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Evaluation of Maize Response (*Zea mays* L.) to Various Modes and Moments of Chicken Manure Spreading in Lubumbashi, DR Congo

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ABSTRACT

Soils of sub-saharan countries have low inherent fertility, this deficiency is main factor determining agricultural production. Most of previous studies showed beneficial effects of organic matter in improving physical and chemical properties of soil and increasing yields. However, it remains unclear about when and how to spread the organic matter to get maximum nutrients for plants. This study was conducted in conditions of Lubumbashi to determine the influence of spreading modes and moments of chicken manure on maize yield. A trial was installed following a 2×5 factorial design. The treatments, in 3 repetitions, included 2 methods of spreading (in localization and in coverage) and 5 spreading moments (0, 1, 2, 3 and 4 weeks before sowing). Chicken manure obtained at DAIPN farm (Kilobelobe) were used as organic manure. A sample of chicken manure was analyzed in the Laboratory of the Faculty of Agricultural Sciences (UNILU) showed high percentage of nitrogen and phosphorus. This study revealed that all treatments were statistically similar regarding all growth and yield parameters. Although, the result of the analysis of variance revealed that there is no significant difference between the treatment, it is observable that spreading in coverage to a week before sowing gave the best yield (4.4 t ha^{-1}). In the conditions of Lubumbashi, where maize is a very important aliment, yield increase generated by the application of chicken manure in coverage a week before sowing would be useful.

Key words: Chicken manure, maize yield, spreading modes, spreading moments

INTRODUCTION

Demographic growth in the Upper-Katanga is very fast and also causes food need increase. According to FAO (2008), one of causes of food insecurity in the world is the rising prices of food commodities following the fall in supply and the increase in demand. It is therefore an obligation for farmers to significantly increase production to feed this growing population. However, in the wake of natural constraints, soils of sub-saharan countries have low inherent fertility. These

deficiencies are factors determining agricultural production (Kimuni *et al*., 2012). According to Ngongo *et al*. (2009), soils in a number of regions in the Democratic Republic of Congo, particularly in Lubumbashi consists ferralsols (lateritic soils), characterized by deep weathering and nutrient element for poverty cultured plants. This poor soils induces crop yield decrease and so constitute a main concern for farmers in this region.

Furthermore, fallow was one of alternatives in former moments to maintain and improve soil fertility. It allowed soils to recover large amounts of organic matter and fertility. However, this practice is no longer compatible with current conditions due to climate change and high population pressure. It is therefore necessary to apply short-term fertilization techniques (Kimuni *et al*., 2014a) and accessible to farmers namely mineral fertilizers and organic fertilization (Gala Bi *et al*., 2011; Kaho *et al*., 2011; Mukonzo *et al*., 2013; FAO., 2008; Kimuni *et al*., 2013). These practices are not without impact on the finance of the farmers who practice a subsistence agriculture. One of promising way to increase agricultural production is to apply different types of organic wastes (Harmand and Balle, 2001; Francis *et al*., 2000) which, improve chemical, physical and biological properties of soils (Cameron *et al*., 2004; Bresson *et al*., 2001; Kimuni *et al*., 2014a, b; Jouquet *et al*., 2010) while releasing the necessary nutrients for plants (Mulaji, 2011; Ojetayo *et al*., 2011). Convertini *et al*. (1999) showed positive effects of these substances on crop yields in various soil and climatic conditions. Recent studies (Abdelrazzag, 2002; Akanza and Yoro, 2003; Boateng *et al*., 2006; Ayeni and Adetunji, 2010; Akanza and Yao-Kouame, 2011; Yoldas *et al*., 2011; Madisa *et al*., 2013; Agyeman *et al*., 2014) demonstrated the effectiveness of chicken manure in increasing yield of different crops, including maize. However, information on method and time of application in maize farming are insufficient in the Lubumbashi region where maize is a staple food crop.

Thus, the objective of this study is to evaluate the effects of different modes and moments of organic waste spreading on the behavior of maize. This study verifies the following hypothesis: Spreading mode and time of organic waste influence their decomposition rates that would impact on the behavior of crops, especially maize.

MATERIALS AND METHODS

Description of the study area: This study was conducted during 2011-2012 crop season in Kassapa Farm, Research Station of Faculty of Agricultural Sciences at the University of Lubumbashi (27°28'37" E, 11°36'44" S and 1274 m altitude), Lubumbashi (11°39' S and 27°28' E).

