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Effect of cropping sequence with integrated nutrient management on soil fertility status in plains of West Bengal

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Abstract
The experiment was carried out under polyhouse conditions in plains of West Bengal during 2016-17 and 2017-18 to standardize vegetable based cropping sequence under integrated nutrient management system. It is concluded that crop nutrients mandatory to apply in the form rational integration of fertilizers and organic manures to obtain monetary margins from cultivation with reference to soil health. The integration of 50% recommended doses through fertilizers and poultry manure @ 1.00 kg sq m^{-1} gave the best result with respect to maintain intact soil health. However, application of FYM @ 2.50 kg sq m^{-1} or vermicompost @ 1.00 kg sq m^{-1} instead of poultry manure also can be recommended in this regard. It can be summarize that cropping sequence of Tomato-Palak-Cucumber and Palak-Early cauliflower-Capsicum Sequence with L2 (Application of 50% recommended doses of fertilizer + Poultry manure @ 1.00 kg sq m-1) type of nutrient management best suited under protected conditions.

Keywords: Cropping sequence, soil fertility, nutrients, vegetables, organic sources

Introduction

The vegetable crops can be grown in small piece of land and their addition in cropping systems can restore the nutritional potential of the soil to get the profitable market from produce. India continues to be the second largest producer of vegetables in the world, with an annual production of 175.008 million tonnes from an area of 10.29 million ha (Anon, 2017) [1]. The production of quality vegetables during off season by adopting suitable cropping sequence in green house provides an option for better utilization of land with increased production per unit area and time. In contest of vegetable crops, cropping system represents the philosophy of maximum crop production per unit area of land within a calendar year with minimum soil deterioration. There is scope for location specific study on soil fertility maintenance with respect of cropping sequence.

The plan of integrated plant nutrient in proper means with balanced doses of fertilizers and organic manures is a much prerequisite for sustainable crop production and for restoration of soil fertility. Similarly, intensive cropping particularly with vegetable crops utilizes the nutrients in soil exhaustively. In this context, optimum level of nutrient management is a prerequisite to improve yield of vegetable crops. The basic concept of the INM is to maintain soil fertility for sustained crop productivity on long-term basis and also reduce fertilizer input cost. It involves proper combination of chemical fertilizers, organic manures, crop residues, N2 fixing crops like pulses, gram and other legumes. The uninterrupted and imbalanced use of chemical fertilizers in intensive cropping system has resulted in decline of soil health and fall in factor productivity (Kumar *et al*., 2008) [2].

In coming decade's application of organic (FYM, vermin compost, poultry manure and green manure) nutrients would be vital for reducing the cost of fertilizer, supplementing nutrients, maintaining the soil health and eco-system stability for sustained crop production. Karchoo and Dixit (2005) [3] reported that incorporation of organics especially crop residues improves crop yield along with nutrient uptake, improved physicochemical and biological properties of the soil and better soil environment for growth and development. The maintenance of soil properties along with yield is one of the prerequisite of sustainable agriculture.

However, systemic research findings are meagre on cropping sequence under integration of organic and inorganic sources of plant nutrients in vegetables especially under protected condition.

Vegetable based cropping system under protected condition has to give importance to get the quality vegetables with profitable production. In the plains of West Bengal cultivation of vegetables under protected condition is a new emerging trend for profitable market, till date not much work has been done on vegetable based cropping sequence under cover. Most of the farmers are not aware of accommodating suitable vegetables under cropping sequence. Keeping the above points in view, the experiment was framed with desirable vegetable based cropping sequences under polyhouse condition.

Materials and Methods

The field experiment was carried out under naturally ventilated arched saw teeth type polyhouse at main campus, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. Topographical situation of the experimental site comes under Gangetic New Alluvial plains of West Bengal. The average temperature ranges from 25.9-36.5 ^{0}C during summer months and 12-25^{0}C during winter months. The average rainfall is about 1500 mm year round during 2016-17 & 2017-18. The attempt made using different vegetable sequences inside polyhouse condition, so that variety of vegetables available to the users round the year without effecting soil properties by following appropriate cropping sequences. In present study different commercial vegetable crops grown in suitable rotations under integrated nutrient management with appropriate cultural practices. The experiment consisted of four different Cropping Sequences.

