D-6082
[1-6]

RESEARCH ARTICLE Agricultural Science Digest, Volume Issue : ()

Assessing the Effects of Yeast Vinasse with Conventional Manures on Soybean Performance and Soil Properties

Anusree Paul[1], Manimala Mahato[1], V.V.S Jayakrishna[1], Madhurima Dey[1], Dhananjoy Dutta[1] 10.18805/ag.D-6082

ABSTRACT

Background: Indiscriminate management of chemical fertilizer is the major cause of deterioration of soil health, yield, sustainability and biodiversity. The effect of Yeast vinasse, a by-product of bakery industry,on the growth, yield and quality of soybean as well as soil fertility and biological properties was evaluated over conventional manures through integrated nutrient management.

Methods: Field experiment was conducted during *kharif* seasons of 2020 and 2021 at Bidhan Chandra Krishi Viswavidyalaya (BCKV), West Bengal, India in sandy loam soil (*Entisol*) with eight nutrient treatments combining organic sources (FYM, Vermicompost and Yeast vinasse) with inorganic NPK fertilizers and $ZnSO_4$ foliar spray in randomised block design replicated thrice. Standard procedures were followed for plant and soil analysis.

Result: Vermicompost 1.5 t ha^{-1} along with 75% RDF and 0.5% $ZnSO_4$ foliar application showed highest growth, yield, quality and nitrogen and phosphorus uptake by the crop, which was statistically at par with 2 t ha^{-1} yeast vinasse along with 75% RDF and 0.5% $ZnSO_4$ foliar spray. The same treatments also exhibited higher soil organic carbon content and microbial activity; available nitrogen (N), phosphorus (P), potassium (K) and zinc (Zn) status of soil over other treatments.

Key words: FYM, INM, Soybean, Vermicompost, Yeast Vinasse, Zinc.

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is an energy rich legume requiring higher amounts of nutrients (Sikka *et al.*, 2018), but the imbalanced application of inorganic fertilizers over a long period causes micronutrient deficiencies and deteriorates the productivity and profitability of soybean day by day (Arbad *et al.,* 2014). To combat such challenges, the strategy for integrated nutrient management (INM) using conventional organic manures like FYM/ vermicompost draws huge attention across the world (Bandyopadhyay *et al.,* 2010). Yeast vinasse is an organic waste from sugarcane processing industry, having low pH, high volatile solids, organic and inorganic nutrients, mainly potassium (Pinto *et al*., 2022). Its use improves the availability of nitrogen, potassium and organic matter in soil (Moran-Salazar *et al.,* 2016), calcium, sulphur and micronutrients to crops (Vadivel *et al*., 2014) and enhances crop yields. However, the information on efficacy of yeast vinasse as organic source of plant nutrients is meagre in India. Again, Zn deficiency in 48% of Indian soils affects the growth and productivity of legumes including soybean (Shukla *et al.,* 2018) due to inhibiting protein synthesis, chlorophyll formation, enzyme activation and stimulation of growth hormones (Singh *et al.,* 2018). Hence, Zn fertilization becomes an integral part of nutrient management to enhance yield and quality of soybean (Yadav *et al.,* 2022).

Keeping in view, an attempt was made to assess the effects of yeast vinasse compared to vermicompost and FYM on soybean productivity and soil properties in INM under Zn deficient alluvial zone of West Bengal.

[1]Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Nadia-741 252, West Bengal, India.

Corresponding Author: Manimala Mahato, Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Nadia-741 252, West Bengal, India. Email: manimalamahato@gmail.com

How to cite this article: Paul, A., Mahato, M., Jayakrishna, V.V.S., Dey. and Dutta, D. (2025). Assessing the Effects of Yeast Vinasse with Conventional Manures on Soybean Performance and Soil Properties. Agricultural Science Digest. 1-6. doi: 10.18805/ag.D-6082.