The region of Lubumbashi (Fig. 1), capital of Upper-Katanga province is located in a climate zone type CW6 according to Koppen classification. It is characterized by an alternation of two seasons in a year, a wet season (November-March) and a dry season (May-September) with October and April as transition months. The annual rainfall is 1270 mm with extreme values of 717 and 1770 mm (Mpundu, 2010). Lubumbashi soils are acidic and belong to ferralsols group according to the World Benchmarks of soil classification and this is due to either the position or topographic or drainage (Mpundu, 2010; Mujinya *et al*., 2011).

The composite soil sample collected on the experimental site and analyzed in the Laboratory of the Centre de Recherche Agro-Alimentaire (CRAA), according to methods described by Mpundu (2010), gave the following results: Total N = 0.224%, total P = 0.0224%, available P = 0.0058%, S = 1.03%, Ca = 0.04% and Mg = 0.816%.

Trial management: Unilu maize variety was used as biological material. This variety has been developed by the Faculty of Agricultural Sciences, University of Lubumbashi. Chicken manure

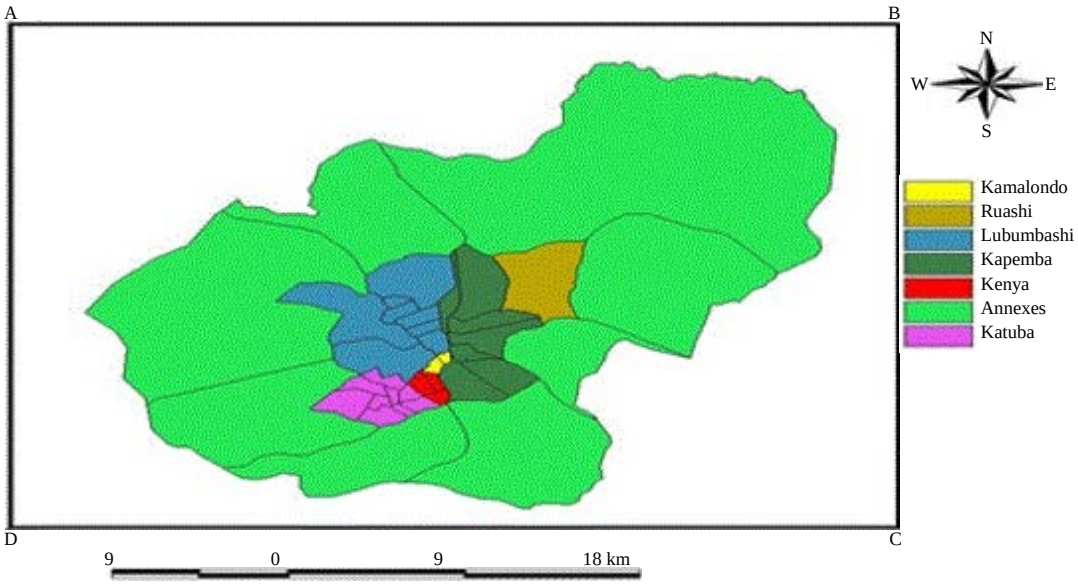

Fig. 1: Localization of the city of Lubumbashi in the province of Upper-Katanga (Munyemba, 2010)

obtained at DAIPN farm (Kilobelobe) were used as organic manure. A sample of chicken manure was analyzed in the Laboratory of the Faculty of Agricultural Sciences (UNILU) as described by Mulaji (2011). The trial was installed following a 2×5 factorial design. The treatments, in three repetitions, included 2 methods of spreading (in localization and in coverage) and 5 spreading moments (0, 1, 2, 3 and 4 weeks before sowing). The soil was tilled (depth 30 cm) and harrowed with the tractor 2 weeks before the spreading of chicken manure. The maize grains were sown to a density of 53333 plants ha^{-1}. To control weeds, two manual weeding's were organized following their abundance with a hoe. The following parameters: Emergence rate, the plant height, height to ear insertion, the number of days to male and female flowering were observed during test. At harvest, the weight of 1000 grains and maize grain yield were determined.

Statistical analysis: The analysis of variance (ANOVA) and the separation medium (Newman-Keuls test) were used to determine differences between treatments using the SAS software 19.

RESULTS

Chemical composition of chicken manure: The laboratory analysis showed that chicken manure contained high percentages of total nitrogen and phosphorus which are among the major elements that plants require. Chicken manure also contained estimable percentages other major elements such as potassium and calcium (Fig. 2).

