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Effect of Combined Application of Treated Sewage Sludge and Inorganic Fertilizers on Yield and Yield Attributes of Maize Crop (*Zea mays* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In present day scenario the production wastes has increased tremendously to point where its disposal is a concern. The sewage sludge generated from sewage treatment plants (STP) contains nutrients which are beneficial to plants. Due to these beneficial qualities, it can be used for agricultural purpose. The purpose of the conducted study was to know the effect of combined

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application of sewage sludge along with inorganic fertilizers on yield of maize crop. Randomized block design involving 10 treatments and 3 replications was adopted for the study. The experiment was carried out from October 2023 to February 2024 at college farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad. The T10 (100% RDF+5 t ha^{-1} ss) treatment showed significant results when compared with T2 (100% RDF) treatment. The results obtained revealed that application of sewage sludge along with inorganic fertilizers (T10=100% RDF+5 t ha^{-1} ss) showed significant results when compared to application of inorganic fertilizers alone. The significantly highest grain yield, grain weight cob^{-1}, no. of grains cob^{-1} and no. of seed rows cob^{-1} were observed in T10 (100% RDF+5 t ha^{-1} ss) treatment followed by T9 (100% RDF+ 2.5 t ha^{-1} ss), T8 (75 % RDF + 5 t ha^{-1} ss) and T2 (100% RDF). According to the results obtained, sewage sludge can be used as source of nutrients for agricultural application by reducing the quantities of inorganic fertilizers and also reduces resource consumption for disposal of sewage sludge.

Keywords: Disposal; inorganic fertilizers; nutrients; resource; sewage sludge.

1. INTRODUCTION

Sewage sludge is an end production of sewage treatment plant (STP). The sewage sludge is the waste product after the aerobic or anaerobic digestion process. The disposal of sewage sludge has always been a concern. In general disposal of sewage sludge includes land filling, incineration etc, which consumes land, time and labor resources. Now a days due to the increased inflow of people to urban areas led to increased quantities of sewage sludge produced.

Sewage sludge is also known for its nutritional value. The nutrient content of sewage sludge varies depending upon the source from which it is being collected and treated. Sewage sludge consists of organic matter, macro and micro nutrients, trace elements, microorganisms. Due to the presence of essential macro and micro nutrients in sewage sludge, it can be used as fertilizer material and the organic matter present in sewage sludge improves soil properties [1,2].

Use of sewage sludge in agriculture is a way of recycling the wastes produced from STP. Agricultural application of sewage sludge reduces the exploitation of land resources for its disposal [3]. Application of sewage sludge in agriculture is a cost-effective and environmentally friendly method of disposal [4]. One of the demerits of application of sewage sludge was presence of heavy metals, so it is necessary to analyze the heavy metal content in sewage sludge [5]. The composition of sewage sludge is based on the source of waste produced and treatment process used to treat the generated wastes [6]. Agricultural use of sewage sludge after proper treatment improves the soil properties by providing the nutrients back to soil which removed before [7,8].

In India, during 2020-21 the total area under maize was 98.6 lakh hectares as compared to *kharif* of 2019-20, which was 81.91 lakh hectares and 79.94 lakh hectares during *kharif* of 2018-19. Globally India is in 4th position in terms of area of cultivation and 7th position in production with an annual production of 31.6 mt [9]. Major maize growing states in India are Madhya Pradesh 15.42 lakh ha, Karnataka 12.15 lakh ha, Maharashtra 8.71 lakh ha and in Telangana 3.92 lakh ha.

Various reports from studies conducted previously states that application of sewage sludge improves productivity of crops. The Application of 2% sewage sludge improved the yield of broad bean in calcareous loam soil [10]. Application of sewage sludge increased the productivity of bread wheat [11], Maize [12]. Application of 62 Mg ha^{-1} was reported to increase the grain yield in maize [13]. Application of sewage was also reported to increase the yield of Barley [14], Sunflower [15].

Total wastewater generation in the country is around 38.3 billion litres per day (BLD) while, the installed sewage treatment capacity is just 11.8 BLD thereby leading to a gap of 26.5 BLD in sewage treatment capacity. It is projected that by 2050, about132 BLD of wastewaters with a potential to meet 4.5% of the total irrigation water demand would be generated thereby further widening this gap [16].

The usage of sewage sludge in agriculture is getting popular as an organic manure and nutrient source. Many countries were using sewage sludge as source of nutrients; in the European community, over 40% of SS out of 10.1 million tonnes (Mt) production is used in agriculture [17]. Sewage sludge is inexpensive and supplies organic matter along with nutrients

to soil in contrary to inorganic fertilizers European Commission [18], Haynes et al. [19], [20]. The nutrients present in sewage sludge are bounded organically which means they are released with the decomposition of organic matter of sewage sludge. So, it can be considered as a slow-release fertilizer. The SS contains high amount of organic carbon (OC) (12.6%), 1.6% N, 1.3% P, 0.8% K and 2.1% S in addition to substantial quantities of micronutrients 232, 186, 260 and 161 mg kg-1 of Fe, Cu, Mn and Zn, respectively [20].

