

GROWTH AND GREEN MANURE POTENTIALS OF TWO VARIETIES OF COWPEA (*Vigna unguiculata* (L.) Walp.) FOR LOW INPUT LEAF VEGETABLE PRODUCTION IN IBADAN, NIGERIA

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SUMMARY

Nitrogen (N) requirement is a critical factor in crop production. However, excessive and inefficient use of inorganic N fertilizers increases production costs and poses economic and environmental risks. To promote sustainable vegetable production and reduce dependence on chemical fertilisers, the effects of two cowpea (*Vigna unguiculata* (L.) Walp.) varieties—Akidi and FUAMPEA-2—used as green manure (GM) were evaluated in the cultivation of *Amaranthus cruentus* L. and *Celosia argentea* L. The study was carried out in Ibadan, Nigeria during the rainy season. Seeds of the varieties of cowpea were sown separately in pots containing 5 kg soil at 5 seeds/pot to assess growth attributes. The GM experiments were laid in a completely randomized design with six treatments and five replications: Akidi incorporated (AKGMI_n), Akidi removed (AKGMR_m), FUAMPEA-2 incorporated (FUGMI_n), FUAMPEA-2 removed (FUGMR_m), urea fertiliser (200 kg/ha), and control. Cowpea shoots (n=5) were either incorporated into or removed from the soil at 42 days after sowing. Two-week-old seedlings of *A. cruentus* and *C. argentea* were transplanted three weeks after incorporation/removal. Growth parameters and biomass were measured four weeks after transplanting. FUAMPEA-2 produced greater biomass and nodulation than Akidi. The GM treatments performed comparably to urea and significantly better than the control in promoting the growth and biomass of both vegetables. The best performance was recorded under FUAMPEA-2 green manure. The results suggest that these cowpea varieties effectively enhanced the growth and yield of *Amaranthus* and *Celosia*, indicating their potential to replace or supplement inorganic nitrogen fertilisers.

Keywords: Legume; *Amaranthus cruentus*; *Celosia argentea*; Nodulation

INTRODUCTION

Nitrogen (N) is one of the most essential nutrients for plant growth and productivity (Zayed *et al.*, 2023). Its adequate supply enhances chlorophyll content, carbon dioxide assimilation, crop quality, yield, and tolerance to environmental stress (Chen *et al.*, 2023). In tropical farming systems, the use of inorganic nitrogen fertilizers is widespread (Okwu and

Ukanwa, 2007). However, excessive and inefficient use of these fertilizers poses serious environmental and health challenges. Plant roots typically absorb only about 50% of the synthetic nitrogen applied to soils (Chandini *et al.*, 2019), while overall nitrogen use efficiency ranges between 30.2% and 53.2% (Anas *et al.*, 2020). The unutilized portion is lost through leaching, runoff, or volatilization

as nitrous oxide—a potent greenhouse gas—thereby contaminating water bodies, contributing to global warming, and impairing human health through conditions such as methemoglobinemia and cyanosis (Singh, 2014). These losses also promote soil acidification and mineral depletion, with groundwater pollution identified as one of the major drawbacks of synthetic fertilizer use (Hazra, 2016).

Green manuring has been recognized as a sustainable alternative to inorganic fertilization for improving soil fertility and crop productivity. Its adoption reduces reliance on synthetic fertilizers and mechanization, thereby minimizing air and water pollution, and mitigating land degradation. The use of green manure crops has been shown to improve the yield and economic returns of arable crops such as maize and other cereals (Fabunmi et al., 2012). Moreover, green manures are cost-effective and environmentally friendly, as they are derived from organic plant materials (Chandini et al., 2019).

Cowpea (*Vigna unguiculata* (L.) Walp.) is a versatile and economically important legume widely cultivated across sub-Saharan Africa. It serves as a major source of affordable protein for many households (Muranaka, 2016) and contributes significantly to sustainable agriculture through biological nitrogen fixation, weed suppression, and soil cover (Sheahan, 2012; Guimarães et al., 2015). Previous studies have demonstrated that nodulating legumes such as *Sesbania pachycarpa*, *Mimosa diplotricha*, and *Mucuna pruriens* possess considerable green manure potential in crop production systems (Egberongbe et al., 2017; Tanimola et al., 2020; Adeniji et al., 2023). The Akidi cowpea variety, in particular, has been reported to be an effective weed suppressant when intercropped with maize,

achieving up to 94.8% weed control efficiency at 40,000 plants ha⁻¹, and increasing soil organic carbon content (Woghiren and Awodoyin, 2018).

