# Effects of Cow Dung, NPK Fertilizer and Mulching on Zn, Pb Dynamics and Yield of *Celosia Argentea*

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**Abstract**

Field experiment was carried out at Teaching and Research Farm of Oyo State College of Agriculture and Technology to evaluate the effects of Cow dung, NPK fertilizer and mulching on heavy metals (Zn and Pb) dynamics in the soil, plant and yield of *Celosia argentea*. The treatments were; Control (CO), Cow-dung (CD) (5t/ha), NPK (120 kg/ha), mulching (MU) (5 t/ha), CD + MU (2.5 t/ha + 2.5 t/ha), CD + NPK (2.5 t/ha + 60 kg/ha), MU + NPK (2.5 t/ha + 60 kg/ha), CD + MU +NPK (1.67 t/ha +1.67 t/ha + 40 kg/ha). The treatments were laid out in Randomized Complete Block Design (RCBD) replicated three times. Data taken were soil, plant uptake (Zn and Pb) at 3, 6, 9, 12 weeks after planting and yield at harvest. Data collected were analyzed with Analysis of Variance (ANOVA) and the means were separated by Duncan Multiple Range Test (DMRT). Significant ($P<0.05$) differences were found among the treatments. The use of CD gave the highest Zn content (106.17 g) and CMN had the highest Pb content (516.17 g) in the soil. Treatment Co gave the highest Zn (62.92 g) while CM had the highest Pb uptake (71.32 g) in plant. Although, the use of CMN gave the highest yield (3.11 g) but low in Pb while NPK gave (9.67 g) of Pb in plant but with higher (2.56 g) yield. Thus, the sole use of NPK and Integrated use of either CMN or MN is therefore recommended for optimum production of *Celocia argentea* and reduction in the uptake of heavy metal (Zn and Pb) which may be threat to human health.

**Keywords:** Organic manure, Inorganic fertilizer, heavy metal, soil properties, vegetable

## Introduction

Soils in Sub-Saharan Africa are inherently infertile and characteristically low in soil organic matter content and cannot support intensive cultivation due to rapid rate of fertility decline under intensive cultivation (Shiyam et al., 2013). The integrated use of various fertilizers have been reported as a means of solving the problems of inadequate fertility status of soil (Ojetayo et al., 2011; Senjobi et al., 2012; Olowoake et al., 2013). The use of inorganic fertilizer to increase yield has been found to be effective as a short term solution which demands constitute the use on a long term basis. The hazardous environmental consequence and high cost of inorganic fertilizers make them not only undesirable but also uneconomic and unaffordable. (Oyedeji et al., 2014).

Soil pollution by heavy metals is great concern to public health (Goyer, 1996). The source of heavy metals in plant is the environments in which they grow and their growth medium (soil) from which heavy metals are taken up by roots or foliage of plants (Okonkwo et al., 2005). Plants grown un polluted environment can accumulate heavy metals at high concentration causing serious risk to human health when consumed. Moreover, heavy metals are toxic because they tend to bio accumulate in plants and animals, bio concentrate in the food chain and attack specific organs in the body (Akinola et al., 2008).

Plants Species have a variety of capacities in removing and accumulating heavy metals. Many findings have been reported indicating that some plant species may accumulate specific heavy metals. The uptake of metals from the soil depends on different factors, such as their soluble content, soil pH, plant species, fertilizers and soil type (Lubben et al., 1991). Vegetables especially leafy vegetables accumulate higher amount of heavy metals. Roots and leaves of herbaceous plants retain higher concentration of heavy metal than stems and fruits (Yargholi et al., 2008). There are limited studies on heavy metal uptake at different growth stages of vegetables, most studies focused on the status of metal content in edible parts of vegetable. Similarly, past investigation also shows a scarcity of data on comparison of metal contents at different leafy vegetable species. Therefore, the objective of the study is to evaluate the effects of mulching, cow dung and N.P.K fertilizer application on heavy metal uptake (Zn and Pb) and yield of *Celosia argentea*.

