CHARACTERIZATION OF FISH POND WASTEWATER-RECEIVING SOIL AND WEIGHT PERAMETERS OF *Zea mays* (POACEAE)

Supported by tetfund

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Received: December 14, 2023 Accepted: March 28, 2024

Abstract: The application of wastewater from fish pond can help boost soil productivity and plant growth. In this study, the effect of irrigation using different type of fish pond wastewaters on soil chemistry and weight parameters of *Zea mays* is assessed. The wastewaters showed acidic values of pH (6.5 to 6.8) and higher values of temperature (27.4 - 30.5 ^{0}C), electrical conductivity (357.3 - 531.3 µs/cm), total dissolved solids (225.3 - 317.9 mg/l) and inorganic element/ compounds (except available phosphorus) compared to the neural borehole water. The wastewater-receiving soils showed ranges of pH, 6.3 – 6.6; temperature, 27.0 – 28.5 ^{0}C, electrical conductivity, 14.01 – 18.0 µs/cm and total dissolved solids, 27.8 – 35.9 mg/g. The amount of all the investigated inorganic elements was found to be higher in wastewater-receiving soil with that from concrete pond having the highest concentration of phosphorus (6.9 mg kg^{-1}), organic carbon (3.4 mg kg^{-1}) and potassium (1.9 mg kg^{-1}), while that of earthen pond showed the highest value of nitrogen (1.9 mg kg^{-1}). The crop irrigated with wastewater from the concrete pond showed significant ($P < 0.05$) highest fresh weight value (12.39±0.10 kg) while the highest chlorophyll concentration was obtained in *Z. mays* irrigated with wastewater from the tarpaulin pond with the value of 0.59 mg g^{-1}. The irrigation of *Z. mays* with fish pond wastewaters especially that of concrete pond is therefore recommended.

Key words: Chlorophyll, crop, fish pond, irrigation, soil chemistry.

Introduction

Agriculture is a predominant activity in Nigeria, with the aquaculture as one of its vibrant sectors. The water used for fish farming in aquaculture was normally dispose-off but over time, the fish ponds have been observed to be enriched with organic matter, nitrogen, phosphorus, and micro and macronutrients, and hence, it can be a potential fertilizer supplement and soil conditioner, which could enhance the environment for crops (Payebo and Ogidi, 2020). Fish Pond Wastewater is a cloudy fluid arising from pond, containing mineral and organic matter in solution or having particles of solid matter floating, in suspension, or in colloidal and pseudocolloidal form in a dispersed state.

The reuse of wastewater, in particular for irrigation, is an increasingly common practice, encouraged by governments and official entities worldwide. According to Ndagi *et al.* (2020), irrigation with wastewater may have implications at two different levels: alter the physico-chemical properties and microbiological content of the soil and/or introduce and contribute to the accumulation of chemical and biological contaminants in soil. The first may affect soil productivity and fertility; the second may pose serious risks to the human and environmental health. The sustainable wastewater reuse in agriculture should prevent both types of effects, requiring a holistic and integrated risk assessment.

The soils of Kano are highly weathered and low fertility status and the dominant coarse fraction also increases the susceptibility of these soils to nutrient leaching (Abdulrahman and Mustapha, 2021). The increasing human population places a huge demand and pressure on agricultural production and one of the key crops in demand is maize. This increasing intensification and production in turn place huge pressure on the fertility of the soil (Mustapha *et al*., 2020). In a bid to improve and preserve soil quality, farmers need to supply additional nutrients to farmlands. Organic sources of nutrients hold significant promise in terms of nutrient content and supply to soils and fish pond water can be used as an important source of nutrients to the soil and crop production (Mustapha *et al*., 2017). With the increasingly high cost of mineral fertilizer as well as the possible acidification of the already fragile soils of Kano by mineral fertilizers, other alternate sources of nutrients need to be sourced.

Zea mays, more commonly referred to as maize, is a member of the grass family Poaceae, or true grasses. It is a crop with a high demand for nutrients with a high yield response to better nutrient availability. It requires a rain fall of 250 mm to 270mm with sufficient water supply at its critical growth period (Payebo and Ogidi, 2020). However, there are few studies on the performance of crop irrigated with fish pond wastewater or effect of varying types of wastewater effluents on the soil quality and maize performance. Therefore, this study was carried out to assess the effect of irrigation using different type of fish pond wastewaters on soil chemistry, weight and yield of *Zea mays*.

Material and Methods

Study Collection

The experiment was carried out at the teaching and research farm of the Faculty of Agriculture, Bayero University Kano (BUK), Nigeria. Kano State lies within Latitude 8° 42'E and Longitude 9° 30'N at about 1,578 feet (481 m) above sea level. The area is characterized by tropical wet and dry climates. Mean annual rainfall and temperature range between 888.6 mm – 960 mm and 21°C in September and 46°C in March respectively (KNARDA, 2006). Three different types of fish ponds were identified; concrete, earthen and tarpaulin (Fig. 1-3).

