



Growth and Development of *Abelmoschus esculentus* (Okra) in Gully Eroded Soil Amended with Different Rates of Cow Dung Manure

**Ekwealor U. Kenneth¹, Okereke E. Kingsley¹, Iroka F. Chisom^{1*},
Okereke N. Chukwu¹ and Francis H. Ibadin²**

¹*Department of Botany, Nnamdi Azikiwe University Awka, Anambra State, Nigeria.*

²*Department of Biological Sciences, College of Basic and Applied Science, Mountain Top University, Ibafo, Ogun State, Nigeria.*

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 growth and development of *Abelmoschus esculentus* (okra) in gully eroded soil amended with different rates of cow dung manure was studied using the complete randomized design; morphometric data such as leaf area, plant height, stem girth, numbers of nodes, number of leaves and percentage flowering was collected and analyzed. A 30 kg of gully eroded soil sample was put into a sac in triplicate and six treatments of cow dung was introduced into it (0.5 kg, 1.0 kg, 1.5 kg, 2.0 kg, 2.5 kg and 3.0 kg) respectively. The results of study showed that there is a significant difference in all the treatments compared to control. Highest petiole length (31.63±1.84) of Okra plant was obtained at week seven with 2.0 kg amended soil. The 2.5 kg treatment of manure at week 7 had the highest leaf length with the mean of 30.36±2.47 while the least leaf length occurred in the 2.5 kg treatment at week 1 with the mean value of 0.49±0.03. The 2.0 kg treatment of manure at week 7 had the highest leaf length with the mean of 36.96±1.15 while the least leaf length occurred in the 2.5 kg treatment at week 1 with the mean value of 0.44±0.03. The 1.0 kg

*Corresponding author: E-mail: harlyz14@yahoo.com;

treatment of manure at week 7 had the highest length of internode (23.16 ± 3.55) while the least length of internode occurred in the control at week 2 (0.86 ± 0.23). At week 1 for all treatments, no result was obtained for length of internodes. The 0.5 kg treatment of manure at week 7 had the highest number of leaves with the mean of 21.33 ± 4.93 while the least number of leaves occurred in the 0.5 kg, 2.0 kg and 2.5 kg treatments respectively at week 1 and in the control sample at week 2. The result also revealed that the 1.0 kg treatment of manure at week 7 had the highest stem length (154.73 ± 30.99) while the least stem length occurred in the 2.0 kg at week 1 (0.46 ± 0.03). The 3.0 kg treatment of manure at week 7 had the highest stem girth (9.33 ± 0.51) while the least stem girth occurred in the 2.5 kg at week 1 (0.31 ± 0.02). The soil analysis result showed that nitrogen was highest in the soil at 2.0 kg treatment of cow dung (402 ± 2.51) while the 1.5 kg treatment and control had the least nitrogen content (322 ± 0.57) and (322 ± 3.05) respectively. The highest phosphorus content was 1.0 kg treatment of cow dung (986 ± 1.53), with the control having the lowest phosphorus content (280 ± 2.00). On the potassium content, the 2.5 kg treatment had the highest (843 ± 0.57) while the control had the least content of potassium (357 ± 1.52). The overall result showed that the growth and development of okra was enhanced by application of cow dung which influenced soil nutrient status positively.

Keywords: Okra; morphometric; soil; organic manure; gully erosion; cow dung; growth; development.

1. INTRODUCTION

Soil erosion is one of the most striking features on the land surface of South Eastern Nigeria, especially in Awka, Anambra State. Several non-responsive human activities by both the Government and the inhabitants have culminated in the devastating soil erosion (gully erosion in particular) in this area. Some of these activities include excavation of red earth (laterite), construction of roads without drainage channels, uncontrolled population growth and poor agricultural practices.

