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Studies on impact of organic manures on soil secondary and micro nutrients following two year vegetable cropping pattern (Okra-Dhaincha-Broccoli)

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Abstract
A study was conducted at Organic Farming Research Centre of SKUAST -Jammu to find out the impact of organic manures on soil secondary and micro nutrients following two-year vegetable cropping pattern. Significant results were obtained in Iron with highest value 32.69 kg ha^{-1} observed in T_8 in okra and 33.68 kg ha^{-1} in broccoli. No significant changes were observed in Exchangeable calcium and Magnesium, Total Nitrogen and in DTPA Copper, Zinc and Manganese in this two-year experiment, however it is possible that after a certain period of time change can be noticed in certain secondary and micro-nutrient availability.

Keywords: Exch, calcium, exch, magnesium, DTPA copper, zinc, manganese and iron

Introduction
Nutrients are the basic need to crop production. The role of both primary and secondary nutrients is depicted in the final outcome, i.e. yield. Ponisio *et al.* (2014) through their meta-analysis showed that organic yields are only 19.2% lower than conventional yields, a smaller yield gap than previous estimates. The nutrients released after the biological breakdown of the soil organic matters supply the nutrients essential for plant growth in organic farming. However, in general, the mineralization rates of soil organic matter is slow both in humid tropical and humid arid region (Fernandez *et al.* 2006 and Mary and Sanchez 1990) (9). Therefore, to establish and maintain soil secondary and micro nutrients content to a certain level in such regions through the continuous application of compost can be effective strategies in organic farming. However, climate and soil significantly affect the accumulation and storage of nutrients in the soil because of the interactions of temperature and moisture on plant productivity. Organic manures as organic fertilizer enriched with all beneficial soil microbes and also contain all the essential soil secondary and micro nutrients. Using organic manures not only supply plant nutrients but also increase the tendency to tolerate and resist the biotic and abiotic stresses to ensure produce quality (Barker and Bryson, 2006) [1]

Material and Method
Available Sulphur
The available sulphur content of soil was extracted by calcium chloride (0.15 percent $CaCl_2.2H_2O$). The sulphur content in the leachate was estimated by adopting barium sulphateturbidometry method using spectrophotometer at 420 nm wavelength (Black, 1965) [2].

Total N
The total N was analyzed by MicroKjeldahl's method using di acid extract. (Humphries 1956) [6]

Exchangeable calcium and Magnesium
Exc. Ca and Mg was analyzed by technique used by Jackson (1973) [7].

Available Micronutrients
Available micronutrients Zn, Cu, Mn and Fe were analyzed through DTPA extractable method (Lindsay and Norvell 1978) [8].

Statistical Analysis
The data on various characters studied during the course of investigation were statistically analyzed by using Tukey's test with an aim to figure out which groups in our sample differ by using "Honest Significant Difference," a number that represents the distance between groups, to compare every mean with every other mean.

Experimental details

The experiment consisted of following 10 treatments

Treatments	Input	Qty. applied tonne ha^{-1} on the basis of Nitrogen requirement *,**
T_1	No application	Nil
T_2	Farm Yard Manure	10.00
T_3	Vermicompost	6.60
T_4	Poultry Manure	2.91
T_5	Neem Cake	2.00
T_6	Farm Yard Manure + Poultry Manure	5 + 1.45
T_7	Farm Yard Manure + Neem Cake	5 + 1.00
T_8	Vermicompost + Poultry Manure	3.30 + 1.45
T_9	Vermicompost + Neem Cake	3.30 + 1.00
T_{10}	Neem Cake + Poultry Manure	1.00 + 1.45

*Blanket application of FYM @10 tonne ha^{-1} was done
**Dhaincha was incorporated as a source of green manure

Crop and Site Detail
- Total treatments: -10
- Total replications: -3
- Total no. of plots: -30
- Design: RCBD

Okra
- Spacing: -45cms (Row) X 30cms (Plant)
- Variety: -Seli Special
- Seed rate: -20-25 kg ha^{-1}
- N: P: K requirement: -100:60:60

Broccoli
- Spacing: -60cms (Row) X 45cms (Plant)
- Variety: -Early Green
- Seed rate: -300-400g ha^{-1}
- N: P: K requirement: -120:60:60

Dhaincha
- Dhaincha seed was broadcasted in the experimental field @ 50 kg ha^{-1} and green matter was incorporated 45 DAS.