Submitted: 06-06-2024 **Accepted:** 29-11-2024 **Online:** 23-01-2025

MATERIALS AND METHODS

Field experiment was carried out in *kharif* seasons (June-October) of 2020 and 2021 at the instructional farm of BCKV, West Bengal under sub-tropical and sub-humid climate of eastern India. The experimental soil was sandy loam in texture (*Entisol*) with 53.91% sand, 21.83% silt and 15.90% clay; and initial soil fertility in 0-30 cm depth is presented in Table 3. Soybean was grown as rainfed crop and the rainfall received in crop period was 1052 mm (67 rainy days) in 2020 and 1186.9 mm (60 rainy days) in 2021. Monthly average maximum and minimum temperatures were recorded in June and October in both the years and the values were 33.5°C (2020) and 33.7°C (2021); 20.8°C (2020) and 21°C (2021) respectively. The experiment was laid out in randomized block design with three replications and eight treatments such as T_1-100% RDF (Control), T_2-75% RDF+1.5 t ha^{-1} vermicompost, T_3-75% RDF+3 t ha^{-1} farmyard manure (FYM), T_4-75% RDF+2 t ha^{-1} yeast vinasse,

T_5-100% RDF+$ZnSO_4$ @ 0.5% foliar spray, T_6-75% RDF+1.5 t ha^{-1} vermicompost+ $ZnSO_4$ @ 0.5% foliar spray, T_7-75% RDF+3 t ha^{-1} FYM + $ZnSO_4$ @ 0.5% foliar spray and T_8-75% RDF+2 t ha^{-1}yeast vinasse+ $ZnSO_4$ @ 0.5% foliar spray. N, P_2O_5 and K_2O were applied @ 20, 60 and 40 kg ha^{-1}, respectively in 100% RDF through of urea (46% N), SSP (16% P_2O_5) and MOP (60% K_2O), respectively. The nutrient composition of different organic sources is presented in below:

Organic source	N (%)	P_2O_5 (%)	K_2O (%)	Zn (%)
FYM	0.61	0.35	0.42	0.01
Vermicompost	1.5	1	1.2	0.03
Yeast vinasse	1.92	0.49	9.02	-

As per the treatments, the organic manures were applied ten days before sowing and NPK fertilizers were applied at sowing and mixed thoroughly with the soil.Seeds of soybean variety 'PS24' having duration of 110-115 days and semi-determinate type was sown on 28th June in 2020 and 25th June in 2021 with 45cm×10cm spacing. Foliar spray of heptahydrate $ZnSO_4$ (containing 31% Zn) was done @ 0.5% at 30 and 60 days after sowing (DAS) as per treatment. The crop was harvested at 22nd and 20th October in 2020 and 2021, respectively. All growth and yield parameters were recorded at harvest; however, number and dry weight of nodules was recorded at 60 DAS.

Collected soil samples at initial and harvest were processed and standard methods were followed for analysis of pH (Jackson, 1973), organic carbon (Walkley and Black wet digestion method; Jackson, 1973), available N (Subbiah and Asajia, 1956), available P_2O_5 (Olsen *et al.*, 1954), available K_2O (flame photometric method; Jackson, 1973) and Zn content (DTPA extraction followed by atomic absorption spectrophotometry method). Total bacteria (Thronton agar medium), fungi (Martin's Rose Bengal medium) and actinomycetes population (actinomycetes isolation agar medium), dehydrogenase activity (Casida *et al.,* 1964) and microbial biomass carbon (MBC) (Vance *et al.,* 1987) of different treatments were analysed at harvest. Plant samples (both seed and stover) at harvest were subjected towet digestion to estimate N (Micro Kjeldahl method; Piper, 1966), P (Vanado Molybdate Phosphoric yellow colour method; Jackson, 1973), K (Flame Photometer method; Jackson, 1973) and Zn (DTPA extraction followed by atomic absorption spectrophotometry method) content (%) and multiplied with biomass to work out nutrient uptake. The nitrogen content of seed samples was also multiplied with a factor of 6.25 to get crude protein (Gupta *et al*., 1972). Soxhlet apparatus method (Ajaye *et al*., 2004) was followed to determine oil content of seeds. The data collected from field and laboratory were analysed through analysis of variance and the comparison among the treatment means wasdone using critical difference (CD) at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth attributes, nodule number and dry weight, yield attributes and yields