Sustainable crop production requires judicious use of inputs such as fertilizers. The use of inorganic fertilizers has drastically declined following the energy crisis, which has immensely affected most of the developing countries [1]. In Nigeria, reduced use of inorganic fertilizers has largely been aggravated by the removal of fertilizer subsidies by the government. This has resulted in low crop yields due to deteriorating land productivity. Nigeria is however, endowed with a large number of livestock such as cattle, goats, sheep, pigs, donkeys and poultry. In view of the apparent decline in soil fertility, deliberate efforts are required to promote utilization of animal manure for crop production. Most studies on utilization of animal manure in Nigeria have largely focused on crop yield responses of field crops with very little effort to relate such responses with availability of nutrients. Efficient utilization of animal manure requires thorough understanding of the relationship between crop responses and availability of nutrients in the soil following animal manure application [2]. Furthermore, there is also a need for comparing

different types of animal manures under similar field conditions. This is important in coming up with indications on manure recommendations. The current study was therefore carried out in order to evaluate the growth and development of *Abelmoschus esculentus* (Okra) in gully eroded soil amended with different rates of cow dung manure. *Abelmoschus esculentus* was chosen as the test crop due to its nutritional and economic importance in most parts of Nigeria. It is the most popular vegetable crop grown in most home gardens and is a fast growing annual crop requiring intensive application of fertilizers.

The present study was undertaken to investigate the growth and development of *Abelmoschus esculentus* L. (Okra) in gully eroded soil amended with different rates of cow dung manure. The objectives include to:

- i. determine the nitrogen, phosphorus and potassium content in the soil before and after the experiment
- ii. explore the effects of cow dung manure on the growth rate of *A. esculentus*
- iii. evaluate the effects of different application rate of cow dung manure on the growth and development of *A. esculentus*
- iv. justify the influence of cow dung on the restoration of gully eroded soil

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out at Botanical Garden, the Department of Botany, Nnamdi Azikiwe University Awka, located at 6°N and 15°S . The

average morning temperature of 22°C and the average day temperature of 36°C were observed. The study was carried out between July 16, 2019 and November 12, 2019.

2.2 Sources of Materials

Seedlings of *Abelmoschus esculentus* used for this work were obtained from the Agricultural Development Centre, Awka. Organic manure (cow dung) and the polythene bag perforated at the base were obtained from Garki market in Amansea, Awka. The soil was obtained from a gully eroded site at Amawbia, Anambra state.

2.3 Experimental Design

Soil sample of 30 kg and different rates of organic manure was measured using a weighing spring balance with model number (M). The soil was mixed homogenously with the organic manure and filled in the polythene bags. The treatments were done in triplicates which include 30 kg of soil uniformly mixed with 0.5 kg, 1.0 kg, 1.5 kg, 2.0 kg, 2.5 kg and 3.0 kg of cow dung manure, after which the mixture was left for 10 days to allow decomposition take place; a control soil sample without (cow dung) manure was also used.

2.4 Cultural Practices

The cultural practices used during this experiment includes: weeding which was done weekly by hand picking and watering, which was done once a week since rainfall at the period was almost consistent.

2.5 Data Collection

Data on the morphological character of the plants were collected at seven days interval. Observations were made on the following parameters.

2.5.1 Leaf area

Leaf area was measured by planimetric method of length area dimension [3]. In this case a tape was used to measure the broadest width of the leaf and the length of the leaf in centimeters to get the leaf area.

2.5.2 Plant height

Plant height was measured using tape from the interface of the soil and stem to the last bud of the shoot [3].

2.5.3 Stem girth

Stem girth were observed in centimeters. A thread was used to get the circumference of the stem 5cm up from the soil interface and then marked thread placed on the tape for measurement [3].

2.5.4 Number of nodes

The number of nodes on each plant was counted up to the last well developed leaf.

2.5.6 Number of leaves

Leaves were observed at seven days interval. Only the well developed leaves were counted [3].

