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RESEARCH ARTICLE

Growth and Physiological Response of *Cleome gynandra* L. to fertilizers on the Field

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ABSTRACT

Wild vegetables are particularly important as adjunct accompaniment to staples. In order to encourage their productivity and utilization, it is necessary to develop suitable agronomic practices on the response of each species to fertilizers. Field trials were conducted to determine the effect of fertilizers on the growth performance of *Cleome gynandra*. The experiment consisted of three treatments (control, 100 kg N/ha and 8 t goat manure/ha) which were arranged in a randomized complete block design with three replicates. Plant height, total number of leaves, chlorophyll content, moisture, root/shoot ratio, leaf area and stem girth were measured. All parameters measured increased with plant age and significant differences ($p < 0.05$) were observed among the treatments. Generally, fertilizers improved the yield, quality and growth of *C. gynandra*, Application of 100kg N/ha produced the maximum plant height, number of leaves, stem girth. Plant root/shoot ratio was significantly higher in the control when compared to organic and inorganic fertilizers. Therefore, it was deduced that optimal growth performance and better establishment of *C. gynandra* could be obtained with the use of organic and inorganic fertilizers. These findings showed that both inorganic and organic fertilizers increased the growth performance of the species. However, inorganic fertilizer was the most effective.

Keywords- : inorganic fertilizers, growth parameters, *Cleome gynandra*, wild vegetables, goat droppings.

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INTRODUCTION

With increasing human populations and high demand for food, soil nutrients are becoming severely depleted due to intensive cultivation of crops. This however, has been associated with a decline in soil fertility with subsequent reduction in crop yields (Cakmak, 2002). The soils found in Africa are usually deficient in macro nutrients such as nitrogen and phosphorus while sulphur, manganese, zinc, copper and boron are readily available (Mandiringana et al., 2005; Bvenura & Afolayan 2014). These nutrients have specific functions when absorbed by plants. For instance, nitrogen plays a crucial role in the chlorophyll synthesis of the leaves (Akanbi & Togun 2002; Olaleye et al., 2008). Inadequate supply of nitrogen results in poor growth rate; earlier maturity and shortened vegetative growth phase (Jasso-Chaverria et al., 2005).

The use of organic fertilizers such as crop residues, animal manure, woodland litter and household waste has a great potential in ameliorating soil fertility and crop productivity through enhancing the physical, chemical and microbiological properties of the soil as well as nutrient supply (Malaiya et al., 2004; Adamu & leye 2012). The micro and macro nutrients found in organic fertilizer are released more slowly through mineralisation. These nutrients are stored for a longer time in the soil and are made available for plant use thus ensuring higher crop yields (Sharma & Mittra, 1991; Abou El Magd et al., 2005; Akande et al., 2010). Inorganic fertilizers are often considered a major source of plant nutrients (Naeem et al., 2006; Ndaeyo et al., 2013). It is usually preferred by farmers because they are readily available to the plant after application; however, its utilization is often restricted due to the negative side effects. These include soil acidity, nutrient imbalance and environmental hazard (Arisha & Bardisi, 1999; Akande et al., 2010).

Cleome gynandra L. (spider plant) is one of the common wild vegetables in South Africa. It is an erect, annual herb belonging to the Capparaceace family. The leaves of this plant are alternate, palmately compound and its petals are white, pink or lilac. The Plant is highly recognized for its numerous nutritional and medicinal uses. Despite its dietary and therapeutic potentials, formal cultivation of the plant either in home gardens or on the fields is still an uncommon practice. This is because, wild vegetables are gathered mainly by collecting from the wild, fields or emerge naturally as weeds in commercial farms. Hence, the availability and utilization of *C. gynandra* will require suitable agronomic practices of this species to fertilizers with regards to its yield performance. Therefore, the present study was carried out to determine the effect of organic and inorganic fertilizers on the growth and physiological response of *C. gynandra* both on the field. This is with the view of domesticating this vegetable.