It was observed in both years that integrated application of organic manures and NPK and Zn fertilizers significantly improved the growth attributes, nodulation and yields of soybean over NPK fertilization alone (control-T_1). Plant height and dry matter accumulation was recorded highest in T_6 (65.57 and 69.73 cm and 481.55 and 516.62 g m^{-2} in 2020 and 2021, respectively), which was statistically at par with T_2, T_7 and T_8 in 2020 and with T_8 in 2021 for plant height and with T_2 and T_8 in 2020 and with T_8 in 2021 for dry matter accumulation (Table 1). Though, significantly the highest number of nodules $plant^{-1}$ was noted in T_2 (35.09) in 2020, which was at par with T_4, T_6 and T_7; and T_6 (41.79) in 2021, which was at par with T_2, T_4 and T_7 (Fig 1). However, the dry weight of nodules $plant^{-1}$ was maximum in T_6 (127.73 mg)

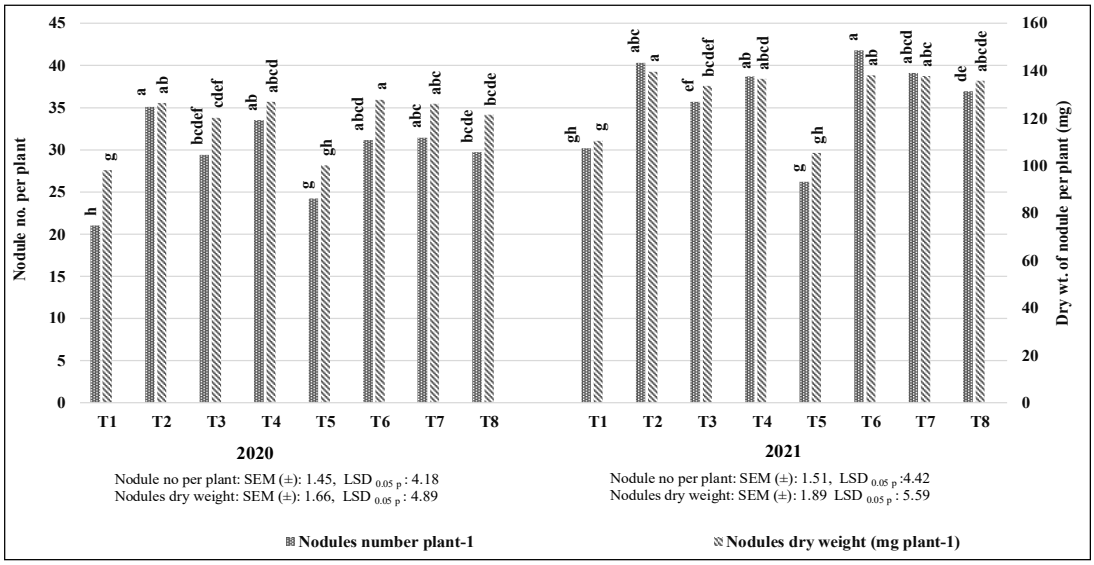

Fig 1: Effect of nutrient management on number and dry weight of nodules of soybean.