2.6 Soil Analysis

Two gram (2g) of each sample of the gully eroded soil was weighed using Metler analytical weighing balance (model AE166) and was transferred into a digestion beaker. 100 ml of aqua regia (70% HCL and 30% HNO₃) was added to the sample and placed in a heating chamber inside a fume hood. The sample was digested for about an hour until a clear solution was obtained and the volume reduced by half . The digested sample was allowed to cool, filtered and made up to 100 ml in a sample bottle for AAS analysis.

The AAS used for the analysis is buck scientific 210/211 model. The machine was calibrated with the respective standards (potassium and phosphorus) and at their respective wavelength the standard and sample were analyzed against distilled water bank.

The Nitrogen content was determined using Standard kit for the determination of nitrogen and the values recorded.

2.7 Data Analysis

The experiment was set in a Completely Randomized Design (CRD) and data were analyzed using Statistical Package for Social Sciences (SPSS) software version 8.

3. RESULTS

The Table 1 showed that nitrogen was highest in the soil at 2.0 kg treatment of cow dung (402±2.51) while the 1.5 kg treatment and control had the least nitrogen content (322±0.57) and (322±3.05) respectively. The highest phosphorus

(986±1.53) content was 1.0 kg treatment of cow dung, with the control having the lowest phosphorus content (280±2.00). On the potassium content, the 2.5 kg treatment had the highest (843±0.57) while the control had the least content of potassium (357±1.52).

Table 2 revealed that at week 7, the soil treated with 2.0 kg of manure had the highest petiole mean length of 31.63±1.84 while the least leaf length occurred in the 2.5 kg treatment at week 1 with the mean value of 0.24±0.03. The control sample at week 1 had no value for leaf length.

Table 3 shows the mean leaf length. It revealed that the 2.5 kg treatment at week 7 had the highest leaf mean length of 30.36±2.47 while the least leaf mean length occurred in the 2.5 kg treatment 0.49±0.03 at week 1. The control sample at week 1 had no value for leaf length.

Table 4 shows the mean leaf width. It revealed that the 2.0 kg treatment of manure at week 7 had the highest mean leaf length of 36.96±1.15 while the least leaf mean length 0.44±0.03 occurred in the 2.5 kg treatment at week 1. The control sample at week 1 had no value for leaf length.

Table 5 shows the mean stem length. It revealed that the 1.0 kg treatment of manure at

week 7 had the highest stem length (154.73±30.99) while the least mean stem length occurred in the 2.0 kg at week 1 (0.46±0.03). The control sample at week 1 showed no stem length.

Table 6 shows the mean length of internode. It revealed that the 1.0 kg treatment of manure at week 7 had the highest mean length of internode (23.16±3.55) while the least length of internode occurred in the control at week 2 (0.86±0.23). At week 1 for all treatments, no result was obtained for length of internodes.

Table 7 shows the mean number of leaves. It revealed that the 0.5 kg treatment of manure at week 7 had the highest mean number of leaves of 21.33±4.93 while the least mean number of leaves occurred in the 0.5 kg, 2.0 kg and 2.5 kg treatments respectively at week 1 and in the control sample at week 2. The control sample at week 1 showed no leaf growth.

Table 8 shows the mean stem girth. It revealed that the 3.0 kg treatment of manure at week 7 had the highest stem girth (9.33±0.51) while the least stem girth occurred in the 2.5 kg at week 1 (0.31±0.02). The control sample at week 1 showed no stem girth.

Table 1. Result of different levels of cow dung (CD) on nitrogen, phosphorus and potassium content of the soil after treatment

Sample (kg)	N (PPM)	P (PPM)	K (PPM)
0.5	358±2.00 ^b	653±0.57 ^d	752±1.15 ^b
1.0	334±2.51 ^c	986±1.53 ^a	722±1.15 ^c
1.5	322±0.57 ^d	847±2.00 ^b	685±2.08 ^d
2.0	402±2.51 ^a	853±2.08 ^b	678±0.57 ^d
2.5	255±2.31 ^f	831±1.00 ^c	843±0.57 ^a
3.0	305±3.05 ^e	823±3.05 ^c	541±1.52 ^e
Control	322±3.05 ^d	280±2.00 ^e	357±1.52 ^f

