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Field Assessment of Influence of Organic Fertilizers on Microbial Profile and Sustainable Maize Production in a Flood Plain in Nigeria

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Abstract: The stabilization and utilization of organic fertilizers in flood plain for sustainable agriculture in the tropics was studied in field experiment conducted at Etinan wetland soil (EW) of Akwa Ibom State, Nigeria in the tropics during two cropping seasons (C. S.) to study the effects of two composted and stabilized organic fertilizers (poultry droppings, PD and cow dung, CD) on the microbial density and structure, soil properties, growth and yield of corn (*Zea mays*) according to standard procedures. The two treatments plus control, (the unfertilized plots) were arranged in a randomized block design with two replications giving three main plots; poultry manured plots (PM), cow manured plots (CM) and the control plots, C, which were sectioned into nine subplots on which was a total of 81 mounds on the study site. Results showed that PD and CD (450 gm^2=4500 $kgha^{-1}$) incorporated into the EW produced higher mean microbial density (Total heterotrophic bacterial counts, THBC=log 7.636 and 8.64, total actinomycetes counts, TAC=log 6.57& 6.62, diazotrophic bacterial counts, DBC=log 5.35 & 5.50 and total fungal counts, TFC=log 5.38 & 5.45 $cfug^{-1}$) in both fertilized plots during the 1st & 2nd C. S respectively than in the control with 6.62 & 7.49, 5.59 & 5.52, 5.44 & 5.54, 4.5 & 5.49 $cfug^{-1}$ of THBC, TAC, DBC and TFC respectively. It was also shown that PD and CD application into EW produced higher physicochemical properties, nutrient salts, compared to the C. Growth/yield of the test crop, *Zea mays* were increased in the PM followed by CM compared to C in the EW during both C. S. Using the mean difference of two years, plants of PM had highest grain yield (4.16±0.16t t/acre) compared to (2.84±0.31t/acre) and (0.09±0.23t/acre) of CM and C respectively. The effects of one time application of the organic fertilizers (without reapplication on the 2nd C. S) indicated higher crop harvest index, H. I. (0.63 and 0.64) of treatment plots compared to 0.19 and 0.20 of the C. Therefore, utilization of PM to soils is recommended for sustainable crop production especially maize in the flood plain and in the tropics as a whole. It is also recommended that the CD could serve as a suitable substitute in the absence of PD. Wetland soils in the tropics should be converted from the hitherto wasteland to useful and sustainable arable lands with the utilization of stabilized and composted organic fertilizers.

Keywords: Organic Fertilizers, Maize Plant, Sustainable Production, Heterotrophic Bacteria, Flood Plain