MATERIALS AND METHODS

Site Description

The experiment was conducted on the field at the University of Fort Hare, Alice campus, South Africa. The site is within the semi-arid ecological zone with an average annual rainfall of approximately 575 mm in summer; mean daily temperatures of 22.5°C during the day and 18.8°C at night while during the winter the temperature is about 13.6°C during the day and less than 10.3°C at night (Marais & Brutsch, 1994). According to the South African system of soil classification, the soils are deep alluvial of the Oakleaf form (Oa) and belong to the Jozini series and

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texturally sandy loam (Soil Working Group, 1991).

Agronomic practices

Mature seeds of *Cleome gynandra* were collected from the University of Fort Hare research farm in Alice. The freshly extracted seeds were air-dried at room temperature on the laboratory bench for few hours and stored in a sealed bottle at ambient temperature for further use.

The study site was ploughed and harrowed. This was then followed by breaking of the clods in order to attain good tilth for easy establishment of the plant. The seedlings were later transplanted on the field at 4 weeks old with at least 5 leaves and at a height of about 10 -15 cm. This was done early in the morning onto moist beds to reduce transplanting shock.

The organic fertilizer (goat droppings) used in this experiment was obtained from the University of Fort Hare animal research farm while the inorganic fertilizers were NPK

Table 1: Chemical Properties of organic fertilizer (goat droppings)

	Soil	**Organic fertiliser**
pH (KCl)	6.45	7.27
Bulk density (g/cm)	1.25	-
EC (µS/cm)	164.35	9.74
CEC $_{sum}$ (meq/100g)	12.31	-
Available P (mg/kg)	74	8 350
Exchangeable K (mg/kg)	401	24 000
Exchangeable Ca (mg/kg)	1753	27 900
Exchangeable Mg (mg/kg)	345	10 900
Exchangeable acidity (cmol/L)	0.07	-
Total cations (cmol/L)	12.31	-
Saturated acid (%)	-	-
Zn (mg/kg)	11.6	192
Mn (mg/kg)	22	495
Cu (mg/kg)	7.5	64
Organic C (mg/kg)	11 000	-
N (mg/kg)	1600	26 400
Clay (%)	16	-
Na (mg/kg)	-	1654
Fe (mg/kg)	-	11 784
Al (mg/kg)	-	5435

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(Nitrogen Phosphorus and Potassium, 2:3:4) and LAN (lime Ammonium Nitrate) were purchased from Umtiza Farmers' Co-operative a local agricultural inputs dealer. The properties of the organic fertilizer (goat droppings) used for the experiment are shown in Table 1.

Treatments

The treatments were as follows:

1. Control (T1)
2. Organic fertilizer: 8 tonnes of manure /ha (T2).
3. Inorganic fertilizer: 100kg N/ha (T3)

The experiments were laid out in a Randomised Complete Block Design (RCBD) with three treatments replicated three times. Plot size was 3m x3m.

The organic (goat droppings) and inorganic (NPK) fertilizers were applied at transplanting while lime ammonium nitrate was applied at 4 weeks after transplanting. This was done by broadcasting at the top of the soil (5 – 7 cm depth) and thoroughly mixing the fertilizers into the experimental plots.

Measurements of growth parameters

The growth and yield parameters were assessed. Eight plants per treatment were randomly selected, uprooted and tagged for data collection on the following parameters:

Plant Height and number of leaves

A metre rule was used to measure the distance from the stem base to the tip of the longest shoot (Ng'etich et al., 2012). However, the height of the plant was measured before uprooting. Leaves formed were counted from each plant and the average of eight plants determined.

Stem girth

The stem girth was determined by measuring about 2.5 cm above ground level using a vernier calliper (US EPA, 2001).

Leaf area

Leaf area was determined by the non-destructive length × width method (Saxena and Singh, 1965) using the relation: LA = 0.75(length × width), where 0.75 is a constant.

Chlorophyll content

The non-destructive method was used to determine the chlorophyll content in fresh leaves from the base or apex of the plant using a spectrophotometer (Konica Minolta SPAD -502 PLUS).