Results are in mean ± standard deviation. Column with different alphabet superscript are significantly different at $P < 0.05$

Table 2. Mean petiole length of *Abelmoschus esculentus* grown on gully eroded soil treated with different rates of cow dung manure

Treatments (manure)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
0.5kg	0.35±0.03 ^b	4.16±0.50 ^d	8.36±0.73 ^c	11.00±0.43 ^e	19.43±1.77 ^f	28.76±3.12 ^d	31.53±2.80 ^b
1.0kg	0.38±0.09 ^b	4.10±1.55 ^d	8.13±4.93 ^d	14.66±5.93 ^c	25.00±4.88 ^c	29.06±4.48 ^c	31.00±4.88 ^c
1.5kg	0.38±0.05 ^b	4.33±0.87 ^c	7.40±1.85 ^e	14.96±2.80 ^b	23.66±1.25 ^e	27.43±1.15 ^f	29.90±0.52 ^e

Treatments (manure)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
2.0kg	-	3.00±1.32 ^e	7.56±1.96 ^e	14.80±2.16 ^b	25.93±2.54 ^b	30.26±1.45 ^b	31.63±1.84 ^a
2.5kg	0.24±0.03 ^c	4.43±1.50 ^b	8.63±1.60 ^b	13.63±3.09 ^d	24.83±2.25 ^d	27.76±2.28 ^e	30.26±2.15 ^d
3.0kg	0.74±0.03 ^a	7.96±0.95 ^a	13.73±3.09 ^a	19.56±0.55 ^a	28.30±5.27 ^a	30.76±4.36 ^a	29.30±0.87 ^f
Control	-	1.90±0.40 ^f	2.10±0.60 ^f	2.46±2.23 ^f	5.53±5.79 ^d	6.23±5.85 ^g	4.56±2.60 ^g
P value	0.000	0.000	0.002	0.000	0.000	0.000	0.000

Results are in mean ± standard deviation. Column with different alphabet superscript are significantly different at $P<0.05$

Table 3. Mean leaf length of *Abelmoschus esculentus* grown on gully eroded soil treated with different rates of cow dung manure

Treatments (manure)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
0.5kg	0.65±0.03 ^b	7.50±1.21 ^c	10.43±1.44 ^e	15.83±0.77 ^f	18.66±0.56 ^f	25.90±1.60 ^d	29.16±0.85 ^c
1.0kg	0.64±0.06 ^b	6.63±3.20 ^e	12.06±5.54 ^d	15.93±6.12 ^e	20.70±2.30 ^d	23.86±2.74 ^e	27.70±1.83 ^e
1.5kg	0.74±0.03 ^a	8.03±1.61 ^a	12.93±2.02 ^b	17.56±1.20 ^d	20.46±1.68 ^e	26.10±2.10 ^c	29.00±2.46 ^d
2.0kg	0.74±0.03 ^a	6.86±1.34 ^e	12.53±1.78 ^d	19.03±1.56 ^c	22.90±1.81 ^c	27.63±1.22 ^a	29.46±0.92 ^b
2.5kg	0.49±0.03 ^c	7.16±1.23 ^d	12.83±2.38 ^c	19.10±3.27 ^b	23.33±1.72 ^b	27.10±2.76 ^b	30.36±2.47 ^a
3.0kg	0.74±0.03 ^a	7.96±0.95 ^b	13.7±1.01 ^a	19.56±0.55 ^a	23.43±3.40 ^a	26.76±2.10 ^c	30.20±2.06 ^a
Control	-	2.76±0.80 ^f	3.53±1.42 ^f	5.06±2.53 ^g	6.60±3.85 ^g	7.10±4.10 ^f	6.90±3.26 ^f
P value	0.000	0.023	0.005	0.000	0.000	0.000	0.000

Results are in mean ± standard deviation. Column with different alphabet superscript are significantly different at $P<0.05$

