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Research Application Summary

Influence of rendered abattoir effluent on fruit yield of chilli pepper and soil properties

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Abstract

Abattoir waste management is of great concern in both urban and rural areas of Nigeria. Despite the potential benefits of abattoir effluent to improve the soil fertility and yield of crops, its integration into agricultural soil management strategies depend on soil type and environment which vary widely. This study was established at the Faculty of Agriculture, University of Ilorin, Nigeria to evaluate the effect of rendered abattoir effluent on performance of pepper and soil properties. The potted experiment was a randomized complete block design. The treatments were: four rates of application (control (0); 15,000; 20,000; and 25,000 L/ha) replicated thrice. Data were collected on the yield and yield parameters such as plant height, number of leaves, number of branches, stem girth, days to flowering, days to fruiting, fruit weight, number of fruits and fruit length. Data were subjected to Analysis of Variance and significant means were separated using New Duncan Multiple Range Test at 5% probability. Results showed that rate of application significantly affected plant height, number of leaves, days to flowering, fruit weight, number of fruit and fruit length($p<0.05$). In conclusion, application at the rate of 20000L/ha gave the best yield parameters in terms of fruit weight, number of fruit, fruit length and improved physical and chemical properties of the soil. This study therefore recommends application of the rendered abattoir effluent at the rate of 20000L/ha to enhance organic pepper production in the study area.

Key words: Abattoir, *Capsicum* spp., environment, slaughter house, soil amendment

Résumé

La gestion des déchets d'abattoir est une préoccupation majeure tant dans les zones urbaines que rurales du Nigeria. Malgré les avantages potentiels des effluents d'abattoir pour améliorer la fertilité du sol et le rendement des cultures, leur intégration dans les stratégies de gestion des sols agricoles dépend du type de sol et de l'environnement, qui varient considérablement. Cette étude a été réalisée à la Faculté d'agriculture de l'Université d'Ilorin, au Nigeria, afin d'évaluer l'effet des effluents d'abattoir rendus sur les performances du piment et les propriétés du sol. L'expérience en pots a été conçue selon un plan en blocs complets randomisés. Les traitements étaient les suivants : quatre doses d'application (témoin (0) ; 15 000 ; 20 000 ; et 25 000 L/ha) répétées trois fois. Les données ont été recueillies sur le rendement et les paramètres de rendement tels que la hauteur des plantes, le nombre de feuilles, le nombre de branches, le tour de tige, le nombre de jours avant la floraison, le nombre de jours avant la fructification, le poids des fruits, le nombre de fruits et la longueur des fruits. Les données ont été soumises à une analyse de variance et les moyennes significatives ont été séparées à l'aide du test de New Duncan à 5 % de probabilité. Les résultats ont montré que la dose d'application avait un effet significatif sur la hauteur des plantes, le nombre de feuilles, le nombre de jours avant la floraison, le poids des fruits, le nombre de fruits et la longueur des fruits (p<0,05). En conclusion, l'application à la dose de 20 000 L/ha a donné les meilleurs paramètres de rendement en termes de poids des fruits, de nombre de fruits, de longueur des fruits et a amélioré les propriétés physiques et chimiques du sol. Cette étude recommande donc l'application des effluents d'abattoir rendus à la dose de 20 000 L/ha pour améliorer la production biologique de piments dans la zone d'étude.