Figure 1: Concrete pond

Figure 2: Earthen pond

Figure 3: Tarpaulin fish pond

Collection of Wastewater and Preparation

The wastewater samples from each pond type, as well as ten kilograms each of untreated soil samples (control) and wastewater-receiving soil samples, were collected from within the farm. Soil samples were obtained using sterile hand trowels at a depth of ten centimeters and promptly placed in sterile polythene bags. These samples were then transported to the Chemistry Laboratory, BUK, within one hour of collection for analysis.

Before collecting the soil samples, land clearing was conducted, preceding the application of wastewater. Additionally, borehole water and control plots—plots not irrigated with wastewater—were prepared for maize irrigation. The experimental treatment involved the use of one maize variety (EVDT) and three distinct types of fish pond wastewaters, alongside borehole water. Surface irrigation was consistently employed throughout the research as the primary source of nutrients for the maize plants.

Laboratory Analysis

The physicochemical properties were determined following the methods outlined by APHA (2005). pH was measured with a Griffin pH meter (model 80). Electrical conductivity (μs/cm) was measured using a Philip PW9505 conductivity meter. Organic carbon was determined using Walkley and Black's rapid titration method. Total N was determined using the Kjeldahl method, and Bray 1-P was used for available Phosphorus extraction. Exchangeable bases were extracted using l M ammonium acetate solution at pH 7. Micronutrients were extracted using l M HCl solution, and the micronutrients in the solution were read using the atomic absorption spectrophotometer while the concentration of other inorganic elements was determined with a flame emission photometer. Chlorophyll concentration is most accurately measured by extraction of chlorophyll in a solvent followed by in vitro measurements in a spectrophotometer (Parry *et al*., 2014).

The weight of the maize crop was calculated as follows:

$$Fresh\ Weight\ [g] = Dry\ Weight\ [g] + Lost\ Water\ Content\ [g]$$

Statistical Analysis

The statistical analysis was performed using Microsoft Excel 2010 and SPSS (Version 21; IBM; USA) software packages. Descriptive statistics were used to describe the soil and water properties while Analysis of variance (ANOVA) and student t- test were used to test the differences in the means of the parameters at significance level of 0.05%.

Results and Discussion

The physical analysis of the fish pond wastewaters and borehole water are shown in Table 1. The wastewaters show acidic values of pH ranging from 6.5 to 6.8 while borehole water gave pH of neutral value of 7.0. Several factors contribute to lowering the pH in ponds; rain is acidic, usually with a pH of 5.2 to 5.6, industrial pollution and fertilizer application can lower the pH of pond regardless of the type. According to Boyd (2017), fish have an average blood pH of 7.4, so pond water with a pH close to this is optimum with an acceptable range of 6.5 to 9.0. Generally, the investigated fish pond wastewaters show higher temperature (27.4 - 30.5 ^{0}C), electrical conductivity (357.3 - 531.3 μs/cm) and total dissolved solids (225.3 - 317.9 mg/l) compared to the borehole water as previously reported by Omofunmi *et al*. (2020).

Table 2 shows the investigated chemical analysis. Concrete pond has the highest amount of inorganic element/ compound such ammonium (68.9 mg/l), chlorine (91.8 mg/l), total nitrogen (0.18 mg/l), zinc (0.09 mg/l), calcium (38.69 mg/l), iron (1.94 mg/l), potassium (1.16 mg/l) and sodium (0.82 mg/l) and these agree with result of Ndagi *et al.* (2020). Furthermore, the result shows that the borehole water contains more available phosphorus than the wastewaters, while manganese was the same in all the four investigated samples with value of 0.07 mg/l.

Table 1: Physical analysis of borehole water and fish pond wastewaters before application to experimental site

Parameters	Borehole water	Wastewaters		
		Concrete Pond	Earthen Pond	Tarpaulin Pond
pH	7.0	6.5	6.8	6.6
Temperature (^{0}C)	25	29.2	30.5	27.4
Electrical conductivity (µs/cm)	301.7	357.3	508.2	531.3
Total dissolved solids (mg/l)	178.4	225.3	306.3	317.9

Table 2. Chemical properties of borehole water and fish pond wastewaters before application to experimental site

Parameters (mg/l)	Borehole water	Wastewaters		
		Concrete Pond	Earthen Pond	Tarpaulin Pond
Ammonium	47.90	68.90	57.20	65.4
Bicarbonate	43.80	53.10	61.62	68.00
Chlorine	65.10	91.80	82.80	86.70
Available Phosphorus	1.31	0.59	1.04	0.75
Sulphur	0.53	0.58	0.74	0.73
Total Nitrogen	0.13	0.18	0.16	0.16
Zinc	0.04	0.09	0.03	0.05
Calcium	22.09	38.69	18.09	26.57
Iron	0.42	1.94	0.64	0.51
Magnesium	1.01	1.13	1.44	1.34
Manganese	0.07	0.07	0.07	0.07
Potassium	0.30	1.16	0.95	0.79
Sodium	0.71	0.82	0.80	0.81

The physical analysis of fish pond wastewater-receiving soils is shown in Table 3. The wastewater-receiving soils showed ranges of pH, 6.3 – 6.6; temperature, 27.0 – 28.5 ^{0}C, electrical conductivity, 14.01 – 18.0 µs/cm and total dissolved solids, 27.8 – 35.9 mg/l, while the control soil had mean higher pH value of 6.8; lower temperature, 26.6 ^{0}C; lower electrical conductivity, 10.7 µs/cm and lower total dissolved solids, 22.0 mg/g.