Sequence- 1 Palak- Early Cauliflower - Capsicum
Sequence- 2 Coriander - Cabbage - Tomato
Sequence- 3 Tomato - Palak - Cucumber
Sequence- 4 Tomato - Coriander - Broccoli

Five different levels of nutrient sources along with their combinations

L1- 100% RDF of NPK through inorganic sources
L2- 50% RDF of NPK through inorganic sources + Vermicompost 1kg /sq. m
L3- 50% RDF of NPK through inorganic sources + FYM 2.5 kg /sq. m
L4- 50% RDF of NPK through inorganic sources + Poultry manure 1kg /sq. m
L5- Full organic source of NPK nutrients (Vermicompost0.5 kg/sq. m + FYM 1.25 kg/ sq. m + Poultry manure 0.5 kg/sq. m)

The different vegetable crops allocated in sequences based on family, rooting depth, feeding habit, and soil improvement character. The experiment was laid out in a Split plot design with four replications. The cropping sequences were taken as main plot treatment and the levels of plant nutrient application as sub-plot treatment during the statistical analysis.

The land of experimental site was thoroughly prepared by repeated ploughing to bring soil into fine tilth. The soil was then pulverized to make it loose and friable. The field was left for a few days for sun drying to kill the harmful microbes and larvae of the insect, if any, present in the soil. Weeds, stubbles, roots etc. were removed. The field was properly leveled and divided by the irrigation channels into plots as per the treatments in each experiment. Most of the cases it was tried to incorporate the required quantity of organic manure to the soil atleast 2 weeks before cultivation of the succeeding crops in the experimental plots at the main field.

In the nursery, the required amount of seeds of tomato, capsicum, cauliflower, cabbage and broccoli of respective varieties were sown first and then the seedlings were transplanted to the main field in accordance with the crops and growing season and with maintenance of recommended spacing (Table -1). Overnight soaking of required amount of seeds of coriander and palak were done before their direct planting in the main field according to the growing season and recommended spacing (Table -1).

Table 1: Fertilizer dose, spacing, seed rate, variety and mean duration of different component crops

crop	Recommended dose kg/ha			Spacing (cm)	Seed rate (kg/ha)	Mean duration of crops (days)	Variety
	N	P	K				
Early cauliflower	125	80	60	45 × 30	500gm	60	Express king
Cabbage	125	80	60	45 × 30	370 gm	70	Don
Sprouting broccoli	125	80	60	45 × 30	500 gm	70	Fiesta
Sweet pepper	150	80	80	50 × 40	700gm	140	B.N.Wonder
Tomato	100	80	80	60 × 45	300 gm	120	PAN 1286
Cucumber	100	60	60	45 × 30	3kg	65	Monorama
Palak	90	50	50	20 × 3	25 kg	60	All green
Coriander	90	50	50	20 × 10	12 kg	60	Jyothi

The recommended dose of organic and inorganic sources of nutrients was applied as shown in experiments (Table-1). The organic fertilizers FYM vermicompost and poultry manure were applied initially during field preparation. Nitrogen was applied in two split doses, the first dose as basal application and the other split dose at 30 days after planting. The entire dose of phosphorus and potash were applied at the time of sowing as basal dose.

Immediately after incorporation of fertilizers and vermicompost, light irrigation was given. Thereafter irrigation was applied as per need of the crops in accordance with growing season. Other cultural practices in each experiment were followed as per the standard and recommended packages of practices of individual crops. All the crops were harvested at their proper maturity and marketable stages.

The data recorded during the period of experimentation was statistically analyzed following analysis of variation method using MSTAT software. For inference 5% level of significance of 'F' and't' test were applied (Chandel, 1978) [4]. The mean data were represented in tabular form with critical differences (C.D.) for comparison and interpretation. However, land use efficiency, production efficiency and benefit: cost (B: C) ratio have been presented as such.

Results & discussion

Effect on soil pH

It was observed from the results that all these four cropping sequences exhibited significant changes from the initial pH value of 6.84 (analyzed before initiation of the investigation) after completion of two years of cropping cycle and these values were recorded as 6.85, 6.84, 6.86and 6.83 for S_1, S_2, S_3

and S_4, respectively (Table-2). The pH value obtained under S_3 showed significant variation from that obtained under S_2 and S_4. So, the cropping sequence might be considered as an important factor that influenced the soil pH value. The two years cropping cycle showed the general trend of changing the soil pH towards soil neutrality. Liebig *et al.* (2002) [2] also reported similar results under four years cropping cycle of corn based cropping sequences.

