Eco. Env. & Cons. 28 (December Suppl. Issue) : 2022; pp. (S266-S270)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i08s.040

Co-application Impact of Sewage sludge and Flyash on Soil Nutrient Index and Spinach in Inceptisols of Prayagraj, U.P., India

Raghu Nandan Singh Khatana[1], Tarence Thomas[2], Narendra Swaroop[3], Akshita Barthwal[4*] and Tarun Kumar[5]

Department of Soil Science and Agricultural Chemistry, NAI, SHUATS, Prayagraj, U.P., India

(Received 9 July, 2022; Accepted 15 September, 2022)

ABSTRACT

The present investigation was to determine whether it would be feasible to grow Spinach in amended soil utilising sewage sludge and fly ash. Different types of nutrients and heavy metals are found in both soil amendments and for growth of the plant and crop yield they are used as ameliorate in acidic soils. In the research trail, soil properties like Bulk density, Particle density and pH are found to be non-significant and Pore space, Water holding capacity, EC, OC, Nitrogen, Phosphorus, Potassium, Iron, Manganese, Zinc and copper are found to be significant. The nutrient index was also examined and it was identified that the Fe has a low fertility nutrient status followed by OC, N, K, Mn with medium fertility nutrient status and P, Zn, Cu with high fertility nutrient status.

Key words: *Flyash, Nutrient Index, Sewage Sludge, Spinach etc.*

Introduction

Spinach (*Spinacia oleracea* L.) is one of the most valuable green vegetable which contains essential nutrients. Because of its many health advantages, such as serving as a source of iron, vitamins, and nutrients, it is widely farmed over the world and is advised by contemporary nutritionists. Spinach leaves include a number of vitamins, including vitamins A and C, as well as antioxidants including lutein, zeaxanthin, and alpha-carotene (Swain *et al.*, 2020).

By applying sewage sludge to the soil, it is possible to recycle nutrients and maybe do away with the requirement for artificial fertilizers on agriculture. Sludges are organic fertilisers, therefore over time the soil's fertility increased. However, it may affect the soil's characteristics, particularly if it contains significant levels of metals and harmful substances.

Fly ash is valuable materials for agriculture and a good soil ameliorate. The addition of Fly ash in soil improves or changes various physical and chemical characteristics of soil. Fly ash is used in clayey soil considerably reduced bulk density and WHC. Fly ash is mixed into soil for increasing soil porosity and soil drainage and mobility of nutrients (Basha *et al.*, 2018).

Sewage sludge may be beneficially used in agriculture which contains some elements like P, Ca, Mg, Fe, Zn, Mn, Cu when added to the soil it helps to improve the soil physicochemical properties and also useful for agricultural production. Fly ash contains all important metals needed for plant growth and its metabolism except organic carbon and nitro-

([1 4 5]Research Scholar [2]Professor and [3]Associate Professor)

gen. It includes some of the important elements like Si, Ca, Mg, Na, K, Cu, Co, Fe, Mn, Mo, Ni, Zn, B and Al (Tsadilas *et al.,* 2009). It was found that applying Sewage sludge and Flyash simultaneously may increase the positive impact of applying these two by-products to the soil (Saima *et al.,* 2016).

Materials and Methods

a) The experiment Research Farm of SSAC, SHUATS, Prayagraj, Uttar Pradesh. The experiment was analysed by randomised block design with 12 treatments and 3 replications. The treatments comprises of three levels of sewage slugde, *i.e.* 0.13 and 26 kgha^{-1} also levels of fly ash taken 0, 26 and 52 kgha^{-1} with or without NPK. The soil samples are collected randomly after harvest of spinach from two depths. The soil is characterized after incorporation of Sewage sludge and flyash and the properties

b) $$\text{Bulk density (Mgm}^{-3}) = \frac{\text{Weight of oven dried soil (Mg)}}{\text{Volume of soil (m}^{-3})}$$

c) $$\text{Particle density (Mgm}^{-3}) = \frac{\text{Mass of soil solid (Mg)}}{\text{Volume of solids (m}^{-3})}$$

d) $$\%\text{ pore space} = (1-)\ \frac{\text{Bulk Density}}{\text{Particle Density}} \times 100$$

d) $$\text{Water holding capacity} = \frac{\text{Vol. of water absorbed by soil}}{\text{Vol. of soil taken}} \times 100$$

