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INTEGRATED USE OF ORGANIC AND INORGANICS SOURCES ON PHYSICO - CHEMICAL PROPERTIES OF LETTUCE GROWN SOIL

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ABSTRACT

The study was focused on the integrated use of organic and inorganics sources on physico-chemical properties of lettuce grown soil. The experiment was carried out at Khalsa College Amritsar, Punjab during *rabi* season in 2021. It was planned in a randomized block design with three replications and nine treatments including recommended dose of fertilizer, vermicompost, sewage sludge and poultry manure in combination. The soil pH and electrical conductivity were statistically non-significant by treatments applied. The organic carbon, available soil N, P, K, exchangeable Ca and Mg significantly enhanced by the application of 50% recommended dose of fertilizer + 50% poultry manure (T_8). Soil micronutrients, (Zn, Cu, Fe and Mn) were found significantly higher in the treatment T_6 (50% RDF + 50% Poultry manure). These two treatments (T_8 and T_6) statistically at par with each other.

(Key words: Lettuce, organic carbon, soil properties, macronutrients, micronutrients)

INTRODUCTION

Vegetables are essential protection substances, also called health capsules. Lettuce is one of the most commercial and major consumption, leafy herbaceous self-pollinated annual plant family belonging to Asteraceae (Pizarro *et al*., 2018).

The largest area of lettuce is also grown in south-eastern Australia, Japan, Israel, northern Mexico, Chile, Argentina Brazil and Peru. At present China is the leading producer of lettuce in the world followed by the USA. India has ranked 3rd in commercial production of lettuce, the area harvested under lettuce production is 176 thousand hectares, and the yield is 6.34 tons (metric) ha^{-1} (Anonymous,2020). The constant and imbalanced use of chemical fertilizers cause major problems of soil nutrient depletion and deteriorate soil health, soil productivity, and sustainability. The soil fertility is boost through the application of organic fertilizers, which are available and inexpensive and can be used solely or integrated with other organic and inorganic resources to build up the soil fertility and raised crop production without having any undesirable impact on the environment (Fayesa and Alemayehu,2021). It is widely acknowledged that neither organic manures nor chemical fertilizers alone can provide crop output sustainability in modern intensive farming. The gap between the nutrient demand and supply can be filled through integrated nutrient management, an approach to maintain soil health and sustainable crop production through a propitious combination of organic and inorganic nutrient application in the field i.e. combination of FYM, poultry manure, vermicompost, natural and mineral fertilizers, soil amendments crop residue, green manure and compost (Singh *et al*., 2021). It is vital to implement organic manures in concert with inorganic fertilizers to optimise yields due to the uneven and inappropriate usage of inorganic nutrients devoid of required nutrients (Sahu *et al*., 2017).

MATERIALS AND METHODS

The field experiment was carried out by the Students' Research Farm, Khalsa College, Amritsar, India. The geographical coordinates of the experimental sites are 31.6˚ 376¯ N and 74.8˚37¯ E and the height above the mean sea level is 234 m. During the *rabi* season of 2021, before land preparation, representative soil samples were collected in a zig-zag manner to analyse the soil textural class and physico-chemical properties. The soil of the experimental field was sandy loam in texture with a slightly alkaline reaction. The cultivated variety was great lakes, seeds were sown in November. Spacing was 45 cm × 30 cm. The experiment was conducted using a randomized block design having three replications with nine treatments combination. Twenty-seven soil samples (0-15 cm) were collected from each plot after harvesting lettuce crop in January. The recommended dose of fertilizer i.e. nitrogen was given @ 25 kg $acre^{-1}$ (55 kg urea) and the phosphorus was 12 kg $acre^{-1}$ (75 kg SSP). The full dose of P and half dose of N were applied as basal dose, as per treatment before sowing and the remaining half dose of N was given after 30 DAS. According to treatments, the nutrients were applied to the plots except for the absolute control.