Table 4. Mean leaf width of *Abelmoschus esculentus* grown on gully eroded soil treated with different rates of cow dung manure

Treatments (manure)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
0.5kg	0.61±0.02 ^c	6.90±0.81 ^c	11.50±1.82 ^e	21.53±1.40 ^c	24.13±1.88 ^f	31.56±3.96 ^d	35.73±3.19 ^c
1.0kg	0.59±0.09 ^d	7.06±4.20 ^b	11.53±2.40 ^e	20.83±8.00 ^e	27.43±4.70 ^d	30.33±4.81 ^f	33.63±4.09 ^e
1.5kg	0.70±0.02 ^a	8.26±2.56 ^a	15.63±2.28 ^a	21.30±0.91 ^d	27.06±3.71 ^e	31.36±4.15 ^e	35.46±2.20 ^d
2.0kg	0.67±0.04 ^b	6.53±0.75 ^d	14.63±2.22 ^d	24.36±1.59 ^b	30.30±3.25 ^a	34.20±1.90 ^a	36.96±1.15 ^a
2.5kg	0.44±0.03 ^e	6.96±1.00 ^c	14.80±2.38 ^c	24.53±4.05 ^a	28.66±0.85 ^c	32.46±1.77 ^c	36.73±1.37 ^b
3.0kg	0.63±0.05 ^b	8.23±0.30 ^a	15.23±1.10 ^b	24.46±1.55 ^a	29.50±1.08 ^b	33.46±1.50 ^b	33.40±2.50 ^f
Control	-	2.4±1.05 ^e	3.46±1.10 ^f	5.63±3.30 ^f	8.53±5.26 ^g	9.10±5.56 ^g	8.63±4.20 ^f
P value	0.001	0.047	0.000	0.000	0.000	0.000	0.000

Results are in mean ± standard deviation. Column with different alphabet superscript are significantly different at $P<0.05$

Table 5. Mean Stem length of *Abelmoschus esculentus* grown on gully eroded soil treated with different rates of cow dung manure

Treatments (manure)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
0.5kg	5.33±0.5 ^{8c}	12.03±2.08 ^b	18.00±4.55 ^d	25.33±4.20 ^d	80.30±13.49 ^f	104.56±10.85 ^f	141.86±41.16 ^b
1.0kg	6.00±0.81 ^b	11.00±2.10 ^d	17.76±5.00 ^e	25.16±6.50 ^e	118.33±29.46 ^b	152.33±17.09 ^a	154.73±30.99 ^a
1.5kg	6.36±0.50 ^a	12.03±1.50 ^b	21.43±6.50 ^b	30.10±8.64 ^a	114.10±18.19 ^c	124.76±15.79 ^c	134.70±18.69 ^c
2.0kg	0.46±0.03 ^e	10.36±2.50 ^e	16.53±3.42 ^f	23.33±3.45 ^f	96.76±7.06 ^e	110.86±8.18 ^e	118.70±4.03 ^f
2.5kg	4.13±1.15 ^d	11.56±2.73 ^c	19.80±6.00 ^c	26.90±6.43 ^c	109.33±5.50 ^d	121.76±2.13 ^d	132.23±7.31 ^d
3.0kg	6.40±0.36 ^a	12.56±1.07 ^a	21.66±1.98 ^a	29.90±2.25 ^b	136.16±9.35 ^a	149.36±6.37 ^b	131.40±15.87 ^e
Control	-	7.2±1.03 ^f	9.30±2.23 ^g	11.53±4.77 ^g	20.83±9.00 ^g	21.36±8.70 ^g	26.00±8.24 ^g
P value	0.000	0.069	0.069	0.018	0.000	0.000	0.000

Results are in mean ± standard deviation. Column with different alphabet superscript are significantly different at $P < 0.05$

Table 6. Mean Length of Internodes of *Abelmoschus esculentus* grown on gully eroded soil treated with different rates of cow dung manure