Mots-clés : Abattoir, *Capsicum* spp., environnement, abattoir, amendement du sol

Introduction

Pepper (*Capsicum* spp) belong to family Solanaceae (Dias *et al.,* 2013). Pepper is an important agricultural crop because of its economic and nutritional importance and medicinal content. Pepper is the world second important vegetable, ranking after tomatoes. It is an excellent source of natural colors and antioxidant compounds (Howard *et al.,* 2000) and the most produced type of spice flavoring and coloring for food while providing essential vitamins (A and E) and minerals (Fe, K, Ca). The crop can also be distinguished by its strong, sharp smell or flavor which varies with cultivar. Both hot and sweet peppers contain more vitamin C which helps to prevent flu colds than any other vegetable crop (Bosland and Votava, 2000). Nigeria is known to be one of the major producers of pepper in the world accounting for about 50% of the African production (Grubben and Tahir, 2004). Although pepper is widely cultivated throughout Nigeria, yields obtained by peasant farmers are often very low majorly due to poor soil and biotic constraints (Adigun, 2001). Investigations on the application of abattoir waste as an organic fertilizer for pepper production is therefore an appropriate proposition.

The continuous increase in the global population, demand for food and decrease in availability of clean water pose serious threat to sustainable development and livelihood (WHO, 2004). Meat industry is a major source of generating waste water (effluent) with damaging effect on the environment particularly fresh water bodies (Adedipe, 2002; Isoken and Ita, 2018). Discharge of untreated waste water from abattoir into natural water bodies particularly in most developing nations often constitute significant quantity of pollutants, pathogens and nutrients leaving more than one quarter of population without safe drinking water (Osibanjo and Adie, 2007; Behailu *et al.,* 2017). Therefore, development of a low-cost waste water management technology is needed to treat the wastewater from various sources particularly abattoir effluent. Abattoir effluent, is the by-product from slaughtered animals not used for human consumption due to its unfit or non-acceptability associated with consumer habits like waste water, condemned meat and carcasses. It also includes those that occur at slaughterhouses due to stabling of some animals for days before slaughtering such as faeces, urine and litter (dung) (Werner and Roland, 2008; Elemile *et al.,* 2019). Considerable quantities of abattoir waste are often disposed of via community sewers with little or no primary treatment (Bridges *et al.,* 2000). Most abattoirs use nearby streams and ponds as means of discharging the effluent (blood, contents of stomach and intestines, bristles) contributing to organic and nutrients (calcium, phosphorus) load of streams leading to eutrophication (Adelegan, 2002; Chukwu *et al.,* 2011). These contributed greatly to possible food-borne diseases and potential health hazards associated with food, especially in developing countries like Nigeria (Adeyemi and Adeyemo, 2007).

The meat processing industry is considered an ever-growing industry in Nigeria like in most parts of the world; and it was projected that more and bigger abattoirs will yet be constructed (Ezeoha and Ugwuishiuwu, 2011). Animals are slaughtered every day and the meat are sold to the public for consumption in all rural and urban markets in Nigeria (Atolagbe, 2015), indicating continuous increase in waste generation all over the country. The need to recycle wastewater generated from slaughterhouse to agriculture is regarded as the best low cost and practicable environmental option which supports waste management and sustainable agricultural intensification (Roy *et al.,* 2013). This approach referred to as 'phytoremediation' promotes gainful utilization of the effluent from slaughterhouses in ways that enable healthy environment, reduced pressure on fresh water resources, increased food production and economic benefit (Roy *et al.,* 2013).

Application of abattoir waste to improve soil is a good option due to its rich mineral content for nourishing plants. Nitrogen and phosphorus are the major nutrients released from the waste for plant uptake after decomposition by heterotrophic microorganisms (Paul 2007). Studies have shown that improved soil fertility, plant growth and improved yield could be achieved (Oladipo *et al.,* 2005; Roy *et al.,* 2013). However, it has been reported that application of abattoir effluent without proper treatment may pose reflective impact on the soil characteristics, which are related to the soil fertility (Adesemoye *et al.,* 2006). Adeyemi and Adeyemo (2007) suggested rendering of the abattoir effluent before use. It is a process of cooking that converts the semi-solid waste into a protein-rich substance that appears like sand or soil. Products derived from rendering permits storage for a long period of time. Rendering allows recycling of what would otherwise have been sizeable amounts of waste and a cheaper way of treating abattoir effluent compared with other methods (Gauri, 2006). This study thus evaluated the performance of pepper on soil amended with rendered abattoir effluent and its effect on the soil physical and chemical properties.

