



## Evaluation of the Restorative Effect of Three Organic Manures in Rill and Gully Eroded Soil Using *Amaranthus hybridus* L. as Test Plant

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### Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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### ABSTRACT

The effect of organic manure in restoration of rill and gully eroded soil using *Amaranthus hybridus* as a test plant was carried out. The aim of this research work was to compare the restorative potentials of cow-dung, goat-dung, and poultry-manure amendment on rill and gully eroded soil. The experiment was laid out in a randomized block design (RBD) with five treatment replicated thrice. Seeds of *Amaranthus hybridus* were sown directly into the bags and were thinned to two seedlings per bag a week after germination. Soil analysis of the treated samples and control was carried out after six weeks to determine the amount of organic carbon, soil pH, potassium, phosphorus and nitrogen. Also soil particles analysis was carried out to determine the amount of sand, silt, clay and bulk density. Stem height of *A. hybridus*, leaf area, number of leaves per plant and stem girth were the parameters monitored on a weekly basis. The data collected were subjected to analysis of variance (ANOVA) and least significant difference (LSD) was used to separate the differences among treatment means. The result showed that goat-dung recorded highest organic carbon content of (1.88 and 1.63) respectively in both rill and gully eroded soil samples. Poultry-manure recorded increase in nitrogen content of (0.92 and 0.84) respectively in both rill and gully eroded soil samples. The combination of goat-dung, poultry-manure and cow-dung recorded the highest pH value of (5.90) in rill eroded soil samples while goat-dung recorded

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the highest pH value of (6.40) in gully eroded soil samples. The least reduction in bulk density in rill soil sample was recorded in goat-dung with value of (1.41) while poultry-manure recorded the least reduction in bulk density of (1.48) in gully eroded soil sample. Percentage clay content recorded highest in control with value of (34.0 and 48.0) respectively in both rill and gully eroded soil samples. The combination of cow-dung, goat-dung and poultry-manure recorded the highest plant height of (21.02cm and 18.10cm) respectively, stem girth (1.36cm and 2.76cm) respectively, leaf area (10.81cm<sup>2</sup> and 16.84cm<sup>2</sup>) respectively in both rill and gully eroded soil sample, in control plant height of (5.64cm and 3.63cm) respectively, in stem girth (0.42cm and 0.32cm) respectively, in number of leaves (7.33cm and 8.33cm) respectively, in leaf area (2.11cm<sup>2</sup> and 1.55cm<sup>2</sup>) respectively recorded the least value in both rill and gully eroded soil samples. Analysis of variance showed significant difference among the treatments and within the weeks.

*Keywords: Cow-dung; goat-dung; poultry-manure; erosion; soil; rill; gully; Amaranthus hybridus.*

## 1. INTRODUCTION

Erosion is one of the surface processes that sculpture the earth's landscape and constitutes one of the global environmental problems. Soil erosion is perhaps the most serious mechanism of land degradation in the tropics [1]. Erosion is a deterioration of soil by the physical movement of soil particles. In agriculture, soil erosion refers to the wearing away of a field's topsoil by the natural physical forces of water and wind or through forces associated with farming activities such as tillage [2].

Soil erosion is the physical removal of topsoil by various agents, including falling rain drops, water flowing over the soil profile and gravitational pull [3]. Erosion, whether it is by water, wind or tillage, involves three distinct actions; soil detachment, movement and deposition [4]. Topsoil, which is high in organic matter, fertility and soil life, is relocated elsewhere "on-site" where it builds up over time or is carried "off-site" where it fills in drainage channels. Soil erosion reduces cropland productivity and contributes to the pollution of adjacent watercourses, wetlands and lakes [5].

The nature of water erosion may involve sheet, rill or gully movement. Irrespective of nature of erosion, the consequences are severe and frequently hazardous to humans and their environment. Gully erosion occurs when water flows in narrow channels during or immediately after heavy rain. This is particularly noticeable in the formation of hollow ways. By 1990, gullies occupy 4% of the land area of Anambra, Imo, Abia and Enugu states. Recently the erosion damage in Imo and Anambra states of Nigeria has been estimated as causing loss of over 20 tons of fertile soil per annum. With gullies extending to the depth of over 120 meters and up to 2 Km wide in some places [5].

