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Mucuna pruriens, Cattle and Chicken Manures Soil Amendment on Some Soil Chemical Properties and the Growth and Yield of Cabbage (*Brassica oleracea*)

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Abstract: ***The study assessed the effect of green manure and animal manure soil amendment on soil nutrients and the growth and yield of cabbage during the 2011 minor and 2012 major seasons. A Randomised Complete Block Design (RCBD) with three replications was used with the following treatments: 27 t ha^{-1} Mucuna pruriens green manure (M), 20 t ha^{-1} cattle manure (CD), 20 t ha^{-1} chicken manure (CM), 14 t ha^{-1} M + 10 t ha^{-1} CM, 14 t ha^{-1} M + 10 t ha^{-1} CD, 10 t ha^{-1} CM + 10 t ha^{-1} CD and a control plot which had no amendment. All the amended plots showed higher increases in soil organic matter percentage, total nitrogen percentage, Exchangeable calcium, magnesium and potassium and Available phosphorus than the control treatment. pH change was not significant. The sole M treatment had the highest organic matter percentage, with the sole CM having almost higher values for other parameters. Cabbage plants from the amended treatments recorded significantly ($p \leq 0.05$) higher number of cabbage leaves and plant height, larger canopy spread, higher fresh head weight (30.03t h^{-1} in 2011; 40.53t h^{-1}in 2012) and dry head weight (2.31t h^{-1} in 2011; 3.94t h^{-1}in 2012) of cabbage than plants from the unamended treatment. The sole chicken manure and its combined treatments recorded higher values of the growth and yield parameters. The CM in both years generally had higher harvest index (HI) values (2011 = 47.72%; 2012 = 69.52%). Fresh head weight of cabbage highly related with some soil nutrients. Planting season affected crop yield, the 2012 cabbage plants had values higher than their corresponding 2011 plants.***

Keywords: Mucuna pruriens, cattle manure, chicken manure, cabbage growth soil nutrients

1. Introduction

Cabbage, (*Brassica oleracea* var. *capitata* L.) belongs to the Family of Brassicaceae (or Cruciferae) and is an exotic leafy green vegetable native to Europe. Within the family of Brassicaceae, cabbage is the most commercially grown in Ghana and elsewhere for the head (Messiaen, 1994). The increase in population coupled with the increase in taste and preference for cabbage has resulted in the increase in the production of cabbage in Ghana. The increased production of cabbage and other exotic vegetables in Ghana on continuously cropped fields has been made possible by the application of added plant nutrients to depleted soils. However, the high cost of chemical fertilizers and the environmental and health issues associated with their usage are causing a paradigm shift to the use of organic manure for the cultivation of the crop. In Ghana, organic manure abounds mostly in the form of animal manure, such as chicken manure, cattle manure and grasscutter manure. Organic matter residues from legumes especially from cover crops have also been reported to improve soil organic matter content and other soil physical properties (Azontoude et al., 1998). It is reported that *Mucuna prurience* var. *utilis* (valvetbean), a leguminous cover crop, could contribute dry matter yield of 7,556 kg ha^{-1} with N credit value between 14 - 90 kg N ha^{-1} (Ennin and Dapaah, 2008).

Organic manures, aside improving both the physical and chemical properties of the soil for the cropping year, also leave a residual effect which is beneficial for the succeeding crops partly because of the slow mineralization rate of manures. Ramamurthy and Shivashankar (1996) explain residual effect of organic matter as the carry-over benefit of the application of the organic matter on the succeeding crop, as nutrients present in organic matter are not fully available to the crops in the season of its application.

This study assessed the effect of *Mucuna pruriens*, cattle manure and chicken manure soil amendment on soil nutrients and the growth and yield performance of cabbage.

2. Materials and Methods

The experiment was carried out on a Bediese series of the savannah Ochrosol soil at the Multi-Purpose Nursery site of the University of Education, Winneba, Mampong campus, Ghana, during the 2011 minor season (October to December) and 2012 major (May to July) season (Figure 1).