As far as the individual effect of nutrient management levels are concerned, it is found that there has been a remarkable reduction in soil pH value (6.79) under L_1 type of nutrient management, where no organic manures were incorporated during crop cultivation (Table-2). This result varied significantly from that of all other nutrient management system and also exhibited a good amount of variation from the initial soil pH of 6.84. The maximum value of soil pH (6.88), after two years of experiment, was noted under L_5 (with application of Vermicompost @ 0.50 kg sq m^{-1} + FYM @ 1.25 kg sq m^{-1} + Poultry manure @ 0.50 kg sq m^{-1}). The values of soil pH under L_3, L_4 and L_5 were higher than that of initial soil pH value (6.84). Application of organic manures as a supplement of inorganic fertilizer might have played its beneficial role in improvement of soil pH levels towards neutrality. On the other hand the reduction in soil pH under sole application of inorganic fertilizer (i.e. L_1) might be due to soil acidification through nitrification of ammonical fertilizers (Gajda *et al.*, 2000) [12].

Effect of interaction of cropping sequence (S) at constant level of nutrient management level (L) and vice–versa showed insignificant variation over soil pH after two consecutive years of cropping cycle (Table-1). However, the maximum reduction of soil pH (6.77) have been registered, where crop cultivation was continued with application of entire recommended doses of nutrients through inorganic fertilizers, under Tomato-Coriander-Broccoli based cropping sequence (S_4L_1). Whereas, S_3L_5 combination of cropping sequence and integrated nutrient management gave highest change of soil pH (6.90) towards soil neutrality.

Effect on soil organic carbon content

With respect to the sole influence of cropping sequence over soil organic carbon content, no tangible variation had been registered (Table-2). The maximum improvement in organic carbon content was recorded as 0.39% under S_4 (Tomato-Coriander-Broccoli). However, the notable fact is that the soil organic carbon content remained unchanged from the initial level (0.38%) (as analyzed before the initiation of the experiment) after two years of cropping cycle for S_1 (Palak-Cauliflower-Capsicum), S_2 (Coriander-Cabbage-Tomato) and S_3 (Tomato-Palak-Cucumber). This result might be due to the fact that soil physico-chemical properties and environmental factors during these two seasons of cropping sequence failed to exert any considerable variation over soil organic carbon content.

Integrated nutrient management showed improvement of soil organic carbon content with application of organic manures as crop nutrient (Table-2). The highest value (0.41%) of soil organic carbon content had been recorded under L_5 type of nutrient management (with application of Vermicompost @ 0.50 kg sq m^{-1} + FYM @ 1.00 kg sq m^{-1} + Poultry manure @ 0.50 kg sq m^{-1}), which differed significantly from all other nutrient management levels. The lowest value (0.36%) was shown by L_1 system, which exhibited considerable reduction from that of initial soil organic carbon content value of 0.38%. The improvement of soil organic carbon content values with application of organic manures might have been due to the enhancement of organic carbon storage in addition to improvement of many other soil function related to the presence of organic matter (Ngo *et al*., 2012) [6].

However, effect of interaction of cropping sequences (S) and integrated nutrient management (L) at the fixed level of each other failed to produce any significant influence with respect to soil organic carbon content (Table-2). The highest depletion of soil organic carbon content, of 0.35%, had been obtained with Coriander-Cabbage-Tomato (S_2) based cropping sequence under L_1 type of nutrient management system. The highest replenishment of the soil organic carbon content (0.42%) had been observed under Tomato-Coriander-Broccoli (S_4) based cropping sequence in combination with L_5 type of nutrient management. The value of soil organic carbon content remained unchanged as compared to that of the initial value of 0.38% under the combination of S_1L_2, S_1L_4, S_2L_2, S_1L_3, S_1L_4 and S_3L_4.

Effect on available soil nitrogen content

Available soil nitrogen content under the individual influence of different cropping sequence (S), integrated nutrient management system (L) and their interactions showed insignificant variation (Table-2).