1. Introduction

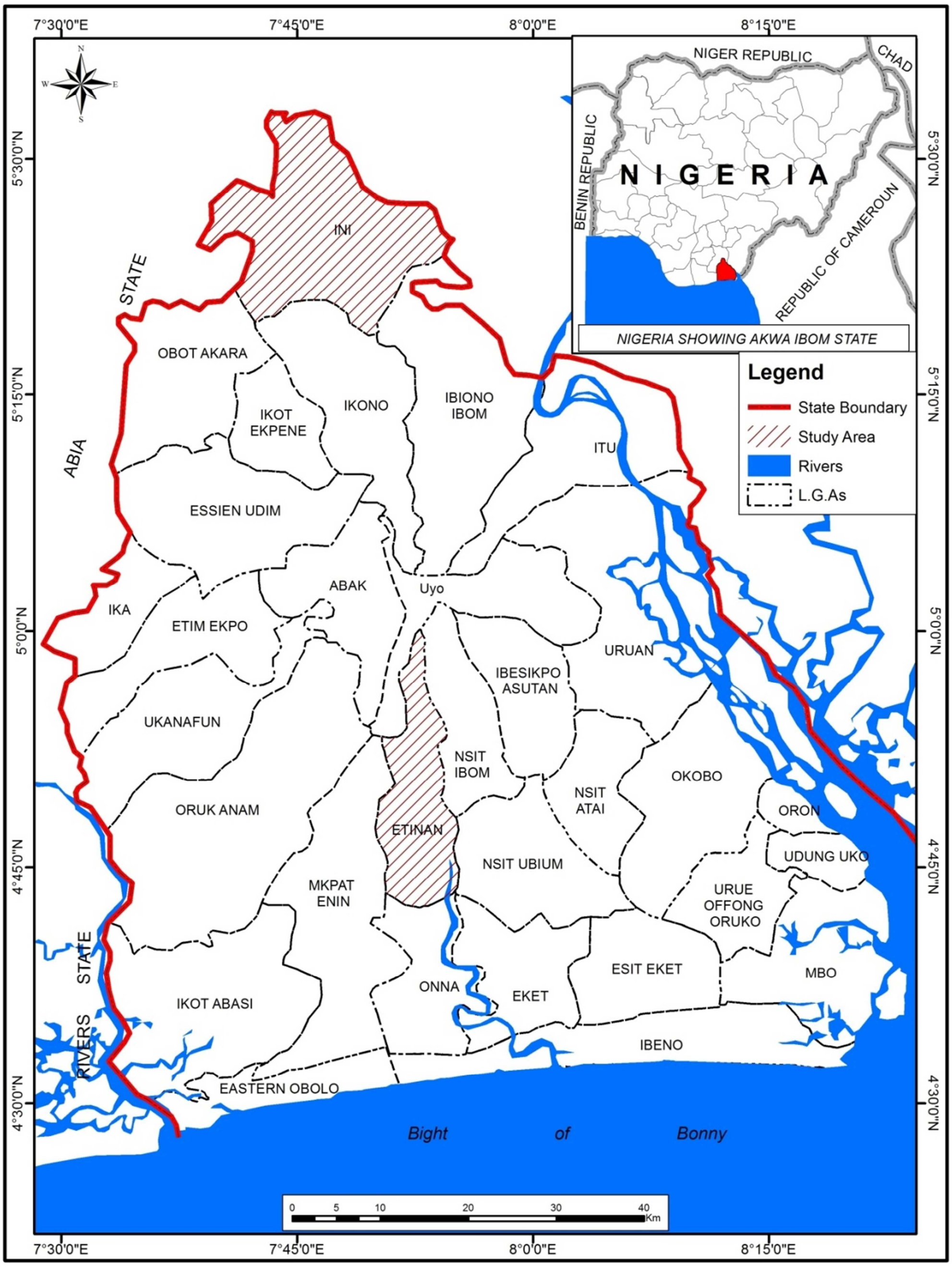
Agricultural activities have propelled the use and disposal of agrochemicals such as inorganic fertilizers into the environment with its attendant adverse effects on the environment (increased soil acidity, nutrient imbalance) as well as microbial activities, hence the need to adopt the less toxic fertilizer-the organic fertilizers e. g cow dung and poultry droppings (CD and PD). Devi, Sharma and Sighn [1] reported that utilization of animal manures (CD, PD etc.) as land fertilizer is an important disposal method as it contributes to diminishing environmental pollution from indiscriminate dumping of animal wastes. In Akwa Ibom State, Nigeria, the problem of appropriate disposal and reutilization of animal manures is being encountered Etuk [2].

Stabilization of organic wastes by composting provides an opportunity to reduce its bulk, odour, pathogens, toxicity and increasing the nutritive value Devi, Sharma and Sighn [1]. Sustainable crop production deals with keeping the soil alive with organic matter, integrated pest management and reduction in usage of chemical inputs, ensuring food safety and food quality, improving nutrient quality and fertilizing the soil with organic fertilizers Imadi, Shazadi, Gul and Hakeem [3]. Mixed microbial communities have bio-degradative potential to degrade the organic compounds Mohapatra [4] present in manure. This research was done in a field experiment in a tropical flood plain located at Etinan, Akwa Ibom State, Nigeria during two cropping seasons to survey the stabilization and utilization of organic fertilizers in a wetland soil for sustainable agriculture in the tropics.

2. Materials and Methods

2.1. Study Area

The study area a tropical flood plain located in Etinan, designated EW (latitude 04°30 and 5°30' N and longitude 07°30' and 8°20' East) of Akwa Ibom State, Nigeria (Figure 1). The climate is humid tropical, annual rainfall (2500–3000mm), mean annual temperature (between 27 and 28°C) and relative humidity (75-80%) Imelda, Oshodeke and Akpan [5].



Source: Ministry of Lands and Town Planning, Akwa Ibom State.

Figure 1. *The study site on the map of Etinan L. G. A., Akwa Ibom State, Nigeria.*

2.2. Research Design

The experiment was randomized complete block {3 treatments (poultry manure and cow dung treatments and control) with 2 replications x six samplings } giving three plots which were subdivided into nine subplots on which were eighty-one mounds (each with a stand of maize plants) in the flood plain.

2.3. Sampling Techniques

2.3.1. Collection of Organic Fertilizers

Organic fertilizers CATTLE dung and poultry droppings were collected from a livestock market and private poultry farms in Uyo metropolis, Akwa Ibom State, Nigeria respectively.

2.3.2. Collection of Test Crop and Soil Samples

Maize (TZSR-W) seeds were collected from Akwa Ibom State Agricultural Development Programme (AKADEP) office. TZSR-W is Tropical *Zea mays* Streak Resistant White species. Homogenized soil samples were collected at depths of 0–10 cm and 20 cm biweekly for all analyses during first & second cropping seasons (1st & 2nd C. S) Vinhal-Freitas, Wanger, Ferreira, Correa and Wendling [6].

