IMPACT OF HUMANURE ON SOIL PROPERTIES AND YIELD OF WATERMELON (*CITRULLUSLANATUS)* IN IMO STATE NIGERIA

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ABSTRACT

A field experiment was carried out at the Centre for Agricultural Research and Extension, Federal University of Technology Owerri to examine the impact of humanure on soil properties and yield of watermelon in Imo State Nigeria. The treatments comprised of T1=Control (0t/ha), T2=NPK (240kg/ha), T3=Humanure (10t/ha), T4= Humanure (15t/ha), T5= Humanure (20t/ha). The treatments were assigned randomly to the plots and incorporated into the soil two weeks before planting. The experiment was laid in a Randomized Complete Block Design (RCBD) with treatments replicated three (3) times to give a total of fifteen (15) plots Watermelon seeds (Kaolack specie) were used as a test crop for the study and were sown by direct seedling two weeks after the incorporation of humanure treatment at the spacing of 70cm×70cm and three seeds were planted per hole at the depth of 2cm. Weeding was carried out two weeks after planting and subsequently as regularly as the need arose. The raw data obtained was subjected to analysis of variance (ANOVA) and significant means were separated using Fisher least significant difference (F-LSD) at probability level of P=0.05.The result indicated that the soil physico-chemical properties improved with the application of humanure treatment at different rates (10t/ha, 15t/ha and 20t/ha) compared to the control and NPK treated plot. The humanure positively improved watermelon yield. The length of fruit (cm), the circumference of fruit (cm), the weight of fruit per plant (kg) and total fruit yield (kg) increased significantly with increasing rates of humanure application, with the highest yield being recorded in the 20t/ha humanure treated plot. This research showed that humanure has the potential to improve soil fertility and watermelon production in Owerri, Imo State.

KEYWORDS

Humanure, Soil properties, Watermelon, Yield.

1. INTRODUCTION

Soil is a vital resource for the future of humanity, it needs to be protected and enhanced, instead more than half of all fertile food-producing soils globally are now classified as degraded, many of them severely degrade [1]. This is largely caused by intense cropping that is associated with short period of fallow and low crop yield. Our traditional approach on the use of mineral fertilizer (NPK) as a common fertilizer to replenish the soil for better crop growth and production can no longer be relied on especially as its use is confronted with high cost and unavailability when needed by farmers [2]. And continuous use of only inorganic fertilizers for replenishing the soil is usually accompanied by the long term reduction in soil organic matter, increase in soil acidity, leaching losses, erosion and degradation of soil physical and chemical properties. To regulate the rate at which farmers demand for commercial fertilizer and build a sustainable society based on resource recycling and low carbon society there is need to consider alternative sources of fertilizer. Amending the soil by use of organic manures is considered less likely to have detrimental effect on soil physical and chemical properties compared to mineral fertilizer [3]. Studies have shown that application of organic manure has positive effects on soil physical and chemical properties mainly due to increase in organic matter [4] [5] [6].

The important roles of organic matter include being rich source of essential plant nutrients, helps in improving water holding capacity of the soil, improves soil structure and aeration and making available micro nutrients to crops [7]. Nutrient availability to crops is affected by soil properties and also influenced by environmental factors such as soil pH, organic matter and soil water content and many series of reaction including decomposition, mineralization, humification, precipitation, adsorption and desorption. This could be triggered by application of humanure and will inevitably lead to changes in soil properties. Therefore organic amendment is appropriate for soil, crop growth, environment and economic growth.

Watermelon (*Citrullus lanatus)* is the most popular Cucurbitaceous fruits. The fruit has high water content which helps consumers in preventing dehydration during drought period and also helps in food digestion, [8]. It is highly nutritious and contains significant amount of sugar, vitamin A, B and C [9]. Watermelon is a warm season plant, largely produced in the drier core savanna zones in Nigeria [10]. Its production across agro-environments in the South East is still low despite high rate of its consumption, this situation is due to high humidity that is known to adversely affect flowering and inappropriate soil and water management practices. Another major challenge associated with its production in the South East is insufficiency of data on adaptability and relative performance of varieties across agro-environments. It was based on the above that watermelon was selected as a test crop in an experiment to assess the impact of humanure on soil properties and yield of watermelon in Imo State, Nigeria.

2. MATERIALS AND METHODS

2.1. Site Description

The study was carried out at the Centre for Agricultural Research and Extension Farm, Federal University of Technology Owerri, from October 2019 to January 2020. The study site was located on latitude $5^0$23'4264"N and Longitude $6^0$57'4264"E. The study site had a humid tropical climate, annual temperature of 27-$29^0$and annual rainfall of 2,500mm [11].Which runs from March to December with its peak in July, through October and November. The dry season last from December to March with a dry dust and cold intervals. The soil of the study area is classified as Ultisols using the USDA soil classification and Acrisol (FAO/UNESCO), [12].The Ultisols, (Acrisols in the FAO\UNESCO World Soil Map) are highly acidic, coarse textured and highly leached upland soils. The soil has low mineral reserve and is therefore, low in fertility [13].