Experimental site: Organic Farming Research Centre of SKUAST -Jammu

Results
Available Sulphur (AS)
The S values are presented in Table 1. In year 2016, S values were found to be non-significant as minor variations in treatments were observed as compared to control. The maximum S observed was 11.88 kg ha^{-1} in okra and 12.85 kg ha^{-1} in broccoli in T_8. Due to the additive effects of organic manures the S trend was continuously observed in increasing pattern as compared to time. The individual and combined applications showed better response as compared to control. In individual applications the T_4 had relatively highest S value (11.68 kg ha^{-1} in okra and 12.64 kg ha^{-1} in broccoli); however, in combinations the highest value observed was 11.88 kg ha^{-1} in case of okra and 12.85 kg ha^{-1} in broccoli in T_8 as stated above.

Table 1: Effect of organic manures on Available Sulphur (kg ha^{-1}) content of soil

S	Okra			Broccoli		
Treatment	2016	2017	Mean	2016	2017	**Mean**
T1: Control	11.22	12.62	11.92	12.14	13.65	12.90
T2: FYM	11.64	13.13	12.39	12.58	14.16	13.37
T3: VC	11.66	13.09	12.38	12.61	14.18	13.40
T4: PM	11.68	13.14	12.41	12.64	14.21	13.43
T5: NC	11.47	13.11	12.30	12.63	14.20	13.42
T6: FYM + PM	11.82	13.16	12.49	12.78	14.38	13.58
T7: FYM + NC	11.85	13.30	12.58	12.82	14.42	13.62
T8: VC + PM	11.88	13.33	12.61	12.85	14.46	13.66
T9: VC + NC	11.70	13.35	12.53	12.65	14.24	13.45
T10: NC + PM	11.87	13.36	12.62	12.84	14.44	13.64

*As per Tukey's Post-hoc analysis, the values are non-significant.

In 2017, also the S was found to be non-significant among the treatments as values followed the same pattern with minor variations. Highest to lowest value observed was 13.36 kg ha^{-1} (T_{10}) to 12.62 kg ha^{-1} (T_1) in okra and 14.44 kg ha^{-1} (T_{10}) to 13.65 kg ha^{-1} (T_1) in broccoli. However, in individual applications, the T_4 had relatively highest S value (13.14 kg ha^{-1} in okra and 14.21 kg ha^{-1} in broccoli) and in combinations the T_{10} outshined in maximizing the S value to 13.36 kg ha^{-1} in okra and 14.44 kg ha^{-1} in broccoli.

The mean values of two years showed the similar increasing pattern in comparison to time. The highest value of S 12.62 kg ha^{-1} was noticed in T_{10} in okra and 14.44 kg ha^{-1} in broccoli and lowest was observed in T_1 as 11.92 kg ha^{-1} in okra and 12.90 kg ha^{-1} in broccoli.

Total Nitrogen (TN)
The TN values are presented in Table 2. In year 2016, TN values were found to be non-significant as minor variations in

treatments were observed as compared to control. The maximum TN observed was 698.8 kg ha^{-1} in okra and 711.4 kg ha^{-1} in broccoli in T_8. Due to the additive effects of organic manures the TN trend was continuously observed in increasing pattern as compared to time. The individual and combined applications showed better response as compared to control. In individual applications the T_4 had relatively highest TN value (692.3 kg ha^{-1} in okra and 704.8 kg ha^{-1} in broccoli); however, in combinations the highest value observed was 668.8 kg ha^{-1} in case of okra and 711.4 kg ha^{-1} in broccoli in T_8 as stated above.

