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RESEARCH ARTICLE

Effect of foliar application of cow dung extract on growth and yield of waterleaf (*Talinum triangulare* Jacq.) in an ultisol

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ABSTRACT

The research was conducted at the Umuowa Ibu 1 community via National Horticultural Research Institute, Mbato, Okigwe Imo State, Nigeria, where waterleaf production and consumption is predominant. The objective of this study was to evaluate the effect of foliar application of cow dung extract on the performance of water leaf. The experiment was laid out in a randomized complete block design. Treatments were four levels of cow dung extract (3.75, 7.50, 11.25, and 15.00 L/ha) and three controls (5t/ha cow dung, 200kg/ha NPK fertilizer, and no soil amendment). Growth and yield data were subjected to analysis of variance. Significant means were compared with the least significant difference at 5%. The result showed a significant increase in waterleaf growth and yield parameters, with an increase in extract application. The foliar yield obtained from the 11.25 L/ha treatment (13.92 and 14.50 t/ha) and 15L/ha (14.46 and 14.75 t/ha) were not significantly different. The lowest foliar yields, 4.31 and 4.26 t/ha, were recorded in no soil amendment. Treatment of 15 L/ha had a significant foliar yield of 3-70% and 1-71% in 2021 and 2022. The result showed liquid manure had lower nutrient content than solid cow dung. In order to reduce frequent application due to its low nutrient content, this study suggests an alternative method of extraction instead of water. Therefore, applying 11.25L/ha to waterleaf was recommended in the interim.

Keywords: Cow dung extract, Growth, Yield, Waterleaf

INTRODUCTION

Waterleaf (*Talinum triangulare* Jacq.) is Nigeria's popular leafy green vegetable. It belongs to the family of *Talinaceae*. This leafy vegetable is a rich source of vitamins, minerals, and protein. Waterleaf as a vegetable can grow and produce edible foliage within 30-45 days after planting under favorable moisture conditions; this quality makes it attractive to small-holder farmers who need quick income-generating crops. The leaves and stems of waterleaf are consumed as vegetables and used to prepare sauces, stews, and famous vegetable soups in the south and eastern parts of Nigeria. The vegetable could soften fibrous vegetables like Afang (*Gnetum africanum*) (Ndaeyo et al., 2013; Ikeh & Udoh, 2022). Waterleaf grows best under humid conditions. It proliferates during the early rainy season but will slow down considerably during the dry season. It grows well under the tree or constructed shade. In an exposed environment, waterleaf plants produce smaller leaves and stems. Most consumers prefer such quality due to f low water content of the foliage. It grows more profuse when the soil moisture is close to field capacity (Owonubi et al., 2021). Waterleaf production has become very popular in many countries due to its increasing importance in the diet of many people, especially in southern Nigeria. In southern Nigeria, water was mainly harvested wild in the early 1970s. However, the increasing demand has forced farmers into small-scale production (Eyo et al., 2001). Waterleaf production has become an essential component of their farming system in most parts of southeastern Nigeria's urban and para-urban areas.

The increasing demand for waterleaf due to its nutritional benefit and as a source of income for farmers has pushed farmers into massive cultivation for small and medium-scale production. In order to sustain waterleaf production and meet its national demand, fertilizer application becomes necessary, especially in an ultisol. Ultisols dominate agricultural land in southern Nigeria. The use of ultisols in southeastern Nigeria is generally for cultivating fields, arable, and plantation crops. Farmers in southeastern Nigeria's ultisols endure low fertility and poor soil characteristics. Ultisols in the southeastern have acidic soil reactions (pH), high Al, Fe, and Mn content, high P adsorption, low cation exchange capacity (CEC), low organic C content, and low element availability (Udoh et al., 2016; Ikeh et al., 2017). Ultisols require particular treatment to optimize soil nutrients and crop productivity. Subsistence and commercial farmers always utilize inorganic fertilizers of various grades, which lower soil pH and pollute the ecosystem. Organic fertilizer and soil conservation improve soil quality (Udoh et al., 2016; Ikeh et al., 2023). Liquid organic fertilizer can replace inorganic fertilizers. Liquid organic fertilizer comprises biological microorganisms and nutrients that promote plant growth (Martínez-Alcántara et al., 2016; Taisa, 2022). Effiong et al. (2006) found that 75% biofertilizer improved maize growth and yield. Liquid organic fertilizer increased cauliflower growth and yield (Taisa et al., 2022).