Influence of modes and moments of organic manure spreading on the behavior of maize crop: Examination of Fig. 3 and 4 show similar results between all the treatments with regard to the different growth parameters observed. As a result, the various spreading mode of chicken manure days to male flowering ($p = 0.089$) and n umber of days to female flowering ($p = 0.53$). Furthermore, the analysis of Fig. 3 showed that the spreading moments of chicken manure had no effect on emergence rate ($p = 0.47$), the plant height ($p = 0.777$), the height to the

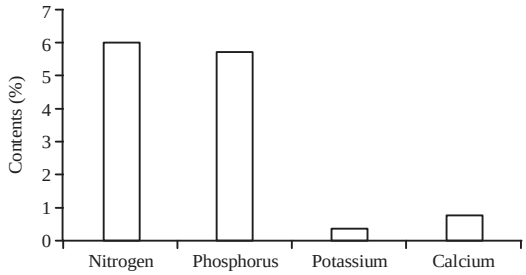

Fig. 2: Chemical composition of chicken manure

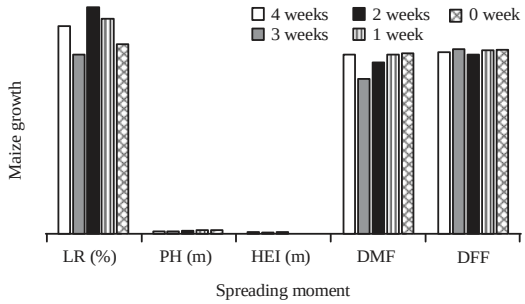

Fig. 3: Effects of chicken manure spreading moments on maize growth, LR: Lifting rate (%), PH: Plant height (m), HEI: Height to ear insertion (m), DMF: Days to male flowering and DFF: Days to female flowering

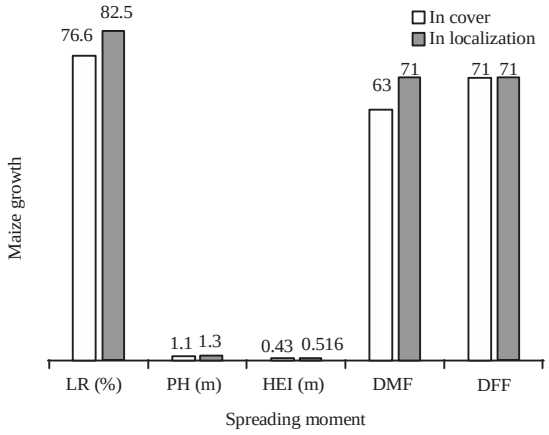

Fig. 4: Effects of chicken manure spreading modes on maize growth, LR: Lifting rate (%), PH: Plant height (m), HEI: Height to ear insertion (m), DMF: Days to male flowering and DFF: Days to female flowering

ear insertion ($p = 0.235$), number of days to male flowering ($p = 0.377$) and number of days to female flowering ($p = 0.258$). This implies that neither the method nor the time spreading of organic waste will significantly influence the growth of maize.

Effect of spreading modes and moments of chicken manure and their interaction on maize growth: The raw results submitted to the analysis of variance (Fig. 5) showed no influence

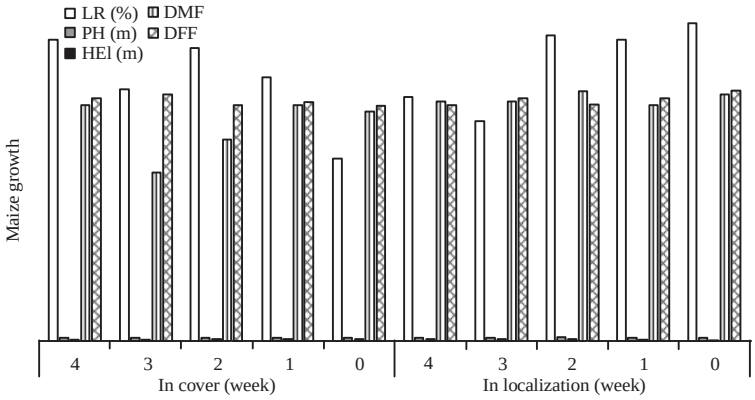

Fig. 5: Combined effect of modes and spreading moments of chicken manure on maize growth, LR: Lifting rate (%), PH: Plant height (m), HEI: Height to ear insertion (cm), DMF: Days to male flowering and DFF: Days to female flowering