2.4. Analysis of Samples

2.4.1. Microbiological and Physicochemistry of Soil / Organic Fertilizers Samples

Prior to cultivation the organic fertilizers were stabilized using the microbe-based active pile windrows composting methods of Mercola [7]. The soil and organic fertilizers were analyzed for their microbiological and physicochemical properties using standard methods of Dubey and Maheshwari, Robertson and Groffman [8, 11] and Traunfeld, [9] respectively at the beginning of the experiment Cenciani, Freitas, Critter and Airoldi [10] and bi-weekly Vinhal-Freitas, Wanger, Ferreira, Correa and Wendling [6] subsequently.

2.4.2. Determination of Growth and Yield of Test Crop

The growth parameters (leaf length, leaf-width, dry weight mass and height of plant aerial part) and yield of maize plants (number of grains per cob, weight of grains) were assessed according to methods of Agbogidi and Okonmah [12]. Maize was harvested fresh at 13 weeks after planting (WAP) Cenciani, Freitas, Critter and Airoldi [10] and the Harvest Index was evaluated after the methods of [19].

2.5. Statistical Analysis

The statistical package for Social Science version 20 (SPSS. 20) with level of significance maintained at 95% for each test was adopted for statistical analysis Sokal, and Rohlf [13].

3. Results

3.1. Heterotrophic Microbial Populations in the Fresh / Composted Organic Fertilizers and in the Flood Plains During 1st and 2nd Cropping Seasons

Results of the microbiological analyses of the fresh animal wastes (CD and PD), the composting animal wastes utilized (CoCD and CoPD) and the soil samples revealed various counts of: (i) total heterotrophic bacteria (THBC), (ii) Actinomycetes (AC), (iii) diazotrophic bacteria (DBC), (iv) total fungi (TFC), (v) total coliform (TCC) and feacal coliform (FCC) at different age of the fertilizers throughout the twelve weeks of composting and cropping as shown in *Table 1*. It was revealed that composted poultry manure (CoPD) had highest THBC with log value of 7.41 followed by TAC > DBC > TFC and the least was TCC (1.11 cfug^{-1}). The mean counts difference between the microbial load in the CoPD and CoCD were mostly not statistically different at P=0.05 except for the actinomycetes counts with mean difference between CoCD and CoPD being significant at P=0.05.

During 1st C. S the results showed the following trend of microbial abundance (log transformed values) in the EW soils sampled: THBC (7.63) > AC (6.57), TFC (5.38) > DBC (5.35)>TCC (Figures 2-5). Thus, from the results, the most abundant of the microbial groups were THBC while the least was TCC in EW. During 2nd C. S, the EW had similar pattern of microbial abundance as in the 1st C. S was obtained (Figures 6-9).

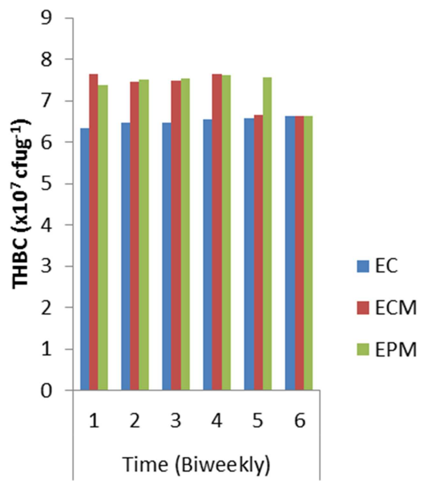


Figure 2. *Total heterotrophic bacterial counts during 1st C. S at Etinan flood plain.*