Materials and Methods

The experiment was carried out at the Faculty of Agriculture Teaching and Research Farm Vegetable unit, University of Ilorin, Kwara State, North central Nigeria. The Farm is located in the southern Guinea Savanna Ecological zone of Nigeria which lies on latitude 8^o 29'20.9N and longitude 4^o 33' 11.1E. It is categorized under the bimodal rainfall pattern with high rainfall in June and September, and a break between mid-July and August. The average annual temperature is 26.5°C while the annual rainfall averages 1217 mm. The temperatures are highest on average in March (29.0°C) and coldest in August (24.5°C).

The potted experiment was a Randomized complete block design with three replicates. Treatments included four levels of application - control (0 L/ha), 15000L/ha, 20000L/ha, 25000L/ha replicated thrice making a total of twelve experimental units. Fresh abattoir effluent was collected from a public slaughter house in Ilorin, Nigeria while the pepper variety used was obtained at the Kwara State Ministry of Agriculture Ilorin, Nigeria. The abattoir effluent was treated by weighing bovine blood and rumen digesta in ratio 3:1 into a metallic container and boiled for 90 minutes by placing the container on a coal-fired earthen stove. The mix was stirred continually until the content was almost free of water. Finally the mass was dried under the sun for 3 days to obtain the dried organic fertilizer. The product was a dry, solid, deep brown-colored powder and easily spread. It was incorporated into the soil accordingly. Dry pepper seeds (Chilli) were used to raise seedlings in four germination boxes of 50 x 50 cm. The seedlings were transplanted 5 weeks after sowing into 48 pots filled with 10kg of heat sterilized soil amended with rendered abattoir effluent. The plants were irrigated throughout the course of the experiment. All necessary agronomic practices such as weeding, protection from pests were applied at when due.

Topsoil samples between 0-15 cm depths were taken randomly from the experimental site to form a composite, air dried, sieved and taken to the laboratory for the determination of some physical and chemical properties using standard laboratory procedures (AOAC, 1990): Particle size was determined by hydrometer method (Bouyoucos, 1962), pH was determined at 1:2.5 in water and KCl using pH meter, exchangeable acidity was determined by titration using 1N KCl extract, organic carbon was determined by dichromate oxidation, total nitrogen was determined by microkjedal wet oxidation, exchangeable bases {calcium (Ca2+), magnesium (Mg2+), potassium (K+) and sodium (Na+)}were extracted with 1N ammonium acetate; K+ and Na+ were determined by flame photometer while Mg2+ and Ca2+ were determined by AAS. Available phosphorus was determined by Bray P-1 method. Also, sample of abattoir effluent was analyzed for the pH, exchangeable bases, nitrogen, phosphorus and potassium. Post planting soil analyses was also conducted. Data were collected on the following parameters : plant height, number of branches, number of leaves, stem girth, Numbers of days to flowering and fruiting, number of fruit /plant and fruit weight / plant. All data were subjected to Analysis of Variance (ANOVA) using Genstat Statistical Package (GENSTAT® 17th Edition). Significant means were separated where appropriate by the New Duncan Multiple Range Test at 5% probability level.

Results and Discussion

Results on initial soil analyses (Table 1) showed that the soil was sandy-loam, low in total nitrogen, organic matter and available phosphorus. The soil was slightly alkaline which is suitable for pepper production. Exchangeable bases (Ca++, Mg++, Na+ and K+) were moderate. Soil fertility status was low hence the need for amendment. The result of the chemical analysis of the abattoir effluent indicated that it was high in most of the nutrient elements particularly N, P and K that can boost agricultural productivity through gradual release of nutrients to crops. The effect of rate of application of abattoir effluent on the mean plant height of chili pepper is presented in Table 2. Plant height increases with age of plants through the period of observation. The varying rate of application of abattoir effluent significantly ($p<0.05$) affected plant height of pepper as shown in Table 2. The highest plant height was recorded for plant on soil treated with 25000L/ha of the rendered abattoir effluent while the control had the least. This could be as a result of high nutrient made available by abattoir effluent as stated in a study conducted by Osemwata (2010) that plant height increases with increase in level of abattoir effluent.