Table 2: Effect of organic manures on Total Nitrogen (kg ha^{-1}) content of soil

TN	Okra			Broccoli		
Treatment	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**
T1: Control	670.1	688.4	679.3	682.3	702.8	692.55
T2: FYM	680.3	698.8	689.6	692.6	711.4	702.00
T3: VC	691.8	710.7	701.3	704.4	723.5	713.95
T4: PM	692.3	711.2	701.8	704.8	724.0	714.40
T5: NC	685.4	704.0	694.7	697.8	716.8	707.30
T6: FYM + PM	694.5	713.4	704.0	707.0	726.3	716.65
T7: FYM + NC	693.6	712.4	703.0	706.1	725.3	715.70
T8: VC + PM	698.8	717.8	708.3	711.4	730.8	721.10
T9: VC + NC	693.4	712.3	702.9	706.0	725.2	715.60
T10: NC + PM	696.1	715.1	705.6	708.7	720.0	714.35

*As per Tukey's Post-hoc analysis, the values are non-significant.

In 2017, also the TN was found to be non-significant among the treatments as values followed the same pattern with minor variations. Highest to lowest value observed was 717.8 kg ha^{-1} (T_8) to 688.4 kg ha^{-1} (T_1) in okra and 730.8 kg ha^{-1} (T_8) to 702.8 kg ha^{-1} (T_1) in broccoli. However, in individual applications, the T_4 had relatively highest TN value (711.2 kg ha^{-1} in okra and 724.0 kg ha^{-1} in broccoli) and in combinations the T_8 outshined in maximizing the TN value to 717.8 kg ha^{-1} in okra and 730.8 kg ha^{-1} in broccoli.
The mean values of two years showed the similar increasing pattern in comparison to time. The highest value of TN 708.3 kg ha^{-1} was noticed in T_8 in okra and 721.1 kg ha^{-1} in broccoli and lowest was observed in T_1 as 679.3 kg ha^{-1} in okra and 692.55 kg ha^{-1} in broccoli.

DTPA extractable Zinc (Zn)
The Zn values are presented in Table 3. In year 2016, Zn values were found to be non-significant as minor variations in treatments were observed as compared to control. The maximum Zn observed was 0.79 mg kg^{-1} in okra and 0.87 mg kg^{-1} in broccoli in T_8. Due to the additive effects of organic manures the Zn trend was continuously observed in increasing pattern as compared to time. The individual and combined applications showed better response as compared to control. In individual applications the T_4 had relatively highest Zn value (0.67 mg kg^{-1} in okra and 0.74 mg kg^{-1} in broccoli); however, in combinations the highest value observed was 0.79 mg kg^{-1} in case of okra and 0.87 mg kg^{-1} in broccoli in T_8 as stated above.

Table 3: Effect of organic manures on DTPA extractable Zinc (mg kg^{-1}) content of soil

Zn	Okra			Broccoli		
Treatment	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**
T1: Control	0.59	0.68	0.64	0.65	0.75	0.70
T2: FYM	0.65	0.75	0.70	0.71	0.82	0.77
T3: VC	0.64	0.77	0.71	0.70	0.84	0.76
T4: PM	0.67	0.78	0.73	0.74	0.86	0.80
T5: NC	0.58	0.67	0.63	0.64	0.74	0.69
T6: FYM + PM	0.68	0.79	0.74	0.75	0.87	0.81
T7: FYM + NC	0.67	0.78	0.73	0.74	0.86	0.80
T8: VC + PM	0.79	0.91	0.85	0.87	1.00	0.93
T9: VC + NC	0.74	0.85	0.80	0.81	0.94	0.88
T10: NC + PM	0.70	0.81	0.76	0.77	0.89	0.83

*As per Tukey's Post-hoc analysis, the values are non-significant.