## Materials and Methods

Field trials were conducted at Oyo State College of Agriculture Igbo-ora spanning from 2016 - 2017 cropping seasons. Igbo-ora, is in Ibarapa zone; the northern part and derived Savannah Zone of South Western Nigeria. It is located between 7$^o$15'- 7$^o$33' North, and 3$^o$56'- 3$^o$57' East. Prior to Land preparation, soil samples (0-15 cm) were collected randomly from 120 spots in the experimental site with the use of an auger. Samples were bulked, air dried and ground to pass through a 2mm sieve. The soil samples were analyzed for physico-chemical properties as follows: soil particle size were evaluated by Bouyoucos method (Bouyoucos, 1962). Soil pH in $H_20$ (1:1) was determined using the standard laboratory apparatus as specified by (IITA, 1982). Organic carbon was determined by chromic acid oxidation method (Walkley et al., 1934). Available phosphorus and total nitrogen were determined separately by Technicon method while exchangeable Ca, Mg, K, Na and effective CEC in soils by use of atomic absorption spectrophotometer (Tel et al., 1984)

The Cow dung manure was worked into the soil two weeks before planting and mulching was also carried out at the same time.

Treatments application is explained in the table below:

**Table 1:** *Treatments combinations*

| S/N | Materials added | Symbol | Rate of application |
|---|---|---|---|
| 1. | No nutrient applied ( Control) | Co | 00 t/ha |
| 2. | Cow-dung manure | CD | 5 t/ha |
| 3. | NPK fertilizer | NF | 120 kg/ha |
| 4. | Mulching | MU | 5 t/ha |
| 5. | Cow dung manure + Mulching | CD + MU | 2.5 t/ha + 2.5 t/ha |
| 6. | Cow dung manure + NPK fertilizer | CD + NF | 2.5 t/ha + 60 kg/ha |
| 7. | Mulching + NPK fertilizer + Cow dung manure | MU + NF + CD | 1.67 t/ha+40 kg/ha + 1.67 t/ha |

The experiment was arranged in Randomized Complete Block Design (RCBD) and the treatments were replicated three times, the blocks were 1m apart and 0.5m between plot and furrow and each plot were measured 1 m × 3 m.

Viable seeds of *C. argentea* seeds were obtained from National Horticultural Research Institute, Ibadan. Before sowing, the seeds were steeped into boiling water for 10 seconds to break dormancy and air-dried for a day. The planting was done directly on the field by broadcasting the seeds on the bed. Each plot was irrigated with equal volume of fresh water every day. Regular weeding was done by hand picking. At 10 weeks after planting (WAP), plant samples were carefully uprooted and the fresh herbage yields as well as the total dry matter obtained using ISTA (1993) procedure.

To extract the heavy metals, 1 g of sieved soil sample was digested with 10 ml of aqua regia (12 M HCl and 6 M $HNO_3$ that was in ratio 3:1) and heated to dryness at a temperature of 100°C in a fume cupboard as reported by Ashwini et al. (2014). This was then leached with 5 ml HCl, filtered and made up to 25 ml and Pb and Zn contents determined with a Perkin Elmer FAAS. One gram of 2 mm sieved air dried soil was weighed into a conical flask and 1 ml of $HNO_3$ and 3 ml of HCl (*aqua regia*) were added to the samples. The content was heated on a hot plate in fume cupboard to dryness at 100°C (Ashwini et al., (2014). The residue was allowed to cool and leached with 5 ml of 2 M HCl. The extract was then used for the determination of the total metals (Zn and Pb) using atomic absorption spectrophotometer (AAS) while K and Na were determined using the flame photometer (Oyedele et al., 2008). The soils pH was determined by the electrometric method using a glass electrode pH meter (Model 20 of Denver instrument, Dallas, USA). To be able to determine the degree of soil contamination, the soil enrichment factor was computed as the ratio of concentration of the metals in plants relative to that of the soil according to the method by Oyedele et al., (1995). Heavy metals uptake (Zn and Pb) were considered at 3, 6, 9 and 12 weeks for soil samples collected and plants using disruptive sampling method.

The plant samples (edible leafy portions) of *C. argentea* from three (3) replicates of 20 stands each were dried using oven-dry method at $60^oC$ for 24 hours to obtain the moisture content. The dried *samples* were grounded with a manual steel blender and passed through a 2mm sieve, 5.0g of each replicate sample was taken into 250 ml conical flask and 10ml of concentrated $HNO_3$ (nitric acid) was added to it and the mixture was evaporated on a hot plate in a fume cupboard until the brown fumes disappear leaving the white fumes.

Data collected were statistically analyzed and means separation were done using analysis of variance and the means were separated by Duncan Multiple Range test (DMRT) at 5% level of significant.