The lowest available soil nitrogen content (235.19 kg ha^{-1}) had been recorded under S_1 (Palak-Cauliflower-Capsicum) and S_3 (Tomato-Palak-Cucumber) based cropping sequences after two years of cropping cycles (Table-2). The other two cropping sequences *viz.*, Coriander-Cabbage-Tomato (S_2) and Tomato-Coriander-Broccoli (S_4) gave available nitrogen content as 235.28 and 235.37 kg ha^{-1}, respectively. The notable fact here is that all these above mentioned values were higher than the initial available soil nitrogen content level of 234.96 kg ha^{-1} (as analyzed before implementation of the present study). This result might be indicating towards the fact that in long run cropping sequence might evolve as a prominent factor to influence available soil nitrogen content in a positive way.

Among the integrated nutrient management levels the highest available soil nitrogen (235.56 kg ha^{-1}) had been obtained under L_5 (Table-2). The values of this parameter had been decreased (235.56 kg ha^{-1}) under crop cultivation with sole application of inorganic source of crop nutrients (i.e. under L_1) irrespective of cropping sequence. In general observation, it was noted here that combined application of organic manure (vermicompost or FYM or poultry manure) and fertilizer caused better replenishment of available soil nitrogen content than that of application of sole inorganic nitrogen. This might be due to the fact that combined addition of organic manures and N fertilizers ensured higher NO_3-N content due to increased microbial activities and consequently enhanced nitrification process with a concomitant reduction in leaching losses (Udayasoorian and Paramasivam, 1991) [7].

The interaction of cropping sequence (S) at same level of nutrient doses (L) and the levels of nutrient management for a fixed cropping sequence produced insignificant effect on available soil nitrogen content (Table-1). The lowest available soil nitrogen (234.99 kg ha^{-1}) had been recorded under Tomato-Palak-Cucumber (S_3), where, the whole amount plant nutrient was supplied through inorganic sources (L_1) and the highest value (235.73 kg^{-1} ha^{-1}) had been observed under Tomato-Coriander-Broccoli (S_4), where crops were applied with entire dose of organic residues. It has been clear here that application of higher doses of organic manures (i.e. under L_5) exhibited better results towards lower depletion of available soil nitrogen reservoir for all the cropping sequences under study. Similar results also had been reported by Khang *et al.* (2008) [8] in soybean-onion based cropping sequence with application 50% recommended dose of N through organic manure.

Effect on available soil phosphorous content

Cropping sequences and their interactions with different nutrient management levels could not able to produce any remarkable variation over available soil phosphorous content after completion of two years cropping sequences. However, sole influence of nutrient management was significant in this aspect (Table-3).

The values for available soil phosphorus content after two years (2016-17 and 2017-18) of cropping cycle were registered as 23.65, 23.69, 23.65 and 23.71 kg^{-1} ha^{-1} under S_1 (Palak-Cauliflower-Capsicum), S_2 (Coriander-Cabbage-Tomato), S_3 (Tomato-Palak-Cucumber) and S_4 (Tomato-coriander-Broccoli) respectively and in numerological comparison all these values are higher than that of the initial soil phosphorous content of 23.64 kg^{-1} ha^{-1}. So, cropping sequence alone might be able to exert considerable changes over available soil phosphorous content under longer experimental duration (Table-3).

The results indicate a considerable increase in the available soil phosphorous content with application of organic residues as crop nutrient (singly or in combined form) over single application of recommended dose of fertilizers (Table-3). The highest available soil phosphorus content (23.87 kg ha^{-1}) had been obtained under L_5 type of nutrient management system, where maximum amount of organic was applied for crop cultivation [Vermicompost @ 0.50 kg sq m^{-1} + FYM @ 1.25 kg sq m^{-1} + Poultry manure @ 0.50 kg sq m^{-1}] and minimum value (23.51 kg ha^{-1}) was recorded with no application of organic manure in the present study. Mehrizi (2015) [9] also suggested that P released at higher rate in soil treated with organic manure (vermicomopost) than non treated soil.

Interaction of cropping sequence and integrated nutrient management at constant level of each other exhibited the lowest available soil phosphorous content of 23.47 kg ha^{-1} with S_1 (Palak-Cauliflower-Capsicum) under L_1 type of nutrient management, where the whole amount of recommended dose of crop nutrient was applied as inorganic sources (Table-3). The highest available soil phosphorus (23.94 kg ha^{-1}) had been registered under L_5 type of nutrient management system with S_4. The reason behind the fact might be attributed to the beneficial role of organic manures in phosphate solubilization in soil environment.

Effect on available soil potassium content

The individual influence of different nutrient management levels could produce significant variation over available soil potassium content. However, the sole effect of cropping sequence and their interaction with nutrient management levels was failed to produce any considerable effect for the same (Table-3).