In central Eastern Nigeria, the major causes of soil erosion include high rainfall, deforestation, and fragile nature of soil and farming activities [5]. As a consequence of soil erosion by agent of water, soil nutrient are depleted leading to decline in crops productivity. Increased soil erosion promotes soil compaction [6] and loss of weakened top layer of the soil. Soil chemistry is also altered as a result of soil erosion on the farmland area. It results in net decrease in soil carbon and nitrogen [7] due to loss of soil organic matter. Lack of soil organic matter in the soil result in soil structural instability since soil organic matter is a major binding object [8].

Plants need a well-balanced diet for better growth and yield. Manures are substances which provide nutrients for proper growth of plants. Manure is anything that has been added to the soil to increase its fertility and enhancing for plant growth [9]. Manure is not just the urine and faeces from livestock, but also the bedding, runoff, spilled feed, palorwash, and anything else mixed with it [10]. Manure contributes to soil fertility and tilth. In addition to nutrients, manure provides carbon and other constituents that affect soil humus content, biological activity, and soil physical structure [11]. Manures contribute to the fertility of the soil due to addition of organic matter and nutrients, such as nitrogen that is trapped by bacteria in the soil [12].

The degradation of land by erosion is of great concern to agricultural activities, thus it is pertinent to ascertain how this eroded soil which lack plant nutrient can be restored. The aim of this research work was to compare the restorative potentials of cow-dung, goat-dung and poultry-manure amendment on rill and gully eroded soil.

## 2. MATERIALS AND METHODS

### 2.1 Description of the Study Area

The study was conducted at the Department of Botany Laboratory/Green house located in Nnamdi Azikiwe University, Awka campus, using soil samples collected at different erosion sites (Rill and Gully) in Amawbia. Amawbia lies between latitudes 7°00'N and 7°10'N and longitudes 6°05'E and 6°15'E in Anambra State of Nigeria. It lies within the humid tropical rainforest belt of Nigeria characterized by trees, evergreen leaves, thick undergrowth, open vegetative lowland, interspersed with tall oil palm trees and deciduous trees. It has an annual rainfall of 1600 mm to 2000 mm on the average [13]. It has a mean annual temperature which ranges between 27°C and 30°C [13].

### 2.2 Sources of Samples Collections

The cow-dung and poultry-manure used were collected from Amaenyi slaughter house and Amansea Awka while the goat-dung was obtained from a goat rearing house inside market II, Ifite Awka. The seeds of *Amaranthus hybridus* were collected from Anambra Agricultural Development Program (ADP), Kwata Awka. Rill and Gully eroded soil samples used were collected from an erosion site situated at Amawbia, Akwa in Awka south local government area of Anambra state.

### 2.3 Experimental Design

The experiment was laid out in a randomized block design (RBD) with five treatments replicated thrice. This design generally assumed that while the general level of the results may be different in the different blocks, the relative effects of the treatment are the same in all blocks apart from the experimental error. In other words, there is no interaction between treatments and blocks.

### 2.4 Planting

Planting was done on the 22<sup>nd</sup> of June, 2016. Four seeds were sown per bag with a spacing of 60 x 60 cm. The polythene bags used were perforated to avoid water logging.

### 2.5 Cultural Practices

The cultural practices adopted after planting include the following:

- Weeding: This is done weekly by hand picking.
- Watering: This is done once a week since rainfall at the time of the experiment was heavy and continuous.

### 2.6 Methods

Five kilogram of the collected eroded soil samples were measured with the aid of a weighing balance and mixed uniformly with 1.5 Kg of the different manure treatments and were filled in perforated polythene bags. The mixture of goat-dung, poultry-mature, cow-dung mixed weighed 0.5 Kg respectively to make up the 1.5 Kg required treatment. Also another soil sample was weighed and put in a polythene bag without treatment to serve as control. Each of these treatments was replicated thrice making a sum total of 15 perforated polythene bags in each experimental soil sample. Soil samples were collected from rill and gully eroded soil with the aid of auger. The soil samples were air dried and passed through 2 mm sieve and store in sample bags for analysis. Organic carbon was determined by dichromate wet oxidation method. Also total Nitrogen and available phosphorus were analyzed while potassium was measured using flame photometer.

### 2.7 Data Collection

The following parameters were collected weekly as the plants germinated and grow.

