrient management on nut yield and nut weight

Treatment	Average of 2011 and 2012									
	Yield /tree (Kg)					Nut weight (g)				
	SKAU /002	SKAU /008	SKAU /024	SKAU /040	Mean	SKAU /002	SKAU /008	SKAU /024	SKAU /040	Mean
NPK (recommended as per package of practices) through inorganic fertilizers	4.89	5.11	4.60	4.22	**4.70**	11.45	12.97	11.22	12.52	**12.04**
100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)	4.87	5.19	4.59	4.20	**4.71**	11.35	11.70	11.23	12.43	**11.68**
75% NPK through inorganic fertilizers + 25% through manure (FYM)	4.88	5.33	4.94	4.24	**4.85**	11.23	12.43	11.72	12.59	**11.99**
75% NPK through inorganic fertilizers + 25% through manure (vermicompost)	6.00	6.82	5.41	5.27	**5.87**	12.93	13.66	12.87	13.19	**13.16**
75% NPK through inorganic fertilizers +25% through manure (poultry manure)	5.19	5.79	5.03	5.18	**5.30**	12.70	12.50	12.13	12.21	**12.38**
75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure)	4.85	4.97	5.21	4.64	**4.92**	12.15	12.09	12.03	11.95	**12.05**
Mean	**5.11**	**5.53**	**4.96**	**4.62**		**11.97**	**12.56**	**11.87**	**12.48**	
C.D≤0.05 (Selection)	**0.32**					**0.57**				
C.D≤0.05 (Treatment)	**0.36**					**0.04**				

Table 3. Effect of integrated nutrient management on soil nitrogen and phosphorus

Treatment	Average of 2011 and 2012									
	N (Kg/ha)					P (Kg/ha)				
	SKAU/ 002	SKAU/ 008	SKAU/ 024	SKAU/ 040	Mean	SKAU /002	SKAU /008	SKAU /024	SKAU /040	Mean
NPK (recommended as per package of practices) through inorganic fertilizers	314.29	322.17	322.03	320.88	**319.84**	19.12	19.87	19.61	19.3	**19.47**
100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)	319.36	323.26	332.69	323.67	**324.74**	19.76	19.84	19.51	19.45	**19.64**
75% NPK through inorganic fertilizers + 25% through manure (FYM)	333.68	324.44	327.73	334.51	**330.09**	19.07	19.24	19.25	18.77	**19.08**
75% NPK through inorganic fertilizers + 25% through manure (vermicompost)	339.64	332.06	339.04	343.6	**338.59**	21.03	21.51	20.58	20.09	**20.8**
75% NPK through inorganic fertilizers +25% through manure (poultry manure)	334.44	327.42	336.54	324.12	**330.63**	19.63	20.04	19.36	18.83	**19.46**
75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure)	318.45	320.41	315.33	316.1	**317.57**	19.52	19.52	19.12	18.39	**19.14**
Mean	**326.64**	**324.96**	**328.89**	**327.15**		**19.69**	**20**	**19.57**	**19.14**	
C.D≤0.05 (Selection)	**NS**					**NS**				
C.D≤0.05 (Treatment)	**12.43**					**0.62**				

Table 4. Effect of integrated nutrient management on soil Potassium and calcium

Treatment	Average of 2011 and 2012									
	Potassium (Kg/ha)					Calcium (ppm)				
	SKAU/002	SKAU/008	SKAU/024	SKAU/040	Mean	SKAU/002	SKAU/008	SKAU/024	SKAU/040	Mean
NPK (recommended as per package of practices) through inorganic fertilizers	250.07	250.78	249.99	250	**250.21**	1242.44	1238.28	1239 .12	1232.62	**1238.11**
100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)	260.72	260.11	259.74	256.51	**259.27**	1284.88	1285.85	1285.28	1289.84	**1286.46**
75% NPK through inorganic fertilizers + 25% through manure (FYM)	251.94	251.62	252.36	253.05	**252.24**	1277.77	1277.12	1283.89	1277.45	**1279.056**
75% NPK through inorganic fertilizers + 25% through manure (vermicompost)	257.6	255.48	256.71	255.75	**256.39**	1289.34	1294.27	1291.39	1289.94	**1291.23**
75% NPK through inorganic fertilizers +25% through manure (poultry manure)	255.72	254.09	253.65	253.78	**254.31**	1291.06	1284.62	1287.01	1284.88	**1286.89**
75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure)	256.25	255.17	254.31	253.28	**254.75**	1288.17	1278.62	1290.45	1288.65	**1286.46**
Mean	**255.38**	**254.54**	**254.46**	**253.73**		**1278.94**	**1276.46**	**1279.52**	**1277.23**	
C.D≤0.05 (Selection)	**NS**					**NS**				
C.D≤0.05 (Treatment)	**4.26**					**NS**				