Liquid fertilizers replace solid manures, which are harder to disperse. Liquid and solid organic fertilizer improves soil fertility, crop growth, development, and yield. After long-term application, organic amendments improve environmental sustainability and plant development (Sun et al., 2014; Atiyeh, 2001). Specialized horticultural production has led to the development of novel liquid organic fertilizers (Pichyangkura & Chadchawan, 2015), which are usually made from natural sources and have low biological activity (Rongting et al., 2017). Liquid organic fertilizers have more organic matter and soluble nutrients than conventional ones, promoting soil sustainability and plant health (Hou et al., 2017). Integrating watering and fertilization strategies could increase nutrient usage efficiency and reduce nutrient loss (Toonsiri et al., 2016).

Chitin, humic and fulvic acids, and other biopolymers in liquid organic fertilizers can biostimulate plants (Canella et al., 2015). Canfora et al. (2015) discovered that liquid organic fertilizers with stillage and vermicompost increased tomato root growth and soil microbiological Eubacterial and Archaeal diversity. Liquid residues from lipopeptide manufacturing improved tomato growth and increased soil microbial diversity, enzyme activity, and nutrient cycles (Canfora et al., 2015; Zhu, 2015). Due to its ecological and economic benefits, analyzing plant development under liquid organic fertilizer could lead to a successful alternative fertilizer for agricultural output in Nigeria and other nations. Waterleaf production in southeastern Nigeria faces the challenges of low soil fertility and flooding due to heavy annual rainfall, which intensifies the problem of leaching and nutrient fixation, especially phosphorus by acid soils (Effiong et al., 2006). One way of reducing these challenges is to adopt the foliar application of organic fertilizers, which provides the quickest means of managing soil macro and micronutrient deficiencies. Research on the foliar application of cow dung extract has yet to be documented in the study area where waterleaf cultivation, consumption, and marketing are predominant.

MATERIALS AND METHODS

The field experiment was conducted in Ndikpaezella in Umuowa Ibu1 via the National Horticultural Research Institute, Okigwe substation. Okigwe is located between latitudes 5°49' 45" N, and longitudes 7° 21' 2" E. Okigwe has a mean annual range of rainfall of 80 to 375 mm, mean relative humidity of 79%, and mean temperature of 22.7 to 34°C. The area lies within Nigeria's humid tropical rainforest zone and has two seasons. The seasons are wet and dry season. The wet season starts between March and April and lasts till October, with a brief break in August traditionally referred to as the "August Break." The dry season begins in November and extends to February and late March.

Experimental Design and Treatment

The experiment was laid out in a randomized complete block design (RCBD) and replicated four times. The treatments used were 3.75, 7.50, 11.25, and 15.00 L/ha of liquid fertilizer, 5t/ha solid form, and 200kg/ha NPK fertilizer and control (no soil amendment), making it seven treatments. The entries' experimental plot size was 24m x 14m (336 m2). Each plot measured 2m x 2m (4m2). Each replication had seven plots, making 28 plots in all the replications. Replication and plots were demarcated with a 1m path, respectively. Weeding was done twice at three weeks and six weeks by hand pulling.

Soil Sampling and Laboratory analysis

Composite soil samples were taken from the surface soil at 0-15cm and 15-30cm depths. The soil samples were air-dried and processed for mechanical and chemical analysis. Particle size distribution was determined by the Bouyoucos hydrometer method. Chemical analysis was done as described by Sparks (1996) for pH, total N, organic carbon, available phosphorus, exchangeable based (Ca, Mg, K, Na), and acidity.

Analysis of cow dung

The cow dung obtained from the Okigwe cattle market was digested by the wet oxidation method and analyzed for pH, total N, available P, and exchangeable bases (Ca, Mg, K, Na) using standard methods adopted for soil analysis (Udo & Ogunwale, 1986). Micronutrients (Fe, Cu, Zn, and Mn) were extracted using DTPA (diethylenetriamine pent acetic acid) method. An atomic absorption spectrophotometer determined the concentration of the extract's micronutrients.

Preparation of Liquid Manure

Seventy-five kilogram (75kg) of cow dung were put into two sack bags, 37.5kg per bag, tried with strings, and placed in a plastic drum 0.8m wide and 1.2m deep. The drum was filled with 180 liters of water until the level covered the bags. Bricks were placed on top of the bags, and the drum was then covered with black polythene sheets to make it airtight. The setup was left for 21 days, after which the bags were removed and squeezed, and the solution (liquid) was ready for use. After three weeks, 150L (81.5%) of the solution was recovered from the drum.