- Stem height of *A. hybridus* in (cm)
- Leaf area of *A. hybridus* in (cm<sup>2</sup>)
- Number of leaves of *A. hybridus*
- Stem girth of *A. hybridus* in (cm)

### 2.8 Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) and Fisher's least significant difference (LSD) was used to separate the differences among treatment means.

## 3. RESULTS

Table 1 showed the nutrients and properties of rill eroded soil sample when treated with goat-dung, cow-dung, poultry-manure and a mixture of goat-dung, cow-dung and poultry-manure. The pH (H<sub>2</sub>O) value of the sample was highest in the mixture of PM+CD+GD (5.90) and was least in the control (5.10). The amount of organic carbon was the highest value when treated with goat

dung ( $1.88 \pm 0.002$ ) and the least was control ( $0.90 \pm 0.010$ ). The amount of nitrogen present in the soil sample was highest when treated with poultry-manure ( $0.92 \pm 0.015$ ) and the least was control ( $0.64 \pm 0.016$ ). The amount of potassium present in the soil sample was highest in the three treatment mixtures ( $0.07 \pm 0.002$ ) and the least in the control ( $0.02 \pm 0.002$ ). The amount of available phosphorus in the soil sample was highest when treated with cow-dung ( $4.66 \pm 0.010$ ) and the least was control ( $1.80 \pm 0.016$ ). The clay percentage of the soil sample was highest in control ( $34.0 \pm 0.016$ ) and the least was goat-dung ( $26.0 \pm 0.002$ ). The percentage silt of the soil sample was highest when treated with poultry-manure ( $14.0 \pm 0.005$ ) and the least was the combination of goat-dung + cow-dung + poultry-manure ( $11.0 \pm 0.004$ ). The fine sand percentage of the sample is highest when treated with the combination of goat-dung + cow-dung + poultry-manure ( $33.0 \pm 0.003$ ) and the least was control ( $26.30 \pm 0.014$ ). The percentage of coarse sand in the soil sample was highest in the control ( $36.0 \pm 0.010$ ) and was least in cow-dung ( $23.0 \pm 0.008$ ). The bulk density of the soil sample was highest in the control ( $1.72 \pm 0.008$ ) and the least was goat-dung ( $1.41 \pm 0.001$ ).

Table 2 showed the nutrients and properties of gully eroded soil sample when treated with goat-dung, cow-dung, poultry-manure and a mixture of goat-dung, cow-dung and poultry-manure. The pH ( $H_2O$ ) value of the sample had the highest value in the sample treated with goat-dung ( $6.40 \pm 0.006$ ) and the least value was in control ( $4.16 \pm 0.002$ ). The amount of organic carbon gave the highest value when treated with goat-dung ( $1.63 \pm 0.013$ ) and the least was control ( $0.53 \pm 0.019$ ). The amount of nitrogen present in the soil sample was highest when treated with poultry-manure ( $0.84 \pm 0.013$ ) and the least was control ( $0.42 \pm 0.011$ ). The amount of potassium present in the soil sample was highest when treated with goat-dung ( $0.13 \pm 0.019$ ) and the least value was in the control ( $0.02 \pm 0.006$ ). The amount of available phosphorus in the soil sample had the highest value when treated with goat-dung ( $4.66 \pm 0.011$ ) and the least was in poultry-manure treatment and control ( $1.87 \pm 0.014$  and  $1.87 \pm 0.009$ ) respectively. The clay percentage of the soil sample was highest in the control ( $48.0 \pm 0.019$ ) and the least was in goat-dung treatment ( $28.0 \pm 0.003$ ). The percentage silt of the soil sample was highest when treated with combination of goat-dung + cow-dung + poultry manure ( $12.0 \pm 0.018$ ) and the

least was control ( $7.0 \pm 0.005$ ). The fine sand percentage of the sample was highest when treated with goat-dung ( $27.67 \pm 0.017$ ) and the least was control ( $18.0 \pm 0.014$ ). The percentage of coarse sand in the soil sample was highest when treated goat-dung ( $37.33 \pm 0.017$ ) and the least was recorded in the combination of goat-dung + cow-dung + poultry manure ( $23.0 \pm 0.003$ ). The bulk density of the soil sample was highest in control ( $1.78 \pm 0.019$ ) and the least was recorded in poultry-manure treatment ( $1.48 \pm 0.018$ ).