Moisture content

The method of Osborne & Voogt (1978) was adopted. Briefly, about 2 g of plant samples were dried to a constant weight in an oven at 110°C in clean and dry porcelain crucibles. Using the final and initial weight of the samples, the percentage content was determined.

Root: Shoot ratio

Roots were separated from the whole plant and dried in the oven at 40°C to a constant weight. The ratio was determined as the dry weight of the roots to the dry weight of the shoot (Harris, 1992). This experiment was terminated when the plant reached 50% flowering at 8 weeks after transplanting on the field. This was done because we were interested in the vegetative phase of the plant.

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Statistical analysis

Data collected were subjected to statistical analysis using MINITAB Release 12. A one way analysis of variance was used to compare the means of various growth parameters among the treatments. A two way analysis of variance was also used to determine interaction between plant age and treatment on various growth parameters. Means were compared using Duncan's multiple range tests. The means were treated as significantly different at $p < 0.05$.

RESULTS AND DISCUSSION

Plant height and number of leaves

The effects of fertilizers on plant height and leaf number of *Cleome gynandra* cultivated on the field are shown in Tables 2a and 2b respectively. There were significant differences ($p < 0.05$) among the treatment means. Generally, plant height increased with plant age from 3.1 to 137.3 cm from the time of transplanting until the termination of the experiment. The highest treatment means for the trial period were attained in T3 (58.8 cm) and the lowest in the control T1 (33.3 cm). Similarly, the total number of leaves also increased with increasing plant age from 6 to 140 leaves. The number of leaves differed significantly among the fertilizer treatments where the treatment means with the highest number of leaves was observed in T3 (60) and the lowest was observed in control (38).

The statistical analysis showed an interaction between the plant age and fertilizer treatment on the plant height and number of leaves. A two-way analysis of variance showed an interaction between plant age and the treatment on height and number of leaves with a coefficient of 95 % and 96 % respectively indicating that plant age had a significant effect on plant height and number of leaves.

Plant height is positively correlated with the yield of plants for sustainable crop production (Saeed et al., 2007). It is evident that plant height was found highest with inorganic fertilizer (T3). Chweya & Mnzava (1997) reported a height of 50cm-150cm in naturally growing *Cleome gynandra*.. Bvenura & Afolayan (2014) reported that 100 kg N / ha gave the best height in *Solanum nigrum* experiment and this observation was similar with the results obtained in this trial, where 100 kg N/ ha gave the maximum plant height on the field. Also, in another study, Mauyo *et al*. (2008) found a significant increase in the plant height and other growth parameters of *Cleome gynandra* grown in Kenya when different rates of inorganic fertilizer was applied. The significant increase in plant height reflects the positive effect of fertilizer nutrients such as N, P and K. These nutrients are readily available and supplied adequately in more soluble forms to the plant for better vegetative growth. On the other hand, the lowest height and number of leaves were observed in the unfertilized control plots (T1) were some of the plants were stunted in growth as they had to rely on the native soil fertility which, from the result of chemical properties was deficient in some macro nutrients.

According to Ng'etich et al. (2012), nitrogen fertilization enhanced the vegetative growth of plants thus influencing the yield of most leafy vegetable. This however confirms the vigorous vegetative growth experienced in this study due to the weekly harvesting of the leaves. This frequent harvesting contributed to the increase in partitioning of photosynthates which lead to the formation of new young shoots and production of more leaves (Frankow-Lindberg, 1997).

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Table 2a: Effect of organic and inorganic fertilizers on plant height (cm) of *Cleome gynandra* L. cultivated on the field

Plant age (weeks after transplanting)									
	0	1	2	3	4	5	6	7	8
T1	3.1 ± 0.23	6.4 ± 0.43[a]	9.6 ± 0.54[a]	16.3 ± 0.54[a]	28 ± 1.66[a]	33 ± 2.05[a]	54.0 ± 3.32[a]	67.7 ± 4.11[a]	81.7 ± 4.64[a]
T2	3.1 ± 0.23	8.5 ± 0.57[a]	13.5 ± 0.62[a]	22 ±0.76[a]	37 ± 2.04[b]	55 ± 3.16[b]	78.3 ± 4.24[b]	84.7 ± 4.84[b]	109.7 ± 7.71[b]
T3	3.1 ± 0.23	10.3 ± 0.53[bc]	18.9 ± 0.64[bc]	35 ± 1.66[bc]	48 ± 2.61[cd]	78.7 ± 4.54[cd]	92.3 ± 5.82[cd]	106.3 ± 7.53[cd]	137.3 ± 11.9[cd]

*Note.*0 indicates readings taken at the time of transplanting

Values shown are mean ± SD.