Analysis of Liquid Manure

The pH, total nitrogen, available P, soluble K, exchangeable Ca, Mg, K, Na, and micronutrients Fe, Mn, Cu, Zn) were determined using standard methods (Effiong et al., 2006).

Application of liquid Manure

Knapsack sprayer was used to apply the liquid manure. The application was conducted four times at 2, 4, 6, and 8 weeks after planting. In each operation; the following levels of manure extract were applied on a treatment basis; 37.5L/ha, 7.5L/ha, 11.25L/ha, and 15.00L/ha. After each operation, the drum was covered with black polythene, and slabs were placed on top to make it airtight and prevent oxidation reactions. The solid cow dung of 5t/ha was incorporated in the soil during land preparation, while mineral fertilizer of 200kg/ha NPK was applied to the crop two weeks after planting (WAP).

Data Collection and Analysis

Growth and yield data were collected on the following parameters: plant height; the height of the plant was determined by measuring from the base of the plant to the terminal bud with the aid of measuring tape. Number of branches per plant; number of branches per plant was determined by physical counting of all branches in each sampled plant. The leaf area of the waterleaf was determined by measuring the length (L) and width (W) of the sample waterleaf leaf. The product of L x W was used as a leaf area. Number of leaves per plant; The Number of leaves per plant was determined by physical counting of functional leaves per sample plant. Dry matter accumulation of foliage was determined using the oven-dry method at a constant 85^{o}C for 5 hours. The initial fresh weight of 100g was oven-dried, and the final weight was also determined. Both initial and final weights were determined with the aid of a sensitive weighing balance. The foliar yield of waterleaf was determined with a top load weighing balance in kilograms and later converted into tonnes per hectare. Data collected were subjected to analysis of variance. Significance means were compared using the least significant difference (LSD) at a 5% probability level.

RESULTS

Some physical and chemical properties of the studied soil are shown in Table 1. The percentage sand fraction was 81.30 and 78.50% in 2021 and 2022, respectively. The clay fraction was 12.02 and 14.20% in both cropping seasons. In 2022 the silt fraction was 6.68%, while 7.30% faction was recorded in the 2022 cropping season (**Table 1**). The soil is generally acidic, with soil pH values in water being 5.10 and 4.60 in 2021 and 2022, respectively. The soil's moderate, high acidic value may likely pose a fertility threat to low acid tolerant crops. Electrical conductivity values of 2021 and 2022 were 0.137 and 0.83 dsm^{-1}, respectively. The organic matter content of the soils was 0.84% in 2021 and 0.91% in 2022. The total nitrogen content of 0.07% and 0.07% was obtained in 2021 and 2022, respectively. The amount of extractable P was high: 54.09 and 60.55 mg kg^{-1} in 2021 and 2022, respectively. The total exchangeable bases were 4.89 and 4.52 cmol kg^{-1} in the 2021 and 2022 cropping seasons (**Table 1**).

The result of cow dung analysis is presented in **Table 2**. The result shows that nutrient was very high in the solid cow dung compared to the liquid type. The nutrient contents of liquid manure have a pH value of 6.18 and 6.20 compared to 8.50 and 8.75 recorded in the solid form. The result showed a 27.3 and 29.1% pH difference between a 27.3 and 29.1% pH difference when solid manure was compared to liquid manure.

The available P content of liquid manure was 97.33 and 95.97 mg kg-1 in 2021 and 2022, respectively. The available P content recorded in solid cow dung was 155.41 and 149.11 mg kg^{-1}, respectively. In solid form, the total N value was 0.38 and 0.41%, while 0.19 and 0.20 % were recorded in the extract. When comparing solid and extract, the results show a percentage difference of 50.0% and 51.2 % of total N. The total nitrogen content was 0.19 and 0.20 % in 2021 and 2022, respectively. Potassium content was 7.37 and 6.75 cmol kg^{-1} in 2021 and 2022, respectively. The liquid extract's Fe (iron) content was 89.38 and 91.50 mg kg^{-1} in 2021 and 2022, respectively. The mean copper content of the extract was 10.59 and 11—61 mg kg^{-1} in 2021 and 2022, respectively.