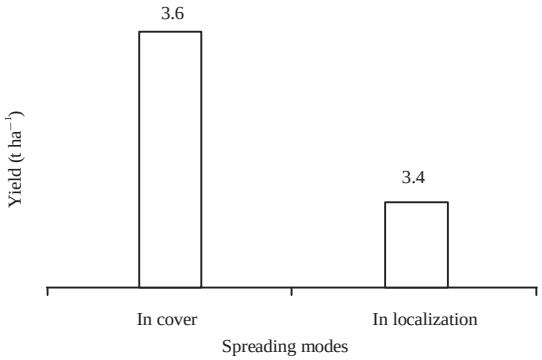

Fig. 6: Chicken manure spreading mode effects on maize yield (p = 0.699)

of modes, application moments of chicken manure and their interaction on emergence rate (p = 0.132), plant height (p = 0.827), the height to ear insertion (p = 0.607), number of days to male flowering (p = 0.455) and number of days to female flowering (p = 0.125). This implies that the interactions between spreading modes and moment of organic matter don't affect in any way the maize growth.

Maize yield under different modes and moments of chicken manure spreading: Examination of Fig. 6 and 7 reveals that the application method and the moment of application induced similar result on maize yield.

The analysis of variance revealed no significant difference between different modes (p = 0.699) and moments (p = 0.836) of chicken manure spreading. These results imply that the mode and time of organic matter spreading does not influence maize yield.

Effect of spreading modes and moments of chicken manure and their interaction on maize yield: Figure 8 and 9 show the weight of 1000 grains and the grain maize yield as a result of different modes and application moments of chicken manure, respectively. Statistical analysis showed a similar effect of spreading modes and time on the 1000 grain weight (p = 0.737) and grain maize yield (p = 0.370). Analysis also showed that interaction produced no significant effect on maize yield parameters.

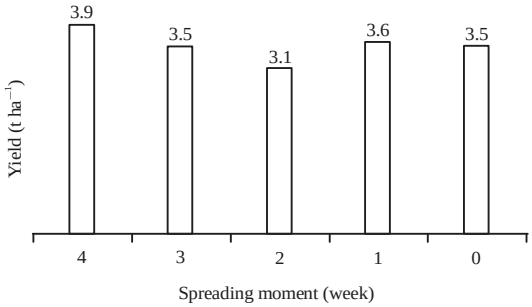

Fig. 7: Chicken manure spreading moment effects on maize yield (p = 0.836)

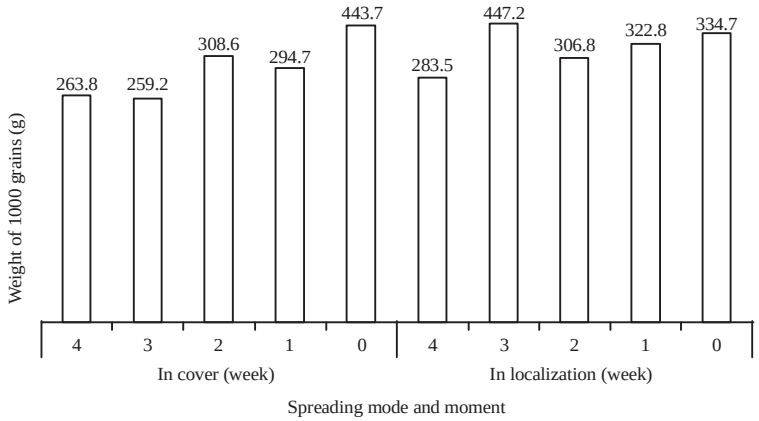

Fig. 8: Combined effect of different spreading modes and moments of chicken manure on 1000 grain weights (p = 0.737)

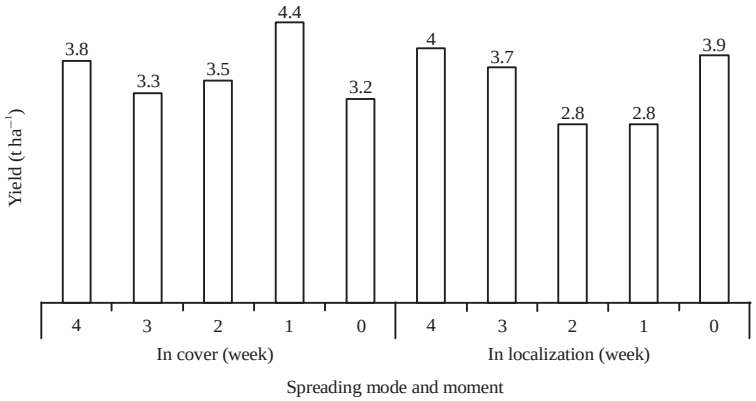

Fig. 9: Combined effects of different spreading modes and moments of chicken manure on maize yield (p = 0.370)

DISCUSSION

Choice of the variety: The choice of variety UNILU is justified by the fact that it is one of the most popularized varieties grown in the study area (Lubumbashi). This variety has a high resistance to diseases (leaf blight, leaf spot and streak), pests, high potential yield (7-8.5 t ha^{-1} at

a density of 53333 plants ha^{-1}). In addition, it is characterized by small size of plants that makes them resistant to lodging (Kimuni *et al*., 2012).