2.2. Land Preparation

A total land area of 123.5m^2 (13×9.5) was used for the study. The experimental site was manually cleared using machetes, spade and hoe. Measuring tapes, pegs and ropes were used in mapping out the treatment plots. Fifteen experimental plots measuring 2.5m×2m were used for the experiment. Each plot was separated by 0.5m to prevent treatments from interfering with each other.

2.3. Experimental Materials and Treatments Allocation

Watermelon seeds (Kaolack Specie) and NPK fertilizer was sourced from Agricultural Development Program (ADP) Owerri Imo State, Nigeria. Humanure treatment was sourced from works layout Owerri and was cured for one month before application to the soil. The Treatments comprised of T1-Control at 0t/ha, T2 - NPK` 20:10:10 at 240kg/ha, T3-Humanure at 10t/ha, T4-Humanure at 15t/ha, T5-Humanure at 20t/ha.

Experimental Design/Field Layout

The experiment was laid out in a randomized complete block design (RCBD) with treatments replicated three times as shown in figure 1.

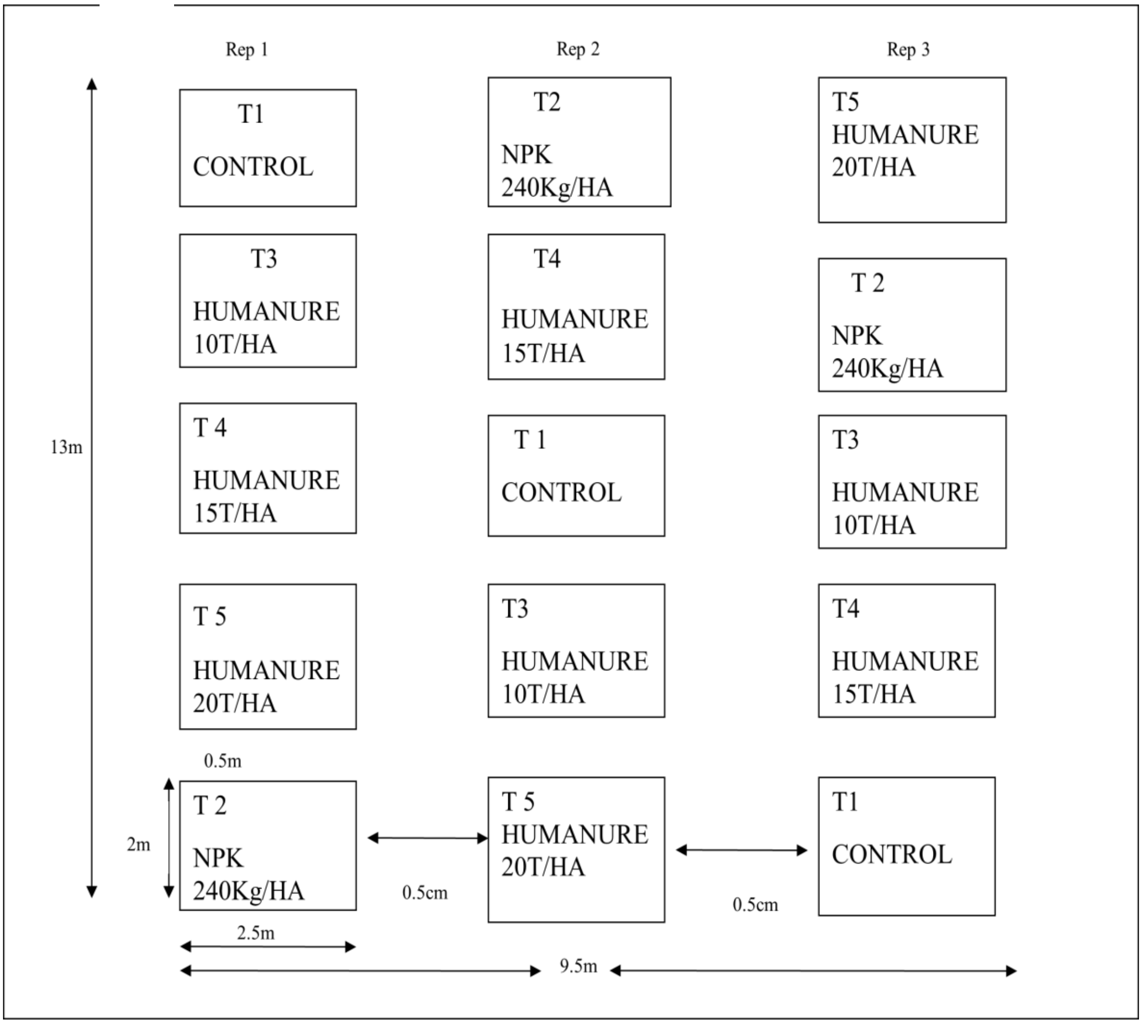

Figure 1. Field Layout of the Experimental Site

2.4. Planting of Test Crop

Watermelon seeds (Kaolack specie) were sown by direct seedling two weeks after the incorporation of humanure treatment at the spacing of 70 cm x 70 cm and three seeds were planted per hole at the depth of 0-2cm to give a plant population of 120,000 seedlings per hectare.