In chemical parameters through method by-

e) Soil pH - by using Digital pH meter of globe instruments given by (Jackson, 1973)
f) Soil EC (dSm^{-1})-Digital EC meter of globe instruments.
g) Organic Carbon (%) - through titration given by Walkley and Black method (1934)
h) Available Nitrogen (Kg ha^{-1})-Kjeldhal Method (Subbaih and Asija, 1956)
i) Available Phosphorus (Kg ha^{-1})- Colorimetric method by using Jasper single beam U.V Spectrophotometer at 660 nm wavelength.
j) Available Potassium (Kg ha^{-1})- Flame photometric method by using Metzer Flame Photometer.
k) Available Fe, Mn, Zn and Cu (ppm)- Atomic Absorption Spectrophotometer by instrument perkinelnmer given by (Lindsay and Norwell)

The nutrient index was calculated using the formula below for the soil samples examined.

Nutrient Index (N.I) = $(N_l i \rightarrow 1 + N_m i \rightarrow 2 + N_h i \rightarrow 3)/N_t$

Where, N_l= represents the number of samples with a lowlevel nutrient status

N_m = represents the number of samples with a medium level nutrient status

N_h = represents the number of samples with a high level nutrient status

N_t= represents the total number of samples analysed in specific area.

Results and Discusion

a) Nutrient Index of Soil

As depicted in the Table 1, the soil nutrient index after application of sewage sludge and fly ash resulted that the soil organic carbon in soil is medium, Available nitrogen is is medium. Available phosphorus is is medium, Available potassium is high, Available Iron is low. Available Manganese is medium, Available Zinc is 2.08 (2020) which indicates that nutrient status of soil is high and Available Copper is high (Amar *et al.,* 2020).

Table 1. Soil Fertility Nutrient Index due to application of Sewage Sludge and Flyash

Soil Chemical Properties	Soil Nutrient Value	Soil Nutrient Index	Soil Nutrient Value	Soil Nutrient Index
	(2020)		(2021)	
Organic Carbon (%)	2.08	Medium	1.83	Medium
Nitrogen (kg/ha)	1.5	Medium	1.91	Medium
Phosphorus (kg/ha)	1.66	High	1.75	High
Potassium (kg/ha)	1.91	Medium	2.08	Medium
Iron (Fe)	1.91	Low	2	Low
Manganese (Mn)	2.25	Medium	2.25	Medium
Zinc (Zn)	2.08	High	1.66	Medium
Copper (Cu)	1.83	High	2.16	High

Table 2. Effect of Co-application of Sewage sludge and Fly-ash on Physical properties of soil in both year at both the depths