in 2020, which was at par with T_2, T_4 and T_7 and in T_2 (139.63 mg) in 2021, which was at par with T_4, T_6, T_7 and T_8 (Fig1). T_6 treatment showed the highest number of pods plant^{-1} (24.17 and 26.41), which was at par with T_2, T_7 and $T_{8;}$ and also100-seed weight (14.81 g and 14.94 g) which was at par with T_7 and T_8 in 2020 and 2021, respectively (Fig 2). The number of seeds pod^{-1} did not vary significantly among the treatments. The greater production of photosynthates enhanced the yield attributes, resulting in the highest seed and stover yields recorded in T_6 (1810 and 1906 kg ha^{-1} and 3820 and 4000 kg ha^{-1} in 1st and 2nd year, respectively), which was on a par with T_2 and T_8 in 2020 and T_7 and T_8 in 2021 in case of seed yield and with T_2 and T_8 for stover yield in both years (Table 1). The lowest values of growth attributes, nodulation, yield components and yields were registered with sole application of 100% RDF. The enhanced results in INM over NPK fertilization alone might be due to the greater and prolong availability of essential nutrients throughout the growth period by the combined sources of nutrients. Moreover, among the organic manures, the more impacts of vermicompost on growth, yield attributes and yields might be attributed to the abundance of readily accessible plant nutrients, growth-promoting substances and a variety of beneficial microorganisms present within it (Rehman *et al*., 2023), however, the effects of vermicompost were also comparable and at par with yeast vinasse and in most of observations, yeast vinasse showed better than FYM. Besides organic manuring and NPK fertilization, the additional effects by foliar feeding of Zn on growth and yield parameters might be the cause of accelerated cell metabolism and hormonal activities (Aytaç, 2007). Our results were similar toVerma *et al.* (2017) and Mahato *et al.* (2020).

Nutrient uptake and quality

Higher biomass production in T_6 encouraged uptake of N (186.22 and 206.45 kg ha^{-1}), P_2O_5 (22.12 and 26.56 kg ha^{-1}), K_2O (93.21and 102.39 kg ha^{-1}) and Zn (182 and 228.85 g ha^{-1}), which was at par with T_8 and with T_7 and T_8 for N uptake in 2020 and 2021, respectively (Table 1). This treatment was also on a par with T_7 and T_8 for P_2O_5 and K_2O uptake; and with T_8 for Zn uptake in both the years. The higher growth and proliferation of roots, better physical condition of the soil and greater availability of nutrients in INM might hasten the uptake of nutrients (Paramesh *et al.,* 2023). The oil content of seeds remained non-significant among the treatments in 2020 (Table 2), but varied significantly in 2021 with maximum oil content in T_5 (20.47 and 20.04%, respectively). Protein content of seeds was highest in T_8 (38.19 and 40.38%, respectively), which was at par with T_6 (Table 2). The results exhibited the favourable effects of yeast vinasse on N uptake and protein content of seeds. The lower values of qualities were recorded in control. Similar findings were reported by Verma *et al*. (2017).

Microbial population, microbial biomass carbon (MBC) and dehydrogenase activity

Application of organics with fertilizers significantly affected the biological properties of the soil (Table 2). T_7 recorded the maximum bacterial population in 2020 (14.19 CFU×10^6) whereas, T_6 during 2021 (15.19 CFU×10^6). T_8 showed the maximum population of fungi (9.88 and 11.31 CFU×10^4) and actinomycetes (6.28 and 8.09 CFU×10^5) for both the years. The highest microbial biomass carbon was obtained in T_7- (171.82 and 188.88 µg C g^{-1} soil in 2020 and 2021, respectively), which was at par with T_3, T_4, T_6 and T_8 in 2020 and T_2, T_3 and T_6 in 2021. T_7 also showed the highest dehydrogenase activity in 2020 (55.66 µg TPF g^{-1} of soil 24 hr^{-1}), at par with T_2, T_4, T_6 and T_8. But in 2021, it was highest