## Results and Discussion

### The pre-physico chemical analysis of the experimental sites

The pre soil analysis of the soil used for the experiment showed that the soil was slightly alkaline with pH 8.0 and relatively low in essential nutrients like N and P having the following 1.50% and 10.5%. Thus, the use of Cowdung manure and NPK fertilizer will improve the performance of C*elosia argentea* (Table 3). The soil sample also contains 71.5% sand, 13.0% silt and 14.2% clay minerals. The textural class of the soil used is sandy loam (Table 2).

**Table 2.** *Pre-soil analysis of the experimental site*

| ELEMENT | VALUES |
|---|---|
| pH | 8.00 |
| Silt (%) | 13.00 |
| Clay (%) | 14.20 |
| Sand (%) | 71.50 |
| **Textural class (USDA)** | **Sandy loam** |
| Avail P (mg/kg) | 10.5 |
| Org. carbon (g/kg) | 14.48 |
| Total N (g/kg) | 1.50 |
| Exch. Acidity | 0.4 |
| Exch. Cations (cmol/kg) | |
| Ca | 3.22 |
| Mg | 1.5 |
| Fe | 220 |
| Cu | 2.00 |
| Mn | 502 |
| Zn | 8.50 |

**Table 3.** *Chemical properties of organic materials used*

| Nutrient element (units) | Cowdung | Grasses |
|---|---|---|
| Total N(%) | 1.65 | 0.42 |
| Available P (g/kg) | 0.39 | 0.19 |
| K (g/kg) | 0.08 | 0.03 |
| Ca (g/kg) | 0.09 | 0.04 |
| Na (g/kg) | 0.07 | 0.03 |
| Mg (g/kg) | 0.37 | 0.25 |
| pH ($H_2O$) | 8.74 | 0.11 |
| Temperature ($^oC$) | 27.4 | 26.6 |

**Zinc uptake of *C. argentea* as influenced by Cow dung, mulching and NPK fertilizer**

The Zn uptake of celosia (g/plant) as influenced by Cow dung, mulching and NPK fertilizer application at 3, 6, 9 and 12 weeks after planting (WAP) is presented in Table 4. Zn uptake by Celosia increased with age. The control recorded the highest Zn uptake. This was closely followed by CD, NK, NPK and CN respectively. There were no significant differences in the amount of Zn uptake by treatments Co, CD, NPK and CN at 3, 6, 9 and 12 WAP.

The amount of Zn uptake by the Celosia plant with treatments Co, CD, NPK and CN were significantly (CP < 0.05) different from those of MU, CM, MN and CMN at 3, 6, 9 and 12 WAP respectively. No significant (P< 0.05) difference was observed from sole treatments (CD and NPK) except the use of MU and integrated applications (CM, MN and CMN) except CN. Thus, Zn application is higher in sole treated plots than in combined applications.

**Table 4.** *Zn uptake as influence by Cow-dung, Mulching and NPK application at 3, 6, 9 and 12 weeks after planting.*

| Treatment | 3WAP | 6WAP | 9WAP | 12WAP |
|---|---|---|---|---|
| CO | 52.92a | 56.96a | 57.60a | 62.92a |
| CD | 51.97a | 56.53a | 57.04a | 62.63a |
| NPK | 50.02a | 54.31a | 58.28a | 60.52a |
| MU | 42.22b | 44.51b | 45.79b | 50.63b |
| CM | 36.97b | 41.35b | 41.95bc | 47.53b |
| CN | 50.57a | 54.63a | 55.50a | 60.31a |
| MN | 31.62c | 35.56c | 36.16c | 47.53b |
| CMN | 39.85b | 43.83b | 44.59b | 48.89b |

*Means followed by the same letters in the same columns are not significantly different at 5% level of probability by DMRT*

*Co -Control, CD- Cow-dung, NPK, MU-Mulching, CM-Cow-dung + Mulching, CN-Cow-dung + NPK, MN-Mulching + NPK, CMN-Cowdung + Mulching + NPK.*

**Lead uptake by *C. argentea* as influenced by Cow dung, mulching and NPK fertilizer**

The Pb uptake of Celosia (g/plant) as influenced by NPK, Cow dung manure and mulching application at 3, 6, 9 and 12 WAP is shown in Table 5. From the result, CM plants recorded the highest Pb uptake (71.32 g) at 12 WAP. This was highly different from CMN and MN plants that followed it (35.17g and 30. 67g) respectively. Hence, the integration with NPK lowers the Pb uptake. Also, Pb uptake by celosia plant increased with age. The treatment application significantly (P <0.05) influence Pb uptake at 3, 6, 9 and 12 WAP.

