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Soil Nutrient and Crop Growth Dynamics in Organically Managed Cropping System

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A B S T R A C T

A study was conducted at Organic Farming Research Centre, SKUAST J in which focus was to analyze the impact of organic manures on soil nutrient availability and crop growth dynamics in legume based cropping system. In the experiment, it was found that from2016 to 2017, available nitrogen in soil depicted significant results as values followed a variable pattern. Change noted with highest to lowest value observed 285.8kg ha^{-1} to 252.9kg ha^{-1}. Available phosphorus was found to be significant as very positive change was observed compared to control. Highest value 21.44kg ha^{-1}P was noted in T_8 in experiment. Available Potassium values in soil were found to be non-significant as minor variations in treatments were observed as compared to control. During 1stand 2nd year of experiment, significant improvement in crop yield and curd weight was observed in Okra and Broccoli as compared to control. The maximum okra yield and curd weight observed was 146.32 q ha^{-1} in T_8 and 314.33 gms in T_8in 2017.

Introduction

Climate change isa major issue worldwide as struggle to tackle the problem continues despite severe efforts and precautions to control which is not affecting much to reduce emissions. However, agricultural science has responded well to the world's call to control and analyze the climate change in a sustainable way. Organic farming has framed some new aspects and trends to visualize and optimize the concept of soil sustainability, soil health and productivity.

The uses of organic and green manures have led to the study of new dynamics in soil and crop study. Organically managed farms are not only eco-friendly but are also sustainable in every aspect. Deputation of legumes along with animal manures is now proven to provide an outstanding response in terms of nutrient dynamics and yield and the same has been proven by many researchers worldwide (Larson and Clapp, 1984; Doran and Parkin, 1994 and Sudha and Chandini, 2003) as the conversion of manures to biomass has improved the fertility and soil in almost every aspect.

Now, organic manures have been accepted as an alternate towards chemical fertilizers in vegetable cropping patterns and their usage is increasing with awareness. (Barik *et al.*, 2006 and Savoshi *et al.*, 2011).

The researchers all around the world has pointed that organic farming plays a significant role in sustainable agriculture, since Jammu falls in sub-tropical zone may contain low organic matter content and highly disturbed soils due to excessive cultivation practices and uncalculated dosage of chemical fertilizers and rapid decomposition of organic matter may be rapid due to high temperatures (Pholsen, 2003; Kasikranan, 2003) in most of the months.

Such problem on soil deterioration should urgently be addressed. So, the benefits of organic implications on food quality and safety have created high global consumption for organic products and utilization of organic wastes as organic fertilizer for growing crops commercially is very much dependent on the availability of organic wastes.

So, to analyze the impact of organic manures on soil quality, a study was conducted at Organic Farming Research Centre, SKUAST Jammu in which main objective was to understand soil available nitrogen, phosphorus and crop growth dynamics in organically managed legume based cropping system.

Materials and Methods

The study was conducted at Organic Farming Research Centre of SKUAST -Jammu during 2016-17 and 2017-18.Geographically the experimental site is located at 32°39'35.5"N latitude and 74°47'35.0"E longitude at an elevation of 332 meters above the mean sea level in site the Shivalik foothill plains of North-Western Himalayas. The analysis was done post-harvest of crops.

Table.1 Initial values of soil of pre-experimental field

Physical Properties	Initial Values
Soil Organic Carbon (g kg^{-1})	6.27
Available Nitrogen (kg ha^{-1})	247.2
Available Phosphorus (kg ha^{-1})	13.95
Available Potassium (kg ha^{-1})	236.1
Particle Size Analysis (Texture): Sandy Clay Loam	Sand- 54.22 Silt- 15.82 Clay- 29.96

Table.2 Treatment details

Treatments	Input	Qty. applied tonne ha^{-1}
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 @10.00tonneha^{-1}was done

Table.3 Analytical methods employed in soil sample analysis for soil organic carbon and soil physical properties

S.No.	Parameter	Method	Source
1	Soil Texture	International Pipette Method	Piper (1966)
2	Soil Organic Carbon	Chromic acid wet digestion method	Walkley and Black (1934)
3	Available Nitrogen	Alkaline permanganate method	Subbiah and Asija(1956)
4	Available Phosphorus	Olsen method using colorimeter	Olsen *et al.*, (1954)
5	Available Potassium	Flame photometric method	Stanford and English (1949)

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.