Weeding was carried out 2weeks after planting by hand picking and subsequently as regularly as the need arose. Liquid form of plant protectants Metazed 72 WP was applied to control pest and disease infestation. Watermelon fruits were harvested 75-80 days after planting when the leaf began to dry and the stalk turned brown [14].

2.5. Soil Sampling

Soil samples were collected at 0-30 cm soil depth using a core sampler attached to a soil Augar according to [15] method of free sampling. Samples collected were used for the determination of soil physical and chemical properties. The samples in the core samplers were first used for the determination of soil physical properties and was later air dried, crushed and sieved using 2mm sieve in preparatory for chemical properties determination.

2.6. Laboratory Analysis

The laboratory soil analysis was carried out at Soil Science Laboratory of Federal University of Technology Owerri, Imo State and the following soil properties were determined

2.7. Soil Chemical Properties

Organic carbon was determined by the [16] wet-oxidation method as modified and described in manual of soil, plant and water analysis [17] and the value for organic matter was obtained by multiplying organic carbon value by 1.724 (Van Bemmelen factor). Available phosphorous was determined by [18] method adopted by [19] in which the phosphorous was extracted with 1ml NH_4F and 0.5ml Hydrochloric acid. Colour development was achieved by adding “reagent B”. Available phosphorous was determined calorimetrically using a photo calorimeter. Total nitrogen was determined by micro Kjeldahl digestion and distillation method of [20] as recently modified and described in the manual of soil and water analysis [17] using concentrated H_2SO_4 and a sodium copper sulphate catalyst mixture. Soil pH was determined in the laboratory with a glass pH meter at a ratio of 1:2.5 water ratios. Exchangeable cations (Ca, Mg, Na and K) were extracted with ammonium acetate solution. Exchangeable calcium and magnesium was determined by the ethylene diaminetetracetic acid titration method as described by Black [21], whereas exchangeable potassium and sodium were determined by flame photometry method. Exchangeable acidity (EA) was determined by the titrimetric method [22]. Total exchangeable acidity (TEA) was determined by the summation of H^+ and Al^{3+}.Total exchangeable bases were determined by the summation of exchangeable cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+). Effective Cation Exchange Capacity was determined by the summation of exchangeable acidity (Al^{3+} and H^+) and exchangeable bases. Percentage base saturation was calculated by the summation of the total exchangeable bases divided by effective cation exchange capacity and then multiplied by 100.

$$\% \, BS = \frac{TEB}{ECEC} \times 100$$

2.7.1. Physical Properties

Bulk density was determined using core method [23].

$$\text{Bulk density} = \frac{\text{Weight of wet soil} - \text{Weight of dry soil}}{\text{Weight of wet soil}} \times 100$$

Total porosity was calculated from the result of bulk density and particle size density.

Total Porosity $= \frac{1-\text{Bulk Density (g/cm3)}}{\text{Particle Density}} \times 100$

Particle size distribution was determined by hydrometric meter in water and Calgon [24], Soil texture was determined by matching the value of the particle size against the textural triangle and Gravimetric moisture content was determined by the gravimetric method calculated mathematically as follows:

$$\%\ \text{MC} = \frac{\text{W2}-\text{W3}}{\text{W3}-\text{W1}} \times 100$$

Where MC = Moisture Content, W1 = Weight of the core, W2 = Weight of wet sample + core, W3 = Weight of oven – dried sample + core.

2.8. Agronomic Data Collection

2.8.1. Total Fruit Yield

The total weight of fruits harvested per plot in the net plots were summed up to get the total fruit yield and converted to yield per hectare and recorded in t/ha

2.9. Statistical Analysis

Data generated were subjected Analysis of variance (ANOVA) based on the procedure outlined by [25]. Significant means were separated using Fisher least significant difference (F-LSD) at a probability level of 5%.

3. Results and Discussion

3.1. Soil Characteristics before Application of Humanure Treatment

The physical and chemical properties of the soil before application of humanure treatment at the experimental site are presented in Table 1.

The result of soil analysis before the experiment is presented in Table 1.The result showed that the sand content was 92.28g/kg Sand while 4.10g/kg was silt and 3.62g/kg was clay. This indicates that the soil of the study site was predominantly sandy and was well drained which could be managed for water melon production. The experimental soil recorded bulk density of 1.245g/cm^3 which was below the critical limit of 1.8 bulk density for sandy soils that restrict root growth and development [26]. Bulk density of 1.245 g/cm^3 indicates that the study site will not restrict root development of watermelon and this is in line with the findings of [27] that it is generally desirable to have soil with low bulk density of (<1.5 g/cm^3) for optimum movement of air and water through the soil. Total porosity of 52.8% was recorded in the experimental site. The soil was slightly acidic with pH of 5.86 in water. Exchangeable Calcium was high and Magnesium was moderate with values of 3.764 and 1.810 Cmol/kg. While Sodium and Potassium were low with values of 0.048 and 0.031 Cmol/kg indicating that soil would be improved by addition of organic manure, so as to adequately support plant growth [28]. Total exchangeable bases recorded 5.653 Cmol/kg while Exchangeable acidity recorded 1.350 Cmol/kg. Percentage base saturation and cation exchange capacity were moderate based on the standard rating of [29]. The result indicates that the soil of the study site is low in fertility. therefore will be unable to sustain crop yield without human intervention.