Means with different letters down the same column represent significant differences $p < 0.05$.

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Table 2b: Effect of organic and inorganic fertilizers on leaf number of *Cleome gynandra* L. cultivated on the field

Plant age (weeks after transplanting)									
	0	1	2	3	4	5	6	7	8
T1	6 ± 0.51	8 ± 0.82	15 ± 1.61[a]	18 ± 1.65[a]	30 ± 2.22[a]	40 ± 3.33[a]	55 ± 6.97[a]	70 ± 6.57[a]	98 ± 7.11[a]
T2	6 ± 0.51	9 ± 0.53	18 ± 0.53[a]	32 ± 2.11[bc]	43 ± 2.93[b]	52 ± 2.92[b]	75 ± 3.63[b]	87 ± 5.95[b]	114 ± 4.53[b]
T3	6 ± 0.51	10± 0.54	23 ± 0.84[b]	38 ± 1.27[bc]	57 ± 2.26[c]	73 ± 3.35[c]	89 ± 8.48[c]	106±10.72[c]	140 ± 9.52[c]

Note. 0 indicates readings taken at the time of transplanting
Values shown are mean ± SD.
Means with different letters down the same column represent significant differences $p < 0.05$.

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Stem girth

The effects of organic and inorganicfertilizers on stem girth of *Cleome gynandra*are shown in Table 3. The treatments varied significantly from each other ($p < 0.05$) in the 3rd, 4th and 8th weeks after transplanting. Although there were no significant difference observed among the treatments during the time of transplanting. The stem girth increased from 0.1 mm to13.8 mm from the time of transplanting to the 8th week. The treatment means observed in the stem girth were highest in T3 (7.91 mm) and the lowest in the control (6.33 mm). Statistical analysis showed that there an interaction between plant age and fertilizer application on the stem girth of *Cleome gynandra*.

Stem girth followed a similar trend of response to inorganic fertilizers as observed in plant height and number of leaves. Increase in stem girth is a reflection of appreciable amount of assimilates stored in the stem for leaf production (Law-Ogbomo&Law-Ogbomo 2009). In this experiment, a positive growth of the stem girth was achieved due to the application of 100 kg N/ha (T3). This conceivably led to the generation of more buds on which the leaf count improved as well as height of the plant. This was followed by the organic fertilizer which also showed a positive trend. This observation corroborates with the findings of Law-Ogbomo&Law-Ogbomo (2009) who reported a sharp increase in the stem girth of *Zea mays* when NPK fertilizer was applied.

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Table 3: Effect of organic and inorganic fertilizers on stem girth (mm) of *Cleome gynandra* L. cultivated on the field

Plant age (weeks after transplanting)									
	0	1	2	3	4	5	6	7	8
T1	0.1 ± 0.01	2.8 ± 0.23	3.3 ± 0.64	4.6 ± 0.86	6.4 ± 1.23	7.4 ± 2.62	9.3 ± 3.42	10.9 ± 3.19	11.9 ± 4.21
T2	0.1 ± 0.01	2.63 ±0.21	3.1 ± 0.53	5.1 ± 0.97	7.2 ± 2.51	8.5 ± 2.91	10.9 ± 3.28	11.5 ± 3.71	12.5 ± 4.71
T3	0.1 ± 0.01	3.1 ± 0.32	4.4 ± 0.85	6.8 ± 1.36	8.2 ± 2.83	10.7 ± 3.89	11.4 ± 3.68	12.7 ± 3.91	13.8 ± 5.04

Note. 0 indicates readings taken at the time of transplanting
Values shown are mean ± SD.
Means with different letters down the same column represent significant differences $p < 0.05$.