Table 4 presents the chemical analysis of the fish pond wastewater-receiving soil. The amount of all the investigated inorganic elements was found to be higher in wastewater-receiving soil with that from concrete pond having the highest concentration of phosphorus (6.9 mg kg^{-1}), organic carbon (3.4 mg kg^{-1}) and potassium (1.9 mg kg^{-1}), while that of earthen pond showed the highest value of nitrogen (1.9 mg kg^{-1}). These were in support of earlier reports that the application of wastewater from fish pond through surface irrigation system improves the physico-chemical properties of the soil in terms of soil electrical conductivity, total soil nitrogen, total organic carbon, total organic matter, soil minerals, exchangeable acidity and cation exchangeable acidity capacity (Nsoanya, 2019; Musa *et al.*, 2020; Samuel *et al*., 2021)

Table 3: Physical analysis of borehole and fish pond wastewater-receiving soils

Parameters	Control	Wastewater-Receiving Soil		
		Concrete Pond	Earthen Pond	Tarpaulin Pond
pH	6.8	6.5	6.6	6.3
Temperature (^{0}C)	26.6	27.0	28.5	27.0
Electrical conductivity (µs/cm)	10.7	14.1	18.0	14.1
Total dissolved solids (mg/g)	22.0	35.3	27.8	35.9

Table 4: Chemical analysis of borehole and fish pond wastewater-receiving soil

Parameters (mg kg^{-1})	Borehole water	Wastewater-Receiving Soil		
		Concrete Pond	Earthen Pond	Tarpaulin Pond
Nitrogen	0.9	1.7	1.9	1.2
Phosphorus	1.5	6.9	1.4	1.3
Organic carbon	1.82	3.4	2.5	2.7
Potassium	0.8	1.9	1.3	1.1

The weight parameters and chlorophyll concentration of wastewater-receiving *Z. mays* are shown in Table 5. The fish pond wastewaters have great influence on the weight of the *Z. may* as wastewater-receiving crops have higher fresh weight ranging from 8.92±0.05 kg (earthen pond wastewater crop) to 12.39 ±0.10 kg (concrete pond wastewater crop). The crop irrigated with wastewater from the concrete pond showed significant (P < 0.05) highest fresh weight value (12.39±0.10 kg). Furthermore, the *Z. mays* irrigated with fish pond wastewater had higher dry weight (3.31±0.01-3.93±0.05 kg) as compared to the control crop weight (3.29±0.04 kg). The result shows a similar trend with result obtained by Ndagi *et al*. (2020), where highest weight yield of 0.35 tone/ha was observed in maize irrigated with fish pond wastewater.

In the present study, the highest chlorophyll concentration was obtained in *Z. mays* irrigated with wastewater from the tarpaulin pond with the value of 0.59 mg g^{-1}. However, there is no significant difference in the chlorophyll concentration between the control and the wastewater-receiving *Z. mays*. Jawale *et al*. (2017) reported similar findings in maize where the highest chlorophyll content of 0.76 mg g^{-1} was observed in treatment receiving complete nutrient package from wastewaters.

Table 5: Weight and chlorophyll content of fish pond wastewater-receiving Z*ea mays*

Parameters	Control	Wastewater-Receiving Maize		
		Concrete Pond	Earthen Pond	Tarpaulin Pond
Fresh Weight (kg)	7.62±0.01^{a}	12.39±0.10^{b}	8.92±0.05^{a}	8.94±0.01^{a}
Dry Weight (kg)	3.29±0.04^{a}	3.93±0.05^{a}	3.40±0.05^{a}	3.31±0.01^{a}
Chlorophyll Contents (mg g^{-1})	0.58±0.02^{a}	0.55±0.01^{a}	0.56±0.05^{a}	0.59±0.01^{a}

Keys. Mean±Standard Error; values with different superscripts across row are significantly different at $P < 0.05$.

Conclusion

The study revealed a higher influence of wastewater from different fish pond over the borehole water on *Zea mays* weight and chlorophyll concentration through soil quality improvement. Maize irrigated with fish pond wastewater had higher fresh and dry weights as compared to the control crop weight but no significant difference in the chlorophyll concentration between the control and the wastewater-receiving crops. However, the influence of wastewater from concrete pond can be concluded to be more efficient for maximum soil quality for *Z mays* production.

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