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Research Article

EFFECT OF HUMAN FECAL SLUDGE AND SEWAGE SLUDGE ON GROWTH AND YIELD OF MAIZE (*Zea mays*)

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Abstract- A field experiment was conducted at F block, Zonal Agricultural Research Station, V.C. Farm, Mandya during kharif season of 2014 to study the effect of humanure, pit toilet sludge and sewage sludge application on growth and yield of maize. In the experiment, three fecal sludges as nutrient sources along with three levels of fertilizers (75, 100 and 150 percent of recommended dose of fertilizers) were compared with FYM alone, recommended dose of fertilizer alone and recommended dose of fertilizer along with FYM were evaluated with thirteen treatments, replicated thrice in RCBD design. The results revealed that better growth and higher yield of maize was recorded with higher levels of manure and fertilizer application. Significantly higher plant height (203.65 cm) and number of leaves per plant (14.25) were recorded with 150 % K through humanure + balance N and P through fertilizers to supply 150 % N and P and was on par with 150 % P through pit toilet sludge + balance N and K through fertilizers to supply 150 % N and K (189.26 cm and 13.24 respectively) and 150 % P through sewage sludge + balance N and K through fertilizers to supply 150 % N and K (183.23 cm and 12.74 respectively) at 90 DAS (days after sowing). The lower plant height (117.11 cm) and number of leaves per plant (8.19) were recorded in control. Similarly, the test weight (31.50 grams), grain yield (87.52 q ha^{-1}) and stover yield (93.93 q ha^{-1}) recorded were significantly higher in treatment which received 150 % K through humanure + balance N and P through fertilizers to supply 150 % N and P. The increase in grain yield was to the tune of 16.99 %, 34.34% and 88.90 percent over RDF (100 % NPK + FYM), RDF alone and FYM alone treatments. The test weight (27.29 grams), grain yield (38.96 q ha^{-1}) and stover yield (42.55 q ha^{-1}) were lower in absolute control.

Keywords- Humanure, Pit toilet sludge, Sewage sludge, Maize

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Introduction

Many countries in the world generate a lot of wastes which includes food wastes, municipal wastes, sewage sludge, agricultural residues and human wastes in the form of digestive refuse material, otherwise known as faecal material and urine which pose the onerous task of their disposal. It has been estimated that in India 17.9 million cubic meters of sewage and 4 million tons of sludge are produced each year with a combined nutrient contribution of 2.4 lakh tons of N, 1.3 lakh tons of P_2O_5 and 1.2 lakh tons of K_2O besides 12 lakh tons of organic carbon most of which are being wasted leading pollution of soil and water bodies. As the population density increases, this task would be more voluminous and challenging. But, due to high level of nutrients present in these wastes, the best option would be to recycle them as an organic amendment or compost in the agricultural field. This inturn would help to reduce the gap between the nutrient demand of crops and addition leading to better soil health and enhanced food production (ddws.nic.in).

However, the use of anthropogenic wastes in agriculture is not possible with the present system of sewage disposal mechanisms. The toilets and urinals in urban centers will have to be redesigned to collect the faecal matter and urine separately. In this direction an eco-friendly design of toilet called 'ECOSAN' needs to be popularized which help in the source separation of human urine and faecal matter in a hygienic way. To exploit the huge potentiality of anthropogenic wastes as a supplement to fertilizers, research on use of anthropogenic wastes in agriculture is the need of the hour. Hence, an attempt has been made to study the effect of humanure, pit toilet sludge and sewage sludge application on growth and yield of maize during kharif 2014 (www.arghyam.in).

Material and Methods

Characterization of humanure, pit toilet sludge and sewage sludge.

Two humanure samples were collected from ECOSAN (urine divert) toilets at community managed resource centre, near Mysore district, pit toilet sludge sample was collected from farmer's home, Devanahalli and sewage sludge samples were collected from sewage treatment plant at Jakkur, Bangalore. These three different kinds of samples were processed and analysed for pH, EC, total organic carbon, major, secondary, micro nutrients and heavy metals (Pb, Cd, Ni and Cr) content by adopting standard procedures. These manures were utilized for conducting experiment in Zonal Agricultural Research Station, V. C. Farm, Mandya near Bangalore.