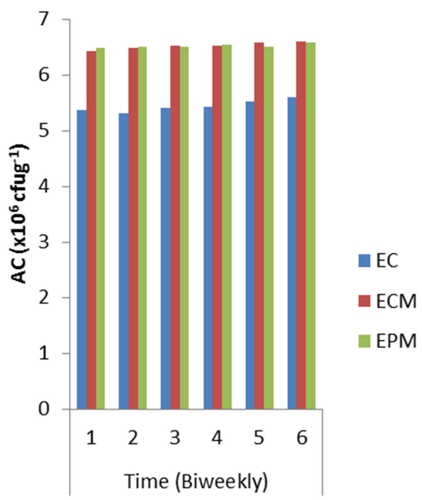


Figure 3. *Actinomycetes counts during 1st C. S at Etinan flood plain.*

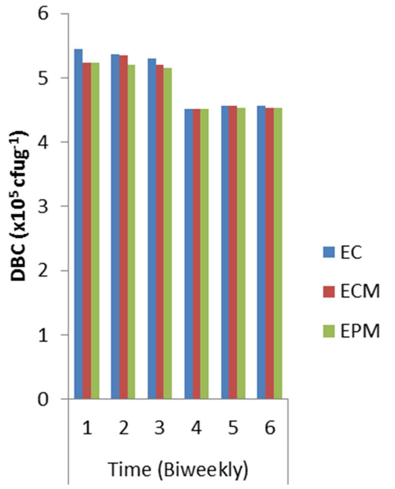


Figure 4. *Diazotrophic bacterial counts during 1st C. S at Etinan flood plain.*

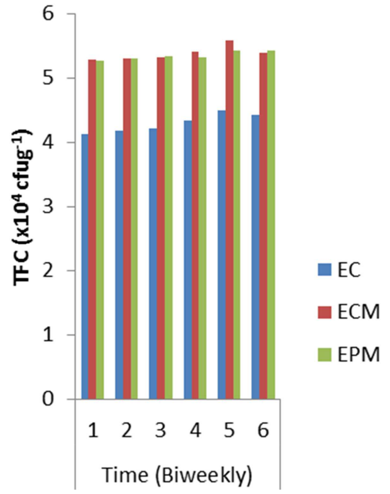


Figure 5. *Total fungal counts during 1st C. S at Etinan flood plain.*

THBC=Total heterotrophic bacterial count, AC=Actinomycetes, DBC=diazotrophic bacterial, TFC=total fungal, TCC=total coliform counts, $cfug^{-1}$=Colony forming unit per gram, EC, ECM, EPM and C. S=Etinan control, cow manured, poultry manured plots, cropping season, respectively.

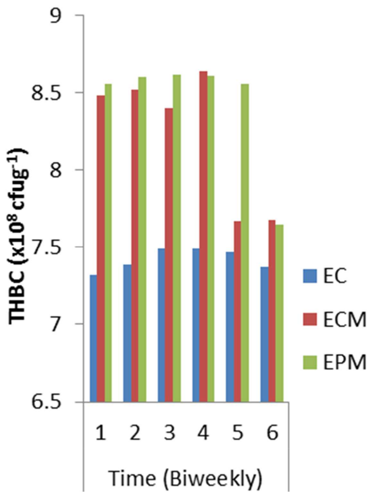


Figure 6. *Total heterotrophic bacterial counts during 2nd C. S at Etinan flood plain.*

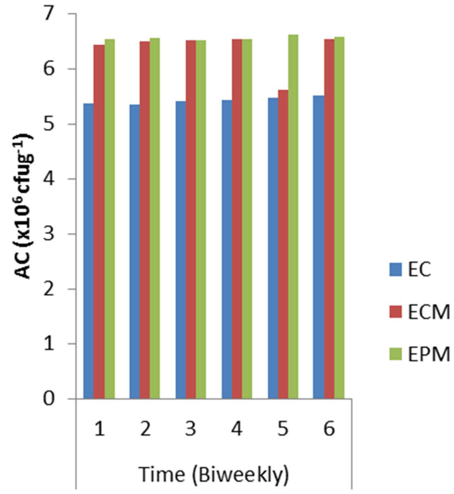


Figure 7. *Actinomycetes counts during 2nd C. S at Etinan flood plain.*

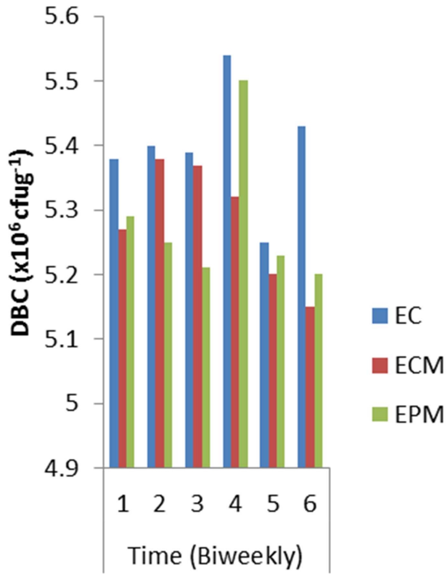


Figure 8. *Diazotrophic bacterial counts during 2nd C. S at Etinan flood plain.*

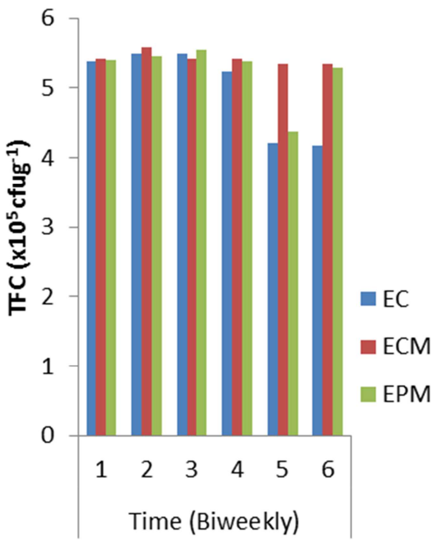


Figure 9. *Total fungal counts during 2nd C. S at Etinan flood plain.*

Bacterial spp. isolated include; Azotobacter chroococum, Alcaligens sp., Nocardia sp., Bacillus marcerans, Enterobacter aerogenes, Clostridium botulinum, Corynebacterium cc Enterococcus faecalis, Flavobacterium breve, Klebsiella pneumoniae, Micrococcus roseus, Nitrobacter sp., Nitrosomonas europea, Proteus mirabilis, Proteus vulgaris, Salmonella sp., Alcaligens sp, Pseudomonas aeruginosa strain B4 (Table 2).