In 2017, also the Zn was found to be non-significant among the treatments as values followed the same pattern with minor variations. Highest to lowest value observed was 0.91 mg kg^{-1} (T_8) to 0.68 mg kg^{-1} (T_1) in okra and 1.00 mg kg^{-1} (T_8) to 0.75 mg kg^{-1} (T_1) in broccoli. However, in individual applications, the T_4 had relatively highest Zn value (0.78 mg kg^{-1} in okra and 0.86 mg kg^{-1} in broccoli) and in combinations the T_8 outshined in maximizing the Zn value to 0.91 mg kg^{-1}in okra and 1.00 mg kg^{-1} in broccoli.
The mean values of two years showed the similar increasing pattern in comparison to time. The highest value of Zn 0.85 mg kg^{-1} was noticed in T_8 in okra and 0.93 mg kg^{-1} in broccoli and lowest was observed in T_1 as 0.64 mg kg^{-1} in okra and 0.70 mg kg^{-1} in broccoli.

DTPA extractable Manganese (Mn)
The Mn values are presented in Table 4. In year 2016, Mn values were found to be non-significant as minor variations in treatments were observed as compared to control. The maximum Mn observed was 14.45 mg kg^{-1} in okra and 15.33 mg kg^{-1} in broccoli in T_8. Due to the additive effects of organic manures the Mn trend was continuously observed in increasing pattern as compared to time. The individual and combined applications showed better response as compared to control. In individual applications the T_4 had relatively highest Mn value (14.39 mg kg^{-1} in okra and 14.69 mg kg^{-1} in broccoli); however, in combinations the highest value observed was 14.45 mg kg^{-1} in case of okra and 15.33 mg kg^{-1} in broccoli in T_8 as stated above.

Table 4: Effect of organic manures on DTPA extractable Manganese (mg kg^{-1}) content

Mn	**Okra**			**Broccoli**		
Treatment	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**
T1: Control	13.21	14.43	13.82	14.02	15.31	14.66
T2: FYM	13.63	14.89	14.26	14.46	15.80	15.13
T3: VC	13.85	15.14	14.50	14.31	15.64	14.98
T4: PM	14.39	15.73	15.06	14.69	16.06	15.38
T5: NC	13.28	14.51	13.90	14.09	15.39	14.74
T6: FYM + PM	13.86	15.15	14.51	14.71	16.07	15.39
T7: FYM + NC	14.09	15.39	14.74	14.94	16.33	15.64
T8: VC + PM	14.45	15.79	15.12	15.33	16.75	16.04
T9: VC + NC	14.09	15.40	14.75	14.95	16.33	15.64
T10: NC + PM	14.50	14.75	14.63	15.27	16.68	15.98

*As per Tukey's Post-hoc analysis, the values are non-significant.

In 2017, also the Mn was found to be non-significant among the treatments as values followed the same pattern with minor variations. Highest to lowest value observed was 15.79 mg kg^{-1} (T_8) to 14.43 mg kg^{-1} (T_1) in okra and 16.75 mg kg^{-1} (T_8) to 15.31 mg kg^{-1} (T_1) in broccoli. However, in individual applications, the T_4 had relatively highest Mn value (15.73 mg kg^{-1} in okra and 16.06 mg kg^{-1} in broccoli) and in combinations the T_8 outshined in maximizing the Mn value to 15.79 mg kg^{-1} in okra and 16.75 mg kg^{-1} in broccoli.

The mean values of two years showed the similar increasing pattern in comparison to time. The highest value of Mn 15.12 mg kg^{-1} was noticed in T_8 in okra and 16.75 mg kg^{-1} in broccoli and lowest was observed in T_1 as 13.82 mg kg^{-1} in okra and 15.31 mg kg^{-1} in broccoli.

DTPA extractable Copper (Cu)

The Mn values are presented in Table 5. In year 2016, Mn values were found to be non-significant as minor variations in treatments were observed as compared to control. The maximum Mn observed was 14.45 mg kg^{-1} in okra and 15.33 mg kg^{-1} in broccoli in T_8. Due to the additive effects of organic manures the Mn trend was continuously observed in increasing pattern as compared to time. The individual and combined applications showed better response as compared to control. In individual applications the T_4 had relatively highest Mn value (14.39 mg kg^{-1} in okra and 14.69 mg kg^{-1} in broccoli); however in combinations the highest value observed was 14.45 mg kg^{-1} in case of okra and 15.33 mg kg^{-1} in broccoli in T_8 as stated above.