The Table 3 showed the effect of cow-dung, goat-dung, poultry-manure and cow-dung mixed with goat-dung and poultry-manure on the amendment of rill eroded soil sample on the plant height of *Amaranthus hybridus* after six weeks. The table indicates that cow-dung mixed with goat-dung and poultry-manure gave the highest plant height ( $21.02 \pm 6.764$  cm) followed by goat-dung ( $17.033 \pm 1.258$  cm) followed by cow-dung ( $11.047 \pm 0.578$  cm) followed by poultry-manure ( $9.033 \pm 1.041$  cm) and the least was the control ( $5.64 \pm 0.524$  cm). Analysis of variance showed significant difference among treatment means and within the weeks.

The Table 4 showed the effect of cow-dung, goat-dung, poultry-manure and cow-dung mixed with goat-dung and poultry-manure on the amendment of rill eroded soil sample on the stem girth of *Amaranthus hybridus* after six weeks. The table indicates that cow-dung mixed with goat-dung and poultry-manure gave the highest stem girth ( $1.364 \pm 0.110$  cm) followed by goat-dung ( $1.22 \pm 0.106$  cm) followed by cow-dung ( $1.120 \pm 0.100$  cm) followed by poultry-manure ( $0.713 \pm 0.053$  cm) and the least is the control ( $0.420 \pm 0.0$  cm). Analysis of variance showed that there was significant difference in the stem girth of *A. hybridus*.

The Table 5 showed the effect of cow-dung, goat-dung, poultry-manure and cow-dung mixed with goat-dung and poultry-manure on the amendment of rill eroded soil sample on the number of leaves of *Amaranthus hybridus* after six weeks. The table indicates that cow dung-mixed with goat-dung and poultry-manure and goat-dung alone gave the highest number of leaves ( $12.333 \pm 0.577$  leaves) followed by cow-dung ( $11.00 \pm 0.00$  leaves) then by poultry-manure ( $10.333 \pm 2.082$  leaves) and the least was recorded in the control ( $7.333 \pm 0.578$  leaves). There was significant difference between the numbers of leaves.

**Table 1. Soil Properties of rill eroded soil**

TRT	pH(H <sub>2</sub> O)	Organic C (g/kg)	Total N (g/kg)	K (cmol/mg)	Avail P mg/kg	Clay %	Silt %	F/Sand %	C/Sand %	BD
GD	5.80±0.009	1.88±0.002	0.84±0.003	0.02±0.008	2.82±0.001	26.0±0.002	13.0±0.002	29.0±0.019	32.0±0.006	1.41±0.001
PM	5.80±0.002	1.69±0.015	0.92±0.015	0.03±0.019	2.87±0.007	26.0±0.015	14.0±0.005	28.0±0.004	32.0±0.014	1.53±0.017
CD	5.10±0.008	1.34±0.005	0.86±0.009	0.06±0.008	4.66±0.010	29.0±0.004	12.0±0.013	31.0±0.015	23.0±0.008	1.56±0.007
GD+PM+CD	5.90±0.003	1.22±0.018	0.82±0.001	0.07±0.011	1.87±0.003	26.0±0.011	11.0±0.004	33.0±0.003	30.0±0.019	1.61±0.011
CTRL	5.10±0.014	0.90±0.010	0.64±0.016	0.02±0.002	1.80±0.016	34.0±0.018	13.70±0.015	26.30±0.014	36.0±0.010	1.72±0.008
P-value	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
LSD	0.015	0.021	0.019	0.020	0.017	0.021	0.017	0.023	0.022	0.019

CD= cow-dung, PM= poultry-manure, GD= goat-dung, GD+PM+CD= goat-dung + poultry-manure + cow-dung, CTRL=Control, F/Sand % = Fine sand, C/Sand % = Coarse sand, BD = Bulk Density