Results and Discussion

The outcome observed in present study as well as discussion has been summarized under following heads:

Available Nitrogen

In 2016 to 2017, available nitrogen in soil depicted significant results as values followed a variable pattern (Table 4). Change noted with highest to lowest value observed 285.8kg ha^{-1} to 252.9kg ha^{-1}. Highest average available nitrogen value 283.5kg ha^{-1} was observed in T_8 (Vermicompost + poultry manure)and was considered best performing treatment. A study by Moyin-Jesu and Atoyosoye (2002); and Adekayode (2010) depicts that poultry manure and vermicompost being the high accumulator of N, P, K and moderate Ca and Mg showed the best performance in terms of soil fertility.

The research results also agreed with Babalo *et al.,* (2000) who reported that poultry manure when applied to soil has the tendency to stimulate the microbial activity and thereby enhance the release of organic nitrogen and phosphorus in soil.

Along with this, there are many researches in science world that depicts higher soil nitrogen and phosphorus in organically treated soils. (Simek *et al.,* 1999; Saviozzi *et al.,* 1999). Also, certain concentrated organic manures like poultry manure have the ability to cause the net mobilization of soil nitrogen Murwira and Kirchrnann, 1993).

Statistical analysis in the experiment showed significant increase in nitrogen and phosphorus which was in agreement with the statement of Dikinya and Mufwanzala (2010) who also observed an increase in available nitrogen content in soil after the addition of poultry and associated manures. Also, the presence of higher nitrogen content in FYM, poultry manure and vermicompost has led to an increased fraction of soil organic matter and biomass (Fig. 1).

Similar findings were also reported by Amanullah *et al.,* 2006 and Prasanthrajan *et al.,* 2008. The incorporation of Dhaincha into the soil increased the plant available nitrate N and more mineral N from residues of legumes (Dalal *et al.,* 1998 and Pilbeam *et al.,* 1998).

Thus it is understandable that inclusion of legume in vegetable cropping patterns can lead to increase in soil nitrogen (Ahmed *et al.,* 2001); however in the experiment there was 13.00 % increase in soil available nitrogen in 2017 as compared to control in 2016.

Available Phosphorus

The values related to soil available phosphorus are presented in Table 5. As per tukey's post-hoc analysis, available phosphorus was found to be significant in year 2016 and 2017 as very positive change was observed as compared to control. Significant results were obtained with highest value 21.44kg ha^{-1} was noted in T_8 in experiment as compared to control T_1 which was 15.98 kg ha^{-1}.

Statistical analysis explained that the significant increase in P concentration in soil was due to the application of combination of organic manure (Vermicompost + Poultry Manure) which was in agreement with studies of Adejoro, 2005; Davis *et al.,* 2006 where P improvement was found significant by application of poultry manure and associated manures (Fig. 2).

The application of organic manures have significantly reduced the fixation of added P as well as native P, making it more available to the plant because of the reaction of intermediate compounds with phosphate-fixing cations such as Al^{3+}, Fe^{3+} etc., thereby reducing P adsorption capacity (Ghosh *et al.,* 1981; Son and Ramaswami, 1997).

Similarly, the application of organic phosphorus has led to increase in labile P through complexing of cations like Ca^{2+} and Mg^{2+} responsible for P fixation has been reported by Balaguravaiah *et al.,* 2005. Also, Gupta *et al.,* 1988 reported that organic manures have the tendency to reduce the activity of polyvalent cations such as Ca^{2+}, Fe^{3+} and Al^{3+} due to chelation which in turn is highly responsible for reduction in fixation of P.