The results show that all the four cropping sequences (S_1 – Palak-Cauliflower-Capsicum; S_2 – Coriander-Cabbage-Tomato; S_3 – Tomato-Palak-Cucumber and S_4 – Tomato-Coriander-Broccoli), in the present investigation, replenished the available soil potassium content to some extent in comparison to that of the initial value (275.47 kg ha^{-1}). The lowest value of available soil potassium content had been recorded as 277.61 kg ha^{-1} under S_2 (Table-3). However, in case of other three cropping sequences also the values were very nearby.

Increase in the application of organic form of plant nutrient showed much higher replenishment of available soil potassium reservoir (Table-3). In fact, considerable improvement of available soil potassium content compared to the initial value (275.47 kg ha^{-1}) had been observed in L_5, where the values of these parameters were 282.17 kg ha^{-1}. The maximum depletion of this parameter (273.77 kg ha^{-1}) had been observed under L_1 system, where the whole amount of recommended dose of crop nutrient has been applied through inorganic source and it differed significantly from all other nutrient combinations. This might be due to the fact that although organic manures contained plant nutrients in small quantities as compared to the chemical fertilizers, the presence of growth promoting substances like enzymes and hormones enhanced the availability of essential soil nutrient and consequently improved soil fertility and productivity (Szczeck, 1999) [10].

From the data in a table (2) it had been found that in general available potassium content was increased with the application of organic manures in the nutrient management levels. The maximum value (284.06 kg ha^{-1}) of available soil potassium content had been observed under L_5 (where, the maximum quantities of organic manures were applied in the present study) for S_4 (Tomato-Coriander-Broccoli). The maximum depletion was noted with a value of 273.44 kg ha^{-1} under L_1 (where, no organic manure was applied for crop cultivation) with S_2 (Coriander-Cabbage-Tomato) after of two years of cropping cycle. This result is in good consensus with the findings of Gopinath *et al.* (2010) [11]. They suggested that in general organic crop production improved the available potassium content of soil.

Table 2: Influence of cropping sequence under integrated nutrient management on soil pH, soil organic carbon content and available soil nitrogen content

	initial and final soil PH, soil organic carbon content and available soil nitrogen content after completion of two years of cropping sequence under INM)											
Particulars	**Soil PH**				**Soil organic carbon (%)**				**Soil available nitrogen content (kg ha^{-1})**			
	Initial soil pH – 6.84				**Initial soil organic carbon content – 0.38%**				**Initial available soil nitrogen content – 234.96 kg ha^{-1}**			
Cropping sequence (S)/ Nutrient Level (L)	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**
L1	6.79	6.78	6.80	6.77	0.36	0.35	0.36	0.37	235.02	235.08	234.99	235.14
L2	6.85	6.84	6.85	6.82	0.38	0.38	0.39	0.39	235.13	235.23	235.18	235.33
L3	6.86	6.85	6.87	6.83	0.39	0.38	0.39	0.40	235.19	235.24	235.22	235.35
L4	6.85	6.85	6.86	6.84	0.38	0.38	0.38	0.39	235.16	235.20	235.17	235.30
L5	6.88	6.87	6.90	6.88	0.41	0.40	0.40	0.42	235.45	235.66	235.40	235.73
Test of Significance	S.Em. (±)		C.D. (0.05)		S.Em. (±)		C.D. (0.05)		S.Em. (±)		C.D. (0.05)	
Cropping sequence (S)	0.005		0.017		0.003		N.S.		0.224		N.S.	
Nutrient level (L)	0.006		0.018		0.005		0.015		0.244		N.S.	

S X L	0.013	N.S.	0.01	N.S.	0.491	N.S.
L X S	0.012	N.S.	0.008	N.S.	0.502	N.S.