Treatments	D_b (Mgm^{-3}) (2020)		D_b (Mgm^{-3}) (2021)		D_p (Mgm^{-3}) (2020)		D_p (Mgm^{-3}) (2021)		PS (%) (2020)		PS (%) (2021)		WHC (%) (2020)		WHC (%) (2021)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	1.28	1.32	1.31	1.34	2.29	2.32	2.38	2.48	44.1	43.1	45.18	45.71	53.15	49.15	51.23	47.32
T_2	1.11	1.14	1.13	1.17	2.13	2.23	2.22	2.3	47.89	48.76	48.89	49.38	57.3	53.37	54.66	50.68
T_3	1.15	1.17	1.17	1.21	2.22	2.25	2.31	2.4	48.2	48	49.19	49.68	56.4	52.58	53.83	48.74
T_4	1.17	1.19	1.19	1.23	2.17	2.28	2.26	2.35	46.08	47.81	47.12	47.63	55.7	51.26	55.28	49.38
T_5	1.18	1.21	1.2	1.24	2.19	2.3	2.28	2.37	46.12	47.39	47.15	47.66	59.75	49.72	54.78	51.82
T_6	1.12	1.15	1.14	1.18	2.14	2.24	2.23	2.31	47.66	48.66	48.67	49.16	55.9	51.87	54.9	51.87
T_7	1.1	1.13	1.12	1.16	2.16	2.23	2.25	2.34	49.07	49.33	50.05	50.53	56.02	52.12	55.21	50.76
T_8	1.25	1.28	1.28	1.31	2.25	2.31	2.34	2.43	44.44	44.59	45.51	46.04	56.39	52.58	55.87	51.12
T_9	1.2	1.24	1.22	1.26	2.2	2.29	2.29	2.38	45.45	45.85	46.5	47.02	57.42	53.62	56.96	51.96
T_{10}	1.19	1.22	1.21	1.25	2.18	2.28	2.27	2.36	45.41	46.49	46.46	46.98	58.12	54.46	56.15	52.89
T_{11}	1.14	1.17	1.16	1.2	2.15	2.26	2.24	2.33	46.98	48.23	48	48.5	59.34	55.08	57.64	54.51
T_{12}	1.08	1.12	1.1	1.13	2.12	2.19	2.2	2.29	49.6	48.86	50.04	50.52	59.89	56.83	58.64	55.32
F test	NS	NS	NS	NS	NS	NS	NS	NS	S	S	S	S	S	S	S	S
SEm±	-	-	-	-	-	-	-	-	0.58	0.87	0.72	0.71	0.9	0.78	0.82	0.86
CD (P=0.05)	-	-	-	-	-	-	-	-	1.71	2.57	2.12	2.08	2.64	2.27	2.24	2.51

Table 3. Effect of Co-application of Sewage sludge and Fly-ash on Chemical properties of soil in both year at both the depths

Treatments	pH (2020)		pH (2021)		EC (dSm^{-1}) (2020)		EC (dSm^{-1}) (2021)		OC (%) (2020)		OC (%) (2021)		N ($kgha^{-1}$) (2020)		N ($kgha^{-1}$) (2021)		P($kgha^{-1}$) (2020)		P ($kgha^{-1}$) (2021)		K ($kgha^{-1}$) (2020)		K ($kgha^{-1}$) (2021)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	7.58	7.62	7.46	7.58	0.29	0.28	0.23	0.32	0.52	0.5	0.45	0.43	276.08	258.42	256.08	268.89	29.2	27.68	28.64	25.62	185.6	172.28	191.6	173.78
T_2	7.33	7.45	7.35	7.41	0.28	0.27	0.32	0.36	0.5	0.48	0.52	0.48	257.16	240.68	267.46	252.95	20.42	20.16	19.42	18.75	179.16	167.24	195.36	175.64
T_3	7.1	7.16	7.32	7.36	0.3	0.29	0.34	0.38	0.6	0.58	0.56	0.52	275.13	252.38	297.23	269.53	27.92	26.98	30.84	28.54	219.52	204.26	249.42	217.86
T_4	7.18	7.24	7.42	7.47	0.25	0.24	0.3	0.34	0.62	0.6	0.55	0.46	279.8	265.98	302.68	277.65	30.7	29.02	29.35	27.78	241.42	232.17	258.62	246.97
T_5	6.98	7.06	7.15	7.19	0.26	0.25	0.33	0.37	0.66	0.64	0.58	0.54	293.68	280.14	315.88	294.47	31.98	31.44	30.21	28.96	255.16	243.64	272.26	257.34
T_6	6.88	7.01	7.22	7.26	0.28	0.27	0.31	0.36	0.73	0.71	0.53	0.51	309.63	295.16	330.43	309.53	34.46	36.52	34.68	32.88	263.82	256.87	281.62	264.57
T_7	7.3	7.36	7.3	7.32	0.26	0.25	0.34	0.39	0.57	0.55	0.59	0.55	291.56	285.31	312.26	301.76	22.06	23.25	24.76	21.57	220.64	208.24	238.74	216.74
T_8	7.31	7.41	7.42	7.5	0.27	0.26	0.32	0.37	0.66	0.64	0.62	0.57	329.54	320.14	350.34	336.68	28.55	27.28	28.54	24.55	251.41	238.16	269.31	244.96
T_9	7.01	7.12	7.21	7.27	0.28	0.27	0.34	0.37	0.68	0.66	0.65	0.59	344.6	331.74	366.26	345.56	33.16	32.25	34.58	31.86	261.12	250.68	278.32	263.48
T_{10}	6.92	7.05	7.19	7.23	0.31	0.3	0.36	04	0.73	0.71	0.67	0.61	368.2	350.54	381.82	368.37	36.23	36.26	37.35	33.21	290.4	277.61	309.14	285.41
T_{11}	6.9	7.04	7.15	7.19	0.32	0.29	0.35	0.39	0.74	0.72	0.7	0.64	379.9	370.44	403.19	389.69	38.28	37.36	41.82	36.34	298.16	289.36	318.26	296.66
T_{12}	7.29	7.41	7.36	7.51	0.34	0.32	0.37	0.41	0.78	0.75	0.76	0.66	407.92	403.67	430.02	417.25	46.64	46.18	44.89	39.78	317.31	305.42	335.21	317.52
F test	NS	NS	NS	NS	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
SEm±	-	-	-	-	0	0	0.01	0	0.01	0.01	0.01	0.01	4.65	3.86	4.69	4.02	0.55	0.46	0.44	0.4	3.52	4.36	4.29	4.42.
CD (P=0.05)	-	-	-	-	0.01	0.01	0.02	0.01	0.03	0.02	0.02	0.02	13.64	11.32	13.76	11.8	1.61	1.35	1.28	1.18	10.32	12.8	12.58	12.96