The present study conducted shows the effect of sewage sludge application in combination with inorganic fertilizers on yield and yield attributes of maize.

2. MATERIALS AND METHODS

2.1 Collection of Sewage Sludge

Sewage sludge was collected from STP (50 MLD) Attapur, Hyderabad. The sewage sludge was aerobically digested, treated and chlorinated before its disposal.

2.2 Location of Experimental Plot

The research work was carried out in College farm, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad. Geographically the site is located 17°19’21.0” N latitude and 78°24’38.9”E longitude.

2.3 Treatments and Design of Experiment

Randomized block design was adopted for conducting experiment. The total no. of treatments includes 10 i.e.

2.4 Initial Soil Characters

The soil was analysed for physical, physico chemical and chemical properties before carrying out the experiment. Soil of the experimental site falls under sandy clay loam. The pH, EC and OC of the soil was 7.34, 0.23 dS m^{-1} and OC content of soil was 4.2 g kg^{-1}. The available N, P2O5 and K2O of the soil was 174.51, 43.34 and 275.7 kg ha^{-1}.

2.5 Crop Management

the crop selected for carrying out the experiment was Maize (*Zea mays* .L). The seed rate of crop is 20 kg ha^{-1}, the recommended dosage of fertilizer is 240:80:80 kg NPK ha^{-1}. The hybrid variety selected was DHM-117. The land was ploughed with disc plough followed by cultivator and harrowing. Furrow and ridges were made with ridger. The spacing adopted for planting was 60×20 cm and the plot was 6×4.2 meters approx.

The crop was sown in *rabi* October 2023. The crop was irrigated regularly. One manual weeding after seed germination was done and pre-emergent herbicide spraying with Atrazine (1 kg 200 lit^{-1} $acre^{-1}$) after 2 days of sowing and post emergent herbicide spray with Calaris (400 ml 200 lit^{-1} $acre^{-1}$) after 20 days after sowing. The crop was infested with stem borer and fall army worm after one week of germination which were controlled with the foliar application of Chlorantraniliprole @ 4ml lit^{-1} $acre^{-1}$.

The weather conditions during the crop period from October 2023 to February 2024. The weekly mean maximum temperature was between 27.7℃ to 33.8℃ with an average of 30.5℃ mean weekly minimum temperature was between 15.3℃ and 21.0℃ with an average temperature of 17.5℃. The weekly morning relative humidity was 81% to 91% with an average of 85.7% and the weekly afternoon relative humidity was between 31.7% to 62.4% with an average of 41.8%. the total rain fall recorded was 14.4 mm. the weekly mean sunshine hours ranged between 3.5 to 9.3 with an average of 6.5 hours day^{-1}.

2.6 Data Analysis

2.6.1 Plant sampling and data collection

Five plants from each plot were tagged and the recorded data was collected from the tagged plants. The data collected includes grain yield, grain weight cob^{-1}, no. of grains cob^{-1}, no. of seed rows cob^{-1} and plant height (cm). The grain weight cob^{-1}, no. of grains cob^{-1} and no. of seed rows cob^{-1} were recorded from tagged plants was taken and then averaged. The plant height was measured using meter scale from base to top of the plant for tagged plants in plot and then averaged. For grain yield, the cobs were harvested, dried and then threshed till the moisture content reaches 10% and then presented in t ha^{-1}.

2.6.2 Statistical analysis

The data collected was subjected to analysis of variance for simple randomized block design (Rao, 1983).

Table 1. Characteristics of sewage sludge

pH	EC (dS m^{-1})	OC (%)	Total N (%)	Total P (%)	Total K (%)
5.9	4.38	12	1.09	0.16	0.019

List 1. Treatments details

T1	control (0:0:0)
T2	100% recommended dosage of fertilizers (RDF)
T3	2.5 t ha^{-1} ss
T4	5 t ha^{-1} ss
T5	50% RDF + 2.5 t ha^{-1} ss
T6	50% RDF + 5 t ha^{-1} ss
T7	75 % RDF + 2.5 t ha^{-1} ss
T8	75 % RDF + 5 t ha^{-1} ss
T9	100% RDF+ 2.5 t ha^{-1} ss
T10	100% RDF+5 t ha^{-1} ss

**ss = sewage sludge*
**RDF = recommended dose of fertilizers*

3. RESULTS AND DISCUSSION

Grain yield: The grain yield ranged between 2.10 t ha^{-1} in control to 8.38 t ha^{-1} in T10. The significant results were obtained with the application of T10 treatment (Table 2). The highest yield was obtained with T10 followed by T9 T8, T7, T2, T6, T5, T4, T3 and T1. Significant difference was recorded between the yields obtained from T10 (100% RDF + % t ha^{-1}) and T2 (100% RDF). The yield obtained in T3 and T4 was slightly higher than T1, but significant difference was not observed. Likewise the results recorded with T10 showed significant difference with T2 but on par with T9, T8. This might be attributed to the presence of macro nutrients present in the sewage sludge similar results were reported by Eghball and Power [21]. The decomposition of organic matter releases organic acids which solubilizes nutrients present in the soil and increases their availability [22].