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Treatments details

T_1 - Absolute control, T_2 - 100% recommended dose of fertilizer, T_3 - 75% RDF + 25% nitrogen through vermicompost, T_4 -75% RDF + 25% N through sewage sludge, T_5 - 75% RDF + 25% N through poultry manure, T_6 -50% RDF + 50% N through vermicompost, T_7 - 50% RDF + 50% N through sewage sludge, T_8 - 50% RDF + 50% N through poultry manure, T_9 – 50% RDF + 50% N through vermicompost + sewage sludge + poultry manure

Soil analysis

The soil samples were processed and analyzed for the nutrient status. pH and EC were estimated as per method suggested by Jackson (1973), organic carbon by Walkley and Black (1934), available N by Subbiah and Asija (1956), available P by Olsen *et al.* (1954), available K_2O by Merwin and Peech (1950). Available micronutrients (Zn, Cu, Fe and Mn) were estimated by using MPAES following the procedure of Lindsay and Norvell (1978) and exchangeable Ca and Mg in soil determined by using an Ammonium acetate method (Sumner and Miller, 1996).

Statistical analysis

The data were statistically analyzed using analysis of variance (ANOVA) for RBD following the standard procedure as suggested by Panse and Sukhatme (1957).

RESULTS AND DISCUSSION

Soil pH

The data indicates that the soil pH was statistically non-significant. In the surface soil depth of 0-15 cm, the lowest pH (8.01) was recorded in treatments T_8 (50% RDF + 50% N through poultry manure), T_9 (50% RDF + 50% N through vermicompost + sewage sludge + poultry manure), T_6 (50% RDF + 50% N through vermicompost), T_7 (50% RDF + 50% N through sewage sludge) T_5 (75% RDF + 25% poultry manure) T_3 (75% RDF + 25% vermicompost) and T_4 (75% RDF + 25% sewage sludge) when compared with 100% RDF and absolute control. The highest pH was recorded in treatment T_2 where 100% recommended dose of fertilizer applied.

Soil electrical conductivity

There was no significant difference in soil electrical conductivity owing to different nutrient management practices during the time of the experiment (Table 1). The highest electrical conductivity (0.34 dS m^{-1}) was recorded in treatment 75% RDF + 25% nitrogen through sewage sludge. The electrical conductivity (0.33 dS m^{-1}) was recorded more in treatment applied with 100% dose of recommended fertilizer, 50% RDF + 50% sewage sludge and absolute control. The lowest electrical conductivity (0.32 dS m^{-1}) was observed by the applications of 50% RDF + 50% poultry manure, 50% RDF + 50% vermicompost, 75% RDF + 25% poultry manure, 75% RDF + 25% vermicompost and 50% RDF + 50% vermicompost + sewage sludge + poultry manure treated plots.

Soil organic carbon

The data depicted (Table 1) under different treatments, the organic carbon content on surface soil (depth 0-15 cm) varied from 0.40 to 0.47 %. Soil organic carbon was recorded (0.47%) maximum where 50% RDF + 50% nitrogen through vermicompost was applied, which was statistically at par with 50% RDF + 50% nitrogen through vermicompost + poultry manure + sewage sludge (0.46 %) and 50% RDF + 50% nitrogen through poultry manure (0.45 %) and lowest in control (0.42 %) and 100% recommended dose of fertilizer (0.43 %). The organic manure-treated plots recorded the highest soil organic carbon content than absolute control as well as RDF.

The increase in soil organic carbon content with the application of different manures may be attributed to the direct incorporation of these materials in the soil and the subsequent decomposition of these materials resulting in the enhanced organic carbon content of the soil. Similar finding was reported by Hati *et al.* (2006), who observed that the 100% RDF + organic manure improved the soil organic carbon.

Available macronutrients

Available nitrogen

The data indicated (Table 2) that the available nitrogen status of soil samples varied between 147.59 kg ha^{-1} in the absolute control treatment (T_1) to 160.79 kg ha^{-1} by the application of 50% RDF + 50% poultry manure (T_8). The available nitrogen increased significantly with the combined application of chemical fertilizers and organic manures as compared to the absolute control. There was a significant build-up of available nitrogen in the soil observed at 160.79 kg ha^{-1} in 50% RDF + 50% poultry manure which was at par with integrated nutrient management treatments T_6 (50% RDF and 50% nitrogen through vermicompost ; 158.61 kg ha^{-1}) and T_9 (50% RDF + 50% nitrogen through organic manure vermicompost + sewage sludge + poultry manure ; 156.85 kg ha^{-1}). Whereas, absolute control and RDF treatments were found to be inferior over integrated use fertilizers. An increase in soil nutrient status might be attributed to an increase in the available form due to greater multiplication of soil microbes, which could convert organically bound nutrients into inorganic form due to the decomposition of organic matter. These results are in conformity with the findings of Kalappanawar and Gali (2019), who also reported highest available nitrogen with treatment receiving 100% RDF + 10 t poultry manure.

