Response of *Cleome Gynandra* to Animal Manure

Tinashe Magada Mwarozva[1*], Lovejoy Tembo[2], Sommerset Mhungu[1], Reason R Charachimwe[3]

[1]Faculty of Agriculture, Women's University in Africa
Mount Pleasant, Harare, Zimbabwe

[2]Faculty of Agriculture, Zimbabwe Open University
Harare, Zimbabwe

[3]Department of Research and Specialist Services, Agronomy Research Institute
Harare, Zimbabwe

[*]*Corresponding author's email: tmagadam [AT] gmail.com*

ABSTRACT — Low inherent soil fertility and high cost of synthetic fertilizers are some of the factors hindering productivity of indigenous leafy vegetables. Response of Cleome gynandra to cattle, goat and chicken manure was thus evaluated at Horticulture Research Institute, Marondera, Zimbabwe. The field trial was laid out as a Randomized Complete Block Design with seven treatments, replicated three times. Treatment levels comprised application rates of 50t/ha, 30t/ha and 0t/ha for cattle, goat and chicken manures. Results showed significant influence (P<0.05) of manure on germination percentage, growth parameters and leaf yield. Goat manure performed better than cattle and chicken manure with the highest germination, plant height and leaf yield of 100%, 48.2cm and 32.68t/ha respectively. Thus production of C. gynandra using goat manure is recommended for optimum yield. However, further studies under different manure type combinations and the cost benefit analysis of using animal manures for C. gynandra production are also recommended.

**Keywords — ***Cleome Gynandra*, manure, vegetable

1. INTRODUCTION

Cleome gynandra is an annual herb belonging to the family Capparaceae and sub-family Cleomoideae (Onyango et al., 2013). The genus Cleome is a phylogenetic near relative of the Cruciferae (Brassicaceae) Family (Bremer and Wanntorp, 1978). It originated from tropical Africa and South-East Asia (Grubben and Denton, 2004) where it grows as a weed but is a semi-cultivated popular leafy vegetable in many parts of Sub-Saharan Africa (Chweya and Mnzava, 1997). *Cleome* has a C_4 photosynthetic pathway which enables it to adapt and survive in dry and hot environments (Rao and Rajendrudu, 1989). In Zimbabwe, the plant naturally grows in arable, wild wasteland and grassland areas during the rainy season (Gonye *et al.*, 2017). The perception of *C. gynandra* as a wild volunteer crop, associated with relatively low yields (Vorster and Ransberg, 2005) and its bitter taste has resulted in its low uptake (Onyango et al., 2016). However, in Sub-Saharan Africa, the status of *C. gynandra* has evolved over the last decade shifting from being considered a poor man's crop to a nutritious strategic crop (Masuka *et al.*, 2012). Its research has recently shifted from a problematic weed of arable lands to a crop capable of alleviating food insecurity and addressing malnutrition concerns of the region (Mbugua et al., 2011). Its popularity in Sub-Saharan Africa is increasing due to its high nutritional and medicinal value (Ranzo *et al*., 2013).

However, the production of *C. gynandra* is mainly limited by poor soil fertility and low yields, leading to the crop being regarded as a minor crop in research and development programs (Sachs, 2004; Onyango *et al.*, 2013; Agbo *et al.*, 2014). Zimbabwean soils are sandy and inherently infertile having been derived from granite parent rock (Soropa et al., 2018) and thus require fertilization for any significant level of production (Nyamapfene, 1989; Grant, 1981). Continuous cultivation, soil erosion and sub-optimal use of synthetic fertilizers in the smallholder farming sectors have worsened the problem (Jonga et al., 1996). Synthetic fertilizers are expensive and beyond the reach of most resource-poor smallholder farmers and thus the use of organic fertilizers is a viable option.

Use of synthetic fertilisers has both positive and adverse effects on the environment as well as the quality of crops produced. Heavy dependence on synthetic fertilizers reduces productivity of the land as the structure of the soil is degraded by acidifying elements in fertilizers (Peters, 2009). Excessive build-up of phosphorous and nitrogen in soils can cause water pollution through nutrient run off, and is an important contributory factor to freshwater eutrophication which can lead to algal bloom and growth of other fresh water weeds (Coetzee and Hill, 2011; Smith and Slate, 2010). Ansari and Waleema (2009), recorded migration of fish, change in the natural soil structure, and increase in salinity of the water and decreased oxygen due to water contamination by chemical fertilizers which affect aquatic ecosystem. Vegetables accumulate a significant portion of nitrates from nitrogen-based fertilizers and their conversion to nitrites and nitric oxide has detrimental effects on human beings. Their potential carcinogenicity and toxicity have been documented (Brkić et al., 2017).