S1=palak-early cauliflower-capsicum, S2=coriander-cabbage-tomato, S3=tomato-palak-cucumber, S4=tomato-coriander-broccoli, L_1 = 100% Recommended dose of NPK (inorganic fertilizers), L_2 = 50% Recommended dose of NPK + Vermicompost@ 1.00 kg sqm^{-1}, L_3 = 50% Recommended dose of NPK+ FYM @ 2.50 kg sqm^{-1}, L_4 = 50% Recommended dose of NPK+ Poultry manure @ 1.00 kg sqm^{-1}, L_5= Vermicompost@ 0.50 kg sqm^{-1} + FYM@ 1.25kg sqm^{-1} + Poultry manure @ 0.50 kg sqm^{-1}, S X L = Influence of L (nutrient level) for fixed cropping sequence (S), L X S = Influence of S (cropping sequence) at a particular nutrient level (L)

Table 3: Influence of cropping sequence under integrated nutrient management on available soil phosphorus content and available soil potassium content

	initial and final soil PH, soil organic carbon content and available soil nitrogen content after completion of two years of cropping sequence under INM)							
Particulars	**Available soil phosphorus** (kg ha^{-1})				**available soil potassium content** (kg ha^{-1})			
	Initial available soil phosphorous content – 23.64 kg ha^{-1}				**Initial available soil potassium content – 275.47 kg ha^{-1}**			
Cropping sequence (S)/ Nutrient Level (L)	**palak-early cauliflower-capsicum (S1)**	**coriander-cabbage-tomato (S2)**	**tomato-palak-cucumber (S3)**	**tomato-coriander-broccoli (S4)**	**palak-early cauliflower-capsicum (S1)**	**coriander-cabbage-tomato (S2)**	**tomato-palak-cucumber (S3)**	**tomato-coriander-broccoli (S4)**
L1	23.47	23.52	23.51	23.55	273.44	273.79	273.69	274.17
L2	23.64	23.67	23.65	23.68	278.03	278.28	278.15	278.41
L3	23.67	23.68	23.65	23.70	278.47	279.20	278.71	279.35
L4	23.64	23.66	23.64	23.67	277.53	277.89	277.66	277.97
L5	23.82	23.90	23.80	23.94	280.59	282.34	281.70	284.06
Test of Significance	S.Em. (±)		C.D. (0.05)		S.Em. (±)		C.D. (0.05)	
Cropping sequence (S)	0.018		N.S.		0.544		N.S.	
Nutrient level (L)	0.022		0.063		0.648		1.849	
S X L	0.043		N.S.		1.217		N.S.	
L X S	0.039		N.S.		1.281		N.S.	

L_1 = 100% Recommended dose of NPK (inorganic fertilizers), L_2 = 50% Recommended dose of NPK + Vermicompost@ 1.00 kg sqm^{-1}, L_3 = 50% Recommended dose of NPK+ FYM @ 2.50 kg sqm^{-1}, L_4 = 50% Recommended dose of NPK+ Poultry manure @ 1.00 kg sqm^{-1}, L_5= Vermicompost@ 0.50 kg sqm^{-1} + FYM@ 1.25kg sqm^{-1} + Poultry manure @ 0.50 kg sqm^{-1}, S X L = Influence of L (nutrient level) for fixed cropping sequence (S), L X S = Influence of S (cropping sequence) at a particular nutrient level (L)

Conclusion

The cropping sequence could not produce any significant results over replenishment of soil health parameters except soil pH. However gradual replenishment of parameters viz. organic carbon, nitrogen, phosphorus and potash observed from first year to second year cropping cycle but maximum replenishment of these parameters observed from S4 (tomato-coriander-broccoli) followed by S3 (tomato-palak-cucumber). The individual influence of nutrient management levels resulted in significant variation over all of the soil health parameters except available soil nitrogen content. The highest values with respect to soil pH, soil organic carbon content, available soil phosphorous and potassium content of 6.88, 0.41%, 23.87 kg ha^{-1} and 282.17 kg ha^{-1} respectively, had been registered, where the crop cultivation was carried on with full organic sources of plant nutrients (L_5). Whereas, the maximum depletion of soil health attributing parameters was documented from L_1, type of nutrient source. Relatively good results for these parameters also had been visualized from combined application of 50% recommended dose of inorganic plant nutrient + vermicompost or FYM or poultry manure (i.e. L_2, L_3 and L_4 respectively) and these varied significantly from the outcomes of L_1.

However, it may be said that Tomato-Coriander-Broccoli (S_4) and Coriander-Cabbage-Tomato (S_2) sequences in combination with L_5 caused better replenishment of available soil nitrogen, phosphorous and potassium content compared to other combinations of cropping sequence and integrated nutrient management and suggested for soil health concern. Whereas, best result with respect to soil pH value (6.86) had been registered from Tomato-Palak-Cucumber sequence (S_3) in combination with L_5.

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