Available phosphorus

The results revealed that available phosphorus status in soil samples varied from 13.39 kg ha^{-1} under control plot to 21.24 kg ha^{-1} under treatment where nutrients were applied through 50% RDF + 50% poultry manure. The reduction in available phosphorus content of the soil observed under the absolute control treatment (13.39 kg ha^{-1}). It might be due to the uptake of phosphorus by crop in the absence of an external source of phosphorus. The incorporation of 50% RDF + 50% poultry manure had higher value of 21.24 kg ha^{-1} of phosphorus. which was at par with treatment T_6 (50% RDF + 50% nitrogen through vermicompost ; 20.84 kg ha^{-1})

and treatment T_9 (50% RDF + 50% nitrogen through vermicompost + sewage sludge + poultry manure ; 20.79 kg ha^{-1}). The application of inorganic fertilizer with poultry manure increased available phosphorus when compared with sole RDF and absolute control.

The conjunctive use of inorganic and organic sources increases phosphorus availability by reducing the fixation of water-soluble phosphorus and by increasing mineralization resulting in more availability of phosphorus. These findings are observed by Kalappanawar and Gali (2019), who also recorded highest available phosphorus contain in maize with treatment receiving 100% RDF + 10 t poultry manure.

Available potassium

The plots applied with 50% RDF + 50% nitrogen through the poultry manure (T_8) recorded significantly maximum available potassium i.e. 325.32 kg ha^{-1} over absolute control and RDF. The lowest value of available potassium was observed under absolute control i.e. 282.32 kg ha^{-1}. Among the integrated nutrient management treatments, poultry manure and vermicompost proved to be the best treatments as compared to sewage sludge due to a higher rate of mineralization resulting in maximum availability of nutrients. It was noticed that the highest available potassium was obtained in treatment T_8 receiving 50% of N through inorganic sources + 50% N through poultry manure which was at par with 50% RDF + 50% vermicompost (318.38 kg ha^{-1}), available potassium was recorded 317.54 kg ha^{-1} when applied 50% RDF + 50% poultry manure + sewage sludge + vermicompost over 100% recommended dose of fertilizer and 75 % RDF + 25% organic manure treated plots and absolute control. The increment in the available potassium content with the integrated application of organic manures and inorganics might be due to the addition of organic matter with clay. Available potassium content in soil ascribes to the reduction of potassium fixation, releasing potassium due to interaction of organic matter with clay and direct addition of potassium to the available pool of soil. These results agree with the findings of Kalappanawar and Gali (2019), who also reported that potassium content was highest in treatment receiving RDF + 10 t poultry manure.

Exchangeable calcium

The highest exchangeable calcium (5.65 me l^{-1}) was found in treatment T_8 (50% RDF + 50% poultry manure) and it was statistically at par with treatments 50% RDF + 50% vermicompost (5.35 me l^{-1}) and 50% RDF + 50% sewage sludge (5.17 me l^{-1}) followed by treatment T_9 (50% RDF + 50% vermicompost + sewage sludge + poultry manure; 4.98 me l^{-1}), in these treatments 50% of nutrients were applied through inorganic fertilizers and 50% nitrogen through organic manures. The lowest exchangeable calcium (1.63 me l^{-1}) was found under the absolute control (T_1). The exchangeable calcium was found high in plots treated with an integrated manner as compared to sole application of inorganic fertilizers and absolute control. However, exchangeable calcium was found highest with the application of 100 % RDF as compared to absolute control which might be due to the addition of calcium from single super phosphate. Treatments T_7 (50% RDF + 50% sewage sludge) and T_5 (75% RDF + 25% poultry manure) were also observed statistically superior over remaining treatments, 100% RDF and absolute control.

Exchangeable magnesium

The average value of exchangeable magnesium ranged from 1.53 to 2.86 me l^{-1}. The results of the present study also revealed that significantly higher exchangeable magnesium content was recorded in integrated nutrient management treatments when compared with absolute control and entirely chemically fertilized plots. Exchangeable magnesium was found highest in treatment T_8 (50% RDF + 50% poultry manure) and it was statistically at par with treatments T_6 (50% RDF + 50% nitrogen through vermicompost) and T_7 (50% RDF + 50% N through sewage sludge). Minimum exchangeable magnesium (1.53 me l^{-1}) was found under the absolute control.