Therefore there was improvement in phosphorus availability with the application of organic manures and it was similar with the findings of Chithesh 2005. In the experiment there was significant rise in available phosphorus by 34.16 % at the end of experiment in 2017.

Available Potassium

Available Potassium values in soil were found to be non-significant as minor variations in treatments were observed as compared to control (Table 6). The maximum potassium observed was 237.8kg ha^{-1} in T_1 in 2016; however after then it consistently decreased with continuation of experiment which can be related to higher depletion of potassium by green manure and vegetable crops as reported by Barik*et al.*, 2006.

Also, another reason can be the ratio of application to consumption might have gone low as removal of potassium by crops might have exceeded the incorporation. The lack of crop ability to extract K from another form of soil K can also be another reason of lowering of available K (Sudhakar, 2000).

The medium content of potassium in soil in pre-experimental field and lack of supplement through external sources can also be a reason of consistently lowering of soil available potassium in experiment (Elangovan, 1984). In this two year experiment, the available potassium loss was greater than 5% with lowest value observed at the end of experiment.

Fig.1 Relationship between Soil Organic Carbon and Soil Available Nitrogen was found positively correlated in 2016 (R^2 = 0.88) and 2017 (R^2 = 0.85)

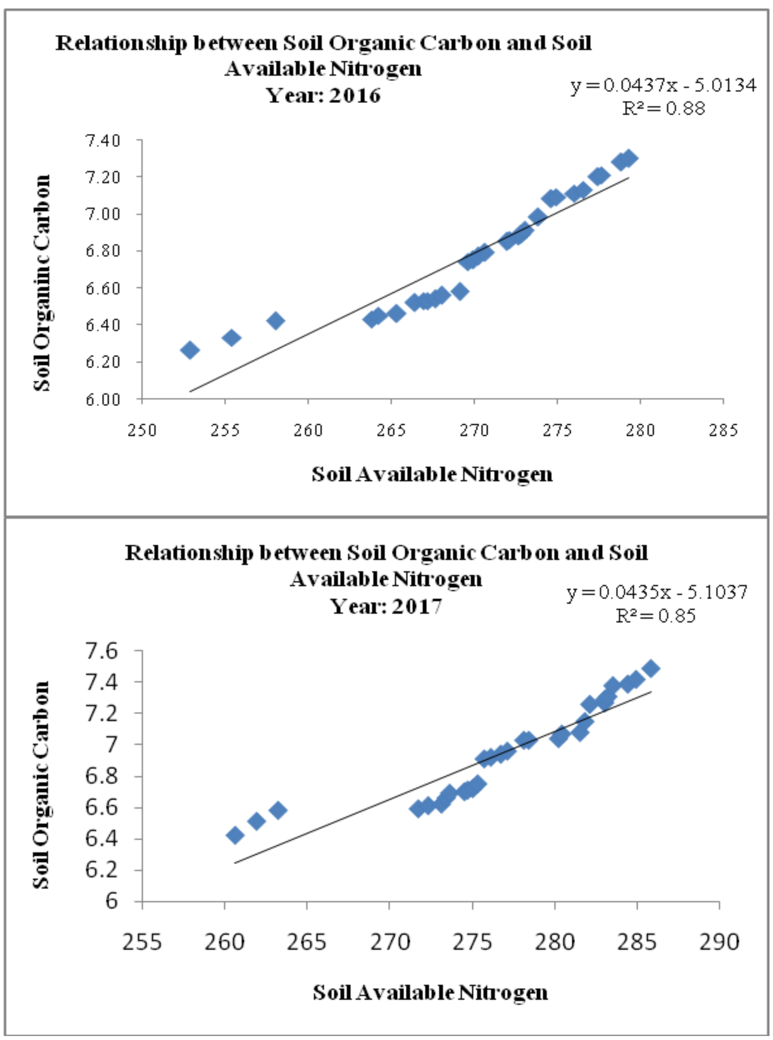

Fig.2 Relationship between Soil Organic Carbon and Soil Available Phosphorus was found positively correlated in 2016 (R^2 = 0.79) and 2017 (R^2 = 0.96)