**Table 2. Soil properties of gully eroded soil**

TRT	pH(H <sub>2</sub> O)	Organic C (g/kg)	Total N (g/kg)	K (cmol/mg)	Avail P mg/kg	Clay %	Silt %	F/Sand %	C/Sand %	BD
GD	6.40±0.006	1.63±0.013	0.65±0.004	0.13±0.019	4.66±0.011	28.0±0.003	7.0±0.017	27.67±0.018	37.33±0.017	1.52±0.006
PM	5.80±0.010	0.98±0.018	0.84±0.013	0.05±0.016	1.87±0.014	37.0±0.001	11.0±0.010	21.0±0.011	35.0±0.006	1.48±0.018
CD	5.10±0.017	0.72±0.007	0.56±0.001	0.04±0.013	2.80±0.002	34.0±0.014	8.0±0.006	23.0±0.016	35.0±0.018	1.57±0.011
GD+PM+CD	5.10±0.008	0.89±0.015	0.58±0.006	0.02±0.008	2.80±0.005	44.0±0.008	12.0±0.018	21.0±0.003	23.0±0.003	1.58±0.005
CTRL	4.16±0.002	0.53±0.019	0.42±0.011	0.02±0.006	1.87±0.009	48.0±0.019	7.0±0.005	18.0±0.014	25.0±0.002	1.78±0.019
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LSD	0.018	0.027	0.015	0.024	0.016	0.020	0.023	0.024	0.021	0.024

CD= cow-dung, PM= poultry-manure, GD= goat-dung, GD+PM+CD= goat-dung + poultry-manure + cow-dung, CTRL=Control, F/Sand % = Fine sand, C/Sand % = Coarse sand, BD = Bulk Density

**Table 3. Effect of organic manure amendment of rill eroded soil on the plant height of *Amaranthus hybridus***

Week (cm)	Control	CD	GD	PM	CD+GD+PM	P-value	LSD
1	2.127±1.363	3.133±0.289	3.167±0.289	2.167±0.116	3.667±0.289	0.060	1.185
2	3.633±7.943	4.667±0.289	5.833±0.289	3.800±0.100	6.533±0.577	0.820	6.488
3	4.333±0.289	6.167±0.764	7.667±3.055	4.671±0.289	9.667±1.155	0.008	2.749
4	4.637±1.041	8.637±2.255	10.833±2.566	6.833±1.041	13.50±2.284	0.002	3.551
5	5.167±1.041	9.833±1.528	14.50±2.180	8.667±1.756	17.50±8.221	0.002	7.224
6	5.64±0.524	11.047±0.578	17.033±1.258	9.033±1.041	21.02±6.764	0.024	5.696

**Table 4. Effect of organic manure amendment of rill eroded soil on stem girth of *Amaranthus hybridus***

Week (cm)	Control	CD	GD	PM	CD+GD+PM	P-value	LSD
1	0.167±0.000	0.183±0.004	0.186±0.0002	0.168±0.00	0.168±0.002	0.000	0.004
2	0.186±0.008	0.261±0.100	0.288±0.053	0.188±0.052	0.363±0.058	0.027	0.112
3	0.200±0.100	0.300±0.100	0.360±0.100	0.210±0.100	0.520±0.100	0.016	0.182
4	0.310±0.100	0.566±0.567	0.707±0.008	0.340±0.00	1.033±0.578	0.174	0.664
5	0.360±0.000	0.803±0.000	1.110±0.100	0.573±0.073	1.167±0.229	0.000	0.212
6	0.420±0.000	1.120±0.100	1.22±0.106	0.713±0.053	1.364±0.110	0.000	0.155

**Table 5. Effect of organic manure amendment of rill eroded soil on number of leaves of *Amaranthus hybridus***

Week	Control	CD	GD	PM	CD+GD+PM	P-value	LSD
1	2.000±0.00	2.333±0.578	2.667±0.578	2.333±0.578	2.667±0.058	0.384	0.816
2	3.00±0.00	4.00±0.00	5.00±1.00	4.00±0.00	5.00±1.00	0.015	1.151
3	3.667±0.577	7.33±0.577	8.333±1.155	4.00±0.00	6.00±0.00	0.000	1.150
4	7.00±1.00	8.333±1.528	9.667±0.577	8.333±0.577	9.667±1.528	0.075	2.048
5	7.333±1.155	8.667±2.082	9.667±0.577	9.333±1.15	10.667±1.155	0.096	2.394
6	7.333±0.578	11.00±0.00	12.333±0.577	10.333±2.082	12.333±0.577	0.001	1.879