Field Experiment

A field experiment was conducted during late kharif 2014 with maize (Hybrid: Hema) as test crop in a ZARS, V.C. Farm, Mandya near Bangalore to study the effect of different levels of fecal manures with graded levels of fertilizers on growth and yield of maize. The soil of the experimental site was red sandy loam with slightly acidic in reaction (pH: 6.80) and electrical conductivity was low (0.13 dSm^{-1}). The experiment was laid out in a Randomized Complete Block Design with thirteen treatments replicated thrice. The treatments tried were: T_1 - 75 % K

through Humanure + balance N and P through fertilizers to supply 75 % N & P, T_2 - 100 % K through Humanure + balance N and P through fertilizers to supply 100 % N & P, T_3- 150 % K through Humanure + balance N and P through fertilizers to supply 150 % N & P, T_4 - 75 % P through pit toilet sludge + balance N and K through fertilizers to supply 75 % N & K, T_5- 100 % P through pit toilet sludge + balance N and K through fertilizers to supply 100 % N & K, T_6- 150 % P through pit toilet sludge + balance N and K through fertilizers to supply 150 % N & K,T_7- 75 % P through Sewage sludge + balance N and K through fertilizers to supply 75 % N & K, T_8-100 % P through Sewage sludge + balance N and K through fertilizers to supply 100 % N & K, T_9 - 150 % P through Sewage sludge + balance N and K through fertilizers to supply 150 % N & K, T_{10}- Recommended dose of NPK + FYM,T_{11} - Recommended dose of fertilizer alone, T_{12} - Recommended dose of FYM alone and T_{13}- Control.

Table-1 *Initial soil properties of the experimental site*

Parameters		Content
Physical properties		
Particle size distribution	Sand (%)	67.10
	Silt (%)	17.60
	Clay (%)	15.30
	Texture	Sandy loam
Bulk density (g cc^{-1})		1.42
Particle density (g cc^{-1})		2.68
Pore space (%)		47.01
Maximum water holding capacity (%)		30.87
Chemical properties		
pH (1:2.5)		6.80
EC (dS m^{-1})		0.13
OC (g kg^{-1})		0.57
CEC (c mol (p+) kg^{-1})		13.36
Available nitrogen (kg ha^{-1})		341.94
Available phosphorus (kg ha^{-1})		40.48
Available potassium (kg ha^{-1})		212.35
Exchangeable calcium (C mol (p+) kg^{-1})		5.20
Exchangeable magnesium (C mol (p+) kg^{-1})		1.90
Available sulphur (mg kg^{-1})		8.03
DTPA-Iron (mg kg^{-1})		16.11
DTPA-Manganese (mg kg^{-1})		12.08
DTPA-Copper (mg kg^{-1})		2.00
DTPA-Zinc (mg kg^{-1})		1.50
Hot water soluble Boron (mg kg^{-1})		0.56
DTPA- Pb		0.65
DTPA-Cd		0.03
DTPA-Cr		ND
DTPA-Ni		0.52

Calculated quantity of manures were applied and incorporated two week before sowing of maize seeds, the full dose of phosphorous and potash fertilizers were applied at the time of sowing where as nitrogen was applied in two split doses, half dose at the time of sowing and another half dose at one month after sowing. During growth stages of the plant and at harvest, the growth and yield observations were recorded and were statistically analysed.

Results and Discussion

Characterization of humanure, sewage sludge and pit toilet sludge:

Lab tests revealed that the manure samples did not have any toxic substances. Among the nutrients, nitrogen was low in all three types of manures but phosphorus content was high in pit toilet sludge and sewage sludge where as potassium content was high in humanure samples. The secondary and micro nutrients were high in all the three manures but heavy metal contents were within the critical limits [Table-2].