**Table 5.** *Pb uptake as influenced by Cow dung, Mulching and NPK application at 3, 6, 9 and 12 weeks after planting.*

| Treatment | 3WAP | 6WAP | 9WAP | 12WAP |
|---|---|---|---|---|
| CO | 17.17cd | 21.92d | 21.17d | 24.42e |
| CD | 23.17cd | 28.42bc | 27.13bc | 29.82cd |
| NPK | 9.67d | 14.92e | 14.00c | 17.42f |
| MU | 21.17cd | 25.67cd | 24.92cd | 27.92cde |
| CM | 63.67a | 68.82a | 67.93a | 71.32a |
| CN | 17.17cd | 22.52d | 21.44d | 24.62de |
| MN | 40.33b | 29.17bc | 27.84bc | 30.67bc |
| CMN | 28.33bc | 33.17b | 32.00b | 35.17b |

*Means followed by the same letters in the same columns are not significantly different at 5% level of probability by DMRT*

*CO- Control, CD-Cow-dung, NPK, MU-Mulching, CM-Cow-dung + Mulching, CN-Cow-dung + NPK, MN-Mulching + NPK, CMN-Cow-dung + Mulching + NPK. WAP-Weeks After Planting.*

From the result, all the nutrient integrations (CM, CMN, MN) gave higher Pb uptake with the exception of CN. Similarly, sole treatments (CD, NPK and MU) had a lower Pb uptake compared with the integration. In all, the least values of Pb uptake were observed for the weeks considered. Also, organic amendments (CD and MU) enhanced Pb uptake than inorganic trials or its combination (NPK and CN). Thus, the more organic a treatment is or the more nutrients integrated the better its Pb accumulation and vice versa.

***C. argentea* yield, Zn and Pb uptake as influenced by Cow dung, Mulching and NPK fertilizer**

From Table 6 and Fig 1, more reduction in the availability of heavy metals under CMN amendment, plants showed highest yield compared to the control and other amendments. Yield increment was, 230, 233, 252, 246, 36 and 304% in CD, NPK, MU, CM, CN and CMN amended soils, respectively, as compared to the control. Hutchinson (2011) reported that the application of FYM to the soil significantly increased the seed yields of *Solanum villosum* and *Cleome gynandra* as compared to plants grown in the control soil. Mandal et al., (2007) and Mahmoud et al., (2009) have also found that application of organic and inorganic fertilizer in combination led to higher yield of wheat and cucumber plants as compared to sole application of inorganic fertilizer

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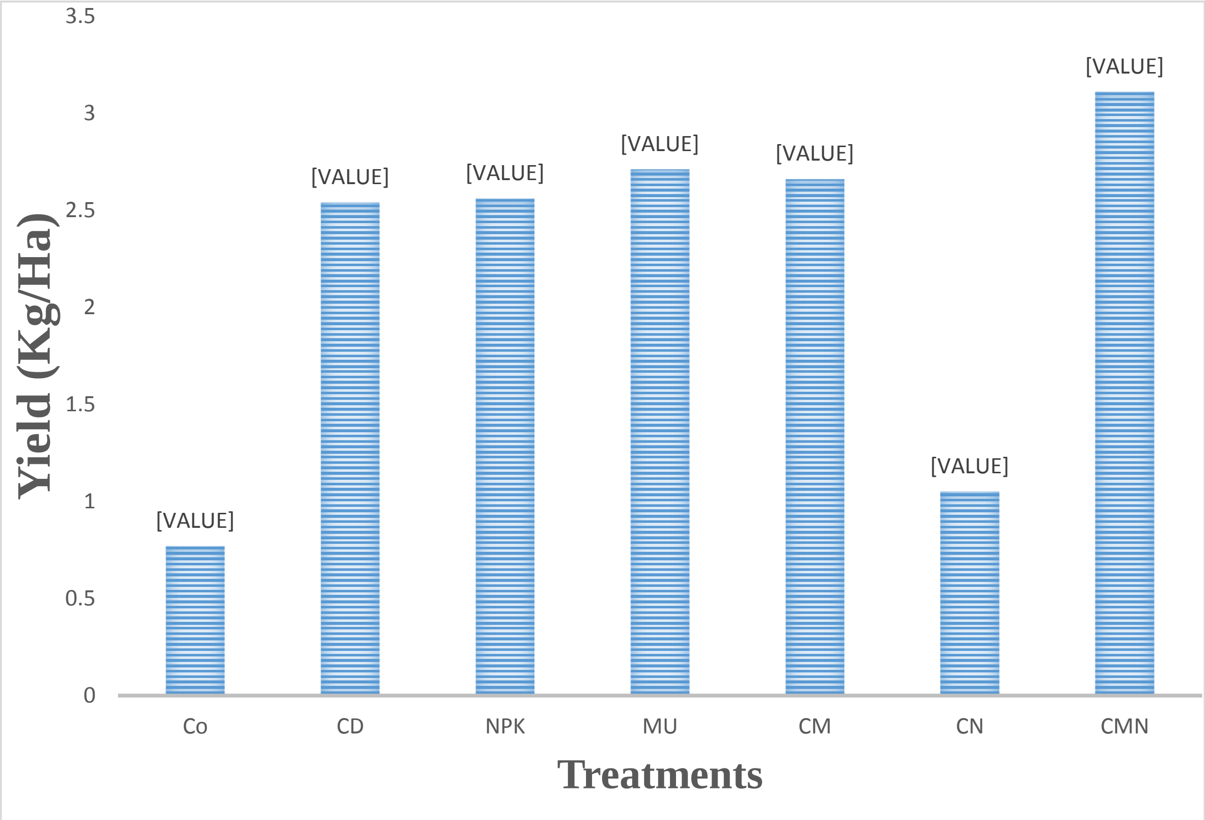