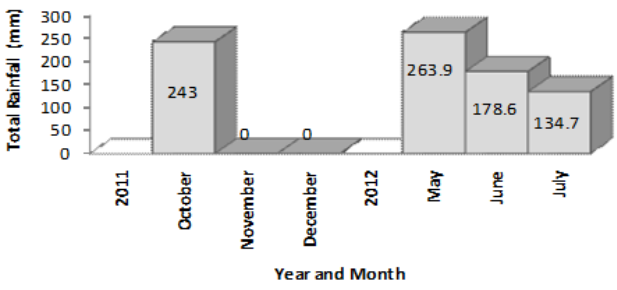

Figure 1: Total monthly rainfall

A Randomised Complete Block Design (RCBD) with three replications was used with the following treatments: 27 t ha^{-1} *Mucuna pruriens* green manure (M), 20 t ha^{-1} cattle manure (CD), 20 t ha^{-1} chicken manure (CM), 14 t ha^{-1} M + 10 t ha^{-1} CM, 14 t ha^{-1} M + 10 t ha^{-1} CD, 10 t ha^{-1} CM + 10 t ha^{-1} CD and a control plot which had no amendment. Twenty-one plots (each measuring 4m x 3m) were established.

Mucuna pruriens seeds were sown at stake at a spacing of 0.4m x 0.4m for the sole *Mucuna* plots and 0.8 x 0.4m for half *Mucuna* plots. Two seeds per hill were sown and later thinned to one plant per hill. The *Mucuna* was applied as green manure when the plants were at the flowering stage. Chicken manure and cattle manure and their combinations were also applied into the soil. The plots were prepared into beds one month after incorporation of the various amendments. Samples of soil (0-15cm) were analysed at this stage to determine the chemical properties of the soil after decomposition of treatment materials. Soil pH at 1:1 was determined using pH meter (FAO, 2008), Percentage Organic Matter was determined by the Walkley and Black (1934) method, Percentage Total Nitrogen was determined by the Kjeldahl method (FAO, 2008), Exchangeable Cations (Ca, Mg and K) were determined by the Ethylenediamine tetraacetic acid (EDTA) titration method (Cheng and Bray, 1951) and Available P by Bray's method (FAO, 2008). Chemical analyses were also carried out on the *Mucuna*, cattle and chicken manures (Table 1) to ascertain their chemical compositions before they were applied into the soil.

The cabbage seeds were nursed and transplanted onto the plots at a spacing of 0.5m x 0.5m. Cultural practices such as weeding, irrigation and insect control were carried out.

Five cabbage plants from the middle rows of each plot were randomly selected and data were collected based on the following growth and yield parameters for both 2011 minor and 2012 major seasons: Number of plant leaves, Plant height, plant canopy spread, Fresh head weight yield, Dry head weight yield and Harvest index.

Data from the study were analysed using the GenStat (Edition 4) Statistical Package. Treatment means found to be significant were separated using the Fishers' unprotected least significant difference (LSD) at $p \leq 0.05$.

3. Results

Amendment effect of Mucuna pruriens and animal manure on some soil nutrients

Table 2 indicates some soil nutrient levels four weeks after soil amendment with *Mucuna pruriens*, cattle manure and chicken manure. The soil pH did not change significantly ($p \leq 0.05$) from the control (treatment with no amendment).

The organic matter percentage was significantly ($p \leq 0.05$) higher in the amended soil than the control treatment. The sole *Mucuna pruriens* treatment had the highest value (1.79%) of the organic matter percentage which was significantly ($p \leq 0.05$) the same as the values from the other treatments with *Mucuna pruriens* combinations. The organic matter percentage value for the chicken manure was significantly ($p \leq 0.05$) the lowest among the amended treatments.