Amaranthus cruentus is a leaf vegetable crop from the Amaranthaceae family that originated from South America (Becker and Saunders, 1984). It is regarded as one of the best leaf vegetables because of its chemical makeup and nutritional values (Makinde, 2012). According to De Lannoy (2000), fresh *A. cruentus* leaves are high in fibre, calcium, plant protein, iron, beta-carotene, and folate. In Nigeria, the vegetable is used to supplement households' nutritional needs (Shuaib et al., 2017). *Celosia argentea* of the Amaranthaceae family is a popular vegetable in Africa, North America, and Asia (Yarger, 2016). According to Adediran et al. (2015), *C. argentea* is an important vegetable in many parts of the world because of its ability to alleviate nutritional deficiencies. The vegetable is rich in calcium, iron, carbohydrates, and phosphorus (Ayodele and Olajide, 2011). It is a high-value crop that provides a living for most rural vegetable growers throughout the dry season, particularly in Nigeria's south-west, where it is known as Sokoyokoto (Akinfasoye et al., 2008).

Despite the proven agronomic benefits of cowpea, information on its green manure potential for the production of *Amaranthus cruentus* and *Celosia argentea* remains scarce in Nigeria. This study, therefore, evaluated the growth performance and green manure potential of two cowpea varieties—Akidi and FUAMPEA-2—in the low-input production of *A. cruentus* and *C. argentea* in Ibadan, Nigeria.

MATERIALS AND METHODS

Study Area

The experiment was conducted between August and November 2021 (rainy season)

at the Rooftop Garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Oyo State, Nigeria (Latitude 7°57' N, Longitude 3°53' E, 211 m above sea level). The experimental site is located within the humid forest agroecological zone.

Plant Materials

Two varieties of cowpea (*Vigna unguiculata* (L.) Walp.) were used: **Akidi**, a landrace variety with a trailing growth habit, spiral fruits, and black seeds widely consumed in southeastern Nigeria, and **FUAMPEA-2**, an improved, bushy and decumbent (partly erect) variety with brown seeds released by the Federal University of Agriculture, Makurdi, Nigeria. Akidi seeds were sourced from southeastern Nigeria, whereas FUAMPEA-2 seeds were obtained from Syngenta Nigeria Limited, Lagos. Seeds of *Amaranthus cruentus* L. and *Celosia argentea* L. were procured from Agrohelf Farm Store, Moniya, Ibadan.

Growth and Biomass Accumulation of Cowpea

Cowpea seeds were sown in five pots per variety (five seeds per pot). Growth data were collected at 42 days after sowing (DAS) on vine length or plant height, number of leaves, stem diameter, number of root nodules, percentage of effective nodules, fresh shoot weight, and dry shoot weight. Root nodules were recovered by gently immersing each plant in water to

loosen soil particles. The percentage of effective nodules was calculated as:

Effective nodules (%) =

$\frac{\text{Number of pink or red nodules}}{\text{Total number of nodules}} \times 100$

Total number of nodules

Plant samples were oven-dried at 80°C to constant weight using a Gallenkamp oven, and dry weights were recorded with a Mettler top-loading balance (Model P1210).

Green Manure Application and Vegetable Cultivation

The experiment was arranged in a completely randomized design (CRD) with six treatments and five replications. The treatments were:

1. Akidi incorporated (AKGMIn),
2. Akidi removed (AKGMRm),
3. FUAMPEA-2 incorporated (FUGMIn),
4. FUAMPEA-2 removed (FUGMRm),
5. Urea fertilizer, and
6. Control (no green manure and no fertilizer).