Table-2 *Chemical properties of humanure, pit toilet sludge and sewage sludge*

Parameters	Humanure	Pit toilet sludge	Sewage sludge
pH (1:5)	8.47	6.01	5.95
EC (1:100) (dS m^{-1})	4.47	1.62	1.12
Total carbon (%)	15.66	14.62	7.13
Total nutrients composition			
N (%)	0.03	0.45	0.44
P (%)	0.58	0.77	1.06
K (%)	2.27	0.13	0.21
Ca (%)	3.08	0.13	3.63
Mg (%)	5.65	2.54	8.34
S (%)	1.61	1.21	1.52
Fe (ppm)	9243.61	6717.00	9921.50
Mn (ppm)	432.43	308.86	469.51
Zn (ppm)	476.62	400.72	457.19
Cu (ppm)	114.60	98.85	107.44
B (ppm)	309.5	263	218
Total heavy metals concentration			
Cd (ppm)	19.91	17.92	13.13
Cr (ppm)	62.64	56.38	54.25
Pb (ppm)	73.89	66.50	59.60
Ni (ppm)	82.40	74.16	53.25

Field experiment: Growth and yield attributes

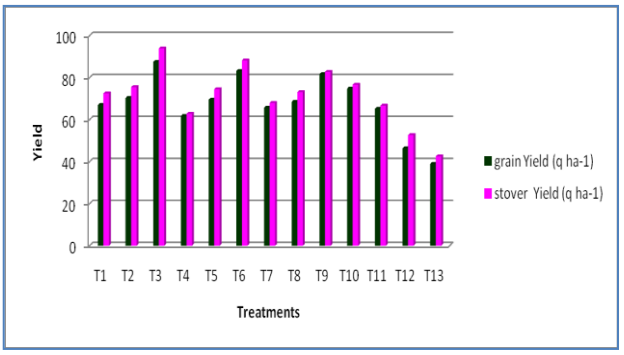
In maize, the growth parameters like plant height (cm) and average number of leaves per plant were significantly higher in plots which received higher dose of fertilizer and manures compared to plots receiving recommended dose of manure and fertilizer, only fertilizer or FYM treated plots and no fertilizer treated plot (control). The higher plant height (203.65 cm) and number of leaves per plant (14.25) were recorded at 150 % K through humanure + balance N and P through fertilizers to supply 150 % N and P (T_3) and was on par with 150 % P through pit toilet sludge + balance N and K through fertilizers to supply 150 % N and K (189.26cm and 13.24 respectively) and 150 % P through sewage sludge + balance N and K through fertilizers to supply 150 % N and K (183.23 cm and 12.74 respectively) at 90 DAS (days after sowing). The lower plant height (117.11 cm) and number of leaves per plant (8.19) was recorded in control. Application of 100 % pit toilet sludge, humanure and sewage sludge along with balanced fertilizer application recorded higher plant height (166.26, 166.18, 164.89 cm) compared to recommended dose of fertilizers (160.05 cm). The trends were similar at 60 and 30 days after sowing. This higher plant growth was due to higher application of manures along with balanced higher (150%) application of NPK fertilizers resulted in increased availability of nutrients which enabled increased plant growth. The organic matter functioned as a source of energy for soil micro flora which brings about solubilisation of inorganic forms of nutrients present in the soil to readily available forms which can be utilized by plants.The other reasons could be stem elongation and enhanced vegetative growth. Similar, types of result were reported by Morgan Peter (2002) and Jogdand *et al*., (2008). Similarly higher chlorophyll content (41.79) recorded in treatment receiving 150 % K through Humanure + balance N and P through fertilizers to supply 150 % N & P (T_3) followed by T_6 (41.36) and T_9 (40.94). This may be due to higher nitrogen (150%) application to maize crop

responses well along with manures application.