Table 3 shows the effect of rate of rendered abattoir effluent on numbers of leaves of chili pepper. Mean number of leaves increase with age of the pepper plants. The application of the effluent had significant effect on mean number of leaves/plant. The highest mean number of leaves/ plant was observed with application of 25000 L/ha though not significantly different from application of 20000 L/ha at later stage (from 3WAT).

Table 1. Physical and chemical properties of the soil of the experimental plot and abattoir effluent before planting

Physical properties	Soil	Abattoir effluent
Clay (%)	6.60 ± 3.60	
Silt (%)	8.08 ± 0.40	
Sand (%)	85.22± 4.26	
Textural class (USDA)	Sandy Loam	
Chemical properties		
pH (H2O)	7.20±0.40	6.77±3.60
pH (KCl)	6.40± 0.30	
Available P (mg/kg)	2.22±0.02	0.29±0.03
Total Nitrogen (mg/g)	0.28±0.03	61.32±3.07
Organic carbon (%)	0.77±0.04	
Organic matter (%)	1.34±0.07	
Exchangeable bases(Cmol/kg)		
Ca+	7.30±0.37	7.50±0.37
Mg+	3.42±0.17	3.89±0.17
Na+	1.20±0.06	8.51±0.40
K+	3.30±0.17	4.80±0.17
Exchangeable H+ (Cmol/kg)	0.31±0.02	1.7±0.07

*values are means of two samples

Table 2. Mean Plant height of chilli pepper on soil amended with rendered abattoir effluent

	Plant height (cm)			
Rate of application	1 WAT	2 WAT	3 WAT	4 WAT
Control (0L/ha)	21.02	22.79	24.30	26.15
15, 000L/ha	29.00	29.63	31.43	32.71
20, 000L/ha	28.25	30.09	32.62	34.21
25, 000L/ha	34.04	36.79	38.41	39.34
S.E	1.70*	1.69*	1.39*	1.62*

*=significant difference @0.05, ns= not significant, WAT= weeks after transplanting. Means followed by the same letter are not significantly different by NDMRT.

Moreover, abattoir effluent contains essential nutrient element associated with high photosynthetic activities (Phosphorus and Nitrogen), thus promote root and vegetative growth (Roy *et al*., 2013). The increase in plant height and number of leaves with increase in level of abattoir effluent application may be attributed to the retention of appreciable amount of assimilates in the stem for node and leaf production (Matheyarasu *et al*., 2015).

Table 3. Mean Number of leaves/ plant of chilli pepper on soil amended with rendered abattoir effluent

	Number of leaves			
Rate of application	1WAT	2 WAT	3 WAT	4 WAT
Control	12.42	38.33	59.33	82.8
15000L/ha	16.42	46.75	71.00	102.2
20000L/ha	18.92	60.42	82.33	115.3
25000L/ha	23.42	72.42	93.67	123.3
S.E	2.78 *	10.20 *	13.67*	16.55

*=significant difference @0.05, ns= not significant, WAT= weeks after transplanting. Means followed by the same letter are not significantly different by NDMRT.

Table 4. Yield and yield parameters of chilli pepper on soil amended with abattoir effluent

Rate of application	Days to flowering	Days to fruiting	Fruit weight per plant (g)	Number of fruit per plant	Fruit length (cm)
Control	24.25	22.42	17.25	7.67	4.54
15000L/ha	27.92	30.44	36.59	15.68	4.77
20000L/ha	29.58	30.42	43.37	18.50	4.86
25000L/ha	36.42	33.25	22.74	15.07	4.96
S.E	2.61*	3.79 *	8.69*	3.34*	0.68ns

*=significant difference @0.05, ns= not significant, WAT= weeks after transplanting. Means followed by the different letter(s) are not significantly different by NDMRT.