Physical Properties of soil

As depicted in the Table 2, shows that the effect of sewage sludge and flyash on the physical properties of soil at both depth in both the years. The B.D (mg/m^3) was non-significant at both the depths and in both the years which was maximum in 1.34 in 2021 at 15-30 cm and minimum was 1.08 in 2020 at 0-15 cm. The PD (mg/m^3) was non-significant in both the depths and in both the years which was maximum in 2.48 in 2021 at 15-30 cm and minimum was 2.12 in 2020 at 0-15 cm. The Pore-space (%) was significant in both the depths and in both the years which was maximum in 50.52 in 2021 at 15-30 cm and minimum was 43.1 in 2020 at 15-30 cm. The WHC (%) was significant in both the depths and in both the years which was maximum in 59.89 in 2020 at 0-15 cm and minimum was 47.32 in 2021 at 15-30 cm (Yeledhalli *et al.*, 2008).

Chemical Properties of soil

As depicted in the Table 3, shows that the effect of sewage sludge and flyash on soil chemical properties.The pH was non-significant in both the depths and in both the years which was maximum in 7.62 in 2020at 15-30 cm and minimum was 7.01 in 2020 at 0-15 cm. The EC (dSm^{-1}) was significant in both the depths and in both the years which was maximum in 0.41 in 2021 at 15-30 cm and minimum was 0.24 in 2020 at 15-30 cm. The OC (%) was significant in both the depths and in both the years which was maximum in 0.78 in 2020 at 0-15 cm and minimum was 0.43 in 2020 at 15-30 cm. The Nitrogen (kg/ha) was significant in both the depths and in both the years which was maximum in 430.02 in 2021 at 0-15 cm and minimum was 240.68 in 2020 at 15-30 cm. The Phosphorus (kg/ha) was significant in both the depths and in both the years which was maximum in 46.64 in 2020 at 0-15 cm and minimum was 18.75 in 2021 at 15-30cm. The Potassium (kg/ha) was significant in both the depths and in both the years which was maximum in 335.21 in 2021 at 0-15 cm and minimum was 173.78 in 2021 at 15-30 cm.