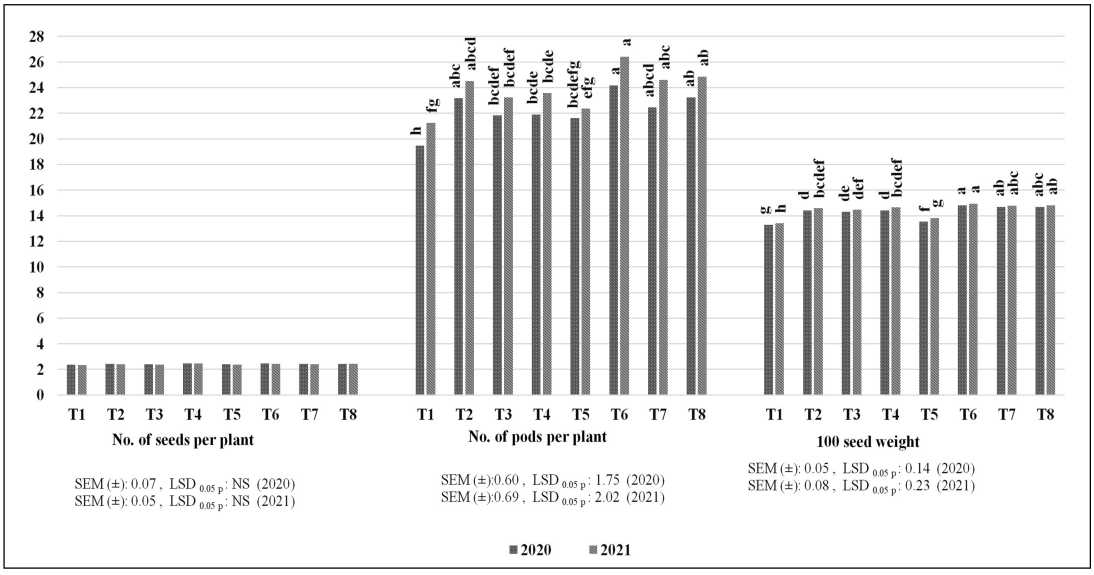

Fig 2: Effect of nutrient management on yield attributes of soybean.

Table 1: Effect of Integrated Nutrient Management (INM) on growth attributes, yield and nutrient uptake of soybean.

Treatments	Plant height (cm)		Dry matter accumulation (gm^{-2})		Seed yield ($kg\ ha^{-1}$)		Stover yield ($kg\ ha^{-1}$)		Uptake ($kg\ ha^{-1}$)							
									N		P_2O_5		K_2O		Zn ($g\ ha^{-1}$)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T_1	49.87	53.91	366.81	402.21	1267	1400	3037	3292	110.02	127.67	8.97	11.52	60.22	70.50	90.65	106.12
T_2	62.27	65.18	447.32	479.73	1655	1740	3612	3819	161.64	178.21	13.20	16.10	82.46	90.36	137.60	162.11
T_3	56.78	61.44	419.87	451.36	1524	1610	3418	3646	142.16	161.75	11.80	14.57	75.48	84.21	126.45	142.05
T_4	60.12	63.36	435.05	465.05	1572	1665	3501	3718	145.98	168.31	12.32	14.31	80.49	89.03	125.70	163.68
T_5	50.17	55.29	389.07	426.59	1436	1504	3184	3368	129.44	146.82	15.08	17.18	69.57	78.34	129.21	154.06
T_6	65.57	69.73	481.55	516.62	1810	1906	3820	4000	186.22	206.45	22.12	26.56	93.21	102.39	182.00	228.85
T_7	61.83	64.88	443.18	480.81	1652	1760	3574	3762	161.97	186.53	19.23	22.73	84.55	93.97	170.04	196.67
T_8	63.34	67.56	458.70	492.73	1690	1805	3651	3843	168.81	196.53	19.35	22.55	89.97	99.68	173.65	227.77
SEM (±)	1.36	1.41	11.33	12.59	52.60	55.49	76.50	78.32	6.92	8.01	1.04	1.44	3.40	4.00	3.78	4.47
$CD_{0.05p}$	3.99	4.15	37.09	33.37	154.76	163.47	225.34	230.72	20.38	23.59	3.06	4.24	10.01	11.78	11.15	13.17

Table 2: Effect of Integrated Nutrient Management (INM) on oil and protein content, soil micro-biota, microbial biomass carbon and dehydrogenase activity.