Table 1. *Microbial counts of organic fertilizers before and during composting.*

Sample Code	Age (Weeks)	THBC (x10^7 cfug^{-1})	Log Value	TFC (x10^5 cfug^{-1})	Log Value	TCC (x10^3 cfug^{-1})	Log Value	DBC (x10^5 cfug^{-1})	Log Value	Total AC (x10^6) cfug^{-1}	Log Value	FCC (x10^2)	Log Value
FPD	24 hours	0.325±0.64	6.51	0.169±0.65	4.23	(0.53±0.35)	1.72	(1.30±0.6)	5.11	(1.69±0.05)	5.23	ND	
FCD		0.231±0.30	6.36	0.317±0.47	4.50	(0.70±0.1)	1.85	(1.34±0.17)	5.13	(2.10±0.17)	5.32	0.16±0.01	1.20
CoPD	2	0.261±0.44	6.42	(0.210±0.10	4.32	(0.13±0.06)	1.11	(0.87±0.48)	4.94	(1.13±0.42)	5.05	ND	
	4	2.570±1.0	7.41	(2.74±1.49)	5.44	ND		(1.38±0.45)	5.14	(1.90±1.31)	5.28	ND	
	6	2.020±0.08	7.31	(2.43±1.03)	5.39	ND		(1.97±0.61)	5.29	(3.87±1.76)	5.59	ND	
	8	0.187±1.01	6.27	(2.57±0.8)	4.41	ND		(1.47±0.02)	5.17	(2.70±0.40)	5.43	ND	
	10	0.203±0.06	6.31	(2.83±1.13)	4.45	ND		(2.04±0.01)	5.31	(3.29±0.71)	5.52	ND	
	12	0.202±0.92	6.32	(2.18±0.24)	5.34	ND		(1.85±0.65)	5.27	(2.43±0.06)	5.39	ND	
CoCD	2	0.247±0.2	6.39	(2.90±1.67)	4.67	(0.27±0.16)	1.43	(0.73±0.55)	4.86	(2.87±1.47)	5.46	0.40±0.03	1.60
	4	2.330±0.35	7.37	(3.23±1.03)	5.55	(0.17±0.06)	1.23	(0.91±0.33)	4.96	(1.90±0.70)	5.28	ND	
	6	2.260±0.17	7.35	(2.63±0.40)	5.42	ND		(0.21±0.19)	4.32	(2.20±0.78)	5.34	ND	
	8	0.213±0.60	6.33	(2.60±1.05)	4.46	ND		(0.13±0.10)	4.12	(2.47±1.10)	5.39	ND	
	10	0.246±0.53	6.39	(2.18±1.08)	4.50	ND		(0.117±0.09)	4.07	(2.24±1.76)	5.35	ND	
	12	2.310±0.60	7.36	(2.10±0.15)	4.42	ND		(0.102±1.22)	4.01	(2.10±1.4)	5.32	ND	

FPD, FCD=fresh poultry and cow manures respectively; 2 - 12=biweekly; CoPD, CoCD=Composting poultry and cow manures.

Table 2. *Microbial isolates obtained from Etinan floodplain during 1st and 2nd cropping seasons, their density and their percentage prevalence.*