The effect of foliar application of liquid manure on the leaf area of waterleaf shown in **Table 3**. The result showed a statistically significant difference (P<0.05). The increase in liquid manure rate significantly enhanced leaf size. The largest leaf area, 20.25, 42.44, and 36.14 cm^2 in 2021 at 3, 6, and 9 weeks after planting (WAP) was recorded in 15L/ha treatment. In 2022, the following significant leaf area; 21.71, 44.18, and 35.18 cm^2 was also recorded in 15 L/ha treatment. Treatment of 5t/ha solid cow dung produced leaf area of 21.33, 40.51, and 33.19 in 2021, while corresponding mean leaf area of 21.91, 39.91, and 32.48 cm^2 at 3, 6, and 9 WAP, respectively, was recorded in 2022. Treatment of 200kg ha^{-1} mineral fertilizer rate produced a leaf area of 13.11, 38.12, and 31.17 at 3, 6, and 9 WAP, respectively, in 2021. In 2022, the following mean leaf area of 12.20, 36.33, and 31.32 cm^2 was recorded in the treatment of 200kg ha^{-1} inorganic fertilizer. The least leaf area in both 2021, and 2022 was recorded in the control treatment (no fertilizer application). The leaf area measured from the control treatment was 13.25, 15.26, and 18.91cm^2 in 2021 while 12.91, 17.18, and 15.33cm^2 was recorded in 2022 at 3, 6, and 9 WAP, respectively.

Plant height as influenced by cow dung extract rates varied significantly different (P<0.05) among the treatments (**Table 4**). The tallest plant, 22.95, 32.75, and 38.86cm in 2021 cropping season was recorded in 15 liters ha^{-1}. In the 2022 cropping season, the corresponding plant height of 23.69, 35.65 and 38.03cm, was recorded. The result showed that the control treatment had the shortest plant; 15.08, 18.36 and 19.72cm in the 2021 cropping season. In 2022, plant height recorded in the treatment of 15 liters ha^{-1} was 14.25, 16.33, and 18.90cm at 3, 6, and 9 WAP, respectively.

The number of branches per plant as influenced by organic fertigation rates is presented in Table 5. Number of branches per plant increases with the increase in organic fertigation rate. Treatment of 15L ha^{-1} had a significant number of branches per plant in both cropping seasons (**Table 5**). Treatment of 15Lha^{-1} of manure extract had a significantly higher number of branches per plant, 19.25 and 22.13 at 9 WAP, in 2021 and 2022, respectively. Treatment of 11.25 L/ha^{-1} had 18.13 and 20.19 branches per plant at 9 WAP. The least number of branches per plant in all the weeks under investigation was recorded in the control treatment (Table 5). In 2021, number of branches per plant recorded in control treatment was 0.23, 1.72, and 4.30 at 3, 6 and 9 WAP, respectively, while 0.32, 1.67, and 5.92 branches per plant, respectively, were recorded in 2022.

The total foliar yield in 2021 and 2022 is shown in Table 6. The foliar yield recorded differed significantly when compared to the yield obtained from the control. The result revealed an increase in foliar yield with an increase in fertigation rate, although no statistically significant difference was recorded in the yields from 11.25 L ha^{-1}, and 15.0 L ha^{-1} treatments. Treatment of 15l/ha produced a significant foliar yield of 16.40 and 16.75t ha^{-1} in 2021 and 2022, respectively. This was followed by 14.92 and 14.78 t ha^{-1} foliar yield recorded in Treatment of 11.25 L ha^{-1}. Treatment of 200kg ha^{-1} mineral fertilizer produced 10.70, and10.05 t ha^{-1} foliar yield in both cropping seasons. The lowest foliar yield, 4.31 and 4.26 t ha^{-1} were recorded in the control treatment.

Table 1. Soil Physico-Chemical Properties of the Experimental Site before Planting in 2021 and 2022. 1.38% in 2021 and 1.42% in 2022.

Soil Parameters	2021	2022
	Soil Depth (0-30 cm)	Soil Depth (0-30 cm)
Soil pH	5.10	5.00
Ec(dsm^{-1})	0.137	0.083
Total Nitrogen	0.08	0.07
Organic Matter (%)	0.84	0.91
Available P ($mgkg^{-1}$)	54.09	60.55
Exchangeable Bases ($cmolkg^{-1}$)		
Calcium	3.15	2.89
Magnesium	1.22	1.18
Potassium	0.17	0.13
Sodium	0.35	0.32
Total Exchangeable Bases	4.89	4.52
Exchange acidity($cmolkg^{-1}$)		
H^+	1.92	1.62
Al^{3+}	1.13	1.57
Particle Size Analysis (%)		
Sand	81.30	78.50
Silt	6.68	7.30
Clay	12.02	14.20
Textural Class	Sandy loam	Sandy loam