Table 5. Effect of integrated nutrient management on soil magnesium and zinc

Treatment	Average of 2011 and 2012									
	Magnesium (ppm)					Zinc (ppm)				
	SKAU/002	SKAU/008	SKAU/024	SKAU/040	Mean	SKAU/002	SKAU/008	SKAU/024	SKAU/040	Mean
NPK (recommended as per package of practices) through inorganic fertilizers	265.95	265.06	266.28	264.41	**265.43**	0.78	0.77	0.65	0.81	**0.75**
100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)	268.32	268.61	269.07	269.43	**268.86**	1.31	1.15	1.12	1.05	**1.16**
75% NPK through inorganic fertilizers + 25% through manure (FYM)	266.78	266.78	267.66	266.49	**266.93**	1.01	0.95	1.03	0.87	**0.96**
75% NPK through inorganic fertilizers + 25% through manure (vermicompost)	266.78	266.41	266.28	265.84	**266.33**	1.21	1.10	1.21	1.24	**1.19**
75% NPK through inorganic fertilizers +25% through manure (poultry manure)	266.88	266.95	266.24	266.91	**266.74**	1.17	1.09	1.03	1.17	**1.11**
75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure)	267.81	267.25	267.65	266.38	**267.27**	1.10	1.10	1.07	1.18	**1.11**
Mean	**267.09**	**266.84**	**267.2**	**266.58**		**1.09**	**1.02**	**1.02**	**1.05**	
C.D≤0.05 (Selection)	**NS**					**NS**				
C.D≤0.05 (Treatment)	**NS**					**0.12**				

Table 6. Effect of integrated nutrient management on soil iron and manganese

Treatment	Average of 2011 and 2012									
	Iron (ppm)					Manganese (ppm)				
	SKAU /002	SKAU /008	SKAU /024	SKAU /040	Mean	SKAU /002	SKAU /008	SKAU /024	SKAU /040	Mean
NPK (recommended as per package of practices) through inorganic fertilizers	51.32	51.51	51.35	52.13	**51.58**	63.71	64.02	63.88	64.2	**63.95**
100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)	54.93	54.78	54.42	54.56	**54.67**	66.4	66.47	66.9	66.87	**66.66**
75% NPK through inorganic fertilizers + 25% through manure (FYM)	52.93	51.88	52.28	53.18	**52.57**	65.41	65.48	65.91	65.88	**65.67**
75% NPK through inorganic fertilizers + 25% through manure (vermicompost)	57.03	55.74	55.52	55.49	**55.95**	65.37	65.72	66.29	66.17	**65.89**
75% NPK through inorganic fertilizers +25% through manure (poultry manure)	53.09	53.00	53.09	53.47	**53.16**	64.65	65.2	64.87	65.64	**65.09**
75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure)	54.03	54.20	53.93	53.68	**53.96**	65.66	65.81	65.77	65.34	**65.65**
Mean	**53.89**	**53.52**	**53.43**	**53.75**		**65.2**	**65.45**	**65.6**	**65.68**	
C.D≤0.05 (Selection)	**NS**					**NS**				
C.D≤0.05 (Treatment)	**2.56**					**0.35**				

Table 7. Effect of integrated nutrient management on soil copper and organic carbon