**Table 6. Effect of organic manure amendment of rill eroded soil sample on leaf area of *Amaranthus hybridus***

Week (cm <sup>2</sup> )	Control	CD	GD	PM	CD+GD+PM	P-value	LSD
1	0.540±0.010	0.630±0.00	0.690±0.37	0.620±0.00	0.973±0.133	0.093	0.32
2	0.610±0.715	1.033±0.029	1.50±0.100	0.726±0.02	1.633±1.531	0.415	1.377
3	0.660±0.815	2.420±1.433	2.663±3.086	0.810±0.08	3.833±3.350	0.391	3.941
4	1.001±0.422	3.810±2.012	4.150±0.00	1.253±0.15	5.667±1.528	0.002	2.087
5	1.407±0.636	5.887±1.811	6.11±1.00	1.927±2.06	8.88±4.713	0.021	4.54
6	2.113±1.263	8.133±4.13	9.717±4.66	2.330±7.0	10.817±1.140	0.084	7.747

**Table 7. Effect of organic manure amendment of gully soil on the plant height of *Amaranthus hybridus***

Week (cm)	Control	CD	GD	PM	CD+GD+PM	P-value	LSD
1	1.647±2.363	1.673±0.289	2.167±0.289	1.612±0.116	1.677±0.289	0.965	1.967
2	1.833±0.943	1.867±0.289	3.813±0.289	1.620±0.100	3.233±0.567	0.001	0.958
3	2.333±0.289	3.167±0.764	5.667±0.055	1.967±0.289	5.767±1.155	0.000	1.176
4	2.677±1.041	5.667±2.255	8.833±2.566	2.833±1.041	9.150±2.784	0.007	3.78
5	3.167±1.041	9.833±1.528	12.522±2.180	3.667±1.756	13.350±2.261	0.000	3.291
6	3.637±0.854	11.667±0.578	16.833±1.258	4.333±1.041	18.100±1.764	0.000	2.128

**Table 8. Effect of organic manure amendment of gully eroded soil on stem girth of *Amaranthu shybridus***

Week (cm)	Control	CD	GD	PM	CD+GD+PM	P-value	LSD
1	0.100±0.000	0.103±0.006	0.110±0.0002	0.100±0.00	0.122±0.003	0.000	0.005
2	0.1667±0.058	0.212±0.10	0.267±0.058	0.183±0.058	0.363±0.058	0.033	0.125
3	0.211±0.100	0.400±0.100	0.560±0.100	0.300±0.100	0.644±0.100	0.002	0.182
4	0.260±0.100	0.767±0.577	0.967±0.058	0.400±0.100	1.263±0.578	0.044	0.676
5	0.300±0.000	1.133±0.058	1.520±0.100	0.633±0.473	1.867±0.289	0.000	0.461
6	0.320±0.000	1.715±0.100	2.267±0.116	1.033±0.153	2.767±0.153	0.000	0.216

The Table 6 showed the effect of cow-dung, goat-dung, poultry-manure and cow-dung mixed with goat-dung and poultry-manure on the amendment of rill eroded soil sample on the leaf area of *Amaranthus hybridus* after six weeks. The table indicates that mixture of cow-dung + goat-dung + poultry-manure gave the highest leaf area ( $10.817 \pm 1.140 \text{ cm}^2$ ) while the goat-dung treatment gave ( $9.717 \pm 4.66 \text{ cm}^2$ ) and the cow-dung gave ( $8.133 \pm 4.13 \text{ cm}^2$ ), finally, poultry-manure gave ( $2.330 \pm 7.0 \text{ cm}^2$ ) and on the other hand, the least was recorded in the control treatment ( $2.113 \pm 1.263 \text{ cm}^2$ ). There was a significant difference in the leave area.

The Table 7 showed the effect of cow-dung, goat-dung, poultry-manure and cow-dung mixed with goat dung and poultry manure on the amendment of gully eroded soil sample on the plant height of *A. hybridus* after six weeks. The table indicates that cow-dung mixed with goat-dung and poultry-manure gave the highest plant height ( $18.100 \pm 1.764 \text{ cm}$ ) followed by goat-dung ( $16.833 \pm 1.258 \text{ cm}$ ) followed by cow-dung ( $11.667 \pm 0.578 \text{ cm}$ ) followed by poultry-manure ( $4.333 \pm 1.041 \text{ cm}$ ) and the least was the control ( $3.637 \pm 0.854 \text{ cm}$ ). There was a significant difference in the height of plant.