The use of animal manure has potential to reclaim degraded soils, reduce environmental pollution and provide cheaper and accessible alternative to chemical fertilizers (Blanco and Lal , 2010). Animal excreta contain readily available essential nutrients such as nitrogen, phosphorous, potassium, calcium, magnesium and have traces of several micronutrients (Plaster, 2014). As a soil amendment, animal manure improves soil quality by neutralizing acidity (FERTASA, 2016) and reduces soil erosion by increasing formation, stability and strength of aggregates due to their buffering capabilities (MacDonald *et al*., 2009). Manure application to soil decreases soil compaction, densification and increases soil self-mulching capacity. Aggregates of animal manure in soil have lower tensile strength and higher water retention capacity compared with non-manured soils, therefore, increases the plant available water (Blanco and Lal , 2010).

Commercialization of *C. gynandra* in Africa is increasing, necessitating the need to establish sustainable agronomic guidelines to facilitate large scale production of the crop. Organic manure from cattle, goats and chicken in varying rates can meet the nutrient requirements of *C. gynandra* and further improve soil structure, soil organic carbon, microbial biomass and yield (Suresh *et al*., 2004). Thus, this research evaluates the application of different animal manures to improve productivity of *C. gynandra*.

2. MATERIALS AND METHODS

2.1 Study site

The trial was conducted in agro-ecological region IIb of Zimbabwe at Horticulture Research Centre in Marondera. The site lies on latitude 18°11' S, longitude 31°28' E and altitude 1630m above sea level. The area receives mean annual rainfall of 873mm and experiences mean annual temperatures ranging between 19.5°C and 24.6°C. The site is characterized by deep sandy soils of granitic origin and has a pH range of 4.0-6.2 $CaCl_2$.

2.2 Experimental design and treatments

The experimental design used was Randomized Complete Block Design (RCBD) with seven treatments, replicated three times. The treatments evaluated were 2 levels of cattle manure, chicken manure and goat manure at 50t/ha and 30t/ha and zero as control. Each plot measured a gross area of $2.25m^{-2}$ and net area of $1.62m^{-2}$. *Cleome gynandra* was planted at inter-row and intra-row spacing of 0.3m by 0.15m respectively. The manure was collected from Tuli beef herd, Boer goat breed and broiler chickens.

2.3 Soil and manure analyses

The soil and manure chemical analysis was carried out before field application to determine chemical composition. The Kjeldahl method was used to determine total nitrogen (Barker and Pilbeam, 2015), Potassium, magnesium and calcium were determined using Atomic Absorption Spectrophotometer (Tan, 2005). Phosphorous was calorimetrically determined using Spectrophotometer (Faithfull, 2002). The pH levels were measured using an electronic pH meter.

Table 1: Chemical composition of soil and manure

Parameter analyzed	Goat manure	Poultry manure	Cattle manure	Soil
Total Nitrogen	2.70%	1.20%	1.60%	0.05%
Available P	1150mg/kg	1250mg/kg	425mg/kg	3mg/kg
Exchangeable Ca	15325mg/kg	4525mg/kg	4775mg/kg	2375mg/kg
Exchangeable Mg	11650mg/kg	3025mg/kg	2525mg/kg	1500mg/kg
Exchangeable Potassium	595mg/kg	190mg/kg	230mg/kg	25mg/kg
pH	7.1	6.6	7.6	5.2

2.4 Trial management

Green stem *C. gynandra* landrace seed variety was used for this research. The seeds were sown in-situ at a seed rate of 40kg/ha at a planting depth of 10mm. Plants were thinned out 14 days after emergence to achieve 22 000 plants per ha. The plots were maintained weed free by hand weeding. Stem boring worm, *Heliothis armigera* and aphids, *Brevicoryne brassicae* were controlled using Carbaryl and Malathion respectively.

2.5 Data collection

Germination was recorded 21 days after planting. Plant growth data was collected from 10 randomly selected plants in each net plot at intervals of seven days for Six weeks. Plant height was measured from ground surface to apical meristem tip of the plant by a graduated metal tape measure. Plant girth was measured at the plant crown using a Vernier caliper. Number of shoots with three newly fully developed leaves was recorded from initial day of harvest. Leaf yield was harvested from both apical and lateral meristems and weighed using electric sensitive scale (Salter- AND Ep 12Ka).