Table 2. Selected nutrient content of cow dung used in 2021 and 2022

Parameters	2021		% Difference	2022		% Difference
	Solid	Liquid		Solid	Liquid	
pH	8.50	6.18	27.3	8.75	6.20	29.1
Available P($mgkg^{-1}$)	155.41	97.33	37.4	149.11	95.97	35.6
Nitrogen (%)	0.38	0.19	50.0	0.41	0.20	51.2
Calcium($cmolkg^{-1}$)	39.00	5.95	85.0	36.90	6.99	81.1
Magnesium($cmolkg^{1}$)	17.46	4.81	72.5	18.36	4.80	73.9
Potassium($cmolkg^{-1}$)	18.25	7.37	59.6	18.70	6.75	63.9
Sodium($cmolkg^{-1}$)	32.80	8.64	73.7	35.30	9.56	72.9
Iron($mgkg^{-1}$)	1572.50	89.38	94.3	1600.70	91.50	94.2
Manganese($mgkg^{-1}$)	344.60	31.18	91.0	373.10	28.23	92.4
Copper($mgkg^{-1}$)	63.00	10.59	83.2	65.50	11.61	82.3

Table 3. Leaf Area (cm^2) of Waterleaf as Influenced by Foliar Application of Cow dung Extract

Cow dung Extract Rate (L/ha)	2021 Weeks after Planting			2022 Weeks after Planting		
	3	6	9	3	6	9
3.75L/ha	15.16	28.40	20.33	13.40	27.63	25.60
7.50 L/ha	17.33	33.18	31.14	18.21	35.14	30.19
11.25 L/ha	20.18	39.46	35.30	21.60	38.60	33.65
15.00 L/ha	20.25	42.44	36.14	21.71	44.18	35.18
5t/h Cow dung	21.33	40.51	33.19	21.91	39.12	32.48
200kg/ha NPK	13.11	38.12	31.17	12.20	36.33	31.32
Control	13.25	15.26	18.91	12.91	17.18	15.33
LSD(p<0.05)	1.93	2.44	2.01	1.78	2.35	3.17

Table 4. Plant Height as Influenced by Application of Cow dung Extract

Cow dung Extract Rate (L/ha)	2021 Weeks after Planting			2022 Weeks after Planting		
	3	6	9	3	6	9
3.75L/ha	18.33	22.46	29.45	15.68	22.61	27.86
7.50 L/ha	19.75	25.81	32.18	20.40	24.11	31.75
11.25 L/ha	22.95	30.33	38.84	23.14	30.52	37.49
15.00 L/ha	20.25	32.75	38.86	23.69	35.65	38.03
5t/ha cow dung	18.41	27.12	36.45	16.50	26.81	36.91
200kg/ha	15.07	27.57	35.60	13.93	30.01	36.77
Control	15.08	18.36	19.72	14.25	16.33	18.90
LSD(p<0.05)	1.94	2.55	3.11	1.65	2.13	3.19

Table 5. Number of branches per plant as by application of cow dung extract

Cow dung Extract Rate (L/ha)	2021 Weeks after Planting			2022 Weeks after Planting		
	3	6	9	3	6	9
3.75	1.61	4.81	7.22	1.33	3.69	8.49
7.50	2.18	8.51	13.50	1.98	9.11	14.30
11.25	2.51	10.33	18.13	2.60	11.26	20.09
15.00	2.86	11.14	19.25	2.91	12.88	22.13
5/ha cow dung	2.01	10.14	17.67	2.45	10.23	19.94
200kg/ha NPK	0.34	10.91	18.94	0.51	11.13	19.77
Control	0.23	1.72	4.30	0.32	1.67	5.92
LSD(p<0.05)	0.68	2.15	2.91	0.47	2.02	3.10

Table 6. Dry Matter Accumulation and Foliar Yield (t/ha) of Waterleaf as Influenced by Cow dung Extract

Cow dung extract rate (L/ha)	2021		2022	
	Dry Matter (100/g)	Foliar Yield (t/ha)	Dry Matter (100/g)	Foliar Yield (t/ha)
3.75	13.32	7.33	12.77	7.59
7.50	17.45	9.97	18.50	9.82
11.25	21.12	14.92	21.01	14.78
15.00	24.63	16.40	23.68	16.75
5/ha cow dung	21.45	12.45	20.91	11.79
200kg/ha NPK	19.34	10.70	19.19	10.05
Control	10.03	4.31	9.32	4.26
LSD(p<0.05)	3.01	2.56	2.98	2.31

DISCUSSION

The result of the study demonstrated that organic fertigation could improve waterleaf yield in the ultisols of southeastern Nigeria. The application of manure extract enhanced both vegetative growth and dry matter accumulation. The result showed a significant increase in vegetative traits with increased extract rates. This observation agrees with the findings of Martínez-Alcántara et al. (2016). Taisa et al. (2022), reported that foliar application of manure is one of the fastest ways to improve soil quality. Taisa et al. (2022) also reported that soil's physical, chemical, and biological quality could be maintained by applying liquid fertilizer.