Treatments (manure)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
0.5kg	-	3.83±1.17 ^a	8.26±3.88 ^a	5.56±1.09 ^e	10.73±2.00 ^e	19.50±6.09 ^d	21.10±6.29 ^d
1.0kg	-	3.13±2.22 ^d	5.10±2.00 ^c	8.36±0.90 ^a	16.73±4.66 ^c	21.16±4.21 ^a	23.16±3.55 ^a
1.5kg	-	3.30±1.40 ^c	6.46±2.32 ^b	7.46±1.79 ^b	17.90±6.54 ^a	19.50±6.22 ^d	19.93±6.31 ^e
2.0kg	-	2.40±0.81 ^e	4.40±0.17 ^d	6.16±1.19 ^d	16.70±6.71 ^c	20.13±5.23 ^c	21.56±5.46 ^b
2.5kg	-	3.13±0.80 ^d	5.10±1.50 ^c	8.66±3.16 ^a	15.00±3.60 ^d	18.70±3.10 ^e	21.23±3.57 ^c
3.0kg	-	3.63±0.61 ^b	6.00±0.85 ^d	6.50±1.00 ^c	17.00±2.00 ^b	20.50±1.13 ^b	21.23±6.47 ^c
Control	-	0.86±0.23 ^f	1.23±0.25 ^e	8.66±3.16 ^a	4.36±0.80 ^f	4.86±0.95 ^f	5.33±1.05 ^f
P value	-	0.117	0.024	0.085	0.018	0.005	0.010

Results are in mean±standard deviation. Column with different alphabet superscript are significantly different at $P < 0.05$

Table 7. Mean Number of Leaves of *Abelmoschus esculentus* grown on gully eroded soil treated with different rates of cow dung manure

Treatments (manure)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
0.5kg	3.00±0.00 ^c	5.00±0.00 ^b	6.66±0.57 ^d	8.00±1.73 ^e	9.66±2.51 ^f	20.00±5.56 ^a	21.33±4.93 ^a
1.0kg	3.33±0.57 ^b	5.66±0.57 ^a	8.00±1.73 ^a	11.66±4.72 ^a	15.33±3.21 ^b	17.00±2.00 ^d	17.00±2.00 ^c

Treatments (manure)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
1.5kg	3.33±0.57 ^b	5.66±0.57 ^a	7.00±0.00 ^c	8.33±0.57 ^d	10.33±0.57 ^d	12.66±1.15 ^f	12.66±1.15 ^e
2.0kg	3.00±0.00 ^c	4.66±0.57 ^c	7.33±0.57 ^b	9.33±0.57 ^b	14.66±2.08 ^c	19.33±6.11 ^b	19.33±6.11 ^b
2.5kg	3.00±0.00 ^c	4.33±1.15 ^d	6.33±0.57 ^e	9.00±0.00 ^c	14.66±3.78 ^c	16.33±2.51 ^e	16.33±2.51 ^d
3.0kg	3.66±0.57 ^a	4.33±0.57 ^d	7.33±1.15 ^b	9.33±0.57 ^b	15.66±1.15 ^a	17.46±0.80 ^c	12.66±1.15 ^e
Control	-	3.00±0.00 ^e	4.00±0.00 ^f	4.33±2.08 ^f	4.66±1.52 ^g	4.66±1.52 ^f	5.00±1.00 ^f
P value	0.315	0.002	0.002	0.029	0.000	0.001	0.001

Results are in mean±standard deviation. Column with different alphabet superscript are significantly different at P<0.05

Table 8. Mean Stem Girth of *Abelmoschus esculentus* grown on gully eroded soil treated with different rates of cow dung manure