In 2017, also the Mn was found to be non-significant among the treatments as values followed the same pattern with minor variations. Highest to lowest value observed was 15.79 mg kg^{-1} (T_8) to 14.43 mg kg^{-1} (T_1) in okra and 16.75 mg kg^{-1} (T_8) to 15.31 mg kg^{-1} (T_1) in broccoli. However, in individual applications, the T_4 had relatively highest Mn value (15.73 mg kg^{-1} in okra and 16.06 mg kg^{-1} in broccoli) and in combinations the T_8 outshined in maximizing the Mn value to 15.79 mg kg^{-1} in okra and 16.75 mg kg^{-1} in broccoli.

The mean values of two years showed the similar increasing pattern in comparison to time. The highest value of Mn 15.12 mg kg^{-1} was noticed in T_8 in okra and 16.75 mg kg^{-1} in broccoli and lowest was observed in T_1 as 13.82 mg kg^{-1} in okra and 15.31 mg kg^{-1} in broccoli.

DTPA extractable Iron (Fe)

The values of Fe are presented in Table 6. As per tukey's post-hoc Analysis, Fe was found to be significant in both 2016 and 2017 as compared to control. Significant results were obtained with highest value 31.26 kg ha^{-1} observed in T_8 in okra and 32.21 kg ha^{-1} in broccoli as compared to control T_1 which was 28.67 kg ha^{-1} in okra and 29.53 kg ha^{-1} in broccoli. However T_4 was at par with T_2, T_3, T_5, T_7, T_9 and T_{10}. Also, T_8 was at par with T_6. In individual application the T_4 had relatively highest value (30.15 in okra and 31.06 kg ha^{-1} in broccoli.)

In 2017, Fe showed significant results as values followed the same pattern of major variations as in 2016 in both crops. Variation in Fe was noted with highest to lowest value observed 32.69 to 29.98 kg ha^{-1} in okra and 33.68 to 30.88 kg ha^{-1} in broccoli. Highest Fe value 32.69 kg ha^{-1} was observed in T_8 in okra and 33.68 kg ha^{-1} in broccoli. However T_4 was at par with T_2, T_3, T_5, T_7, T_9 and T_{10}. Also, T_8 was at par with T_6 in both the crops followed by lowest value 29.98 in T_1 in okra and 30.88 kg ha^{-1}. However, in individual application, the T_4 had relatively highest value (31.53 kg ha^{-1} in okra and 32.48 kg ha^{-1} in broccoli).

The Fe values showed the similar increasing pattern as above. The highest value of Fe 31.98 kg ha^{-1} was noticed in okra and 32.94 kg ha^{-1} in broccoli in T_8 and lowest was observed in T_1 as 29.32 kg ha^{-1} in okra and 30.88 kg ha^{-1} in broccoli. However T_4 was at par with T_2, T_3, T_5, T_7, T_9 and T_{10}. Also, T_8 was at par with T_6 in both the crops.

Exchangeable Calcium (Ca)

The Ca values are presented in Table 7. In year 2016, Ca values were found to be non-significant as minor variations in treatments were observed as compared to control. The maximum Ca observed was 7.26 cmol (p^+) kg^{-1} in okra and 8.06 cmol (p^+) kg^{-1}in broccoli in T_8. Due to the additive effects of organic manures the Ca trend was continuously observed in increasing pattern as compared to time. The individual and combined applications showed better response as compared to control. In individual applications the T_4 had relatively highest Ca value (6.70 cmol (p^+) kg^{-1} in okra and 7.38 cmol (p^+) kg^{-1} in broccoli); however in combinations the highest value observed was 7.26 cmol (p^+) kg^{-1} in case of okra and 8.01 cmol (p^+) kg^{-1} in broccoli in T_8 as stated above.