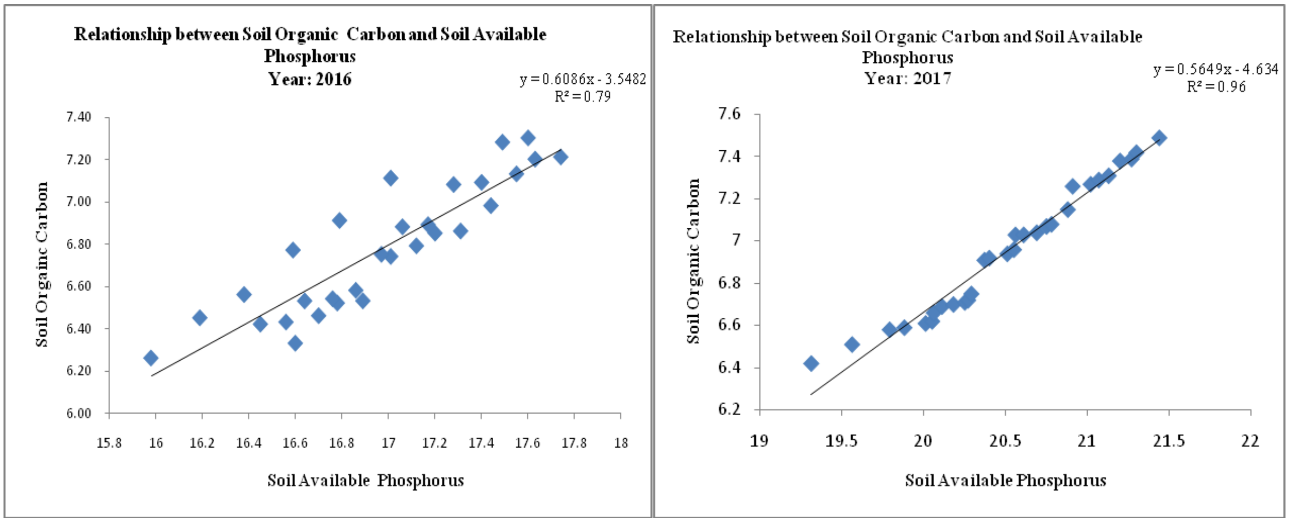

Table.4 Impact of organic manures on Available Nitrogen (kg ha^{-1}) post-harvest soils

N	Okra			Dhaincha			Broccoli		
Treatment	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**
T1: Control	252.9[a]	260.6[a]	256.7[a]	255.4[a]	263.2[a]	259.3[a]	258.0[a]	261.9[a]	261.9[a]
T2: FYM	264.2[b]	272.3[b]	268.2[b]	266.9[b]	275.0[b]	270.9[b]	269.6[b]	273.6[b]	273.6[b]
T3: VC	265.3[b]	273.4[b]	269.3[b]	268.0[b]	276.1[b]	272.0[b]	270.6[b]	274.7[b]	274.7[b]
T4: PM	267.2[b]	275.3[b]	271.3[b]	269.9[b]	278.1[b]	274.0[b]	272.6[b]	276.7[b]	276.7[b]
T5: NC	263.8[b]	271.7[b]	267.8[b]	266.4[b]	274.5[b]	270.4[b]	269.1[b]	273.1[b]	273.1[b]
T6: FYM + PM	272.8[c]	281.5[c]	276.6[c]	276.0[c]	284.4[c]	280.2[c]	278.8[b]	283.0[c]	280.9[c]
T7: FYM + NC	272.1[b]	280.4[c]	276.3[c]	274.9[c]	283.2[c]	279.0[c]	277.6[b]	281.8[c]	281.8[c]
T8: VC + PM	273.8[c]	282.1[c]	277.9[c]	276.5[c]	284.9[c]	280.7[c]	279.3[b]	283.5[c]	283.5[c]
T9: VC + NC	267.6[b]	275.7[b]	271.6[b]	270.2[b]	278.4[b]	274.3[b]	273.0[b]	277.1[b]	277.1[b]
T10: NC + PM	271.9[c]	280.2[c]	276.0[c]	274.6[c]	283.0[c]	278.8[c]	277.4[b]	285.8[c]	281.6[c]