Among inorganic and organic manures, the maximum exchangeable calcium and magnesium was recorded with poultry manure. The organic acids released from the decomposition of organic manures might have released calcium and magnesium from the exchangeable sites in the soil. Reddy *et al.* (2020) also recorded maximum exchangeable cation by the application of poultry manure @ 4 t ha^{-1} in groundnut.

Available micronutrients

The data (Table 2) revealed that the application of integrated use of organic and inorganic manure significantly increased the available Zn, Cu, Fe and Mn content in soil when compared with initial status in all the treatments except T_1 (absolute control). There was a significant gain in available micronutrients in soil due to the integrated use of organic manures and chemical fertilizers under the lettuce crop. Significantly, higher availability of micronutrients was recorded in treatment T_8 where 50% RDF + 50% nitrogen through poultry manure was added (Zn 2.88, Cu 0.88, Fe 3.75 and Mn 11.08 ppm) and the lowest under treatment T_1 i.e. absolute control (Zn 0.56, Cu 0.55, Fe 2.74 and Mn 8.51 ppm)

The treatment T_8 (50% RDF + 50% poultry manure) remained at par with treatment T_6 (50% RDF + 50% nitrogen through vermicompost) and T_7 (50% RDF + 50% nitrogen through sewage sludge). These three treatments were found significantly superior over absolute control and rest of the treatments.

The increase in the availability of micronutrients may be attributed to the decomposition of organic sources, which increases the availability of micronutrients by preventing fixation, oxidation, precipitation and leaching. Organic fertilizers have a significant impact on biological and chemical reactions, increasing the accessible micronutrients. Kalappanawar and Gali (2019) reported that DTPA extractable micronutrients was highest in treatment receiving RDF + poultry manure.

Table 1. Soil pH, electrical conductivity and soil organic carbon as influenced by integrated nutrient management in lettuce

Treatments	pH	EC(dS m^{-1})	Organic carbon (%)
T_1 Control	8.28	0.33	0.42
T_2 100% RDF	8.28	0.33	0.43
T_3 75% RDF + 25% N through Vermicompost	8.10	0.32	0.45
T_4 75% RDF + 25% N through Sewage sludge	8.15	0.34	0.43
T_5 75% RDF + 25% N through Poultry manure	8.10	0.32	0.44
T_6 50% RDF + 50% N through Vermicompost	8.01	0.32	0.47
T_7 50% RDF + 50% N through Sewage sludge	8.07	0.33	0.44
T_8 50% RDF + 50% N through Poultry manure	8.01	0.32	0.45
T_9 50% RDF + 50% N through Vermicompost + Sewage sludge + Poultry manure	8.01	0.32	0.46
SE(m)±	-	-	0.06
CD at 5%	-	-	0.17

Table 2. Available nitrogen, phosphorus, potassium, exchangeable calcium, magnesium and soil micronutrients as influenced by integrated nutrient management in lettuce

Treatments	N(kg ha^{-1})	P(kg ha^{-1})	K(kg ha^{-1})	Ca(me l^{-1})	Mg(me l^{-1})	Zn(ppm)	Cu(ppm)	Fe(ppm)	Mn(ppm)
T_1	147.59	13.39	282.32	1.63	1.53	0.56	0.55	2.74	8.51
T_2	150.38	17.83	283.77	3.20	1.83	0.62	0.58	2.76	8.52
T_3	153.76	15.22	307.12	4.21	2.17	2.29	0.72	3.36	8.95
T_4	150.80	15.13	302.47	3.50	2.06	2.13	0.69	2.93	8.65
T_5	154.08	16.40	312.63	4.40	2.44	2.41	0.76	3.45	9.12
T_6	158.61	20.84	318.38	5.35	2.80	2.85	0.86	3.72	10.89
T_7	156.71	20.25	314.34	5.17	2.78	2.70	0.80	2.98	9.45
T_8	160.79	21.24	325.32	5.65	2.86	2.88	0.88	3.75	11.08
T_9	156.85	20.79	317.54	4.98	2.75	2.66	0.60	2.80	8.51
SE(m)±	1.41	0.69	2.20	0.17	0.02	0.34	0.08	0.05	0.19
CD at 5%	4.22	2.03	6.58	0.51	0.06	1.01	0.23	0.14	0.56

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