Treatment	Average of 2011 and 2012									
	Copper (ppm)					Organic Carbon (%)				
	SKAU /002	SKAU /008	SKAU /024	SKAU /040	Mean	SKAU /002	SKAU /008	SKAU /024	SKAU /040	Mean
NPK (recommended as per package of practices) through inorganic fertilizers	2.64	2.60	2.62	2.61	**2.62**	1.18	1.19	1.17	1.17	**1.18**
100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)	2.70	2.70	2.72	2.71	**2.71**	1.43	1.44	1.44	1.44	**1.43**
75% NPK through inorganic fertilizers + 25% through manure (FYM)	2.62	2.60	2.64	2.65	**2.63**	1.34	1.32	1.31	1.32	**1.32**
75% NPK through inorganic fertilizers + 25% through manure (vermicompost)	2.75	2.75	2.75	2.73	**2.74**	1.30	1.32	1.29	1.32	**1.31**
75% NPK through inorganic fertilizers +25% through manure (poultry manure)	2.69	2.68	2.71	2.70	**2.69**	1.28	1.30	1.28	1.31	**1.29**
75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure)	2.71	2.71	2.72	2.70	**2.71**	1.30	1.30	1.30	1.31	**1.30**
Mean	**2.68**	**2.67**	**2.69**	**2.68**		**1.29**	**1.30**	**1.30**	**1.31**	
C.D≤0.05 (S)	**NS**					**NS**				
C.D≤0.05 (T)	**0.03**					**0.09**				

Table 8. Effect of integrated nutrient management on soil pH

Treatment	Average of 2011 and 2012				
	pH (ppm)				
	SKAU/002	SKAU/008	SKAU/024	SKAU/040	Mean
NPK (recommended as per package of practices) through inorganic fertilizers	6.67	6.60	6.60	6.50	**6.59**
100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%)	6.10	6.03	6.10	5.96	**6.05**
75% NPK through inorganic fertilizers + 25% through manure (FYM)	6.36	6.42	6.40	6.43	**6.40**
75% NPK through inorganic fertilizers + 25% through manure (vermicompost)	6.50	6.39	6.36	6.46	**6.43**
75% NPK through inorganic fertilizers +25% through manure (poultry manure)	6.82	6.54	6.54	6.57	**6.62**
75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure)	6.23	6.06	6.20	6.03	**6.13**
Mean	**6.44**	**6.34**	**6.36**	**6.33**	
C.D≤0.05 (S)	**NS**				
C.D≤0.05 (T)	**NS**				

Macro-nutrient availability in soil was significantly influenced by integrated application of organic and inorganic fertilizers (Tables 2 and 3). It is evident from the present findings that maximum available nitrogen (338.59 kg/ha) was observed in treatment 75% NPK through inorganic fertilizers + 25% through manure (vermicompost) and differs significantly from all other treatments while the minimum available N (317.57 kg/ha) was recorded in treatment 75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure). Phosphorus availability was highest (20.80 kg/ha) in treatment 75% NPK through inorganic fertilizers + 25% through manure (vermicompost) and lowest phosphorus (19.08 kg/ha) availability was observed when 75% NPK through inorganic fertilizers + 25% through manure (FYM) was applied. Potassium availability was highest (259.27 Kg/ha) with 100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%) application but the value was statistically at par with the treatment, 75% NPK through inorganic fertilizers + 25% through manure (vermicompost) and lowest (250.21 Kg/ha) in treatment NPK (recommended as per package of practices) through inorganic fertilizers. Available NPK status of the soil might have increased due to enhanced mineralization of organic nitrogen and phosphorus with application of organic manures [21]. The combination of nitrogen fertilizer with vermicompost might have reduced nitrogen losses, in addition to increasing the availability of soil nitrogen. Nethera et al. [22] have also reported that vermicompost plus chemical fertilizer increases the availability of N, P and K. The increase in P with the application of vermicompost might be due to the fact that phosphatase activity in the gut of earthworms convert bound P to soluble form thus making more P available to the plants. Mixing of inorganic and organic fertilizers reduces nitrogen losses, phosphorus fixation, increases biological fixation and improve fertilizer use efficiency. This might be due to the reason that more NPK is absorbed with the application of vermicompost along with chemical fertilizer application. Different workers reported enhanced available N, P and K with conjoint application of organic and inorganic fertilizers [20,23,24,25]. Zhao et al. [26] also found increased available N, P and K content in treatment containing inorganic fertilizer plus farm yard manure as compared to inorganic treatment alone. The effect of different fertilizer treatments on available calcium and magnesium was non-significant with the different fertilizer treatments (Tables 3 and 4). Highest available calcium was observed with treatment 75% NPK through inorganic fertilizers + 25% through manure (vermicompost) while the lowest with treatment 100% NPK (recommended as per package of practices) through inorganic fertilizers. This which may be due to production of acids during mineralization and subsequently causing release of calcium and magnesium from the parent material.

