YIELD RESPONSE OF FINGER MILLET (ELEUSINE CORACANA L.) TO POULTRY MANURE APPLICATION IN WESTERN KENYA

Kenya Agricultural and Livestock Research Organization
P.O. Box 169-50100, Kakamega

ABSTRACT
Declining soil fertility is affecting finger millet production in western Kenya and inorganic fertilizer use is expensive for most small holder farmers. With over 90% of farmers keeping poultry, its manure appears to be a potential alternative source of fertilizer for finger millet production. An experiment was conducted at KALRO - Kakamega to evaluate the yield response of finger millet (Eleusine coracana L.) to different rates of poultry manure (0, 5, 10, 15, 20, 25 and 30 t/ha). This was carried out during the long rains season (March - August) and short rains season (September - December) of 2016. Experimental layout was a Randomized Complete Block Design with three replications. Results indicated significant yield increase from 1,148 kg/ha (control 0 t/ha rate) to 1,925.9 kg/ha (5 t/ha rate), which was significantly different from the 10 t/ha rate (2,463 kg/ha) during the long rains season. No significant yield increase was observed beyond 10 t/ha. Similarly, no significant yield difference was recorded with increasing rates of poultry manure during the short rains season. This clearly indicated that, during the short rains season, finger millet yield may have been affected by other factors besides poultry manure rates. Significantly higher mean yields were recorded during the long rains (2,431.7 kg/ha) when compared to the short rains season (936.5 kg/ha). The positive yield response of finger millet to increased rates of poultry manure application during the long rains season indicates that smallholder farmers can consider using poultry manure (5-10 t/ha) as an alternative fertilizer for finger millet production.

Keywords: Finger millet, soil fertility, poultry manure

INTRODUCTION
Finger millet is an important food security and cash crop for small holder farmers in western Kenya, with major production areas being Busia, Kisii, Nyamira, and Bungoma counties (National Research Council, 1996; Mgonja et al., 2007). Production constraints include declining soil fertility, high labour requirements, pests and diseases (Takan et al., 2002). The most outstanding milestone in finger millet research has been yield increase resulting from inorganic fertilizer use (Malinda and Manish, 2015). Research from International Crops Research Institute for the Semi-arid Tropics (ICRISAT) revealed the benefits of micro-dose fertilizer recommendations for finger millet production (ICRISAT, 2009). However, small scale farmers are still unable to adopt this recommended amounts of fertilizer for use on large plots of land.

Improved finger millet varieties promoted in western Kenya have recorded good performance during long rainy seasons (Wafula et al., 2016). However, prolonged drought experienced during short rainy seasons has led to poor performance of late - maturing finger millet varieties. Early - maturing finger millet variety U-15 shows remarkable field performance during both seasons hence popular with farmers in western Kenya (Wafula et al., 2016).

Soil fertility in western Kenya is declining due to soil fertility mining resulting from continuous cropping patterns (Shepherd and Soule, 1998; Soule and Shepherd, 2000; Okalebo et al., 2005). Some soil health management practices, such as crop residue recycling, biomass transfer, short fallows in addition to other organic practices being used by small scale farmers in the region seem inadequate in countering nutrient outflows (Bekunda et al., 2002). Despite positive responses witnessed from application of inorganic fertilizers, these have proved expensive for most poor small holder farmers thus posing a threat to finger millet production in western Kenya. About 31.5% of rural households in western Kenya are living in poverty (Place et al., 2003). Use of alternative organic fertilizer sources such as use of green, farmyard and poultry

*Corresponding author: neks2030@yahoo.com
manures and use of legumes have been recommended for crop production. Organic fertilizer studies on African indigenous vegetables indicated that poultry manure gave the highest yield response (Koura et al., 2013). Poultry manure has also been reported to be the most valuable of all animal manures if handled properly (Adekiya and Agbede, 2009).

Over 90% of western Kenya farmers keep poultry (Otiang et al., 2020). Poultry manure therefore, appears to be potentially more accessible and easier to collect and use. However, its potential contribution to the faster recovery of soils with low fertility, while improving finger millet yields is still unknown. The aim of this study was to evaluate yield response of finger millet variety (U-15) to different rates of poultry manure application.

MATERIALS AND METHODS

Study Area
The study was conducted on-station at Kenya Agricultural and Livestock Research Organization (KALRO) - Kakamega (Longitude 34° 47' E and Latitude 00° 17' N) during the long rains (March - August) and short rains (September - December) of 2016. The research station is located in Upper Midland zone 1 at an altitude of 1585 m a.s.l., receiving an annual rainfall of 1600 - 2000 mm and mean temperature ranges of 18.5 – 21°C.