Grain weight cob^{-1}: Among the treatments employed the grain weight cob^{-1} ranged from 25.17g to 100.37 g (Table 2). The highest results were recorded with T10 followed by T9, T8, T7, T2, T6, T5, T4, T3 and T1. The weights recorded with T10 was on par with weights obtained with the T7 and T7 was on par with T2. The highest weights in T10 might be attributed to application of sewage sludge along with RDF. The lesser weights obtained in T1 might be due no application of fertilizers. The weights obtained were in similar trend as that of grain yield. Similar results were reported by Hussain. [23] as he reported that difference in the weights might be attributed to different levels of fertilizers involved in treatments.

Table 2. Effect of different doses of combined application of Sewahe sludge and inorganic fertilizers

Treatments	Grain yield (t/ha)	Grain weight cob^{-1} (g)	No. of grains cob^{-1}	No. of seed rows cob^{-1}	Plant height (cm)
T1=control (0:0:0)	2.10	25.17	205.20	12.60	134.07
T2=100% recommended dosage of fertilizers (RDF)	7.51	91.66	360.27	14.93	180.80
T3=2.5 t ha^{-1} ss	2.18	26.10	224.83	13.40	144.90
T4=5 t ha^{-1} ss	2.71	32.43	235.60	13.87	147.33
T5=50% RDF + 2.5 t ha^{-1} ss	5.43	65.09	323.13	13.60	158.33
T6=50% RDF + 5 t ha^{-1} ss	6.06	72.57	347.40	14.20	164.53
T7=75 % RDF + 2.5 t ha^{-1} ss	7.49	89.53	358.60	14.63	177.18
T8=75 % RDF + 5 t ha^{-1} ss	7.76	92.99	370.03	15.07	179.97
T9=100% RDF+ 2.5 t ha^{-1} ss	8.11	97.13	375.33	15.13	194.83
T10=100% RDF+5 t ha^{-1} ss	8.38	100.37	395.07	16.53	199.50
SEM	0.22	2.61	11.57	0.50	8.58
CD	0.65	7.77	34.37	1.50	18.02
CV	6.56	6.56	6.27	6.06	6.25

*$P < 0.01$***

No. of grains cob^{-1}: The no. of grains cob $^{-1}$ ranged between 205 to 395. The trend was similar to that obtained in grain yield. The highest results were recorded with T10 due to highest doses of fertilizers and sewage sludge applied and the lowest were recorded with T1 plot due to no application of fertilizers and manures (Table 2). The results recorded with T10 showed significant difference with T2 and on par with T9 and T8. The results recorded with T2 were on par with T8. This might be due to the application of difference in levels of fertilizers and sewage sludge. The results were in accordance with the results reported by Sharar et al*.,* [24] and Oktem et al*.,* [25] as they reported that no. of grains $^{cob-1}$ were affected with different doses of fertilizers applied.

No. of grain rows cob^{-1}: The recorded results ranged between 12.60 to 16.53 (Table 2). the highest results were recorded with T10 and the lowest results were recorded with T1. The T10 was significantly superior than T2 and was on par with T9 and T8. The trend obtained is similar to that obtained with grain yield. The highest results recorded were attributed to application of highest dosage of fertilizers and sewage sludge. The lesser results recorded were attributed to 0:0:0 application of fertilizers. Similar results were recorded by Ali et al., [26] and Younas. [27].

Plant height: The plant height recorded ranged between 134.07 cm to 199.50 cm (Table 2). the highest results were recoded with T10 and the lowest was recorded with T1. The plant height recorded with T10 was on par with T9, T8 and T7 but significant difference was reported with T2. The significantly higher value might be attributed to application of fertilizers and additional availability of nutrients through sewage sludge. The results obtained were in agreement with results reported by Sharar et al*.,* [24] and Ayub et al., [28] who reported that availability of different levels of nutrients to plants effects plant height [29].

4. CONCLUSIONS

Application of sewage sludge in combination with sewage sludge improved Maize yield. T10 treatment showed significant results when compared to T2 treatment. Due to the beneficial properties of sewage sludge, it improves soil properties. Sewage sludge can also replace the inorganic fertilizers to some extent for crop application. Use of sewage sludge in agriculture helps in its disposal. So, it is concluded that application of sewage sludge in agricultural land is way of recycling generated organic wastes and reduces land resource consumption.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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