Tables 4, 5 and 6 revealed that availability of micronutrient like iron, zinc and copper and manganese were significantly influenced by different fertilizer treatments. Maximum available zinc content (1.19 ppm) was found when 75% NPK + 25% manure (vermicompost) while the minimum Zn (0.75 ppm) was observed with the application of 100% NPK. Maximum available copper (2.74 ppm) content was obtained with the application of 75% NPK inorganic fertilizers + 25% vermicompost and the minimum (2.62 ppm) with the application of 100% NPK. Available manganese content was maximum (66.66 ppm) in treatment 75% NPK through inorganic fertilizers + 25% through manure (vermicompost) and minimum (63.95 ppm) in treatment 100% NPK. Treatment 75% NPK through inorganic fertilizers + 25% through manure (vermicompost) differs significantly from treatments 100% NPK (recommended as per package of practices) through inorganic fertilizers, 75% NPK through inorganic fertilizers + 25% through manure (FYM), and 75% NPK through inorganic fertilizers +25% through manure (poultry manure) but is at par with 100% through manure (FYM 50% + vermicompost 25% + poultry manure 25%) and 75% NPK through inorganic fertilizers + 25% through manure (1/3 FYM + 1/3 vermicompost + 1/3 poultry manure) with regard to available iron content of soil. Highest availability of Fe, Cu, Zn and Mn in present study by conjoint application of vermicompost and inorganic fertilizer may be ascribed to enhance microbial activity in soil and consequent release of organic substances (chelating agent) which could have prevented micronutrients from precipitation, fixation, oxidation and leaching [27]. The higher availability of micronutrients in vermicompost treated plots might be because of its inherent capacity to add good amount of organic carbon content to soil which hastens process of mineralization of organically bound micronutrients in native soil [28]. Different workers have reported improved micronutrient availability with combined application of organic

and inorganic fertilizers in different crops [21,29,24,20].

Soil pH was not influenced significantly by different fertilizer treatments. However, organic carbon showed marked differences within different treatments. Highest soil organic carbon (1.43%) was observed with 100% manure (FYM 50% + vermicompost 25% + poultry manure 25%) application while lowest soil organic carbon (1.18%) was found in treatment NPK 100% NPK (recommended as per package of practices) through inorganic fertilizers (Table 6). The improvement in physical properties of soil with organic manure application might be attributed to increased organic matter of the soil and improved soil structure. Similar observations in organic carbon have been reported by different workers [30,12,20]. Muzaffar et al. [30] also found that conjoint application of bio-fertilizers 80 g/tree, vermicompost 20 kg/tree, FYM 20 kg/tree, green manure (GM) sunnhemp (*Crotalaria juncea* L.) and recommended dose of fertilizers (RDF) of Nitrogen, Phosphorus and Potassium (NPK), resulted in significantly maximum organic carbon (1.90%), soil pH (6.89), soil N (405.56%), P (22.02%), K (419.00%), Iron (Fe) (66.92 ppm), Maganese (61.95 ppm), Zinc (2.33 ppm) and Cupper (3.25 ppm)

4. CONCLUSION

Combined application of inorganic fertilisers and organic manures exerted a significant role in improving walnut yield, macro and micro nutrient status of soil. Among the fertilizer amendments studied, the application of 75% NPK coupled with 25% vermicompost enhanced greatest yield and enhanced better soil nutrient status followed by the application of 75% NPK + 25% poultry manure.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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