3.2. Mineral Composition of Humanure Used in the Study

The mineral composition of the humanure used in the research is presented in Table 2.

The result of the analysis of humanure used in the study recorded a pH value of 6.52 in H_2O. The organic matte content was high with value of 32.6% indicating that application of humanure to the soil will not only add nutrients to the soil but would also improve soil physical properties. Total Nitrogen, available phosphorous, potassium and sodium were high and this indicates that humanure would provide adequate nutrient needed for plant growth when added to the soil.

Table 1. Pre-planting Soil Analysis

Soil Parameters and Units of Measurement	**Value**
Physical properties	
Sand (%)	92.28
Silt (%)	4.10
Clay ((%)	3.62
Textural class	Sandy soil
Bulk density (g/cm^3)	1.245
Moisture content (g/kg)	18.324
Particle density (g/cm^3)	2.65
Total porosity (%)	52.8
Chemical properties	
pH in H_2O (1:2:5)	5.86
pH KCl (1:2:5)	4.92
Organic Carbon (%)	1.216
Organic Matter (%)	2.096
Available phosphorous mg/kg	10.92
Total Nitrogen (%)	0.130
Calcium (Cmol/kg)	3.764
Magnesium (Cmol/kg)	1.810
Sodium (Cmol/kg)	0.048
Potassium (Cmol/kg)	0.031
Hydrogen (Cmol/kg)	0.500
Aluminum (Cmol/kg)	0.850
Exchangeable acidity (Cmol/kg)	1.350
Total Exchangeable Base (Cmol/kg)	5.653
Effective cation exchange capacity (Cmol/kg)	7.003
Percentage base saturation (%)	80.72

Table 2. Mineral Composition of Humanure Used in the Study

Soil Parameters/Minerals	Values
pH in H_2O (1:2:5)	6.52
Organic Carbon (%)	18.92
Organic Matter (%)	32.6
Total Nitrogen (mg/100g)	456.0
Available phosphorous (mg/100g)	565.0
Calcium (Ca) (mg/100g)	530.0
Magnesium (Mg) (mg/100g)	190.0
Potassium (K) (mg/100g)	485.0
Sodium (Na) (mg/100g)	285.0

3.3. The Effect of Humanure on Soil Physical Properties at Post Harvest

The results of the effect of humanure treatment on particles size distribution, bulk density; total porosity and moisture content of the experimental site at post harvest are present in Table 3.

3.3.1. Particle Size Distribution

The result showed that the soil of the study site at harvest were predominantly sandy soil, when the values obtained was placed on a textural triangle according to the United State Department of Agricultural USDA. There was no significant difference observed in soil texture, however, variation in values was observed. This might be due to the fact that organic manures added to the soil improves the structure of the soil but does not affect the texture [30]. When the control plot was compared with the treatment, the control plot produced 0.04, 1.30, 2.07 and 2.57 more sand than the NPK, 10t/ha, 15t/ha and 20t/ha humanure treated plot. Also the NPK treated plot when compared with the humanure treated plots produced 1.26, 2.03 and 2.53 more in sand than the 10t/ha, 15t/ha and 20t/ha humanure treated plot respectively. However, when the humanure treated plot where compared with one another the 20t/ha humanure treated plot recorded less sand (89.93%) than the 15t/ha (90.43) and 10t/ha (91.20%) respectively. Nevertheless, the control plot recorded 0.07, 0.73, 0.87 and 0.89 less in silt content than the NPK treated plot, 10t/ha, 15t/ha and 20t/ha humanure treated plot respectively.

Table 3. Effect of Humanure on Soil Physical Properties at Post Harvest

Treatment	BD (g/cm^3)	TP (%)	MC (g/kg)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Textural Class
T1	1.24^a	52.96^b	7.47^a	925.00	39.30	35.60	Sandy Soil
T2	1.24^a	52.86^a	7.96^b	924.60	40.00	33.30	Sandy Soil
T3	1.23^b	53.43^c	7.95^b	912.00	46.60	41.60	Sandy Soil
T4	1.23^b	53.60^d	8.29^c	904.30	48.00	41.30	Sandy Soil
T5	1.22^c	53.66^e	8.45^c	899.30	48.20	43.30	Sandy Soil
F-LSD P=(0.05)	0.001	0.042	0.189	NS	NS	NS	

Legend: T1 = Control, T2 = NPK at 240kg/ha, T3 = Humanure at 10t/ha, T4 = Humanure at 15 t /ha, T5 = Humanure at 20t/ha, BD = Bulk density, TP = Total porosity, MC=Moisture Content.