Treatments	Oil content (%)		Protein content (%)		Total bacteria ($CFU\times10^6$)		Fungi ($CFU\times10^4$)		Actinomycetes ($CFU\times10^5$)		MBC ($\mu g\ C\ g^{-1}$ soil)		Dehydrogenase activity (μg TPF g^{-1} of soil 24 hr^{-1})	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T_1	20.33	19.07	34.50	35.69	9.14	10.72	4.89	7.32	3.82	5.06	143.92	159.05	45.25	52.28
T_2	19.14	18.58	36.63	37.81	12.86	15.05	9.21	10.13	5.91	7.27	161.36	180.07	54.14	65.08
T_3	20.23	19.36	35.88	37.31	13.92	14.83	9.46	10.82	5.64	7.16	169.60	183.23	50.95	66.35
T_4	20.02	18.11	34.94	37.50	12.18	13.58	9.05	9.95	6.21	7.81	165.92	177.02	52.69	63.29
T_5	20.47	20.04	35.69	37.50	9.64	10.52	5.42	6.84	2.52	4.75	140.04	154.78	42.64	55.42
T_6	19.97	17.99	37.39	39.63	13.08	15.19	9.44	11.07	5.59	7.57	163.18	185.01	54.20	61.98
T_7	19.88	18.44	36.94	39.25	14.19	15.03	9.18	10.52	5.35	6.93	171.82	188.88	55.66	64.54
T_8	19.72	17.89	38.19	40.38	12.01	13.35	9.88	11.31	6.28	8.09	163.70	174.83	53.61	60.95
SEM (±)	0.49	0.47	0.28	0.29	0.69	0.74	0.28	0.36	0.18	0.23	2.97	3.29	1.08	1.12
$LSD_{0.05p}$	NS	1.38	0.82	0.85	1.90	2.20	0.83	1.09	0.55	0.70	8.80	9.60	3.21	3.30

SMBC= Soil microbial biomass carbon, CFU= Colony forming unit; INM = Integrated nutrient management

Table 3: Effect of Integrated Nutrient Management (INM) on residual soil fertility.

Treatments	Organic carbon (%)		Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})		Available Zn (ppm)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
T_1	0.54	0.58	204.41	219.43	28.18	27.05	183.34	204.06	0.50	0.52
T_2	0.56	0.61	210.75	224.36	33.29	30.05	175.67	198.74	0.53	0.54
T_3	0.57	0.61	212.94	226.76	33.67	30.71	182.67	201.90	0.52	0.53
T_4	0.56	0.60	209.91	225.16	32.61	29.73	240.74	260.48	0.51	0.53
T_5	0.54	0.59	206.96	220.32	29.06	26.17	178.82	202.11	0.51	0.52
T_6	0.58	0.62	214.89	231.53	31.50	28.90	169.57	187.97	0.52	0.54
T_7	0.59	0.63	218.95	235.43	32.25	29.31	172.13	190.82	0.52	0.54
T_8	0.58	0.62	215.81	232.87	31.83	28.73	235.76	254.55	0.51	0.53
SEM (±)	0.01	0.02	2.73	3.41	0.78	0.68	2.30	3.09	0.01	0.01
$LSD_{0.05p}$	0.03	NS	8.03	10.05	2.31	2.01	6.78	9.10	NS	NS
Initial	0.54	0.58	198.63	209.81	30.24	26.68	180.27	196.32	0.51	0.53

under T_3 (66.35µg TPF g^{-1} of soil 24 hr^{-1}), at par with T_2, T_4 and T_7. Integration of nutrient sources, where organics served as feeding materials for the microorganisms, resulted to greater counts of microbes and higher microbial biomass carbon and more activities of dehydrogenase due to higher activity of microorganisms. Similar finding was reported by Paramesh *et al.* (2023).