In 2017, also the Ca was found to be non-significant among the treatments as values followed the same pattern with minor variations. Highest to lowest value observed was 8.41 (T_8) to 7.51 cmol (p^+) kg^{-1} (T_1) in okra and 9.27 cmol (p^+) kg^{-1} (T_8) to 8.28 cmol (p^+) kg^{-1} (T_1) in broccoli. However, in individual applications, the T_4 had relatively highest Ca value (7.71 cmol (p^+) kg^{-1} in okra and 8.55 cmol (p^+) kg^{-1} in broccoli) and in combinations the T_8 outshined in maximizing the Ca value to 8.41 cmol (p^+) kg^{-1}in okra and 9.27 cmol (p^+) kg^{-1} in broccoli.

The mean values of two years showed the similar increasing pattern in comparison to time. The highest value of Ca 7.84 cmol (p^+) kg^{-1} was noticed in T_8 in okra and 8.64 cmol (p^+)

kg^{-1} in broccoli and lowest was observed in T_1 as 7.00 cmol (p^+) kg^{-1} in okra and 7.71 cmol (p^+) kg^{-1} in broccoli.

Exchangeable Magnesium (Mg)

The Mg values are presented in Table 8. In year 2016, Mg values were found to be non-significant as minor variations in treatments were observed as compared to control. The maximum Mg observed was 0.98 cmol (p^+) kg^{-1} in okra and 1.08 cmol (p^+) kg^{-1}in broccoli in T_8 and T_{10}. Due to the additive effects of organic manures the Mg trend was continuously observed in increasing pattern as compared to time. The individual and combined applications showed better response as compared to control. In individual applications the T_4 had relatively highest Mg value (0.93 cmol (p^+) kg^{-1} in okra and 1.02 cmol (p^+) kg^{-1} in broccoli); however, in combinations the highest value observed was 0.98 cmol (p^+) kg^{-1} in case of okra in T_8 and 1.08 cmol (p^+) kg^{-1} in broccoli in T_{10} as stated above.

Table 8: Effect of organic manures on Exchangeable Magnesium (cmol (p^+) kg^{-1}) content of soil

Mg	Okra			Broccoli		
Treatment	2016	2017	Mean	2016	2017	Mean
T1: Control	0.74	0.86	0.80	0.82	0.95	0.89
T2: FYM	0.81	0.93	0.87	0.89	1.03	0.96
T3: VC	0.88	1.02	0.95	0.98	1.13	1.06
T4: PM	0.93	1.07	1.00	1.02	1.18	1.10
T5: NC	0.94	1.09	1.02	1.00	1.22	1.11
T6: FYM + PM	0.95	1.10	1.03	1.05	1.22	1.14
T7: FYM + NC	0.94	1.10	1.02	1.06	1.22	1.14
T8: VC + PM	0.98	1.13	1.06	1.07	1.25	1.16
T9: VC + NC	0.95	1.10	1.03	1.05	1.21	1.13
T10: NC + PM	0.97	1.12	1.05	1.08	1.24	1.16

*As per Tukey's Post-hoc analysis, the values are non-significant.

In 2017, also the Mg was found to be non-significant among the treatments as values followed the same pattern with minor variations. Highest to lowest value observed was 1.13 mg kg^{-1} (T_8) to 0.86 cmol (p^+) kg^{-1} (T_1) in okra and 1.25 cmol (p^+) kg^{-1} (T_8) to 0.95 cmol (p^+) kg^{-1} (T_1) in broccoli. However, in individual applications, the T_5 had relatively highest Mg value (1.09 cmol (p^+) kg^{-1} in okra and 1.22 cmol (p^+) kg^{-1} in broccoli) and in combinations the T_8 outshined in maximizing the Mg value to 1.13 cmol (p^+) kg^{-1}in okra and 1.25 cmol (p^+) kg^{-1} in broccoli.