Note: Figures with the same superscript are not statistically significantly different

When the NPK treated plot were compared with the humanure treated plot. The NPK treated plot produced 0.66, 0.80 and 0.82 less in silt content than the 10t/ha, 15t/ha and 20t/ha humanure treated plot, respectively. The 20t/ha humanure treated plot recorded the highest value of silt (4.82%) whereas the least value (3.93) was observed in the control plot. Again, the control plot recorded 0.23 more in clay content than the NPK treated plot and 0.06, 057 and 0.77 less in clay than the 10t/ha, 15t/ha and 20t/ha humanure treated plot respectively. Also the NPK treated plot recorded 0.83, 0.80 and 1.00 less in clay than the 10t/ha, 15t/ha and 20t/ha humanure treated plot respectively. The 20t/ha humanure treated plot recorded the highest value of clay content. The soil clay content increased with increased rate of humanure application.

3.3.2. Bulk Density (g/cm^3)

The result showed that there were significant differences when the soil bulk density of the control was compared with the humanure treated plots. The control plot produced 0.01, 0.01, 0.01, 0.02 (g/cm^3) higher bulk density than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. There were also significant differences when the NPK treated plot was compared with the humanure treated plot. However, there was no significant different when the 10t/ha was compared with the 15t/ha humanure treated plot. The 20t/ha humanure treated plot recorded the least value (1.22g/cm^3). Soil bulk density decreased with increased rate of humanure application. This decrease maybe due to the homogenous distribution of manure constituents between soil particles and also the decomposition by micro organisms which produced cementing agent that linked the soil particles and formed soil aggregates [31] [32]. Similar results were recorded by [33] [34].

3.3.3. Total Porosity (TP %)

The result of the effect of treatments on soil total porosity at harvest showed that there was significant difference when the control was compared with the treated plots. The control plot recorded 0.47, 0.64 and 0.70 less in TP than the humanure treated plots and 0.10 more in TP than NPK treated plot. The NPK treated plot was compared with the 10t/ha, 15t/ha and 20t/ha humanure treated plots. The NPK treated plot recorded 0.57, 0.74 and 0.80 less TP than the human treated plots respectively. Furthermore, there were significant differences when the humanure treated plots were compared with one another. The 10t/ha humanure treated plot recorded 0.17 and 0.23 than the 15t/ha and 20t/ha humanure treated plots respectively. Soil total porosity increased with increasing rate of human treatment. This increase could be associated with the reduction of soil bulk density because of the direct relationship they share, [34].

3.3.4. Moisture Content (g/kg)

The result of analysis of treatments on soil moisture content at harvest showed that there were significant differences when the control plot was compared with the treatments plot and when the humanure treatments where compared with one another. The control plot recorded 0.48, 0.82 and 0.98 less in soil moisture content when compared with the 10t/ha, 15t/ha and 20t/ha humanure treated plots and 0.49 less in moisture content than the NPK treated plot. The NPK treated plot produced 0.33 and 0.49 less in moisture content than the 15t/ha and 20t/ha humanure treated plots respectively. There was no significant difference when the NPK treated plot was compared with the 10t/ha humanure treated plot. However, when the humanure treated plots were compared with one another there was no significant difference in the 15t/ha and 20t/ha. The increased soil moisture content recorded in the humanure treated plots could be attributed to the increased soil organic matter from the humanure treatments. This result confirms the report of [35]. Who noted that application of manure supplies required plant nutrients, improves soil structure and moisture retention.

3.4. Effect of Humanure on Soil Chemical Properties at Post Harvest

Results of the effect of humanure on soil chemical properties at post harvest are shown in Table 4.

3.4.1. Soil pH_w

The result of the effect of treatments on soil pH_w at harvest showed that there was significant difference when the result from the control was compared with those from treated plots. The control plot recorded 0.09 pH_w higher in pH than the NPK treated plot and 0.23, 0.26 and 0.28 pH_w lower than the humanure treated plots, respectively. The NPK treated plot produced 0.32, 0.35 and 0.37 lower in pH_w than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. However when the humanure treated plots were compared with one another 10t/ha humanure treated plot produced 0.03 and 0.05 lower in pH_w than the 15t/ha and 20t/ha humanure treated plot respectively. The highest pH_w value was recorded from the 20t/ha humanure treated plot. This increase in soil pH_w observed in the humanure treated plots explains the acidifying effects of the NPK fertilizer and the neutralizing effects of humanure treatment [36]. Similar result was reported by [37].

3.4.2. Organic Matter (O.M)

The result of treatments on soil organic matter content at post harvest showed that there was significant difference when the control was compared with the treated plots. The control plot produced 0.29, 2.93, 3.22 and 3.46 lower soil organic matter content than the NPK, 10t/ha, 15t/ha and 20t/ha humanure treated plot respectively. There were also significant differences when the humanure treated plot was compared with the NPK treated plot. The 10t/ha, 15t/ha and 20t/ha humanure treated plots recorded 2.64, 2.94 and 3.16 higher soil organic matter content than the NPK treated plot respectively. When the humanure treated plots were compared with one another, soil organic matter content increased as the rate of application of humanure increased. The 10t/ha humanure treated plot produced 0.29 and 0.52 less in soil organic matter content than the 15t/ha and 20t/ha humanure treated plot. This result is in agreement with the result of [38].Who noted that organic manure added to the soil increases soil organic matter content due to the release of organic bound nutrients from the decomposition of the organic waste.