Chemical composition of chicken manure: The results showed that the chicken manure used in this study contained high nitrogen and phosphorus content, compared to other types of organic waste (Jama *et al*., 2000; Kaho *et al*., 2007; Kimuni *et al*., 2014b). These are among the major elements that the plant needs to complete its growth cycle and produce. The chemical composition of chicken manure shows that they have a great ability to improve soil quality and crop yields.

The decomposition of organic matter releases nutrients to plants and humus increases the nutrient content, which has a positive effect on the physical, chemical and biological properties of soil. Thus the fertility of a soil is determined by the presence and content of nutrients and organic matter (Kaho *et al*., 2007). This hypothesis was confirmed by Rahman and Parkinson (2007) in MOSES (2012), stating that the organic matter is an important component of soil fertility. This means that a soil with high in organic matter has a good structure, high stability, good mobility and availability of nutrients (Ros *et al*., 2006). This justifies the increase in the yield of maize fertilized with chicken manure. In this study, compared yield with those obtained by Kimuni *et al*. (2012) (2.1 t ha^{-1}) and MOSES (2012) (1.2 t ha^{-1}), using the same variety on unfertilized plots.

Effect of modes and moments of chicken manure spreading on maize growth: The results on the effects of modes and moments of organic manure spreading have revealed no significant difference on all growth parameters observed. This would be justified by the fact that organic fertilizers are mineralized throughout the growing season; their mineralization and nitrogen availability does not always coincide with the cycle of crop growth. This hypothesis was proven by Giroux *et al*. (2007), who reported that the accumulation of organic matter in the soil is a slow, much slower than the decline.

Effect of modes and moments of chicken manure spreading on maize yield: The average yields obtained with different moments and modes of chicken manure spreading and their interactions were similar. This means, nor how nor the time of application or their interaction did not induce a significant effect on maize yield. These results, which are in contrary to the hypothesis, would be justified by the fact that organic matter (manure from chickens) applied to the soil to different modes and moments does not influence the release of nutrients to the plant. Similar results have been obtained by Weill and Duval (2009) in Canada who showed that total and marketable yields of potatoes were not significantly different between autumn spreading periods or spring, but were between types of organic fertilizers for total yields. In relation to this study, although the statistical analysis have revealed similar results between different modes and moments of organic waste spreading, observing results reveals that the highest efficiency is however obtained on plots with the organic waste covered one week before sowing (4.4 t ha^{-1}). The results, which are out of the imagination, be due to the mode of spreading of chicken manure. Indeed, topdressing allowed good mineralization of organic matter, since the large area occupied by the organic material spread promotes good growth of microorganisms involved in decomposition and mineralization. However, the spreading localization was not a good decomposition of organic matter. There where manure or compost are applied in anaerobic conditions, they break bad, did not provide their nitrogen and other plant nutrients and can even be toxic. This clearly demonstrates that the application by location induced a pile of manure, putting it in the anaerobic

conditions. Therefore, the mineralization of mineral elements was inhibited. These results are beneficial for the small farmer producing at reduced cost. Indeed, it is advantageous to spread the organic matter in coverage than in location which requires a huge cost of labor.

CONCLUSION

The results obtained in this study showed that the different modes and moments of chicken manure spreading induced similar behavior for all parameters studied. However, observing the results reveals that the chicken manure spreading 1 week before sowing induces good yield (4.4 t ha^{-1}). This method of application seems to be advantageous for farmers (small producers) regarding labor cost. The agricultural use of organic waste is an effective asset for sanitation in urban areas and increased crop yield improvement.

SIGNIFICANT STATEMENTS

In most cities organic waste production is common, in parallel the productivity of food crops is very low either because of the scarcity of mineral fertilizers or due to misuse of organic matter. Thus, this study trying to answer the following questions:

- When chicken manure spreading improves the growth and increases maize yield?
- Which mode of spreading of chicken manure improves the growth and increases maize yield?

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