Table 2: Soil properties before planting in 2011

Treatment t ha^{-1}	pH	OM (%)	N (%)	Exch. Ca me$100g^{-1}$	Exch. Mg me $100g^{-1}$	Exch. K me$100g^{-1}$	Avail. P mg kg^{-1}
27 *M*	5.48	1.79	0.23	3.47	0.80	0.27	19.11
20CD	5.45	1.53	0.21	3.20	0.93	0.25	20.30
20CM	5.74	1.47	0.30	4.54	0.93	0.24	62.16
14*M* + 10CM	5.65	1.72	0.24	4.01	1.00	0.26	45.43
14*M* + 10CD	5.58	1.67	0.23	3.20	0.80	0.25	34.23
10CM +10CD	5.66	1.53	0.28	4.01	0.85	0.24	41.80
Control	5.40	0.81	0.06	2.48	0.80	0.21	9.52
$LSD_{(0.05)}$	0.39	0.12	0.04	0.88	0.25	0.05	1.69
CV(%)	3.30	5.60	15.00	12.60	10.40	7.80	2.30

The sole chicken manure treatment had the highest total nitrogen percentage value (0.30%) which was significantly ($p \leq 0.05$) the same as the values from the other treatments with chicken manure combinations.

The percentage nitrogen in the amended treatments increased significantly ($p \leq 0.05$) over the unamended soil.

Exchangeable calcium value in the amended treatments increased significantly ($p \leq 0.05$) over the unamended soil. The sole chicken manure treatment had the highest exchangeable calcium value (4.54 me$100g^{-1}$) which was significantly ($p \leq 0.05$) the same as the values from the other treatments with chicken manure combinations.

Though some exchangeable magnesium values of the amended treatments were higher than the value from the unamended soil, the values were not significantly ($p \leq 0.05$) different.

Apart from the sole *Mucuna pruriens* treatment with an exchangeable K value of 0.27 me100g^{-1} which was significantly ($p \leq 0.05$) higher than the value from the unamended soil, the rest of the values from the amended soil were not significantly ($p \leq 0.05$) different from the unamended soil treatment value.

All the amended soil treatments had available P values that were significantly ($p \leq 0.05$) higher than the value from the unamended soil treatment. The sole chicken manure treatment recorded significantly ($p \leq 0.05$) the highest available P value of 62.16 mg kg^{-1}.

Manure effect on cabbage growth and yield

Plants grown in the major rain season (2012) had higher number of leaves than those planted in the minor rain season (2011) for each treatment (Fig. 2).

The differences were mostly not significant ($p \leq 0.05$) within treatments. Within each season the amended treatments recorded significantly ($p \leq 0.05$) higher number of cabbage leaves than plants from the unamended treatment; the sole chicken manure (CM) treatment had the highest number (2011 = 19; 2012=21) which was not statistically different from the other amended treatments.

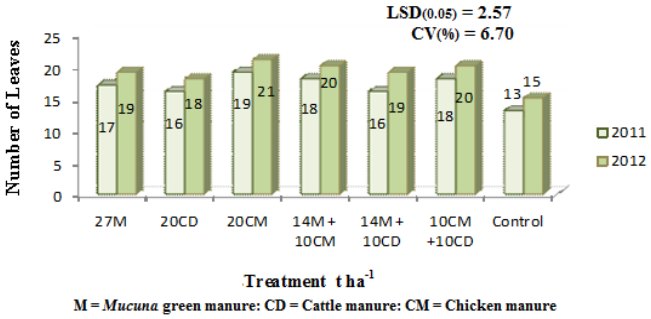

Figure 2: Treatment effect on cabbage leaf number

Plant heights of cabbage grown in the major season were found to be higher than those in the minor season (Fig. 3). As found in Fig. 2, the differences were mostly not significant ($p \leq 0.05$) within treatments. Within each season the amended treatments recorded significantly ($p \leq 0.05$) higher plant height of cabbage than plants from the unamended treatment. All the treatments with the chicken manure had plant height values which were not statistically different each other but were significantly different from the other amended treatments. The sole CM treatment, however, had the highest plant height (2011 = 30.70cm; 2012 = 31.50cm).