	Isolates (Bacterial)	EC				ECM				EPM			
		No. of Colonies		Prevalence (%)		No. of Colonies		Prevalence (%)		No. of Colonies		Prevalence (%)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	*Azotobacter* chroocоcum.	20	20	2.7	3.68	22	29	2.19	2.22	18	16	1.5	0.99
3	*Pseudomona aeruginosa*.	110	59	14.85	10.85	150	164	14.93	12.41	141	169	11.75	10.48
4	*Flavobacterium breve.*	96	60	12.96	11.03	131	102	13.03	7..72	152	70	12.67	7.44
5	*Alcaligenes* sp.	30	21	4.05	3.86	33	130	3.28	9.81	116	140	12.17	9.92
6	*Micrococcus* sp.	30	41	4.05	7.54	127	149	12.64	11.28	84	102	7.00	6.32
7	*Corynebacterium bovis*,	44	43	5.94	7.9	27	122	2.69	9.24	47	69	3.92	4.28
8	*Bacillus marceran*s	106	80	14.3	14.71	101	138	10.05	10.45	127	140	10.58	8.68
9	*Enterococcus* sp.	48	21	6.48	3.86	33	75	3.28	5.68	58	50	4.83	9.3
10	*Klebsiella* sp.	40	23	5.4	4.23	25	37	2.49	2.89	58	43	4.83	2.67
11	*Alcaligens eutrophus*	106	72	14.3	13.24	123	92	12.24	6.96	185	190	15.42	11.78
12	*Nitrobacter* sp.	18	18	2.43	3.3	10	9	0.99	0.68	10	12	0.83	0.74
13	*N. europea*	23	20	3.1	3.68	13	14	1.29	1.06	15	18	1.25	1.12
16	*Proteus mirabilis*	10	12	1.35	2.21	70	85	6.97	6.43	29	108	2.42	6.7
17	*Proteus vulgaris*	10	10	1.35	1.84	55	73	5.47	5.53	18	50	1.5	9.3
18	*Salmonella* sp	27	14	3.64	2.57	35	63	3.48	4.77	92	96	7.67	5.95
19	*Nocardia* sp.	10	12	1.35	2.21	25	19	2.49	1.44	30	50	2.5	3.09
20	*E. aerogenes*	13	20	1.75	3.68	25	20	2.49	1.51	20	20	1.67	1.24
	Total	741	546	100%	100	1005	1321	100	100	1200	1613	100%	100
1	Isolates (Fungal)	6	10	6	8.6	8	14	6.6	6.63	12	24	7.45	10.76
2	*Penicillium sp.*	12	14	12	12.1	18	28	13.9	13.27	10	16	6.21	7.17
3	*Aspergillus fumigatus*	9	11	9	9.5	10	22	8.2	10.42	13	23	8.07	10.31
4	*Fusarium sp.*	14	29	14	25	6	2	4.9	0.94	8	1	4.97	0.45
5	*Mucor sp.*	6	9	6	7.8	2	27	1.6	12.79	17	18	10.56	8.07
6	*Aspergillus flavus*	7	10	7	8.6	11	18	9	8.53	18	27	11.18	12.11
7	*Rhizopus sp*	2	4	2	3.4	11	12	9	5.68	13	15	8.07	6.73
8	*Saccharomyces sp.*	13	8	13	6.9	10	16	8.2	7.58	14	20s	8.7	8.97
9	*Trichoderma sp.*	16	8	16	6.9	27	41	22.1	19.43	28	36	17.39	16.14
10	*Glomus sp.*	3	6	3	5.2	9	12	7.4	5.68	10	20	6.21	8.97
11	*Acaulospora sp.*	11	5	11	4.3	10	18	8.2	8.53	17	22	10.56	9.87
12	*Alternaria alternaria*	1	2	1	1.7	1	1	0.8	0.47	1	1	0.62	0.45
	Total	100	116	100	100	122	211	100	100	161	223	100	100

3.2. The Occurrence of Microbial Isolates in Fresh, Composted Organic Fertilizers and Flood Plain Samples During 1st and 2nd Cropping Seasons

In the EW soil samples the bacteria with highest prevalence (15.42 and 14.71%) during 1st and 2nd C. S respectively were *Alcaligenes eutrophus* and *Bacillus* sp. from EPM and EC respectively while the bacteria with least percentage of occurrence (0.83 & 0.68%) was *Nitrobacter* sp. isolated from both EPM and ECM during 1st and 2nd C. S respectively (*Table* 2). Fungal isolates with highest percentage prevalence (22.1 & 19.43%) was *Trichoderma* sp. from ECM soil samples, during 1st & 2nd C. S respectively (*Table* 2).

3.3. The Physicochemical Properties of the Flood Plain

The mean values of the physicochemical properties of the EW (*Table 3*) during 1st C. S revealed as follows: highest mean temperature (30.81±0.11°C) in EPM plot, pH value of the initial (EBSO) and EC soils were acidic (5.55±0.04 and 5.21±0.05) but the pH of the treated plots during both seasons increased to neutral (7.48±0.07) at ECM. Electrical conductivity was lower in the treated soil. Higher values of total organic carbon, organic matter, base saturation, total nitrogen, and nutritive salts were obtained in treatment plots than in the EC plots. However, there was slight decrease in concentrations of available phosphorous in the ECM plots than in the EC during 2nd C. S (*Table 3*).