The soil analysis showed that the soil was low in pH, total N, Mg, organic matter, and available P, while exchangeable bases were very low. Considering the soil's low nutrient content, liquid organic fertilizer has fulfilled the minimum soil nutrient above the critical range, as described by Udoh et al., 2005. The characteristics indicated that the soil and liquid organic fertilizer used in the study have a good condition to support plant growth and production.

The soil analysis in both cropping seasons showed that the soils were acidic. Solid and liquid manure analysis showed an increase in soil pH, indicating that both solid and liquid manure components had the affinity to ameliorate soil acidity by increasing the pH range. The treatment of liquid manure at 11.25L/ha, 15L/ha, and solid-state cow dung out-yielded the treatment of 200kg/ha inorganic fertilizer. This observation was in line with the report of Soti et al. (2015) that pH is one of the determinants of soil fertility because soil pH describes the availability of nutrients in the soil. According to Soti et al. (2015), macro and micronutrients are available in optimum conditions at a pH range of 5.5 to 7. Ikeh et al. (2012) reported that organic fertilizer application not only supplies micro and macronutrient to the soils but also play a role as a liming material. The significance of organic liquid fertigation in crop production has been reported to be beneficial in enhancing crop yield and fast correction of nutrient deficiencies in the plant and soil. Effiong et al. (2006) reported that applying liquid manure could control nutrient deficiencies in maize and improve the growth and yield of maize in the acid coastal plain soil of Uyo, southeastern Nigeria. Martínez-Alcántara et al. (2016) reported that liquid organic fertilizer could be an alternative option to reduce the utilization of inorganic fertilizers due to its high content in biological microorganisms and nutrients beneficial for plant growth. Treatments of 11.25 and 15.0 L ha^{-1} had significant foliar yields compared to the treatments of 5 t ha^{-1}. Cow dung and recommended mineral fertilizer rate even when the liquid fertilizer nutrient content was low compared to solid manure. The increase in yield could be that bi-weekly application could have been ideal for supplying nutrients to waterleaf. Also, the study was carried out in October in both cropping seasons, when moisture stress would have affected nutrient absorption. Applying liquid fertilizer was another way to increase water availability to the plant. Cow dung and recommended rate of mineral fertilizer even when the nutrient content of the liquid fertilizer was low compared to solid manure. The increase in yield could be that bi-weekly application could have been ideal for supplying nutrients to waterleaf. Also, the study was carried out in October in both cropping seasons, when moisture stress would have affected nutrient absorption. Applying liquid fertilizer was another way to increase water availability to the plant. Treatment of 11.25 L ha^{-1} had significant foliar yields compared to the treatments of 5t ha^{-1} cow dung and the recommended rate of mineral fertilizer even when the nutrient content of the liquid fertilizer was low compared to solid manure. The increase in yield could be that bi-weekly application could have been ideal for supplying nutrients to waterleaf. Also, the study was carried out in October in both cropping seasons, when moisture stress would have affected nutrient absorption. Applying liquid fertilizer was another way to increase water availability to the plant.

CONCLUSION

The outcome of this present study has further stressed the significance of organic fertilizer and its foliar application method for ameliorating soil nutrient deficiencies and improving crop yield. However, the foliar yield obtained from 11.25 and 15 L ha^{-1} cow dung extract revealed that foliar application of organic fertilizer extract can potentially improve crop yield in an ultisol of southeastern. They were considering that the soils of the study are acid and sandy, which makes such soils susceptible to nutrient leaching due to heavy and torrential rainfall. Foliar application of organic fertilizer could be an alternative means of minimizing soil nutrients. The results of organic fertilizer analysis showed high nutrient content in solid cow dung compared to water extract; this indicates that extractants other than water should be studied or tested as an alternative. Therefore, the study recommended that an in-depth study be carried out on extractants while waterleaf farmers should adopt 11.25 L ha^{-1} as an interim recommendation.

DISCLOSURE STATEMENT

The author declares no competing interests

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