The Table 8 showed the effect of cow-dung, goat-dung, poultry-manure and cow-dung mixed with goat dung and poultry manure on the amendment of gully eroded soil sample on the stem girth of *A. hybridus* after six weeks. The table indicates that cow-dung mixed with goat-dung and poultry-manure gave the highest stem girth ( $2.767 \pm 0.153 \text{ cm}$ ), goat-dung ( $2.267 \pm 0.116 \text{ cm}$ ), cow-dung ( $1.715 \pm 0.100 \text{ cm}$ ), poultry-manure ( $1.033 \pm 0.153 \text{ cm}$ ) and the least was the control ( $0.320 \pm 0.000 \text{ cm}$ ). There was significant difference in the stem girth.

The Table 9 showed the effect of cow-dung, goat-dung, poultry-manure and cow-dung mixed with goat-dung and poultry-manure on the amendment of gully eroded soil sample on the number of leaves of *A. hybridus* after six weeks. The table indicates that cow-dung mixed with goat-dung and poultry-manure gave the highest number of leaves ( $15.667 \pm 4.509$  leaves), goat-dung ( $15.333 \pm 0.577$  leaves), cow-dung ( $12.00 \pm 0.00$  leaves), poultry-manure ( $10.333 \pm 2.082$  leaves) and the least was the control ( $8.333 \pm 0.578$  leaves). There was significant difference in the number of leaves.

The Table 10 showed the effect of cow-dung, goat-dung, poultry-manure and cow-dung mixed

with goat-dung and poultry-manure on the amendment of gully eroded soil sample on the leaf area of *A. hybridus* after six weeks. The table indicates that cow-dung mixed with goat-dung and poultry-manure gave the highest leaf area ( $16.847 \pm 3.640 \text{ cm}^2$ ), goat-dung ( $16.717 \pm 2.66 \text{ cm}^2$ ), cow-dung ( $12.733 \pm 1.13 \text{ cm}^2$ ), poultry-manure ( $2.330 \pm 0.00 \text{ cm}^2$ ) and the least was the control ( $1.553 \pm 0.663 \text{ cm}^2$ ). Analysis of variance showed that there was significant difference in the leaf area.

#### 4. DISCUSSION

Analysis of rill and gully eroded soil as shown in Table 1 showed that goat-dung increased the pH content of the soil by 5.80, poultry-manure by 5.80, cow-dung by 5.10, mixture of the three by 5.90 and finally control without amendment by 5.10. Goat-dung added the highest amount of organic carbon (1.88), poultry-manure (0.92), cow-dung (0.86), followed closely by the mixture of goat-dung, cow-dung and poultry-manure (0.82), control being the least with (0.64). This confirmed the report of Wagner and George [11] which indicated that in addition to nutrients, cow manure provides carbon and other constituents that affect soil humus content, biological activity, and soil physical structure.

From the nitrogen content in the rill and gully eroded soil, it was observed that poultry-manure increased the nitrogen content by 0.92, cow-dung 0.86, goat-dung 0.84, followed by the mixture of goat-dung, poultry-manure and cow-dung with 0.82 and control with 0.64 as the least. Examining the potassium and the phosphorus content from Table 2, goat-dung has the highest value (0.13 for potassium, 4.66 for phosphorus). Cow-dung was (0.04 for potassium and 2.80 for phosphorus). This was in agreement with the report of Merka and Segars [14] which stated that chicken-manure fertilizer is very high in nitrogen and also contains a good amount of potassium and phosphorus.

Analysis on gully eroded soil treated with different organic manure showed that the mixture of goat-dung, poultry-manure and cow-dung has value (5.10) for the pH content added to the soil while control has the least (4.16). Goat-dung has the highest value (6.40) and poultry-manure added pH to the soil by (5.80). The analysis on the amount of organic carbon shows that the highest input was given by goat-dung (1.63) while the least was control (0.53).



**Table 9. Effect of organic manure amendment of gully eroded soil on number of leaves of *A. hybridus***

Week	Control	CD	GD	PM	CD+GD+PM	P-value	LSD
1	2.333±0.578	2.333±0.578	2.667±0.578	2.333±0.578	2.667±0.578	0.871	1.051
2	4.00±0.00	4.00±0.00	5.00±1.00	4.00±0.00	6.00±0.00	0.001	0.814
3	4.00±0.00	7.33±0.577	8.333±1.155	4.667±0.577	8.333±1.528	0.000	1.694
4	5.00±1.00	9.667±0.577	10.333±1.15	7.333±0.577	11.00±0.00	0.000	1.406
5	7.333±1.155	11.667±2.082	12.333±0.577	9.333±1.15	12.667±1.155	0.002	2.394
6	8.333±0.578	12.00±0.00	15.333±0.577	10.333±2.082	15.667±4.509	0.010	1.879