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Leaf area

The leaf area of *Cleome gynandra* differed significantly among the different fertilizer treatments. The leaf area varied from 0.8 cm^2 at the time of transplanting to 56.2 cm^2 in the 5th week in T3 (Table 4). The highest mean was observed at T3 (26.5 cm^2) followed by T2 (22.3 cm^2) while the least was observed in T1 (21.9 cm^2). The leaf area also increased with plant age at a peak which was observed at the 5th week and started to decrease in the 6th, 7th and 8th week of transplanting in all treatments. However, the analysis of variance showed an interaction between plant age and the fertilizer treatments on the leaf area.

Leaf area is an important factor in assessing the growth and vigour in plants (Gobron 2009). It is also a vital tool in understanding the water and nutrient use of the plant as well as its growth and yield potential (Pandey& Singh 2011). In this study, leaf area was significantly varied with different types of fertilizer treatments for the growth and development of *Cleome gynandra* on the field. It was observed that the highest leaf area was obtained with inorganic fertilizer (T3). A similar work conducted by Ng'etich et al. (2012) reported a high (62 cm^2) leaf area in *Cleome gynandra* at 100 Kg N/ha after 100 days of planting. In this study, the highest value (56.2 cm^2) was obtained in the treatment with 100 kg N/ha (T3) on the field.

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Table 4: Effect of organic and inorganic fertilizers on leaf area (cm^2) of *Cleome gynandra* L. cultivated on the field

	Plant age (weeks after transplanting)								
	0	1	2	3	4	5	6	7	8
T1	0.8 ± 0.04	2.4 ± 0.42	4.2 ± 0.55	27.0 ± 3.92[a]	30.8 ± 3.77[a]	36.1 ± 6.13[a]	30.3 ± 5.93[a]	27.7 ± 0.64[a]	22.5 ± 0.43[a]
T2	0.8 ± 0.04	1.9 ± 0.35	3.5 ± 0.37	14.3 ± 1.65[b]	24.9 ± 1.72[a]	49.9 ±5.45[b]	45.3 ± 5.03[b]	29.4 ± 2.21[a]	21.0 ± 3.08[a]
T3	0.8 ± 0.04	2.5 ± 0.41	3.9 ± 0.51	22.7 ± 0.77[b]	34.3 ± 6.72[b]	56.2 ± 11.2[c]	55.9 ± 9.83[c]	26.1 ± 9.35[a]	36.0 ± 0.63[b]

Note. 0 indicates readings taken at the time of transplanting
Values shown are mean ± SD.
Means with different letters down the same column represent significant differences $p < 0.05$.

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Chlorophyll content

The chlorophyll content increased from the time of transplanting to the 6th week after which it started decreasing in the 7th and 8th week (Table 5). The treatment means were significantly different ($p < 0.05$) from each other where the highest means of the treatments were observed in T3 (60.2 SPAD values) followed by T2 (49.2 SPAD values) and the least T1 (38.7 SPAD values). The chlorophyll content ranged from 11.5 SPAD values to 84.9 SPAD values in the 6th week. There was interaction between plant age and treatment on chlorophyll content indicating that plant age had an effect on chlorophyll content of *Cleome gynandra* leaves.