The yield parameters of chilli pepper as affected by application of the effluent is presented in Table 4. Application of the effluent affected significantly all the yield parameters observed except fruit length. All yield parameters evaluated were significantly higher with application of the effluent compared with the control. Days to first flower and fruit appearance were lowest with control possibly because of low nutrient availability. The plants on soil amended with highest rate of the effluent had delayed flowering and onset of fruiting possibly due to very high available nitrogen which supported prolonged vegetative growth. This implied that application of abattoir effluent at very high rate has the potential to inhibit early flowering and fruiting of chili pepper. This can be as a result of the abattoir effluent having high nitrogen content and excessive nitrogen leads to formation of leaves in expense of flowering and fruiting. Application of abattoir effluent at the rate of 20000L/ha gave the highest mean number of fruit and fruit weight/plant while control had the least. The similarity in fruit length may be due to genetic composition of the pepper variety. Results in Table 5 show the physical and chemical properties of amended soil after planting. The soil was predominantly sandy loam even after at post planting time. The application of abattoir effluent led to increase in the percentage of silt and clay thus increasing the water holding capacity of the soil and nutrient uptake by plants. The soil pH after application of abattoir effluent increases and tends towards neutrality which encourages ion exchange as against the slightly acidic soil under the control. Application of abattoir effluent tends to draw pH of the soil toward neutrality.

The total nitrogen, organic matter, and organic carbon of the soil increased by the application of rendered abattoir effluent. The organic carbon and organic matter were highest in soil treated with 25000L/ha of abattoir effluent. The phosphorus content of the soil was highest in the soil treated with the abattoir effluent which is in tandem with Osemwota (2010) who said phosphorus level increase as the level of application increases. Exchangeable Ca and K increased after the application of abattoir effluent to soil. The uptake and utilization of applied abattoir effluent significantly enhanced the growth components such as plant height, number of leaves /plant days to flowering and fruiting, fruit weight and number of fruit /plant. The significant response to abattoir effluent might be as result of nutrient supplied as well as positive impact on soil physical and chemical properties such as moisture retention, soil structure and aeration (Matheyarasu *et al.,* 2015). Increase in the quantity of abattoir effluent beyond 20000L/ha did not resulted to appreciable increase in the effect on the plant growth, which might be as a result of immobilisation activity of the high level phosphorus released from the effluent (Ediene and Iren, 2017).

Table 5. Physical and chemical properties of amended soil after planting

Rate of application	pH (H_2O)	Clay	Sand	Silt	Organic carbon	Organic matter	N	P	Ca	Mg	K	Na
			-----------%-------------			------------mg/g------------			-------------------Cmol/kg------------			
Control	6.46	6.48	85.52	8.00	0.32	0.65	2.1	1.84	1.63	0.24	0.74	0.08
15000 L/ha	7.85	7.48	82.52	10.00	0.83	1.08	2.3	1.97	2.38	0.16	0.76	0.14
20000 L/ha	7.68	8.48	82.52	9.00	0.70	1.25	2.7	2.18	2.64	0.23	0.88	0.15
25000 L/ha	7.54	9.48	80.52	9.00	0.86	1.52	2.8	2.32	2.69	0.25	1.28	0.15
SE	0.39	0.47	4.27	0.49	0.04	0.07	0.1	0.11	0.13	0.012	0.06	0.007

Conclusion

The study concluded that the use of rendered abattoir effluent as soil amendment significantly improved growth and yield parameters of Chilli pepper plant as well as soil physical and chemical properties. Application of abattoir effluent at 20,000 l/ha which had the highest effect on the number of fruit and fruit weight/plant is recommended in the study area.

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