*Mean values with single alphabet are statistically significant

Table.5 Impact of organic manures on Available Phosphorus (kg ha^{-1}) post-harvest soils

P	Okra			Dhaincha			Broccoli		
Treatment	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**
T1: Control	15.98[a]	19.31[a]	17.64[a]	16.38[a]	19.79[a]	7.65[a]	16.79[a]	20.29[a]	18.54[a]
T2: FYM	16.60[abc]	20.06[abc]	18.33[abc]	16.86a[bc]	20.37[abc]	18.[16abc]	17.44[abc]	21.07[abc]	19.25[abc]
T3: VC	16.45[abc]	19.88[abc]	18.16[abc]	17.01[abc]	20.56[abc]	18.33[abc]	17.28[abc]	20.88[abc]	19.08[abc]
T4: PM	16.56[abc]	20.01[abc]	18.28[abc]	16.97[abc]	20.51[abc]	18.29[abc]	17.40[abc]	21.02[abc]	19.21[abc]
T5: NC	16.19[ab]	19.56[ab]	17.85[ab]	16.59[ab]	20.05[ab]	17.88[ab]	17.01[ab]	20.55[ab]	18.78[ab]
T6: FYM + PM	16.70[bc]	20.18[bc]	18.44[bc]	17.12[bc]	20.69[bc]	18.44[bc]	17.55[bc]	21.20[bc]	19.37[bc]
T7: FYM + NC	16.78[bc]	20.27[bc]	18.52[bc]	17.20[bc]	20.78[bc]	18.52[bc]	17.63[bc]	21.30[bc]	19.46[bc]
T8: VC + PM	16.89[c]	20.40[c]	18.64[c]	17.31[c]	20.91[c]	18.65[c]	17.74[c]	21.44[c]	19.59[c]
T9: VC + NC	16.64[bc]	20.11[bc]	18.37[bc]	17.06[bc]	20.61[bc]	18.38[bc]	17.49[bc]	21.13[bc]	19.31[bc]
T10: NC + PM	16.76[bc]	20.25[bc]	18.50[bc]	17.17[bc]	20.75[bc]	18.50[bc]	17.60[bc]	21.27[bc]	19.43[bc]

*Mean values with single alphabet are statistically significant

Table.6 Impact of organic manures on Available Potassium (kg ha^{-1}) post-harvest soils

K	Okra			Dhaincha			Broccoli		
Treatment	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**	**2016**	**2017**	**Mean**
T1: Control	237.8	234.2	236.0	236.6	233.0	234.8	235.4	231.8	233.6
T2: FYM	233.2	229.7	231.5	232.0	228.5	230.3	230.8	227.3	229.05
T3: VC	235.1	232.5	233.8	233.9	230.3	232.1	232.7	229.2	230.95
T4: PM	234.8	231.3	233.1	233.6	230.1	231.9	232.5	228.9	230.7
T5: NC	234.6	231.0	232.8	233.4	229.9	231.7	232.2	228.7	230.45
T6: FYM + PM	233.7	230.2	232.0	232.5	229.0	230.8	231.3	227.8	229.55
T7: FYM + NC	234.8	231.1	233.0	233.4	229.9	231.7	232.2	228.7	230.45
T8: VC + PM	235.2	231.6	233.4	234.0	230.4	232.2	232.8	229.8	231.3
T9: VC + NC	230.7	227.2	229.0	229.6	226.1	227.9	228.4	224.9	226.65
T10: NC + PM	234.1	230.6	232.4	232.9	229.4	231.2	231.7	228.2	229.95