**Table 10. Effect of Organic manure amendment of gully eroded soil sample on leaf area of *A. hybridus***

Week (cm <sup>2</sup> )	Control	CD	GD	PM	CD+GD+PM	P-value	LSD
1	0.040±0.010	0.046±0.00	0.190±0.37	0.040±0.00	0.197±0.133	0.628	0.320
2	0.130±0.715	1.733±0.029	2.56±0.100	0.171±0.02	3.333±1.531	0.001	1.377
3	0.600±0.805	3.400±1.473	4.967±3.086	0.810±0.28	5.833±1.350	0.010	3.070
4	0.757±0.422	6.890±2.072	7.250±0.00	1.253±0.15	9.627±7.528	0.040	6.363
5	1.407±0.636	8.877±1.811	13.00±1.090	1.947±2.06	13.58±2.773	0.000	3.335
6	1.553±0.663	12.733±1.13	16.717±2.66	2.230±0.00	16.847±3.640	0.000	3.820

Poultry-manure added the highest amount of nitrogen nutrient by (0.84), closely followed by goat-dung (0.65). Analysis on rill eroded soil the combination of goat-dung, poultry-manure and cow-dung had potassium content of (0.07) than any of the organic manures used as treatment for the rill eroded soil where goat-dung and control recorded the least content of (0.02). Cow-dung increased the phosphorus content by 4.66 and the least was control having the value 1.80. Analysis of gully eroded soil showed that goat-dung increased the organic carbon of the soil by 1.63, poultry-manure by 0.98, goat-dung +cow-dung+ poultry-manure by 0.89, cow-dung by 0.72 and finally control without amendment by 0.53. According to Table 2 Control has the least value of 0.53 for carbon analysis in gully eroded soil while goat-dung showed the highest value of 1.63.

From the result of the nitrogen analysis in gully eroded soil, it was observed that poultry-manure treatment had the highest value of nitrogen (0.84) while control had the least value (0.42) which is significantly different from their control value 0.42. Soil nutrient like organic matter, total nitrogen and phosphorus are lost mostly in gully erosion system than in sheet and rill erosion [3] therefore, results from Table 2 showed that these lost nutrient can be restored by amendment of gully eroded soil with organic manure such as goat dung which had the highest of 1.63 increase for carbon and poultry-manure which had the highest of 0.84 for nitrogen content as observed from the soil treated with goat-dung and poultry-manure respectively to show higher plant height, leaf area, stem girth and number of leaves compare to *Amaranthus* growing on gully eroded soil amended with other treatments. But *Amaranthus* grown on gully eroded soil treated with poultry-manure showed the least development in the growth parameter mentioned above.

*Amaranthus* that grew on gully eroded soil with no amendment that is control treatment, showed no growth in the first week, and slow progressive growth as the plant progresses with age. It also had small leaves, thin and weak stem due to inadequate essential soil nutrients. Soil mineral deficiency often limits the growth of crops and may even cause soil failure [15].

Potassium analysis from Table 2 shows that goat-dung increased the presence of potassium and phosphorus in the gully eroded soil by 0.13 compared to others. It was observed that control

and the mixture of goat-dung mixed with poultry-manure and cow-dung had the same amount of potassium to the soil by 0.02, which is the least of all. Cow-dung and the mixture of goat-dung, poultry-manure and cow-dung added the same amount of phosphorus to the soil (2.80) while the control (1.87) which was also the least.

The early seedling growth of *A. hybridus* in the two eroded soil samples showed that goat dung recorded the highest amendment option in the four growth parameters studied (plant height, stem girth, leaf area and number of leaves). There was significant difference in the effect of the different treatments on plant height and leaf area as seen in the tables while growth parameters such as stem girth and number of leaves of *A. hybridus* showed no significant difference, the findings of this is in agreement with the study by Ekwealor et al. [16] where gully eroded soil was restored and *Abelmoschus esculentus* thrived very well on it.

## 5. CONCLUSION

The ability of the organic manure used as treatment to effect significant amendments in the two eroded soil samples especially in the gully eroded soil sample was an indication that organic manure has great potentials in restoration of organic carbon content, available nitrogen, reduction of soil bulk density and increased productivity in plants.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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