Residual fertility

Organic carbon of the soil was increased at harvest from initial level in the plots where organic manures were added to the soil and it was maximumin T_7 (0.59 and 0.63% in 2020 and 2021, respectively), followed by T_6 and T_8 (Table 3). Similarly, the residual soil N improved from initial status in all treatments in two years might be the contribution of biological nitrogen fixation by legumes. It was maximum under T_7 (218.95 kg ha^{-1} and 235.43 kg ha^{-1}, respectively), at par with T_3, T_6 and T_8 during both the years. T_3 recorded the maximum soil available P_2O_5 (33.67 and 30.71 kg ha^{-1} in 2020 and 2021, respectively), at par with T_2, T_4, T_6, T_7 and T_8 in both years (Table 3). Residual soil K_2O was highest under T_4 (240.74 and 260.48 kg ha^{-1} in 2020 and 2021, respectively), at par with T_8. However, Zn content of soil at harvest was non-significant among the treatments. Integrated application of nutrients kept higher levels of residual NPK than sole inorganic fertilizers even after meeting the nutrient demand for the exhaustive legume soyabean and it was attributed to the slow nutrient release property of organic manures. The greater carbon sequestration of organic manures might improve organic carbon of the soil. More residual nutrients after harvest in second year than first year might be the cumulative effects of organic manures added in two years. Higher residual organic carbon, N and P_2O_5 in FYM treated plots followed by vermicompost and yeast vinasse treatments indicated the potentiality of yeast vinasse in enhancing soil fertility. Moreover, the significant enrichment of soil K_2O by yeast vinasse might be the addition of substantial amount K_2O through it. However, the non-significant effects of treatments on soil residual zinc might be due to foliar application of Zn fertilizer.This result was in congruities with the findings of Vyas and Kushwah (2015).

CONCLUSION

The two years study exhibited that though the integrated application of vermicompost along with 75% RDF and 0.5% $ZnSO_4$ as foliar spray (T_6) was found superior over other treatments but it was statistically comparable with the application of yeast vinasse along with 75% RDF and foliar spray of 0.5% $ZnSO_4$ (T_8) in terms of growth attributes, yield and yield attributes as well as uptake of nutrients. Therefore, T_8 can be a viable option for soybean cultivation in per-humid region of West Bengal under alluvial soil. It also saved 25 % of inorganic fertilizer (NPK). Besides, yeast vinasse application also increased seed protein %, residual fertility and fungi and actinomycetes population and K_2O in soil. Therefore, this comparative study revealed the potentiality of yeast vinasseas organic source of nutrients in soybean crop like other conventional manures and hence, it is necessary to explore this organic waste as an alternative source of nutrients in other crops.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

Ajaye, I.A., Adebowale, K.O., Dawodu, F.O. and Oderinde, R.A. (2004). A study of the oil content of nigerian grown monodoramyristica seeds for its nutritional and industrial applications. Pakistan Journal of Scientific and Industrial Research. 47(1): 60-65.

Arbad, B.K., Ismail, S. and Dhawan, A.S. (2014). Influence of long-term use of farmyard manure and inorganic fertilizer on grain yield and nutrient availability in vertisols under soyabean-safflower sequence cropping. Legume Research-An International Journal. 37(6): 600-6. doi: 10.5958/0976-0571.2014.00683.3.

Aytaç, S. (2007). Foliar zinc application on yield and quality characters of soybean. Asian Journal of Chemistry. 19(3): 2410.

Bandyopadhyay, K., Misra, A., Ghosh, P. and Hati, K. (2010). Effect of integrated use of farmyard manure and chemical fertilizers on soil physical properties and productivity of soybean. Soil Tillage Research. 110: 115-125.

Casida, L.E. JR., Klein, D.A., Santoro, T. (1964). Soil dehydrogenase activity. Soil Science. 98(6): 371-376.

Gomez, K.A., Gomez, A.A. (1984). Statistical procedures for agricultural research. John Willey and Sons. New York.

Gupta, B.R., Pathak, R.K., Bhan, S., Singh, A. (1972). Effect of NPK on yield, nutrient uptake and quality of toria. Indian Journal of Agronomy. 17(1): 88-91.