Table 3. *Physicochemical properties measured at Etinan floodplain in the 0–15 cm surface layer and core sample during 1st and 2nd cropping seasons.*

Properties	site						
	$EBSO_1$	EC1	EC2	EPM1	EPM2	ECM1	ECM2
Temp (°C)	29.33±0.01	29.07±0.04	29.94±0.12	30.81±0.11	30.22±0.02	30.00±0.1 8	29.90±0.1 8
pH (H_2O)	5.55±0.04	5.21±0.05	5.83±0.07	6.56±0.07	6.77±0.06	6.06±0.04	7.48±0.07
EC ($mScm^{-1}$)	3.29±0.03	3.52±0.08	3.51±0.02	2.87±0.02	3.18±0.03	2.72±0.02	3.05±0.02
BS (%)	50.40±0.13	55.32±0.22	57.17±0.12	57.17±0.42	61.61±0.22	58.02±0.12	63.98±0.19
Moisture content (%)	42.90±0.20	42.47±0.09	42.84±0.10	53.97±0.12	54.86±0.11	53.53±0.09	55.01±0.14
TOC (%)	1.21±0.01	1.10±0.01	0.76±0.03	1.59±0.02	2.58±0.01	1.42±0.01	1.60±0.02
OM (%)	2.35±0.07	2.52±0.01	2.24±0.02	3.76±0.03	12.34±0.02	4.73±0.02	8.58±0.04
Total N (%)	0.04±0.02	0.03±0.02	0.05±0.01	0.08±0.02	0.12±0.02	0.09±0.05	0.07±0.02
C/N ratio	30.25±0.13	39.72±0.08	16.65±0.11	20.81±0.07	21.48±0.12	17.91±0.09	22.93±0.12
Available P (mg kg^{-1})	52.01±0.08	45.38±0.09	24.45±0.22	56.98±0.11	30.64±0.19	53.53±0.13	20.35±0.22
B. D (g cm^{-3}) at 0-2cm	1.96±0.01	1.68±0.02	1.45±0.02	1.54±0.01	1.32±0.02	1.49±0.03	1.43±0.02
CO_3^{2-} (mg kg^{-1})	2.40±0.01	9.87±0.02	10.1±0.05	18.58±0.04	14.24±0.02	12.19±0.05	16.8±0.02
NO_3^- (mg kg^{-1})	6.80±0.05	9.15±0.04	7.8±0.02	8.46±0.03	12.67±0.09	7.99±0.03	10.36±0.03
NH_4^+ (mg kg^{-1})	0.01±0.03	0.03±0.01	0.08±0.02	0.06±0.01	0.10±0.01	0.18±0.02	0.23±0.01
SO_4^{2-} (mg kg^{-1})	24.00±0.11	28.25±0.21	47.87±0.19	45.88±0.10	61.12±0.11	80.05±0.22	44.14±0.21
PO_4^{3-} (mg kg^{-1})	13.40±0.06	16.27±0.13	18.80±0.06	33.9±0.12	20.07±0.08	46.71±0.07	14.52±0.07
Cl^- (mg kg^{-1})	6.90±0.11	8.00±0.02	9.63±0.08	37.00±0.14	9.16±0.10	14.31±0.12	4.78±0.03
Ex. Ca ($Cmolkg^{-1}$)	5.56±0.04	4.95±0.02	6.65±0.06	6.51±0.02	8.15±0.02	5.27±0.02	13.21±0.07
Ex. Mg ($Cmolkg^{-1}$)	2.80±0.16	2.20±0.01	2.49±0.02	8.46±0.02	13.78±0.09	9.16±0.05	13.87±0.12
Ex. Na ($Cmolkg^{-1}$)	0.13±0.01	0.12±0.02	0.07±0.02	0.09±0.01	0.05±0.01	0.13±0.02	0.06±0.02
Ex. K ($Cmolkg^{-1}$)	0.02±0.01	0.08±0.02	0.06±0.02	0.52±0.02	0.28±0.02	0.17±0.02	0.14±0.02
Ex. A ($Cmolkg^{-1}$)	1.23±0.01	1.16±0.02	0.91±0.02	0.91±0.02	0.88±0.01	1.25±0.02	0.69±0.02
ECEC ($Cmolkg^{-1}$)	9.74±0.03	8.50±0.06	10.17±0.16	16.48±0.04	22.8±0.09	15.98±0.02	27.98±0.10

3.4. Effects of Organic Fertilizers Application on Growth / Yield of Maize Plants

The effects of the organic fertilizers application on maize growth and yield presented in *Table* 4 revealed the mean plant heights were 34.67±1.69 and 26.61±1.60 cm (EC) compared to 113.77±90.39 and 138.79±90.93 cm (EPM) and 102.73±92.28 and 137.94±107.51 cm (ECM) during 1st and 2nd C. S respectively. The highest average number of leaves (13.1±1.20) was observed in the plants grown on EPM followed by ECM plots (11.85±0.50) while EC had the least (6.5±1.15) average number of leaves (*Table 4*).