2.6 Data analysis

Data were subjected to Analysis of Variance using Genstat 14th edition. Separation of means was carried using the least significant difference test at 0.05 probability level.

3. RESULTS AND DISCUSSION

3.1 Germination percentage

The addition of manure significantly influenced ($p<0.05$) germination of *C. gynandra*. The highest mean germination of 100% was obtained from application of 50t/ha chicken manure and both application rates of goat manure (50t/ha and 30t/ha) (Figure 1). Genus *Cleome* has been reported to experience different types of seed dormancy. Geneve (1998) classified it as a plant with primary non-deep endogenous physiological seed dormancy and Zharare (2012) determined the cleome seed to have an after-harvest latent period which can extend to five months. Other researchers (Ochuodho and Modi, 2013) attributed the poor germination of *Cleome* to hard seed coat. These types of dormancy have been broken by pre-heating, chemical and physical treatments among other methods (Shilla et al., 2016; Ochuodho et al., 2004; Ochuodho and Modi, 2005). In this study, higher germination rates were attained at higher manure application rates. This could be attributed to increased temperatures during decomposition of manure. Upadhyaya and Blackshaw (2007) reported a soil temperature increase of 1-3^{o}C due to higher levels of animal manure which improves thermal conductivity of moist soil and enhances seed germination. Higher rates of goat and chicken manure could have produced more heat resulting in the decomposition of the endocarp enhancing permeability of the seed coat leading to higher germination (Mwaburi *et al*., 2005). Motsa et al (2015) reported positive influence of temperature on germination of cleome seed. Various studies have shown higher levels of potassium to be associated with breaking seed dormancy of most weed species including cleome and amaranthus (Baskin and Baskin 1998: Alboresi *et al*., 2005: Charachimwe *et al*.,2018). Therefore, higher levels of germination percentage in goat and chicken manure can also be ascribed to higher levels of potassium in the manure (Table. 1) However, higher rates of cattle manure had low germination percentage (73.3%) which concurs with Zharare (2012), who observed no significant influence of cattle manure on seed germination of *C. gynandra*. The lowest mean germination percentage (46.7%) was obtained on application of 30t/ha cattle manure.

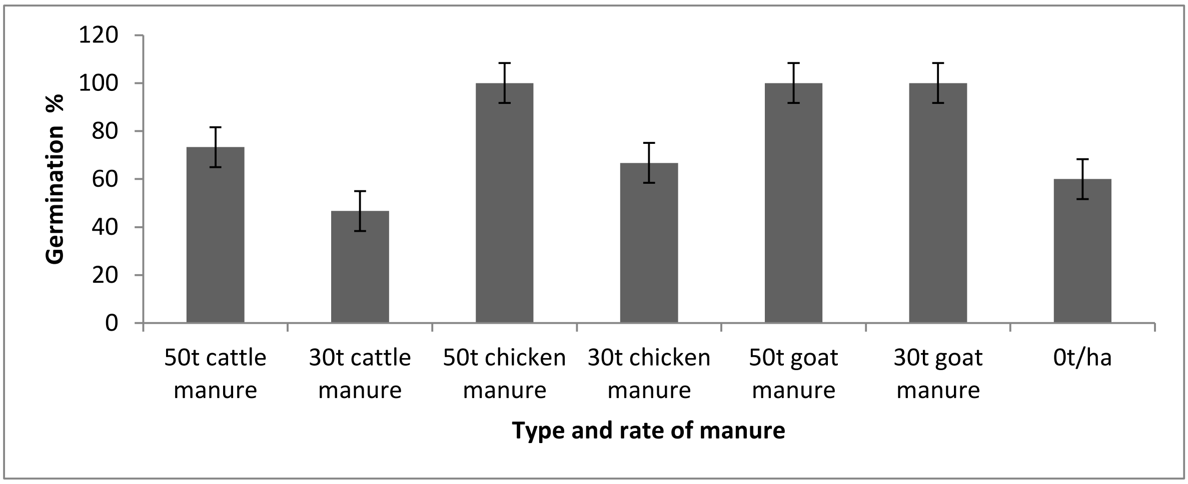

Figure 1: Effects of Type and Rate of Organic Manure on Germination of C. Gynandra Vertical Bars Represent Standard Error Bars of Means

3.2 Growth parameters

Growth parameters (plant height, stem girth and number of shoots) were significantly ($p<0.05$) influenced by application of animal manure. Plants treated with goat manure performed better than the other treatments across all parameters (Figure 2). The highest plant height was observed in plants treated with 50t/ha goat manure (48.2cm) followed by 30t/ha goat manure while the control treatment produced the lowest plant height (12.4cm) (Figure 2a). No significant differences ($p>0.05$) were observed between cattle and chicken manure treatments.