The mean values of two years showed the similar increasing pattern in comparison to time. The highest value of Mg 1.06 cmol (p^+) kg^{-1} was noticed in T_8 in okra and 1.16 cmol (p^+) kg^{-1} in T_8 and T_{10} in broccoli and lowest was observed in T_1 as 0.80 cmol (p^+) kg^{-1} in okra and 0.89 cmol (p^+) kg^{-1} in broccoli.

Discussion

Available Sulphur

Sulphur is an indispensable nutrient and its deficit in soil makes it impossible for plants to develop an adequate biomass yield and, at the same time, deteriorates the biological value of the yield (Scherer, 2009) [13]. Available Sulphur was however non-significant among treatments after harvest of each of crop. The minor increase in T_8 consisting of Vermicompost + Poultry Manure could be because of progressing processes of biochemical and biological mineralization (Scherer, 2009) [13] of the organic material. The content of available forms of sulphur depended on the processes of mineralization and immobilization that occurred in soils and on the soil type, soil moisture content, aeration and temperature (Scherer, 2009) [13].

Total Nitrogen

The total N content showed non-significant increase but minor variation could be due to influence of various organic treatments indicated that higher values of N content was obtained from surface soil in T_8 (730.8 kg ha^{-1}) in 2017 and could be due to the presence of residues after the harvest of crop as suggested by Meints and Peterson (1977) [10].

Exchangeable Calcium and Magnesium

The calcium and magnesium content was found non-significant in the experiment, however slight increase in both the parameters was observed as compared to control. Related to this, Yaduvanshi *et al.* (1985) [16] reported that continuous application of organic manures would increase the exchangeable calcium and magnesium contents in the soil. They also reported that the continuous use of only chemical fertilizer would cause depletion in Ca and Mg contents of soil due to release of higher levels of exchangeable H^+ and Al^{3+} ions. Since the present study was only of two years significant changes were not observed.

DTPA extractable micro-nutrients (Zn, Cu, Mn and Fe)

Four micronutrients zinc, copper, manganese and iron were studied and among all iron was found increased significantly as compared to rest of the three micronutrients. However, the Zn, Cu and Mn also increased to a certain extent as compared to control. Increased availability of these micronutrient cations in soil might be due to application of organic manures was ascribed to the formation of chelates with organic ligands which have lowered susceptibility to adsorption, fixation and precipitation in the soil and also to mineralization of organic manures and consequent release of micronutrients. The same was stated by Vidyavathi *et al.* (2018). Also, the higher availability of micro nutrients in soil due to application of manures could be ascribed to mineralization of manures, reduction in fixation and complexing properties of decomposition products of manures with micronutrients (Reddy and Reddy 1998). Higher levels of micro- nutrient in poultry manure and vermicompost treated plots could also be attributed due to chelating action of organic compounds released during decomposition of organic manures which protect these cations from fixation, precipitation, oxidation and leaching (Yadav and Kumar 1998) [15] of nutrient at harvest. Devarajan *et al.* (1980) [3] reported that the micronutrient content in the organic manure and also the effect of organic acids produced during decomposition of soil minerals increased the Zinc, Copper and Manganese content. Rathore *et al.* (1980) [12] reported that any little rise in soil organic matter appeared to enhance copper availability in organic matter deficient soils of arid and semi-arid tropics. Zinc availability is enhanced with the formation of organic-zinc complexes, which are soluble, mobile and absorbable by plant roots (Harter 1991) [5].

Conclusion

In the experiment, applications of organic manures have a significant impact on the Iron availability. However, Exch. Calcium, Magnesium, DTPA extractable Zinc, Manganese and Copper was found to be non-significant in two-year cropping system. The best performing treatment was Treatment No. 8 which includes the application of combination of Vermicompost and Poultry Manure as compared to control. In non-significant pattern observed in Exch. Calcium, Magnesium, Total Nitrogen, DTPA extractable Zinc, Manganese and Copper, further improvement can be noticed because two years may not be sufficient to realize the significant change through the application of organic manures. In overall aspect, the application of manures and their combination can have a deep impact on soil functioning and availability of secondary and micro-nutrients.

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