3.4.3. Total Nitrogen (N)

The result of the effects of treatments on soil total nitrogen at post harvest showed that there were significant differences when the control was compared with humanure treated plots and when the humanure treatment were compared with one another. The control plot produced 0.10, 0.08, 0.13 and 0.14 lower NPK treated plot, 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. The NPK treated plot recorded 0.02 higher nitrogen content than the 10t/ha humanure treated plot and 0.03 and 0.04 lower nitrogen content than the 15t/ha and 20t/ha humanure treated plot respectively. The 10t/ha, 15t/ha and 20t/ha recorded 0.21, 0.26, and 0.27 N con tent respectively. The soil total nitrogen content increased as the rate of application increased. The increased soil total N observed agrees with the reports of [39] and [40] with the application of organic waste.

3.4.4. Available Phosphorous

The result of the effect treatments on soil available phosphorous at post harvest showed that there were significant differences when the control plot was compared with the treated plots. The control plot recorded 7.46, 6.30, 9.80 and 10.20 lower available P content than the NPK, 10t/ha, 15t/ha and 20t/ha humanure treated plot respectively. The NPK treated recorded 7.46 higher available P content than the 15t/ha and 20t/ha humanure treated plots. When the 10t/ha, 15t/ha and 20t/ha humanure treated plot were compared with one another, significant differences were also observed, the 10t/ha recorded 3.50 and 3.90 lower P content then the 15t/ha and 20t/ha respectively. The 20t/ha humanure treated plot recorded the highest value (20.70 mg/kg) of P in the soil at harvest. This Increment in the humanure treated plot could be attributed to the fact that mineralization of organic P releases P into the soil solution, [37].

3.4.5. Calcium (ca^{2+})

The result of the effects of treatments on soil calcium at post harvest showed that there were significant differences when the control plot was compared with the humanure treated plots. The control plot recorded 0.38, 1.11 and 1.41 Cmol/kg lower calcium content than the 10t/ha, 15t/ha and 20t/ha humanure treated plot respectively. When the values from the NPK treated plot was compare Cmol/kg lower calcium content than the 15t/ha and 20t/ha humanure treated plot respectively. The highest value (5.13 Cmol/kg) of calcium at harvest was recorded by the 20t/ha humanure treated plot. Similar result was obtained by [34].

3.4.6. Magnesium (mg^{2+})

The result of the effect of treatments on soil magnesium at harvest showed that there were significant differences when the control plot was compared with the treated plots. The control plot recorded 0.03, 0.17, 0.29 and 0.44 Cmol/kg lower magnesium than the NPK treated plot, 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. Also there were significant differences when NPK treated plot was compared with humanure treated plots. The NPK treated plot recorded 0.14, 0.26 and 0.41 Cmol/kg lower magnesium content than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. However, significant differences were also observed when the humanure treated plots were compared with one another. The 10t/ha, 15t/ha and 20t/ha recorded 1.92, 2.04 and 2.19 Cmol/kg respectively. This confirms the report of [41] who noted that application of organic manure to the soil increase ca^{2+}, $Mg,^{2+}$ k^{+}, and Na in the soil.

3.4.7. Potassium (k^{+})

The result of the effect treatments on soil potassium at harvest showed that there was significant difference when the control plot values were compared with the treated plots. The control plot recorded 0.04, 0.05, 0.06 and 0.07 Cmol/kg less in potassium content than the NPK treated plot, 10t/ha, 15t/ha and 20t/ha humanure treated plot. The NPK treated plot recorded 0.01, 0.02 and 0.03 Cmol/kg lower in soil potassium content than the 10t/ha, 15t/ha and 20t/ha humanure treated plots. However, when the humanure treated plots were compared with one another, soil potassium content increased as the rates of application increased. The highest value (0.09 Cmol/kg) of potassium content was recorded from the plots treated with 20t/ha humanure treated plot whereas the control plot recorded the lowest value (0.02 Cmol/kg). This agrees with the result of [38].who reported increase in soil potassium with the application of organic manure.

Table 4. Post Harvest Soil Chemical Properties as Influenced by Humanure Treatment

TRET	$P^H{}_w$	OC (%)	OM (%)	N (%)	AVP (mg/kg)	Ca^{2+}	Mg^{2+}	K^+	Na^+	H^+	AL^{3+}	TEA	TEB	ECEC	BS %
TI	5.67^a	1.48^a	2.55^a	0.13^a	10.53^a	3.72^a	1.75^a	0.02^a	0.04^a	0.48^a	0.86^d	1.34^a	5.53^a	6.87^a	80.49a
T2	5.57^b	1.65^b	2.84^b	0.23^c	17.96^c	3.74^a	1.78^b	0.06^b	0.05^b	0.46^b	0.89^e	1.35^b	5.63^b	6.98^b	80.65^b
T3	5.90^c	3.18^c	5.48c	0.21^b	16.80^b	4.10^b	1.92^c	0.07^c	0.08^c	0.54^c	0.72^c	1.26^c	6.17^c	7.43^c	83.04^c
T4	5.93^d	3.35^d	5.77^d	0.26^d	20.30^d	4.83^c	2.04^d	0.08^d	0.08^c	0.58^d	0.67^b	1.25^d	7.03^c	8.28^d	84.90^d
T5	5.95^d	3.48^e	6.00^e	0.27^e	20.70^e	5.13^d	2.19^e	0.09^e	0.11^d	0.54^c	0.63^e	1.17^a	7.52^d	8.69^e	86.53^e
F-LSD P =0.05	0.027	0.008	0.014	0.003	0.312	0.046	0.017	0.005	0.004	0.035	0.008	0.011	0.049	0.053	0.123