Available Micro-nutrients in soil

As depicted in the Table 4, shows that the effect of sewage sludge and flyash on soil micronutrients. The Iron was significant in both the depths

Table 4. Effect of Co-application of Sewage sludge and Fly-ash on available micro-nutrients in soil in both year at both the depths

Treatments	Fe (mgkg^{-1}) (2020)		Fe (mgkg^{-1}) (2021)		Mn (mgkg^{-1}) (2020)		Mn (mgkg^{-1}) (2021)		Zn (mgkg^{-1}) (2020)		Zn (mgkg^{-1}) (2021)		Cu(mgkg^{-1}) (2020)		Cu (mgkg^{-1}) (2021)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	6.62	4.4	6.95	4.62	6.22	5.42	6.53	5.69	1.04	1.01	1.29	1.06	2.04	1.12	2.14	1.83
T_2	18.42	16.05	19.34	16.85	13.24	11.04	13.90	11.59	1.23	1.84	1.09	0.88	2.24	1.87	2.35	1.96
T_3	17.68	15.42	18.56	16.19	14.56	12.36	15.28	12.97	1.5	1.52	1.57	1.15	3.09	2.45	3.24	2.57
T_4	19.85	17.2	20.84	18.06	15.42	13.34	16.19	14.07	2.45	1.9	2.57	1.99	3.85	2.86	4.04	3.03
T_5	28.94	25.42	30.38	26.69	17.84	15.45	18.73	16.22	3.02	2.45	3.71	3.09	4.1	3.24	4.30	3.40
T_6	33.23	30.2	34.89	31.71	19.46	17.24	20.43	18.10	3.12	2.32	4.03	3.19	3.9	3.01	4.09	3.16
T_7	26.78	23.54	28.11	24.71	15.54	13.24	16.31	13.90	2.04	1.85	1.09	0.89	2.2	2.65	2.31	1.73
T_8	21.2	19.85	22.26	20.84	17.42	15.32	18.29	16.08	2.53	1.72	1.60	1.08	2.94	1.98	3.08	2.07
T_9	21.85	20.23	22.94	21.24	21.09	19.05	22.14	20.02	2.65	1.94	2.78	2.03	3.04	2.24	3.19	2.35
T_{10}	20.82	19.24	21.86	20.20	21.45	19.62	22.52	20.60	2.98	2.16	3.12	2.20	3.68	3.01	3.86	3.16
T_{11}	30.54	27.34	32.06	28.70	22.34	20.45	23.45	21.47	3.18	2.48	3.25	2.52	3.94	3.36	4.13	3.36
T_{12}	36.54	33.08	38.36	34.73	25.84	23.64	27.13	24.82	3.54	2.85	3.71	2.99	4.34	3.78	4.55	3.96
F test	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
SEm±	0.4	0.25	0.53	0.4	0.16	0.24	0.31	0.23	0.05	0.04	0.04	0.04	0.05	0.04	0.06	0.05
CD (P=0.05)	1.16	0.75	1.55	1.17	0.46	0.2	0.91	0.67	0.13	0.1	0.13	0.11	0.16	0.13	0.19	0.13

and in both the years which was maximum in 38.367 in 2021 at 0-15 cm and minimum was 4.4 in 2020 at 15-30 cm. The Manganese was significant in both the depths and in both the years which was maximum in 27.132 in 2021 at 0-15 cm and minimum was 5.42 in 2020 at 15-30 cm. The Zinc was significant in both the depths and in both the years which was maximum in 3.717 in 2021 at 0-15 cm and minimum was 1.01 in 2020 at 15-30 cm. The Copper was significant in both the depths and in both the years which was maximum in 4.557 in 2021 at 0-15 cm and minimum was 1.12 in 2020 at 15-30 cm (Singh *et al.*, 2008).