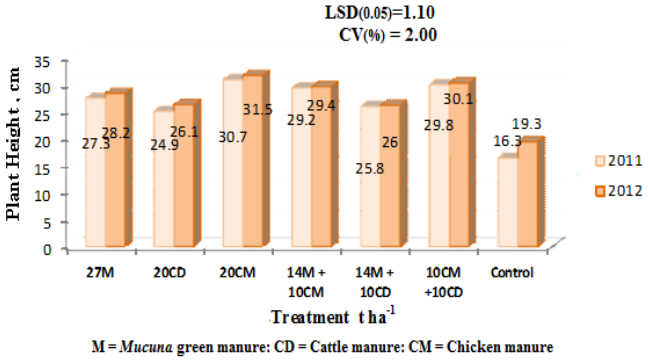

Figure 3: Treatment effect on plant height of cabbage

Treatments with the chicken manure recorded significantly ($p \leq 0.05$) larger canopy spread (2011 = 47.30cm; 2012 = 49.00cm) than the rest of the treatments within each of the two growing periods (Fig. 4). The 2012 canopy spread for the treatments were significantly ($p \leq 0.05$) larger than their corresponding treatments in 2011. In both years of planting the control treatment had the smallest canopy spread.

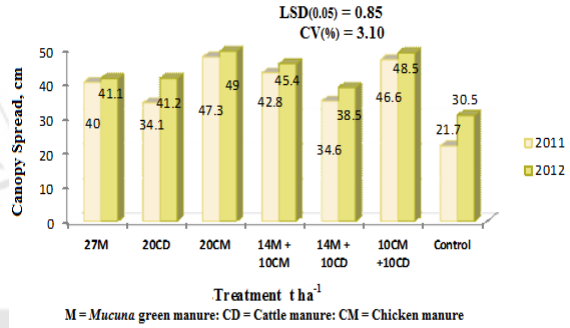

Figure 4: Treatment effect on canopy spread of cabbage

Values for the fresh head weight of cabbage for the treatments in 2012 were significantly ($p \leq 0.05$) higher than their corresponding treatments in 2011 (Fig. 5). Within each year of planting the sole CM treatment recorded significantly ($p \leq 0.05$) higher values (30.03t h^{-1} in 2011; 40.53t h^{-1}in 2012) of the fresh weight. The CM + CD treatment in both years had values that were close to the sole CM treatment but were significantly ($p \leq 0.05$) lower. In both years of planting the control treatment had the lowest fresh head weight values of cabbage.

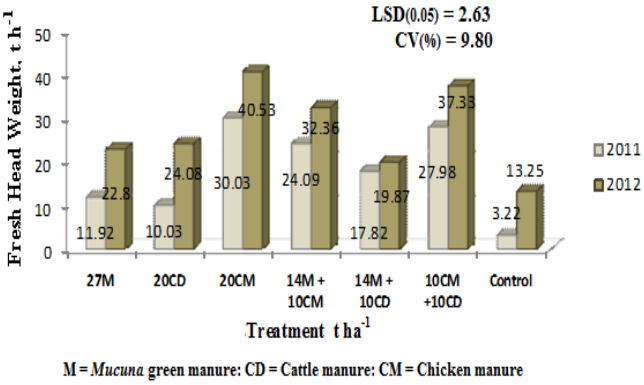

Figure 5: Treatment effect on cabbage fresh head weight

The dry head weight of cabbage for the treatments in 2012 were significantly ($p \leq 0.05$) higher than their corresponding treatments in 2011 (Fig. 6). The distribution pattern of the dry head weight values was similar to the fresh head weight values. The sole CM treatment recorded significantly ($p \leq 0.05$) higher dry weight values (2.31t h^{-1} in 2011; 3.94t h^{-1}in 2012) in both years. Also, the CM + CD treatment in both years had values that were close to the sole CM treatment but were significantly ($p \leq 0.05$) lower. As usual the control treatment had the lowest dry head weight values of cabbage.