Legend: T1 =Control, T2 = NPK at 240kg/ha, T3 =Humanure at 10t/ha, T4 = Humanure at 15t/ha T5 = Humanure at 20t/ha , OC = Organic carbon, OM = Organic matter, N = Nitrogen, AVP = Available phosphorous, Ca = Calcium, Mg = ,Magnesium, K = Potassium , Na = Sodium , H = Hydrogen, AL = Aluminum, TEA = Total Exchangeable Acidity, TEB = Total Exchangeable Bases, ECEC = Effective Cation Exchange Capacity, BS = Base Saturation.

Note: Figures with the same superscript are not statistically significant.

3.4.8. Sodium (Na^+)

The result of the effect of treatments on soil sodium content at harvest showed that there were significant differences when the results from the control was compared with those from treated plots. The control plot recorded 0.01, 0.04, 0.04 and 0.07 Cmol/kg lower sodium content than the NPK treated plot and humanure treated plots. Also, when the values from the NPK treated plot was compared with those from the humanure treated plots. The NPK treated plot recorded 0.03, 0.03 and 0.06 Cmol/kg less in sodium content than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. However when the 10t/ha and 15t/ha humanure treated plots were compared with one another, there was no significant difference observed. Thus the 20t/ha humanure treated plot recorded 0.03 and 0.03 more in sodium content than the 10t/ha and 15t/ha humanure treated plot. All the values obtained in the humanure treated plots was rated medium (0.1-0.3 (mol/kg) according to the rating of [29].

3.4.9. Hydrogen (H^+)

The result of the effect of treatments on soil hydrogen at harvest showed that there were significant differences when the values from the control plot was compared with those from the humanure treated plots. The control plot recorded 0.06, 0.10 and 0.06 Cmol/kg lower in hydrogen content than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. However when the NPK treated plot was compared with the humanure treated plots. The NPK treated plot recorded 0.08, 0.12 and 0.08 Cmol/kg lower in hydrogen content than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. When the humanure treated plots were compared with one another, there were no significant differences observed when the 10t/ha was compared with the 20t/ha humanure treated plot. The highest value (0.58 Cmol/kg) was recorded in the 15t/ha humanure treated plot.

3.5. Aluminum (AL^{3+})

The result of the effect of treatments on soil aluminum at post harvest showed that there were significant differences when results from the control plot was compared with those from the treated plots. The control plot recorded 0.14, 0.19 and 0.23 Cmol/kg more in Aluminum content when compared with the 10t/ha, 15t/ha and 20t/ha humanure treated plots and 0.03 Cmol/kg lower aluminum content when compared with the NPK treated plot. There were also significant differences when the NPK treated plot was compared with the humanure treated plots respectively. The NPK treated plot revealed 0.17, 0.22 and 0.26 Cmol/kg higher aluminum content than the 10t/ha, 15t/ha and 20t/ha humanure treated plot. However when the humanure treated plots were compared with one another, the 20t/ha recorded 0.09 and 0.04 Cmol/kg less in Aluminum content when compared with the 10t/ha and 15t/ha humanure treated plots respectively. Soil aluminum content decreased with increasing rate of humanure application.

3.5.1. Total Exchangeable Acidity (TEA)

The result of the effect of treatment on soil total exchangeable acidity at post harvest showed that there was significant differences when the values from the control was compared with those from the humanure treated plots. The control plot recorded 0.08, 0.09 and 0.17 Cmol/kg more in TEA than the 10t/ha, 15t/hand 20t/ha humanure treated plots respectively. There was no significant difference observed when the control plot was compared with the NPK treated plot. Also, when the NPK treated plot was compared with the humanure treated plots, the NPK treated plot produced 0.09, 0.10 and 0.18 Cmol/kg higher TEA than the humanure treated plots respectively. When the humanure treated plots were compared with one another, there was no significant difference observed in the 10t/ha treatment when compared with the 15t/ha treatment. The 20t/ha humanure treated plot recorded 0.09 and 0.08 Cmol/kg lower TEA when compared with the 10t/ha and 15t/ha humanure treated plots. The total exchangeable acidity in the soil decreased with an increasing rate of humanure application. The highest value (1.35 Cmol/kg) of TEA was recorded in the NPK treated plot whereas the 20t/ha humanure treated plot recorded the least value (1.17 Cmol/kg).The reduction in exchangeable acidity could be attributed to the uptake of exchangeable cations by plants which was released during mineralization [42].