Jackson, M.L. (1973). Soil chemical analysis, pentice hall of India Pvt. Ltd., New Delhi, India. 498: 151-154.

Mahato, M., Biswas, S. and Dutta, D. (2020). Effect of integrated nutrient management on growth, yield and economics of hybrid maize (*Zea mays* L.). Current Journal of Applied Science and Technology. 39(3): 78-86.

Moran-Salazar, R.G., Sanchez-Lizarraga, A.L., Rodriguez-Campos, J., Davila-Vazquez, G., Marino-Marmolejo, E.N., Dendooven, L. and Contreras-Ramos, S.M. (2016). Utilization of vinasses as soil amendment: consequences and perspectives. Springer Plus. 5: 1-11. doi: https://doi.org/10.1186/s40064-016-2410-3.

Olsen, S.R. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Department of Agriculture, Circular No. 939, US Government Printing Office, Washington DC.

Paramesh, V., Mohan Kumar, R., Rajanna, G.A., Gowda ,S., Nath, A.J., Madival, Y., Jinger, D., Bhat, S. and Toraskar, S. (2023). Integrated nutrient management for improving crop yields, soil properties and reducing greenhouse gas emissions. Frontiers in Sustainable Food System. 7: 1173258. doi: 10.3389/fsufs.2023.1173258

Pinto, L.E., Cordeiro, C.F., Araujo, A.S. and Araujo, F.F. (2022). Vinasse improves soil quality and increases the yields of soybean, maize and pasture. Revista Brasileira deEngenhariaAgrícola e Ambiental. 26(21): 335-40.

Piper, C.S. (1966). In: Soil and Plant Analysis, Academic Press, New York and Hons Publications, Bombay. pp 28-46.

Rehman, Su., De Castro, F., Aprile, A., Benedetti, M. and Fanizzi, F.P. (2023). Vermicompost: Enhancing plant growth and combating abiotic and biotic stress. Agronomy. 13(4): 1134. doi: https://doi.org/10.3390/agronomy13041134

Shukla, A.K., Behera, S.K., Pakhre, A. and Chaudhari, S.K. (2018). Micronutrients in soils, plants, animals and humans. Indian Journal of Fertilisers. 14(3): 30- 54.

Sikka, R., Singh, D., Deol, J.S. and Kumar, N. (2018). Effect of integrated nutrient and agronomic management on growth, productivity, nutrient uptake and soil residual fertility status of soybean. Agricultural Science Digest. 38(2): 103-107. doi: 10.18805/ag.LR-3994.

Singh, S., Singh, V., Shukla, R.D. and Dubey, D. (2018). Influences of sulphur and zinc levels on soybean and residual effect on succeeding crop in soybean-wheat cropping system. International Journal of Chemical Studies. 6(3): 1130-4.

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

Vadivel, R., Minhas, P.S., Kumar, S., Singh, Y., Nageshwar, R.D. and Nirmale, A. (2014). Significance of vinasses waste management in agriculture and environmental quality-Review. African Journal of Agricultural Research. 9(38): 2862-2873.

Vance, E.D., Brookes, P.C. and Jenkinson, D.S. (1987). An extraction method for measuring soil microbial biomass C. Soil Biology and Biochemistry. 19(6): 703-707. doi: https://doi.org/10.1016/0038-0717(87)90052-6.

Verma, S.N., Sharma, N. and Verma, A. (2017). Effect of integrated nutrient management on growth, quality and yield of soybean (*Glycine max*). Annals of Plant and Soil Research. 19: 372-376.

Vyas, M.D. and Kushwah, S.S. (2015). Response of soybean [*Glycine max* (L.) Merrill] varieties to fertility levels in vertisols of Vindhyan plateau of Madhya Pradesh. Soybean Research. 13(2): 9-18.

Yadav, S.L., Rai, H.K., Yadav, I.R., Kumar, A. and Choudhary, M. (2022). Effect of zinc application strategies on growth and yield of soybean in central India. International Journal of Plant and Soil Science. 33(24): 490-497.