**Figure 1***: Yield response as influenced by the application of Cow dung, Mulching and NPK fertilizer*

**Table 6:** *Response of yield, Zn and Pb uptake with the application of Cow dung, Mulching and NPK fertilizer*

| Treatment | Yield | Zn uptake | Pb uptake |
|---|---|---|---|
| **Co** | 0.77e | 57.60 | 21.7 |
| **CD** | 2.54b | 57.04 | 27.14 |
| **NPK** | 2.56b | 55.78 | 14.00 |
| **MU** | 2.71b | 45.79 | 24.92 |
| **CM** | 2.66b | 41.95 | 67.94 |
| **CN** | 1.05d | 55.25 | 21.44 |
| **CMN** | 3.11a | 44.29 | 32.17 |

*Means followed by the same letters in the same columns are not significantly different at 5% level of probability by DMRT*

Under NPK amendment, plant showed lower yield compared to other amendments, because the amount of photosynthates produced in plants was utilized in the defense against heavy metals rather than contributing to the growth of the plants. Zn and Pb concentrations in plants under NPK amended soil, more antioxidants were inducted in order to reduce the oxidative stress caused by the heavy metals. Lower availability of heavy metals in plants under CD, MU and CM amendment led to the improvement in physiological status and yield.

The result supported the findings of Wu Yongsheng et al. (2011), who observed that higher Pb in soils may decrease soil productivity and very low Pb may inhibit some vital plant processes. Similarly, Nguyen Xuan Cu (2015) established that the concentration of heavy metals in soil could increase the accumulation in plants as well when he found out a positive relationship between heavy metals in soil and their contents in Lettuce.

The transfer factor indicates that the uptake of metal varied from one treatment to the other and from one plant species to the other. Chambers et al. (1991) found that plant metal levels were highly variable when related to soil metal levels. Similarly, Fleming et al. (1977) observed that uptake of heavy metals vary widely depending on the plant species studied. Alternatively, metal uptake could be controlled by such variables as pH, organic matter content and the degree of soil moisture (Fleming et al., 1977).

## Conclusions

The experiment indicated that the complementary use of cow-dung manure, mulching and NPK have significant effect on *Celosia argentea* production compared with the control. Optimum yield was given by CMN followed by that produced by CN that were statistically the same with NPK, MU and CM. Thus, the application of either CN or MN and the combination of Cow dung and mulching with NPK significantly ($P < 0.05$) increased soil Pb and Zn uptake. This finding has shown that intensification of *Celosia argentea production* with integrated use of NPK fertilizer, cow-dung manure and mulching is a vital method for judicious production and a means to minimizing uptake of heavy metal (Zn and Pb).

The present study concludes that CD alone and in combination with NPK and mulching may be used to reduce the phyto-availability of heavy metals in the soil to improve the yield of plants and reduce the food chain contamination. Therefore, application of CD alone and in combination with NPK and Mulching at regular intervals may be able to reduce food chain contamination by lowering the availability of heavy metals to the plants grown in metal contaminated area.

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