Table -3 *Effect of Humanure, pit toilet sludge and Sewage Sludge Application on Plant height (cm) number of leaves and chlorophyll content of maize*

Treatments	Plant height (cm)			Number of leaves plant^{-1}			Chlorophyll content		
	DAS			DAS			DAS		
	30	60	90	30	60	90	30	60	90
T_1	53.51	149.81	154.31	6.96	10.09	10.79	19.40	31.52	35.68
T_2	57.65	161.42	166.26	7.49	10.87	11.63	20.49	33.30	37.34
T_3	70.62	197.72	203.65	9.18	13.31	14.24	22.93	37.26	41.79
T_4	52.49	146.97	151.38	6.82	9.89	10.59	19.18	31.17	34.95
T_5	57.62	161.34	166.18	7.49	10.86	11.62	19.84	32.24	36.16
T_6	65.62	183.75	189.26	8.53	12.37	13.24	22.69	36.88	41.36
T_7	48.74	136.47	140.56	5.81	8.42	9.01	18.35	29.82	33.44
T_8	57.17	160.09	164.89	6.84	9.92	10.62	18.81	30.56	34.28
T_9	63.53	177.89	183.23	8.21	11.91	12.74	22.28	36.21	40.94
T_{10}	59.74	167.27	172.28	7.79	11.30	12.09	20.68	33.61	37.69
T_{11}	55.50	155.39	160.05	7.12	10.33	11.05	19.71	32.04	35.93
T_{12}	42.70	119.56	123.14	6.22	9.01	9.64	17.70	28.76	33.26
T_{13}	40.61	113.70	117.11	5.28	7.65	8.19	16.58	26.94	29.19
S. Em±	**3.84**	**10.76**	**11.08**	**0.46**	**0.66**	**0.71**	**0.46**	**0.96**	**1.17**
C. D. at 5 %	**11.52**	**32.26**	**33.23**	**1.37**	**1.99**	**2.13**	**1.37**	**2.86**	**3.50**

Yield attributes recorded were also higher in treatments receiving higher doses of manures and fertilizers than the only fertilizer and only manure applied plots. Significantly higher yield parameters like number of cobs per plant, Cob length (cm), number of rows per cob, number of grains per cob, Cob weight per plant (g), Test weight (g), grain yield (q ha^{-1}) and stover yield (q ha^{-1}) were recorded in treatment T_3 (1.20,18.47cm, 16.42, 468.91, 221.07 g, 31.50 g, 87.52 q ha^{-1}, 93.93 q ha^{-1}) which received 150 % K through Humanure + balance N and P through fertilizers to supply 150 % N & P followed by T_6 (150 % P through pit toilet sludge + balance N and K through fertilizers to supply 150 % N & K) and T_9 (150 % P through Sewage sludge + balance N and K through fertilizers to supply 150 % N & K) which were on par with T_{10} (1.20, 17.02 cm, 15.29, 436.82, 173.33 g, 30.60 g, 74.81 q ha^{-1}, 76.66 q ha^{-1}) which received Recommended dose of NPK + FYM. The increase in grain yield was to the tune of 16.99 %, 34.34% and 88.90 percent over RDF (100 % NPK + FYM), RDF alone and FYM alone treatments. The test weight (27.29 grams), grain yield (38.96 q ha^{-1}) and stover yield (42.55 q ha^{-1}) were lower in absolute control. This increase in yield in humanure, pit toilet sludge, and sewage sludge treated plots at 150 % may be due to higher level of manures and fertilizer application may be attributed to the release of nutrients in available forms from manures and FYM during its decomposition and the absorption of the These results corroborate with the observations made by Jagadeeshwari and Kumaraswami (2000). It reflects on better source sink relationship, translocation of metabolites to reproductive organs leading to improved grain yield. These findings are in line with Sahoo *et al.* (2001). The increased biomass yield was observed in treatments which received 150% manures along with balanced fertilizer applied plots than the imbalanced fertilizer and manure applied plots was due to increased nutrient availability through manures application and more microbial activity and also influenced the biomass production by growth promoting substance like IAA present in anthropogenic solid waste same by the crops and also due to its nutrient and moisture retention functions.