Conclusion

The research study has revealed that the use of sewage sludge and fly ash has improved the soil physico-chemical properties, the combined use of FA and sewage sludge has been proposed to reduce the bioavailability of heavy metals these ameliorant has potential liming capabilities, decreasing pH and having a long-term residual effect. It can be seen as a slow-release supply of components needed for plant growth, as well as a good source of nutrients required for plant growth.

References

Amar, A. and Shanmugasundaram, R. 2020. Nutrient index values and soil fertility ratings for Available Sulphur and Micronutrients of Tiruchirappalli District of Tamil Nadu, India. *International Journal of Current Microbiology and Applied Sciences,* ISSN: 2319-7706 9(3).

Basha, N. A. I., James, A., Bharose, R. and Rao, P. S. 2018. Impact of Flyash on Soil physical Properties under Sunflower-SpinachSunflower Crop Rotation System in Central India. *International Journal of Current Microbiology and Applied Sciences.* 7(12): 2319.

Black, C. A. 1965. Methods of Soil Analysis. Amer. Soc.ofAgro. Inc. Publ. Madison, Wisconsin, USA.

Eid, M. E., Bebany, A. F., Alrumman, A., Hesham, A. L., Taher, A. M. and K. 2017. Effects of different sewage sludge applications on heavy metal accumulation, growth and yield of spinach (*Spinacia oleracea* L.). *International Journal of Phytoremediation*. 19(4) : 274-277.

Faizan Shahla and Kausar Saima* 2016. Growth and Yield of Spinach (Spinaceaolearacea) grown in Fly Ash Amended Soils. *The Journal of Indian Botanical Society*. 89 : 0019-4468.

Jackson, M. L. 1967. *Soil Chemical Analysis.* Prentice Hall Inc. Englewood cliffs, NJ, USA.

Jackson, M.L. 1973. *Soil Chemical Analysis.* Prentice Hall of India Pvt. Ltd., NewDelhi.

Majaule U. B., Dikinya, O., Moseki, B. and Glaser, B. 2020. Effects of biochar and sewage sludge on spinach (*Spinacia oleracea* L.) yield and soil NO_3 - content in texturally different soils in Glen Valley. *African Journal of Biotechnology*. 19(5) : 287-300.

Olsen, S. R., Cole, C. V., Watnable, F. S. and Dean, L. A. 1954. Estimation of available Phosphorous in soils by extraction with sodium carbonate. *U.S.D.A. Cir.*, 933: 1-10.

Piper, C. S. 1966. *Soil and Plant Analysis,* Hans Publishers: Bombay. India.

Singh, R. P. and Agrawal, M. 2007. Potential benefits and risks of land application of sewage sludge. *Journal of Waste Management*. 28 : 347–358.

Singh, A., Sharma, R . K. and Agarwal, S. B. 2008. Effects of fly ash incorporation on heavy metal accumulation, growth and yield responses of Beta vulgaris plants. *Journal of Bioresource Technology*. 99 : 7200-7207.

Subbaiah, B. V. and Asija, G. L. 1956. A rapid method for estimation of available N in soil. *Current Science*. 25: 259-260.

Subbiah, B. V. and Asija, G. L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci*. 25(8) : 259-260.

Swain, A. Singh, S.K., Mohapatra, K. K. and Patra, A. 2020. Effect of sewage sludge application on yield, nutrient uptake and nutrient use efficiency of spinach (*Spinacia oleracea* L.). *Annals of Plant and Soil Research.* 22(3): 305-309.

Tsadilas, C., Shaheen, S., Samaras, V. and Gizas, D., Z. 2009. Influence of fly ash application on copper and zinc sorption by acidic soil amended with sewage sludge. *Commun Soil Sci Plant Anal.* 40(6) : 273-284.

Walkley, A. and Black, I. A. 1934. An examination of the Digestion method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science*. 37(1) : 29-38.

Yeledhalli, N. A. and Ravi, M.V. 2008. Effect of co-application of flyash and sewage sludge on growth, yield of okra and some soil properties. *Asian Journal of Soil Science.* 3(1) : 71-75.