In this study, mineral fertilizer enhanced the chlorophyll content of *Cleome gynandra* leaves at the 6th week after transplanting on the field. This plausible reason shows that the use of organic manure and inorganic fertilizer is beneficial on the chlorophyll content of the plant. In a related study, Ng'etich *et al*. (2012) reported values between 28 and 49.7 SPAD units in *Cleome gynandra* cultivated during two seasons at different rates of inorganic fertilizer whereas in the present study, the range was observed to be between 11.5 and 87.9 SPAD units. This observation is slightly lower than the values obtained in both trials. This might be attributed to the different methods used during chlorophyll determination which could be interpreted several ways. In addition, the variation could also be attributed to the efficient absorption and assimilation of nitrogen by the plant which serves as a constituent of chlorophyll in the plant tissue. According to the SPAD-502 Plus manual (2009), the SPAD meter measures the greenness of the relative chlorophyll concentration of leaves by measuring the absorbance of the leaf in two wavelengths (400–500 nm and 600–700 nm). Furthermore, plant photosynthetic potential is directly proportional to leaf chlorophyll intensity which is predetermined by nitrogen availability in the soil (Biljana & Aca, 2009). Moreover, nitrogen is the main constituent of all amino acids in proteins and lipids which acts as a structural compound of the chloroplast and determines the rate of photosynthates manufactured through the process of photosynthesis (Badr & Fekry, 1998). This explains the high number of leaves observed in the inorganic fertilizer treatment.

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Table 5: Effect of organic and inorganic fertilizers on chlorophyll content (SPAD units) of *Cleome gynandra* L. cultivated on the field

	Plant age (weeks after transplanting)								
	0	1	2	3	4	5	6	7	8
T1	11.5 ± 0.93	24.5 ± 1.53^a	37.3 ± 1.83^a	44.5 ± 2.62^a	40.3 ± 2.32^a	45.4 ± 2.64^a	56.2 ± 3.13^a	47.9 ± 2.63^a	40.7 ± 2.43^a
T2	11.5 ± 0.93	34.5 ±1.82^b	46.8 ± 2.72^a	57.2 ± 3.23^b	53.8 ± 3.14^b	56.4 ± 3.22^b	66.8 ± 3.77^a	63.9 ± 3.42^b	51.9 ± 3.14^a
T3	11.5 ± 0.93	38.1 ± 1.16^b	59.1 ± 3.45^b	68.9 ± 3.97^c	63.8 ± 3.63^c	72.5 ± 4.25^c	84.9 ± 5.96^b	76.6 ± 4.43^c	67. 2 ± 3.84^b

Note. 0 indicates readings taken at the time of transplanting
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Moisture content

The moisture content varied from 76.9% in the week of transplanting to 94.6% in the 6th week as shown in table 6. The treatment means did not differ significantly (p < 0.05) among the treatments but remained high throughout the observation period. The mean moisture content of the treatments were 85.08, 87.9 and 85.9% in T1– T3 respectively. Irrespective of no fertilizer application in T1, the moisture content showed an upward trend with plant age having a similar value with T3. The analysis of variation showed that there was an interaction between plant age and treatment on leaf moisture content with a coefficient of 59.7% which also indicates that the plant age had a minimal effect on moisture composition of *Cleome gynandra* leaves.

The moisture content ranged between 76.9 and 94.6 % with the highest value observed in leaves grown with organic fertilizer (8 t goat manure / ha). This observation is similar to the findings of Bvenura & Afolayan (2014) who reported the moisture content of *Solanum nigrum* to range between 75.16 and 92.08 %. Similarly, Ng *et al*. (2012) also reported the moisture content of six wild vegetables to range between 92.6% and 96.8% and these results are not very different from the present study. Water constitutes about 80-95 % of the mass of a growing plant and thus plays an essential role in the lifecycle of plants. Water is needed to maintain physiological processes such as cell enlargement, gas exchange in the leaves, transport in the phloem and various transport processes across membranes (Dainty, 1976; Bvenura & Afolayan 2014). The results obtained in this study, indicates high moisture content in *Cleome gynandra* leaves which signifies sufficient water for plant growth thus, enhancing more activity for water soluble enzymes and co-enzymes required for metabolic processes (Iheanacho & Udebuani, 2009).