Treatments (manure)	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
0.5kg	0.52±0.04 ^b	1.33±0.55 ^d	2.10±0.20 ^c	2.93±1.15 ^f	5.20±0.26 ^f	7.43±0.70 ^d	7.83±0.90 ^c
1.0kg	0.46±0.06 ^c	1.48±1.00 ^c	2.33±0.77 ^b	3.23±0.70 ^e	6.53±0.66 ^c	7.26±0.47 ^e	7.86±0.49 ^c
1.5kg	0.66±0.27 ^a	1.63±0.25 ^a	2.33±0.25 ^b	3.73±0.50 ^c	6.13±1.15 ^e	8.86±0.28 ^a	9.16±1.15 ^a
2.0kg	0.43±0.02 ^d	1.53±1.15 ^b	1.93±1.15 ^d	3.36±0.37 ^d	6.36±0.55 ^d	7.40±0.62 ^d	8.33±1.05 ^b
2.5kg	0.31±0.02 ^d	1.26±0.49 ^e	2.13±0.35 ^c	3.96±0.47 ^a	6.63±0.77 ^b	7.50±0.72 ^c	8.20±0.20 ^b
3.0kg	0.51±0.01 ^b	1.43±1.15 ^c	2.60±0.50 ^a	3.83±0.35 ^b	7.26±0.25 ^a	8.26±0.05 ^b	9.33±0.51 ^a
Control	-	0.83±0.30 ^f	1.03±0.37 ^e	1.56±1.15 ^g	1.76±1.15 ^g	2.06±0.25 ^f	2.66±0.32 ^d
P value	0.058	0.573	0.012	0.000	0.000	0.000	0.000

Results are in mean±standard deviation. Column with different alphabet superscript are significantly different at P<0.05

4. DISCUSSION

Organic manures as a source of plant nutrients for cultivation of field crops has received worldwide attention due to rising costs, rapid nutrient loss and adverse environmental impacts from inorganic fertilizers [4]. Amendment of organic materials such as crop residues, animal manures, green manures to soils directly affect soil organic matter content, soil fertility, soil physical characteristics, and augmentation of microbial activities and amelioration of metal toxicity [5]. Cow dung has long been recognized as perhaps the most desirable animal manures because of its high nutrient and organic matter content. Addition of cow dung increases the organic carbon content of degraded soil which may lead to the increasing activity of beneficial

soil microorganisms as well as the fertility status of soil by increasing the availability of nutrients for the plants from soil [6]. As depicted in Table 3.1, amendments of cow dung (CD) in soil significantly affected petiole length of the plant. Petiole is a stalk that attaches a leaf to the plant stem. The application of CD influenced petiole length and it was increased with increasing doses of CD. The shortest petiole length were recorded when 2.5 kg of CD was amended with the gully eroded soil at week one of planting while the tallest petiole length was recorded when 2.0 kg of CD was amended with gully eroded soil at week seven of planting. This is consistent with the findings of [6] and [7]. The effect of different levels of cow dung (CD) on leaf length of Okra plant was also determined. Application of CD at different rates showed

significant effect on the number of leaves of Okra plants at all growth stages except for control group at week one. Leaf length increase was very slow at the early growth stages (week one – week three) while it was rapid between week four and week seven irrespective of CD levels except control.

The main limiting factor for slower growth at early stage may be the nutrient deficiency in the soil as the organic manure had not been fully decomposed. But there was a contrary situation in the later growth stage, the Okra plant got sufficient nutrient; so the growth was rapid and length of leaves got increased. Highest leaf length (30.20 ± 2.06) was observed at week seven when 3.0 kg of CD was amended with the eroded soil while the shortest leaf length (0.49 ± 0.03) was observed at week one when 2.5 kg of CD was amended with the soil, this result is in agreement with the findings of [8]. Similarly, Mujahid and Gupta used oilcake to enhance the leaf structure, number and quality of lettuce. Akdeniz *et al.* [9] had earlier reported that sewage sludge application positively affected grain yield, leaf number, leaf nitrogen, harvest index, and total N uptake by sorghum plant.