Table 4. *Effect of organic fertilizer application on growth/yield of maize plants.*

Site	Av. Plant Ht. (cm)	Av. LA (cm^2)	Av. No. of Leaves	Av. Stem girth (cm)	Av. LAI
1st Cropping Season					
EC	34.67±1.69	108.9±27.22	7.2±7.51	3.77±0.55	6.12±0.45
EPM	113.77± 90.39	634.36±50.31	12.28±0.95	6.55± 0.01	51.73±5.26
ECM	102.73±92.28	515.7±20.45	10.83±2.01	5.50±0.07	38.92±3.20
2nd Cropping Season					
EC	26.61±1.60	80.32±13.54	6.5±1.15	3.32±0.11	3.46±0.11
EPM	138.79±90.93	707.74± 37.51	13.1±1.20	7.98±0.05	60.45±8.00
ECM	137.94±107.51	672.28±41.36	11.85±0.50	7.2±0.80	52.61±4.22

Table 4. *Continued.*

Site	Fresh Corn EarMean Wt (g)	HS. Wt (g)	Av. GNC--1	Grain Yield (tonnes/acre)	Stover Yield (tonnes/acre)	H. I (GY/SY±GY)
1st Cropping Season						
EC	83.06±0.08	19.00±0.10	30.00±0.05 (6)	0.09±0.23	0.15±0.60	0.38±0.44
EPM	205.00±0.09	32.17±0.05	492.70±0.30 (35)	2.19±0.08	1.50±0.01	0.59±1.10
ECM	201.15±0.19	33.00±0.10	420.00±0.01 (30)	2.01±0.01	1.93±0.01	0.51±0.06
2nd Cropping Season						
EC	60.00±0.07	16.13±0.10	23.00±0.05 (4)	0.05±0.09	0.21±0.25	0.02±0.01
EPM	247.61±0.08	39.00±0.11	540.00±0.09 (36)	4.16±0.16	2.40±0.21	0.63±0.07
ECM	226.10±0.03	38.00±0.06	480.11±0.02 (32)	2.84±0.31	1.79±1.71	0.61±0.10

Key: Av.=average, Ht.=height, LA=leaf area, No.=number, LAI=leaf area index, Wt=weight, HS=hundred seed, GNC-1=Grain number per cob, HI=Harvest index, GY=Grain yield, SY=stover yield, Numbers in bracket=Numbers of row ear-1. Average of ten crops were used for each analysis except for seed weight and grain number per cob.

4. Discussion

4.1. Microbial Counts of the Flood Plain During 1st / 2nd Cropping Seasons

The total microbial counts of the soils are very important microbiological parameters and indicate the fertility and the activity of the soil. The increase in THBC populations during first 2 weeks could be explained to have co-incided with period of high rate decomposition stage when organic manure is transformed Jilani [14]. This result corroborates with the findings of Malik and Chauhan [15]. The values were statistically different at P=0.05. The results of higher microbial abundance in the treated plots than in the control and higher in 2nd C. S than in the 1st C. S. corroborates observations Mandic, Djukic, Beatovic, Zoran, Pesakovic and Stevovic [16]. Previous investigations have also demonstrated that animal compost increase microbial abundance by increasing the carbon pool of the soil thus improving the living conditions for indigenous microbial populations Zhen, Liu, Wang, Guo, Meng, Ding, Wu, and Jiang [17].

4.2. Effects of Organic Fertilizers on Growth and Yield of Maize

The results of the greater ear mean weight (Ear Wt) of plants on manured plots (ECM & EPM) than on EC during both C. S is consistent with the findings of Okoroafor, Okelola, Edeh, Emehute, Onu, Nwaneri, and Chinaka [18] who reported that poultry droppings gave higher mean weight of fresh cob of maize than the control. This research indicates that organic fertilizers improve the maize growth/yield and that the PM gave highest effect than the CM and control. The grain yields of maize obtained in this study, though lower than the standard real yield potential of 4.6 tha^{-1} Pennington [19] had shown positive yield potential (more grain yield greater than stover yield) in both treatment plots. This signifies the importance of organic manuring of the flood plain in maize cultivation. Organic manuring could enhance special traits such as the ability to adapt to environmental stresses, disease existence which could have been enhanced by the rhizosphere microbes Nihorimbere, Ongena, Smargiassi, and Thonard [20].

4.3. The Harvest Index

The management of the plots (organic fertilizer application) had been suggested to contribute to the value of harvest index, H. I by Pennington [19]. Thus the satisfactory values (0.51 to 0.63) of the studied plants especially on the EPM and ECM is explained and is within the recommended range (0.50) as documented by Pennington [19]. Ion, Deu, Dumbrawa *et al.* [21] have recorded H. I similar (0.4) to these research findings.

5. Conclusion

A two year experiment at the Etinan flood plains provided a unique opportunity for the assessment of the effects of the utilization of organic fertilizers (cow dung and poultry droppings) on soil microbes, soil properties and maize growth/yield. The one time application of the organic fertilizers resulted in higher beneficial microbial density as well as increased physical and chemical properties (e.g. TOC, soil organic matter, nutritive salts–NO_3, SO_4, PO_4, CO_3 in the 2nd cropping season than the 1st. Thus, the utilization of composted organic fertilizers especially (poultry droppings) which showed (better effects) than cow dung on the wetland soil can indeed enhance sustainable agriculture.

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