3.5.2. Total Exchangeable Bases (TEB)

The result of the effect of treatments on soil total exchangeable bases at post harvest showed that there were significant differences when the control plot was compared with the treated plots. The control plot produced 0.10, 0.64, 1.50 and 1.99 Cmol/kg lower TEB when compared with the NPK treated plot, 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. Significant difference was also observed when the NPK treated plot was compared with the humanure treated plots, the NPK treated plot produced 0.54, 1.40 and 1.89 Cmol/kg lower TEB content than the 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. Also, there was significant difference observed when the humanure treated plots were compared with one another. The 10t/ha humanure treated plot recorded 0.85 and 1.26 Cmol/kg lower TEB than the 15t/ha and 20t/ha humanure treated plots respectively. Thus the 20t/ha humanure treated plot recorded the highest value (7.52 Cmol/kg) of TEB content in the soil. Similar results were reported by [43] and [44].

3.5.3. Effective Cation Exchange Capacity (ECEC)

The result of the effect of treatments on soil ECEC at post harvest showed that there were significant differences when the control was compared with the treated plots and when the treated plots were compared with one another. The control plot recorded 0.11, 0.56, 1.41 and 1.82 Cmol/kg lower ECEC than the NPK treated plot, 10t/ha, 15t/ha and 20t/ha humanure treated plot respectively. When the NPK treated plot was compared with the humanure treated plot, the NPK treated plot recorded 0.45, 1.30 and 1.71 Cmol/kg less in ECEC content than the 10t/ha,15t/ha and 20t/ha humanure treated plot respectively. However, there was also significant difference when the humanure treated plots were compared with one another. The soil ECEC at post harvest increased with increasing rate of humanure treatment application. The 10t/ha, 15t/ha and 20t/ha humanure treated plots recorded 7.43, 8.28 and 8.69 Cmol/kg respectively. This result is in line with the findings of [42], who noted that organic manure added to the increased soil effective cation exchange capacity.

3.5.4. Percentage Base Saturation (%BS)

The result of the effects of treatments on percentage base saturation at post harvest showed that there were significant differences when the control plot was compared with the treated plots and when the treated plots were compared with one another. The control plot recorded 0.16, 2.55, 4.41 and 6.04 lower soil base saturation than the NPK treated plot 10t/ha,15t/ha and 20t/ha humanure treated plots. When the NPK treated plot was compared with the humanure treated plot the NPK plot recorded 2.39, 4.25 and 5.88 lower base saturation than the humanure treated plots respectively. However, when the humanure treated plots were compared with one another, significant differences were also observed. The 10t/ha humanure treated plot recorded 1.86, 3.49 lower soil base saturation than the 15t/ha and 20t/ha humanure treated plot. The soil percentage base saturation increased with an increasing rate of humanure treatment with the highest value (86.53%) recorded in the 20t/ha humanure treated plot. [45] Reported similar result that soil ECEC and percentage base saturation increased with the addition of humanure in the soil.

3.6. Effect of Humanure on the Yield of Watermelon

Results of the effect of humanure on yield of watermelon at post harvest are shown in Table 5

3.6.1. Total Fruit Yield (t/ha)

The effect of hmanure on toltal fruit yield is shown in Table 5

The result showed that statistically, significant differences were observed when the total watermelon yield from the control plot was compared with the NPK treated plot and humanure treated plots, and when the humanure treated plots were compared with one another. The control plot recorded 3.40kg, 1.60kg, 5.80kg and 6,93kg less total fruit yield than the NPK treated plot, 10t/ha, 15t/ha and 20t/ha humanure treated plots respectively. Also there were significant differences when the total watermelon yield from the NPK treated plot was compared with the humanure treated plots. The NPK treated plot recorded 1.80kg more in total watermelon yield when compared with the 10t/ha humanure treated plot and 2.40kg and 3.53kg less in total watermelon yield than the 15t/ha and 20t/ha humanure treated plots. When humanure treated plots were compared with one another the 10t/ha humanure treated plot recorded 4.20kg and 5.33kg less in total watermelon yield than the 15t/ha and 20t/ha humanure treated plot. The highest mean value 20.33kg was recorded in the 20t/ha humanure treated plot. The 20t/ha humanure treated plot recorded 6.93, 3.53, 5.33, 1.73kg more in total watermelon yield than the control plot, NPK treated plot, 10t/ha and 15t/ha humanure treated plots respectively. The significant performance of watermelon in the humanure treated plots over the control plot and the NPK treated plot agreed with the report of [9]. This author noted that watermelon responded well to organic manure which may contain essential nutrient elements associated with high photosynthetic activities to have promoted root and vegetative growth.

Table 5. Effect of Humanure on the Yield of Watermelon

Treatment	Total fruit yield (t/ha)
T1	13.40[a]
T2	16.80[c]
T3	15.00[b]
T4	19.20[d]
T5	20.33[e]
FLSD (P=0.05)	0.985

Legend: T1 = Control, T2 = NPK at 240kg/ha, T3 = Humanure at 10t/ha, T4 = Humaure at 15t/ha, T5 = Humanure at 20t/ha

4. CONCLUSION

The results from this study have shown that the incorporation of humanure to the soil improved the soil physico-chemical properties and increased watermelon yield at an increasing rate of 10t/ha, 15t/ha and 20t/ha. Therefore humanure could be used by poor farmers who cannot afford fertilizers due to its high cost, for sustainable agricultural production

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