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

Table.7 Impact of organic manures on Crop yield of okra (kg ha^{-1}) post-harvest soils

Crop Yield	Okra		
Treatment	**2016**	**2017**	**Mean**
T1: Control	105.87^{a}	111.03^{a}	108.45^{a}
T2: FYM	120.86^{b}	130.67^{b}	125.77^{b}
T3: VC	131.02^{e}	133.95^{c}	132.49^{d}
T4: PM	134.78^{f}	139.29^{e}	137.04^{f}
T5: NC	126.52^{c}	131.06^{b}	128.80^{c}
T6: FYM + PM	131.08^{e}	141.02^{e}	136.06^{ef}
T7: FYM + NC	129.03^{d}	135.27^{cd}	132.15^{d}
T8: VC + PM	135.49^{f}	146.32^{f}	140.91^{g}
T9: VC + NC	129.15^{d}	136.74^{d}	132.95^{d}
T10: NC + PM	131.30^{e}	139.13^{e}	135.22^{e}

Table.8 Impact of organic manures on Curd Weight of Broccoli (g) post-harvest soils

Curd weight	Broccoli		
Treatment	**2016**	**2017**	**Mean**
T1: Control	269.33^{a}	275.66^{a}	272.50^{a}
T2: FYM	282.33^{b}	292.66^{b}	287.50^{b}
T3: VC	282.33^{b}	294.00^{b}	288.16^{bc}
T4: PM	289.66^{bc}	300.33^{bc}	295.00^{cde}
T5: NC	283.66^{b}	293.00^{b}	288.33^{bc}
T6: FYM + PM	294.00^{c}	306.66^{c}	300.33^{e}
T7: FYM + NC	288.00^{bc}	296.33^{b}	292.16^{bcd}
T8: VC + PM	301.66^{d}	314.33^{d}	308.00^{f}
T9: VC + NC	288.00^{bc}	296.66^{b}	292.33^{bcd}
T10: NC + PM	291.33^{c}	306.66^{c}	299.00^{de}

Okra yield and Curd Weight of Broccoli

During 1stand 2nd year of experiment, significant improvement in crop yield and curd weight was observed in Okra and Broccoli as compared to control (Table 7 & 8). The maximum okra yield and curd weight observed was 146.32 q ha^{-1} in T_8 and 314.33 gms in T_8in 2017.

The increase in yield of okra can be attributed to poultry manure application because of its easy solubilization effect of released plant nutrients leading to improved soil physical properties and nutrient status of soil.

The results were in agreement with the findings of Sanwal *et al.*, 2007 in turmeric and Premsekhar and Rajashree 2009 in okra in which credit to higher yield of crops was given to organic manure application thereby improving physical and biological properties of soil resulting in better supply of nutrients to plants.

The yield improvement also confirms the findings of Akande *et al.*, 2003 which explained that organic manures has the ability to ameliorate slightly alkaline or acidic soils that will ultimately boost crop yield and related parameters.

The increase in curd weight as compared to control can be attributed to the application of poultry manure and combinations thereby causing an increase in ammonia concentration resulting in immediate and efficient utilization for better curd development.

These results were supported by Chaterjee *et al.*, 2001. The okra yield and broccoli curd weight increased by33.07 and 16.70%.

Higher available nitrogen and phosphorus was observed in soil after the application of organic manures. The same trend was noticed on okra yield and size of curd with the progress in investigation.

The best performing treatment in every parameter was T8 in which the combination of Vermi compost + Poultry Manure was found.

And it is having a great potential to change the dynamics of nutrient and growth with time. So, it can be concluded that the addition of organic manure in vegetable crops can build up the soil fertility over a period of time and the availability of nutrient can be boosted.

The incorporation of dhaincha as source of organic manure can also have a direct impact on soil health and soil productivity with time.

Organic manures thus have a great potential to maintain soil fertility, boost nutrient supply and could contribute to greater food security (Palaniappan, 2000), which also describes organic farming an eco-friendly way to curb climate change and soil lacking quality.

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