The highest girth (1.21cm) was also recorded in plots treated with 50t/ha goat manure followed by 30t/ha goat manure (1.00cm). However, plants treated with 50t/ha and 30t/ha chicken manure produced the lowest girth of 0.657cm and 0.757cm respectively (Figure 2b). Furthermore, plants treated with 50t/ha goat manure had the highest number of lateral shoots (27.2) and the control treatment had the lowest (10.13). There was no significant difference ($p>0.05$) in number of shoots between application of 50t/ha cattle manure and control treatment (Figure 2c).

The higher growth parameters observed in goat treated Cleome could be because the goat manure used had high levels of nitrogen (Table 1) which positively influenced vegetative growth and shoot development due to rapid cell division (Barker and Pilbeam, 2015). These findings concur with Seeiso and Materechera (2012), who noted that *C. gynandra* grown in soil amended with goat manure performed better due to higher nutrient content than cattle manure. The high response of *C. gynandra* growth parameters is positively correlated to high N, P, K, Mg, Ca and neutral pH levels in the goat manure amended soil (Table 1). This was also affirmed by Onyango *et al*., (2016) and Adeoye *et al*., (2011) in cassava and cowpea trials respectively. Contrary to these results, Kisetu and Assenga (2013), found poultry manure to be superior at increasing crop growth than goat manure.

The poor *C. gynandra* growth responses in the control treatment resulted from low inherent soil fertility and acidity status which may have limited plant nutrient sufficiency and availability for uptake. *Cleome gynandra* thrives in soil pH range of 5.5-7.0 (DPP, 2010) and this was achieved in the goat and chicken manure. Un-amended soil in this study was slightly acidic which could have affected the availability of other essential nutrients and thus poor growth (Reddy, 2006) (Table I).