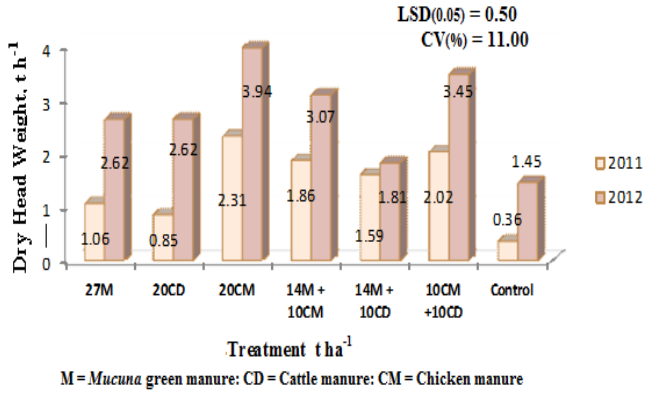

Figure 6: Treatment effect on cabbage dry head weight

Considering the harvest index (HI) values for the planting times, the 2012 treatments values were significantly ($p \leq 0.05$) higher than their corresponding treatments in 2011 (Fig. 7). Within each growing season the sole CM treatment had the highest HI values (2011 = 47.72%; 2012 = 69.52%) which were significantly ($p \leq 0.05$) higher than the other treatments. The control had the lowest HI values.

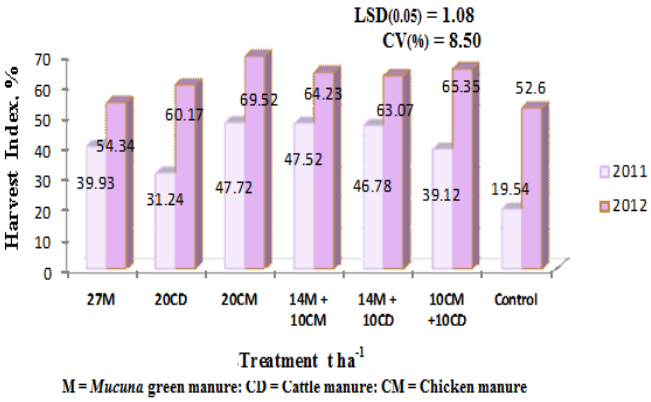

Figure 7: Treatment effect on harvest index of cabbage

Table 3 shows the relationship (R^2) between the fresh head weight of cabbage values in 2011 and 2012 and the various soil nutrient values assessed in 2011. It was found out that the fresh head weight of cabbage strongly depended on the soil percentage N (R^2=0.76 in 2011; R^2=0.73 in 2012), Exch. Ca(R^2=0.88 in 2011; R^2=0.94 in 2012) and Avail. P(R^2=0.92 in 2011; R^2=0.80 in 2012). The fresh head weight of the cabbage was weakly dependant on %OM, Exch. Mg and Exch. K.

Table 3: Relationship between soil nutrients and fresh head weight of cabbage

Soil Nutrients	Fresh Head Weight of Cabbage (t ha^{-1})	
	R^2	
	2011	2012
Organic Matter (%)	0.23	0.17
Nitrogen (%)	0.76	0.73
Exch. Ca	0.88	0.94
Exch. Mg	0.23	0.36
Exch. K	0.07	0.06
Avail. P	0.92	0.80

4. Discussion

Amendment effect of Mucuna pruriens and animal manure on some soil nutrients

All the amended plots showed higher increase in all the nutrient levels than the control treatment (Table 2). Manure application has been found to bring variations in soil pH. Significant increase in pH has been noted for applying organic manure (Angelova et al., 2013; Whalen et al., 2000; O'Hallorans et al., 1997; Wong et al., 1998; Ziblim et al., 2013) and in some situations pH is found to decrease significantly (Walker et al., 2003; Yaduvanshi, 2001). The change in pH in the current study was, however, insignificant which is similar to the findings of Ramesh et al. (2010).