The data on the leaf width of the plant as influenced by different levels of CD in gully eroded soil at various weeks after planting is presented in Table 3.3. Leaf width of the plant responded variably due to the application of different levels of CD. There was steady increase in the leaf width of okra plant with increasing CD doses. The highest total leaf width of the plant (36.96 ± 1.15) was obtained at week seven when 2.0 kg of CD was amended with the eroded soil while shortest leaf width was observed at week one of plantation (0.44 ± 0.03) when 2.5 kg of CD was amended with the soil. However, the control group showed the lowest leaf width even at week seven (8.63 ± 4.20). Identical leaf width (36.73 ± 1.37) was also obtained from the plants fertilized with 2.5 kg CD at week seven. Similar type of result was found by [7] and [10] in the cultivation of *Stevia rebaudiana* and okra using cow dung respectively.

It is well established that the addition of organic fertilizers increased the organic matter contents of the soil and availability of other plant nutrients [11]. For this reason the Stem length of okra plant was significantly increased due to the application of different levels of CD in gully eroded soil. The result revealed that stem length of plant progressively increased with increasing

levels of CD up to week seven. The highest number of stem length of plant was observed at week seven (141.86 ± 41.16) when 0.5 kg of CD was amended with the soil while the shortest stem length (0.46 ± 0.03) was observed at week one when 2.0 kg CD was amended with the soil. However, there was no visible growth in the control group. This result is analogous to the findings reported by different researchers [12], [13], [11]. Ailincăi *et al.* [14] also reported highest increase in the number of tillers of wheat and different horticultural crops treated with high dose of oilcake and sewage sludge. Increased stem length in plants grown on amended gully eroded soil indicated good crop growth obviously due to the beneficial effect of cow dung compost manure on the soil. Organic manures have been reported to contain beneficial microorganism that digest organic matter into humus and mineralized nutrients in the soil and form symbiotic association with plants for enhanced crop health and productivity [15].

As depicted in the study, length of internodes of okra plant progressively increased with increasing levels of CD application up to week seven. Results revealed that length of internodes progressively increased with increasing levels of CD. The highest internode length of the plant was observed at week seven (21.23 ± 6.47) when 3.0 kg of CD was amended with the eroded soil while the shortest internodes length (2.40 ± 0.81) was recorded at week two when 2.0 kg of CD was amended with the soil. Meanwhile, there was no visible result observed at week one of planting throughout the treatment groups. Tanimu *et al.* [15] confirmed similar result in case of Maize. El-Dewiny *et al.* showed that internode length of spinach plants increased with application of sewage sludge.

Application of CD at different rates showed significant effect on the number of leaves of okra plants at all growth stages with highest leaf number (21.33 ± 4.93) recorded at week seven when 0.5 kg of CD was amended with the soil. Leaf number increase was very slow at the early growth stages (week one to week three) while it was rapid between week four and week seven irrespective of CD levels except control. The amount of nutrients released into the soil depends largely on the quantity and quality of organic manure and other factors. The highest rate of cow dung compost manure application released more nutrients than other rates and this might have been responsible for the best performance of plants in that treatment. Similar

observations have been reported by Gudugi [6]. Stem girth of plant responded variably due to the application of different levels of CD. There were steady increases in the stem girth of okra plant with increasing CD doses. The highest stem girth of the plant (9.33 ± 0.51) was obtained at week seven when 3.0 kg of CD was amended with the eroded soil while shortest stem girth was observed at week one of plantation (0.31 ± 0.02) when 2.5 kg of CD was added to the soil. However, the control group showed the lowest Stem girth even at week seven (2.66 ± 0.32) and this is in agreement with the findings of Garjila et al. [16].

5. CONCLUSION

In Conclusion, this study showed that the growth and development of okra was significantly enhanced on gully eroded soil treated cow dung manure. The cow dung manure improved the gully eroded soil by replenishing the nutrients, repairing the soil texture and fertility which consequently improved the wellbeing of *Abelmoschus esculentus*.

6. RECOMMENDATION

It is recommended that further studies be carried out on this topic especially in comparing the effect of various types of manure and N.P.K fertilizers on the growth and development various cash crops on gully eroded soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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