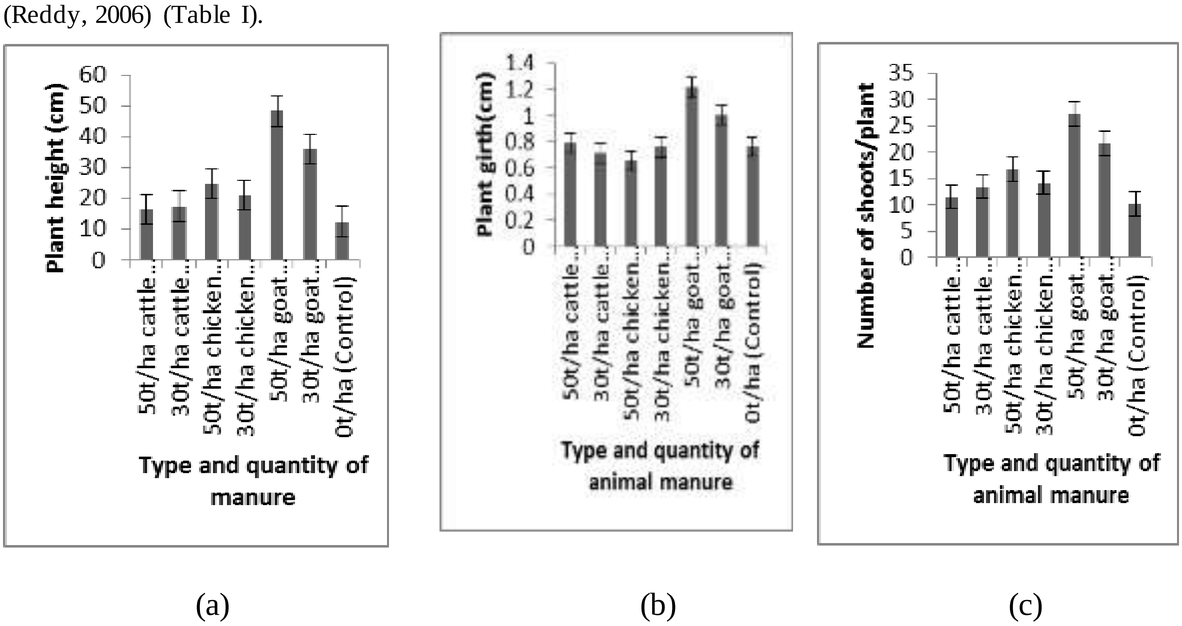

Figure 2: Effects of Organic Manure on Growth Parameters of *C. Gynandra*

Vertical Bars Represent Standard Error Bars of Means

3.3 Fresh leaf yield

Leaf yield was significantly ($p<0.001$) affected by manure application and 50t/ha goat manure had the highest yield of 32.68t/ha while the lowest yield (4.94t/ha) was observed from the control treatment. (Figure 3). The better performance of goat manure is attributed to high nitrogen content in goat manure due to the browsing nature of goats which avail a wide source of rich nutrients (Masinde and Agong, 2011). Therefore, higher levels of nitrogen results in the production of protein and enlargement of cells, thus increasing the leaf yield (Barker and Pilbeam, 2015).

These results concur with Seeiso and Materechera (2012), who recorded 52.3t/ha and 36t/ha *C. gynandra* leaf yield after application of goat and cattle manure respectively at soil: manure ratio of 50: 50. In general the results of this study indicated that fresh leaf yield increased with increased application rate of manure regardless of the source.

Akparobi (2009), also observed a positive correlation in yield of *Amaranthus cruentus* with subsequent increase in application rate of animal manure.

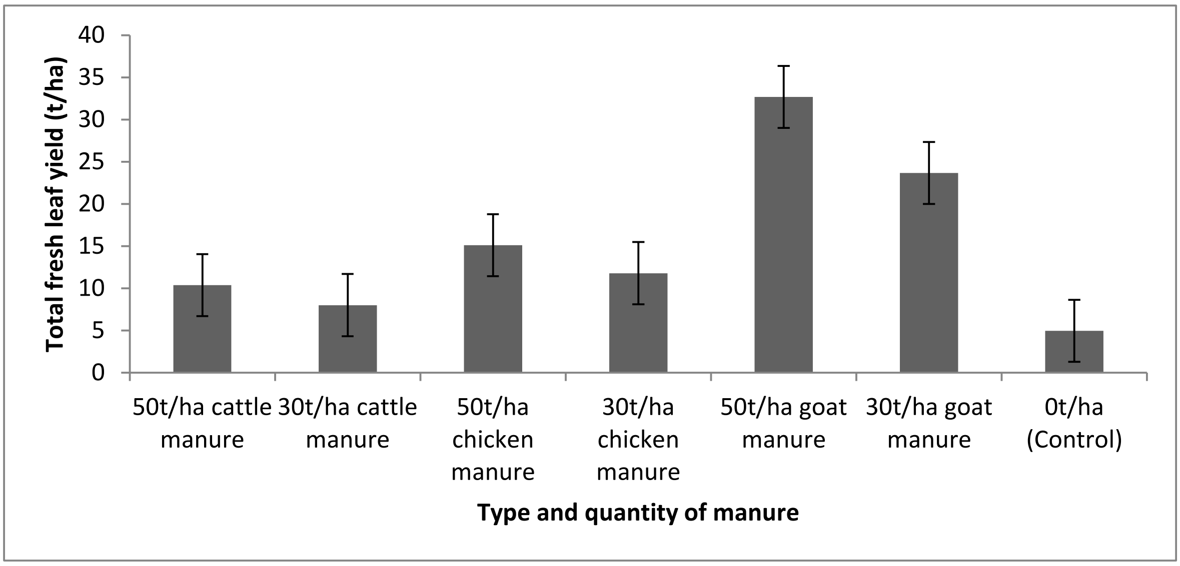

Figure 3: Effects of Type and Rate of Organic Manure on Fresh Leaf Yield of *C. Gynandra*

Vertical Bars Represent Standard Error Bars of Means

4. CONCLUSIONS

A positive response of *C. gynandra* to application of animal manure was observed. Among animal manures, goat manure was superior on germination, growth parameters and fresh leaf yield. However, further research is recommended to evaluate the response of *C. gynandra* to combinations of different animal manure types and the cost benefit analysis of using animal manures as fertilizer for *C. gynandra* production.

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