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Table 3: Effect of organic and inorganic fertilizers on stem girth (mm) of *Cleome gynandra* L. cultivated on the field

Plant age (weeks after transplanting)									
	0	1	2	3	4	5	6	7	8
T1	76.9 ± 0.52	82.6 ± 1.72[a]	81.7 ± 1.91[a]	87.5 ± 2.24[a]	80.9 ± 2.04[a]	88.6 ± 2.43[a]	94.6 ± 2.76[a]	90.6 ± 2.41[a]	89.2 ± 2.32[a]
T2	76.9 ± 0.52	78.7 ± 1.65[a]	88.9 ± 2.42[b]	89.7 ± 2.64[a]	88.8 ± 2.53[b]	92.4 ± 2.88[b]	93.9 ± 2.45[a]	91.7 ± 2.52[b]	90.8 ± 2.42[b]
T3	76.9 ± 0.52	77.4 ± 1.56[a]	83.4 ± 1.03[a]	86.6 ± 2.45[a]	87.6 ± 2.24[b]	89.7 ± 2.52[c]	90.4 ± 2.28[b]	92.4 ± 2.68[c]	89.1 ± 2.32[a]

Note. 0 indicates readings taken at the time of transplanting
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Root: shoot ratio

The results showed the root/shoot ratios to range between 0.23 and 0.17. The ratio decreased from the time of transplanting to the 6th week and began to vary in the control (Table 7). A different trend was observed in T2 and T3 where it consistently decreased till the 4th week after which it showed an increase in the 5th and 6th weeks. The means for the duration of the trial were highest at T1 (0.15) followed by a tie in T2 and T3 where a similar value occurred. Statistical analysis showed an interaction between plant age and the fertilizer treatment on the root: shoot ratio. The analysis also showed a coefficient of determination (R^2) of 43.3 % indicating that plant age had a minimal effect on the root to shoot ratio.

It was found that the ratio of root dry weights to shoot dry weight in the unfertilized control plot was consistently higher when compared to the other treatments. The ratios ranged between 0.17 and 0.23. These values imply that the amount of dry matter incorporated into the roots per plant varies from 17 to 23%. In the current study, the ratio conceivably increased in response to nutrient stress since soil moisture was kept at field capacity throughout the study period. Nutrient depletion in the control treatment apparently led to a high root: shoot ratio while the other treatments lowered the ratio. This could be attributed to NPK being part of the essential macro nutrients required for the production of the meristematic and physiological activities such as leaves, roots, shoots, dry matter production, leading to an efficient translocation of water and nutrients, interception of solar radiation and carbon dioxide.

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Table 7: Effect of organic and inorganic fertilizers on Root: Shoot ratio of *Cleome gynandra* L. cultivated on the field

	Plant age (weeks after transplanting)								
	0	1	2	3	4	5	6	7	8
T1	0.23 ± 0.01	0.15 ± 0.01	0.15 ± 0.02	0.13 ± 0.02	0.13 ± 0.02	0.14 ± 0.02	0.14 ± 0.03	0.13 ± 0.01	0.14 ± 0.02
T2	0.23 ± 0.01	0.12 ± 0.02	0.11 ± 0.01	0.09 ± 0.05	0.06 ± 0.04	0.11 ± 0.04	0.13 ± 0.06	0.11 ± 0.03	0.06 ± 0.01
T3	0.23 ± 0.01	0.11 ± 0.03	0.10 ± 0.04	0.10 ± 0.03	0.08 ± 0.01	0.12 ± 0.03	0.12 ± 0.04	0.10 ± 0.04	0.09 ± 0.04

Note. 0 indicates readings taken at the time of transplanting
Values shown are mean ± SD.
Means with different letters down the same column represent significant differences $p < 0.05$.

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CONCLUSION

The response of this plant to different types of fertilizersis documented in the study. Both inorganic and organic fertilizers have their own roles to play in the growth and performance of *Cleome gynandra*. Growth parameters showed that plant height, no of leaves, stem girth, chlorophyll content were increased by the application of 100 kg N/ha of inorganic fertilizer. However, the application of 8 t/ ha of organic manure significantly boosted the moisture content and leaf area of the plant. Both fertilizers increased the growth performance of *C. gynandra* in varying degrees. The treatment with inorganic fertilizer was found to be the most effective. Furthermore, due to the low amounts of nitrogen and phosphorus observed in the study site, it is thereby recommended that the incorporation of NPK fertilizers should be encouraged in order to increase the production of vegetables like *C. gynandra*.

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