Significant increases of soil organic matter levels in plots treated with organic manure have been reported (Angelova et al., 2013). In the present study, the sole *Mucuna pruriens* and treatments with *Mucuna pruriens* combinations gave the highest organic matter content which is similar to the findings of Atta-Poku et al.(2014) who studied on the influence of *Mucuna pruriens* green manuring on soil properties. The higher percentage of the organic manure recorded by the *Mucuna pruriens* might due to the higher amount in the soil amendment, and also its high dry matter yield (Ennin and Dapaah, 2008).

Chicken manure with higher content of percentage Ca, P and N in the treatment material (Table 1) resulted in the higher levels of Exch. Ca, Avail. P and percentage N recorded in the study as has been so for some previous studies by Adekiya and Agbede (2016), Dikinya and Mufwanzala (2010) and Agbede et al. (2008).

Manure effect on cabbage growth and yield

Cabbage plants from the amended treatments recorded significantly ($p \leq 0.05$) higher number of cabbage leaves and plant height, larger canopy spread, higher fresh and dry head weight of cabbage than plants from the unamended treatment. Applications of manures generally have brought significant increases in growth and yield parameters of crops (Becker and Johnson, 1989; Agyenim-Boateng and Peprah, 2001; N'Dayegamiye and Tran, 2001; Agyarko et al., 2006; Zayed et al., 2013; Ibrahim and Fadni, 2013; Atta-Poku et al., 2014).

Specifically manure application has had also positive effects on growth and yield of cabbage, with chicken manure application having higher effects than any other manure materials in treatments (Baitilwake et al. 2011; Moyin-Jesu, 2015; Hussain et al, 2016) as in the current study. The sole chicken manure and its combined treatments recorded significantly higher growth and yield values of cabbage. Atta-Poku et al. (2014), also in a similar study where chicken manure was combined with *Mucuna pruriens* in soil amendment for the growth and yield of carrot, observed similar trend of results.

The sole chicken manure recorded higher HI values in both years of planting, where the yields of cabbage recorded were also the highest. HI of a crop is higher when its crop yield is higher (Arshad, 2017).

The fresh head weight of cabbage highly related with some soil nutrients, which is obviously expected for all crops, for the yield of crops depends on soil nutrients, and the aim of all fertilizer applications is to increase the level of soil nutrients for better crop yield.

The year of planting affects crop yield, especially under rain-fed farming and this is reflected in the results where the 2012 cabbage plants had values higher than their corresponding 2011 plants which may due to the differences in the rainfall regimes (Fig. 1) and higher release of nutrients from the amendments in the second planting season (Ramamurthy and Shivashankar, 1996).

5. Conclusion

The *Mucuna pruriens*(M), cattle manure and chicken manure(CM) soil amendment increased the soil organic matter percentage, total nitrogen percentage, exchangeable calcium, magnesium and potassium and available phosphorus. The soil pH did not change significantly. The highest organic matter percentage was recorded by the sole M treatment, with the sole CM having almost higher values for the other parameters. Cabbage plants from the amended treatments recorded significantly ($p \leq 0.05$) higher number of cabbage leaves and plant height, larger canopy spread, higher fresh head weight and dry head weight of cabbage than plants from the unamended treatment. The sole CM and its combined treatments recorded higher values of the growth and yield parameters. The CM in both years generally had higher harvest index (HI) values. Fresh head weight of cabbage highly related in some situations with the soil nutrients. Planting season affected crop yield, the 2012 cabbage plants had values higher than their corresponding 2011 plants.

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