a) Changes in yield due to the application of humanure, pit toilet sludge and sewage sludge on growth and yield of maize

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Table-4 *Effect of Humanure and Sewage Sludge Application on Yield of Maize*

TREATMENTS	No of cobs per plant	Cob length (cm)	No of rows per cob	No. of grains cob^{-1}	Cob weight per plant (g)	Test weight (g)	Yield (q ha^{-1})	
							Grain	Stover
T_1	1.13	16.75	13.90	397.03	153.13	29.53	67.00	72.48
T_2	1.13	16.95	15.00	428.45	168.93	30.13	70.37	78.86
T_3	1.20	18.47	16.42	468.91	221.07	31.50	87.52	93.93
T_4	1.00	16.55	13.71	391.60	133.60	28.52	61.81	62.77
T_5	1.13	16.92	14.78	422.26	165.33	30.11	69.48	74.16
T_6	1.20	18.40	16.19	462.53	214.07	31.40	83.19	88.24
T_7	1.00	16.27	13.80	394.17	126.53	28.47	65.74	68.00
T_8	1.07	16.77	14.50	414.16	165.73	29.85	68.52	72.13
T_9	1.13	17.92	15.99	456.82	181.20	30.67	81.67	82.78
T_{10}	1.20	17.02	15.29	436.82	173.33	30.60	74.81	76.66
T_{11}	1.27	14.85	12.44	355.32	161.33	29.95	65.15	66.68
T_{12}	1.00	14.04	11.09	316.67	123.95	27.34	46.33	52.66
T_{13}	1.00	12.30	8.80	251.35	96.67	27.29	38.96	42.55
S. Em±	**NS**	**0.27**	**0.09**	**2.69**	**26.45**	**1.17**	**1.92**	**1.84**
C. D. at 5 %		**0.82**	**0.28**	**8.06**	**79.30**	**3.50**	**5.77**	**5.51**

a) Variation in cob size due to higher doses of fertilizers in comparison with RDF

b) Cob size in treatments receiving recommended dose of NPK + FYM, Fertilizer alone, FYM alone and control

Conclusion

From the above data, it can be inferred that three different sources of anthropogenic wastes like humanure, pit toilet sludge and sewage sludge are wholesome nutrient sources. These wastes should be recycled and used as an organic amendment in the agricultural field for crop production. It also helps to rejuvenate soil fertility, enhance the yield of crops help to save money on fertilizers and helps in solving the problems of unscientific sanitation leading to environmental pollution.

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Author Contributions:

Pushpa, H.M: Ph.D scholar, involved in conducting experimental research from sowing to harvest, recorded all growth and yield observations, lab analysis, statistical data analysis and paper writing

Subbarayappa, C.T: As a guide, involved in treatments finalization and given various suggestions for crop establishment and lab analysis work and paper writing.

Srinivasamurthy, C.A: As a project leader, involved in treatments finalization, created facility for lab analysis, given various suggestions for lab analysis work and and paper writing.

Ramakrishna parama, V. R: As a member involved in treatments finalization and given various suggestions for lab analysis work and paper writing.

Venkate Gowda, J: As a Research Associate involved in design of field layout and managing field activities.

Abbreviations

CAU-Central Agricultural University, Ca-Calcium, cm- Centimeter, C.D-Critical Difference, Cd-Cadmium, Cr-Chromium, DAS-Days after Sowing, EC-Electric Conductivity, FYM- Farm Yard Manure, GKVK-Gandhi Krishi Vignana Kendra, ha-hectare, K-Potassium, N-Nitrogen, NS-Non Significant, Mg-magnesium, Ni-Nickel, P-Phosphorus, Pb-Lead, RCBD-Randomized Complete Block Design, RDF-Recommended Dose of Fertilizer, S-Sulphur, SEm-Standard Error mean, q-Quintal, ZARS-Zonal Agricultural Research Station, %- per cent.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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