A total of thirty pots (20 cm top diameter × 22 cm depth) were filled with 5 kg of topsoil (dry weight). Cowpea seeds were sown in ten pots per variety (five seeds per pot). Twenty pots were allocated to cowpea green manure (GM) treatments, and five each to urea and control treatments. The soil, collected from the Department's crop garden, was slightly alkaline with low organic carbon and nitrogen contents (Table 1).

Table 1. Some Properties of Soil used to grow the cowpea

Property	Average P (mg/kg)	Total Nitrogen (g/kg)	Organic Carbon (%)	Organic Matter (%)	pH	K (cmol/kg)	Na (cmol/kg)
Value	76.14	2.99	4.225	7.283	7.15	0.59	0.30

At 42 DAS, cowpea shoots (five each) were harvested and used as green manure. For incorporated treatments, the shoots were chopped and incorporated into the soil, followed by a three-week decomposition period. For removal treatments, shoots were removed while roots were left to decompose in situ. Two-week-old seedlings of *A. cruentus* and *C. argentea* were transplanted (one seedling per pot) three weeks after incorporation/removal. Pots were watered when rainfall was absent for 72 hours.

Urea (46% N) was applied at 0.5 g per pot (200kg/ha) one week after transplanting in the fertilizer treatment. At four weeks after transplanting, data were collected on plant height, stem diameter, number of leaves, leaf area, and fresh shoot weight. Leaf area was determined by multiplying leaf length by width and adjusting with species-specific correction factors of 0.64 for *A.*

cruentus Kolawole and Sarah (2009) and 0.75 for *C. argentea* (Ologunduduet *al.*, 2013).

Statistical Analysis

Data were analyzed using DSAASTAT (2012 version) software. Treatment means were compared using the Least Significant Difference (LSD) test at 5% probability level. Differences were considered significant at $p < 0.05$.

RESULTS

Growth and Biomass Accumulation

The vine length and percentage of effective root nodules of *Akidi* were significantly higher than those of FUAMPEA-2 (Table 2). However, the number of root nodules and number of effective root nodules were significantly higher in FUAMPEA-2 than in *Akidi*. The fresh and dry weights of FUAMPEA-2 plants were not significantly different from those of *Akidi*.

Table 2. Growth and biomass accumulation of the varieties of *Vigna unguiculata* (L.) Walp. (*Akidi* and FUAMPEA 2) at 42 days after sowing. Values are mean $\pm$ SE (n = 1).

Growth and yield parameters	Akidi	FUAMPEA-2	LSD
Vine length/Plant height (cm)	70.37 $\pm$ 4.23	34.96 $\pm$ 0.87	11.34
Stem diameter (mm)	3.3 $\pm$ 0.06	3.8 $\pm$ 0.07	NS
Number of root nodules	11.73 $\pm$ 2.19	20.67 $\pm$ 2.95	7.90
Number of effective root nodules	11.73 $\pm$ 2.08	19.71 $\pm$ 3.86	7.68
Percentage effective root nodules	100.00 $\pm$ 0.00	95.36 $\pm$ 2.15	2.57
Plant fresh weight (g)	24.93 $\pm$ 2.03	24.98 $\pm$ 2.49	NS
Plant dry weight (g)	4.85 $\pm$ 0.29	4.37 $\pm$ 0.37	NS

Green Manure Potentials of Two Varieties of Cowpea on the Growth and Yield of *Amaranthus cruentus* L. at 4 WAT

Plant Height

Plant height was highest in *Amaranthus* and *Celosia* treated with FUGMRm and lowest in the Control (Table 3). In both crops, all green manure (GM) and urea treatments were not significantly different. However, the plant height of *Amaranthus* treated with AKGMIn, FUGMRm, and urea was

significantly higher than the Control. In *Celosia*, FUGMIn, FUGMRm, and urea were significantly higher than the Control.

Stem Diameter

In *Amaranthus* and *Celosia*, all GM treatments and urea were not significantly different but were significantly higher than the Control, which had the least stem diameter (Table 3). The urea treatment had the highest stem diameter in *Amaranthus*, while treatments with incorporated cowpea GM performed best in *Celosia*.

Table 3. Effect of cowpea green manure and inorganic fertilizers on mean plant height (cm) and stem diameter (mm) of *Amaranthus cruentus* L. and *Celosia argentea* L. at 4 WAT

TREATMENTS	Plant Height (cm)		Stem Diameter (mm)	
	<i>Amaranthus cruentus</i>	<i>Celosia argentea</i>	<i>Amaranthus cruentus</i>	<i>Celosia argentea</i>
AKGMIn	35.8±5.28	30.60±2.18	2.93±0.18	3.30±1.14
AKGMRm	28.3±3.49	27.90±1.10	2.33±0.32	3.27±0.12
FUGMIn	32.97±6.4	31.10±1.44	2.37±0.28	3.30±0.22
FUGMRm	38.63±2.80	32.27±2.59	3.43±0.44	3.13±0.07
UREA	34.6±4.16	31.10±2.62	3.63±0.55	3.13±0.07
CONTROL	17.77±1.22	24.57±2.77	1.37±0.10	2.47±0.12
LSD	16.03	8.32	0.75	0.49

AKGMIn = Akidi shoot incorporated; AKGMRm = Akidi shoot removed;

FUGMIn = FUAMPEA-2 shoot incorporated; FUGMRm = FUAMPEA-2 shoot removed;

UREA = inorganic fertilizer; LSD = Least significant difference.

Number of Leaves

The number of leaves was highest in the Urea treatment for *Amaranthus* and in FUGMIn for *Celosia*, but lowest in the Control for both crops. In *Amaranthus*, all GM and urea treatments were similar, and all except AKGMRm and FUGMIn were significantly higher than the Control. In *Celosia*, all GM and urea treatments were similar and significantly higher than the Control.

Leaf Area

Leaf area was highest in *Amaranthus* plants treated with AKGMIn and in *Celosia* plants treated with FUGMIn, but lowest in the Control in both crops (Table 4). Only the leaf area of plants treated with AKGMIn and FUGMRm were significantly higher than the Control in *Amaranthus*, whereas all GM and urea treatments were significantly higher than the Control in *Celosia* (Table 4).

Table 4. Effect of cowpea green manure and urea fertilizer on mean number of leaves and leaf area (cm²) of *Amaranthus cruentus* L. and *Celosia argentea* L. at 4 WAT

TREATMENTS	Number of leaves		Leaf Area (cm ²)	
	<i>Amaranthus cruentus</i>	<i>Celosia argentea</i>	<i>Amaranthus cruentus</i>	<i>Celosia argentea</i>
AKGMIn	28.00±4.99	32.33±2.99	50.32±10.58	45.63±3.49
AKGMRm	23.67±6.68	32.67±2.38	36.40±3.45	53.73±0.94
FUGMIn	24.33±5.09	42.00±1.25	38.47±11.97	63.35±3.45
FUGMRm	30.00±5.56	36.00±2.87	45.15±5.22	55.23±2.01
UREA	37.67±8.51	33.67±3.82	39.35±6.07	62.28±2.94
CONTROL	13.00±2.06	22.00±0.12	20.33±2.33	30.99±0.73
LSD	21.93	9.69	21.74	9.56

AKGMIn = Akidi shoot incorporated; AKGMRm = Akidi shoot removed;

FUGMIn = FUAMPEA-2 shoot incorporated; FUGMRm = FUAMPEA-2 shoot removed;

UREA = inorganic fertilizer; LSD = Least significant difference.

Shoot Fresh and Dry Weight

The highest shoot fresh weight (SFW) was obtained in *Amaranthus* plants treated with FUGMRm and in *Celosia* plants treated with FUGMIn, while the lowest occurred in the Control (Table 5). Only the FSW of plants treated with FUGMRm and Urea were significantly higher than that of the Control in *Amaranthus*, while in *Celosia*, FUGM and Urea were significantly higher than the Control (Table 5).

In *Amaranthus*, the FUGMRm treatment had the highest shoot dry weight (SDW), whereas AKGMRm recorded the least. All treatments and the Control were not significantly different. However, in *Celosia*, FUGMIn had the highest SDW, and the Control the least. All FUGM and Urea treatments were similar and significantly higher than the Control and AKGM treatments (Table 5).

Table 5. Effect of cowpea green manure and urea fertilizer on mean shoot fresh weight (g) and shoot dry weight (g) of *Amaranthus cruentus* L. and *Celosia argentea* L. at 4 WAT

TREATMENTS	Shoot Fresh Weight (g)		Shoot Dry Weight (g)	
	<i>Amaranthus cruentus</i>	<i>Celosia argentea</i>	<i>Amaranthus cruentus</i>	<i>Celosia argentea</i>
AKGMIn	13.40±0.25	15.14±0.73	1.43±0.80	2.23±0.07
AKGMRm	10.47±2.86	16.04±2.87	1.33±0.41	2.10±0.17
FUGMIn	15.00±5.32	22.40±0.73	1.83±0.64	3.37±0.64
FUGMRm	26.30±7.50	20.13±3.04	3.63±1.19	3.33±0.68
UREA	25.47±9.61	18.76±2.66	3.20±1.34	3.23±0.19
CONTROL	4.20±1.63	9.96±1.82	2.13±1.09	1.47±0.30
LSD	21.10	8.31	NS	1.68

KEY: AKGMIn = Akidi shoot incorporated; AKGMRm = Akidi shoot removed; FUGMIn = FUAMPEA-2 shoot incorporated; FUGMRm = FUAMPEA-2 shoot removed; UREA = inorganic fertilizer; LSD = Least significant difference.

DISCUSSION

There were slight differences in the growth parameters of the two cowpea varieties studied. *Akidi* exhibited a trailing growth habit, whereas FUAMPEA-2 was decumbent (not fully erect), which may explain the longer vine length observed in *Akidi*. This supports the information from Abana *et al.* (2021) that *Akidi*'s growth habit is either climbing or prostrate, and Omoiguiet *et al.* (2018) that FUAMPEA-2's growth habit is semi erect. Despite *Akidi*'s superior growth, FUAMPEA-2 produced more root nodules, effective nodules, and biomass. These variations may be attributed to differences in genetic makeup.

Results from the green manure experiment indicated that, regardless of whether shoots were incorporated or removed, both cowpea varieties enhanced the growth and yield of *Amaranthus cruentus* and *Celosia argentea*. The superior performance of FUAMPEA-2 could be linked to its higher number of nodules and effectiveness, leading to increased nitrogen fixation compared to *Akidi*. Similarly, Ravi *et al.* (2018) observed that increase in number of root nodules per plant and root nodule weight may be responsible for increase in N_2 -fixation in velvet bean. Ineffective root nodules, as indicated by white, greenish, or black colourations in solely planted legumes, may be responsible for low N_2

fixation (Ibeawuchiet al., 2008).

Furthermore, *A. cruentus* performed best when FUAMPEA-2 shoots were removed rather than incorporated. The decomposition process of incorporated shoots may have temporarily immobilized nutrients or produced allelopathic compounds not fully degraded during the three-week waiting period. According to Jansson and Persson (1982), incorporation of plant residues enhances immobilization processes in the soil for a short period of time.

The improved performance of both vegetable crops confirms the green-manure potential of these cowpea varieties. Similar observations were reported by Egberongbe et al. (2017), who found that *Sesbania pachycarpa* incorporated at 45 days after sowing increased *A. cruentus* height by 19.34%. Tanimola et al. (2020) also observed that *Mimosa diplotricha* incorporated at 120 days after sowing enhanced maize dry weight and yield by 91.5% and 100%, respectively. Adeniji et al. (2023) reported that *Mucuna pruriens* sown six weeks prior to incorporation improved subsequent crop performance. Interplanting maize with *Akidi* cowpea at 20,000 and 40,000 plants ha⁻¹ increased maize grain yield by 213.1% and 215.9%, respectively (Woghiren and Awodoyin, 2018).

There was no substantial difference between the effects of green manure and inorganic fertilizer (urea) on the performance of *A. cruentus* and *C. argentea* in this study.

CONCLUSION

Both cowpea varieties (*Akidi* and FUAMPEA-2) demonstrated strong potential for soil rejuvenation and improved crop productivity. When used as green manure, these varieties can serve as

sustainable alternatives to nitrogen-based inorganic fertilizers, contributing to environmentally friendly soil fertility management.

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