Experimental Design
Treatments involved testing different poultry manure rates (0, 5, 10, 15, 20, 25 and 30 t/ha) on finger millet variety, U-15 with 0 t/ha manure rate as control. Experimental design was Randomized Complete Block Design with three replications. Well-decomposed poultry manure was incorporated into 3 m × 3 m plots before planting. Finger millet seed was sown by drilling at a spacing of 30 cm × 15 cm in plots prepared to a fine tilth at the on-set of rains. Data was collected on plant height, tiller number and grain yield for each treatment at physiological maturity.

Statistical Data analysis
SAS GLM procedure was used to analyse data and the treatment means were separated by Fischer’s protected LSD method.

RESULTS

<table>
<thead>
<tr>
<th>Treatment (t/ha)</th>
<th>Plant height (cm)</th>
<th>Tiller Number</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>73.47 c</td>
<td>2.9 a</td>
<td>1,148.1 d</td>
</tr>
<tr>
<td>5</td>
<td>74.33 bc</td>
<td>2.8 a</td>
<td>1,925.9 c</td>
</tr>
<tr>
<td>10</td>
<td>76.93 abc</td>
<td>3.1 a</td>
<td>2,463.0 b</td>
</tr>
<tr>
<td>15</td>
<td>78.43 abc</td>
<td>2.9 a</td>
<td>2,481.5 b</td>
</tr>
<tr>
<td>20</td>
<td>81.17 a</td>
<td>2.6 a</td>
<td>2,855.6 ab</td>
</tr>
<tr>
<td>25</td>
<td>79.97 ab</td>
<td>3.4 a</td>
<td>3,037.0 a</td>
</tr>
<tr>
<td>30</td>
<td>80.87 a</td>
<td>3.3 a</td>
<td>3,111.1 a</td>
</tr>
</tbody>
</table>

Mean: 77.88  3  2,431.74  433.26  10.2
LSD(0.05): 6.36  0.87  16.2
C.V. (%): 53.10  2.95  3.12

Means followed by the same letter in a column are not different (P ≥ 0.05)

Finger millet yield increased with increasing rates of poultry manure during the 2016 long rains (Table I). Control (0 t/ha) lower yield (P ≥ 0.05) compared to all other treatments while no significant difference in finger millet yield with application of poultry manure of 10, 15 and 20 t/ha observed. The 5 t/ha application gave lower yields (P ≥ 0.05) compared to the 10, 15 and 20 t/ha manure application. Yields of poultry manure applied at 20 t/ha did not significantly differ from those of 25 and 30 t/ha. Similarly, finger millet height increased with additional application of poultry manure during the 2016 long rains season. However, this increase was not significantly different across treatments 10 to 30 t/ha (P < 0.05). There were also no significant differences in tiller numbers across all treatments.

<table>
<thead>
<tr>
<th>Treatment (t/ha)</th>
<th>Plant height (cm)</th>
<th>Tiller Number</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50.77 b</td>
<td>4.9 a</td>
<td>870.4 a</td>
</tr>
<tr>
<td>5</td>
<td>53.63 ab</td>
<td>4.2 ab</td>
<td>1,025.9 a</td>
</tr>
<tr>
<td>10</td>
<td>53.30 ab</td>
<td>3.5 c</td>
<td>1,014.8 a</td>
</tr>
<tr>
<td>15</td>
<td>53.17 ab</td>
<td>4.6 ab</td>
<td>966.7 a</td>
</tr>
<tr>
<td>20</td>
<td>53.27 ab</td>
<td>4.2 abc</td>
<td>925.9 a</td>
</tr>
<tr>
<td>25</td>
<td>55.30 a</td>
<td>3.8 bc</td>
<td>870.4 a</td>
</tr>
<tr>
<td>30</td>
<td>52.30 b</td>
<td>3.7 bc</td>
<td>881.5 a</td>
</tr>
</tbody>
</table>

Mean: 53.10  4.12  936.51
LSD(0.05): 2.95  0.96  274.25
C.V. (%): 3.12  12.9  16.4

Means followed by the same letter in a column are not different (P ≥ 0.05)
In contrast to the long rains, no significant yield differences were observed across treatments applied during the short rains season. There were also no significant differences in plant height and tiller numbers with increased application of poultry manure (Table II).

### TABLE III - MEAN FINGER MILLET YIELD AND YIELD PARAMETERS ACROSS PLANTING SEASONS

<table>
<thead>
<tr>
<th>Season</th>
<th>Plant Height (cm)</th>
<th>Tiller number</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long rains</td>
<td>77.88 a</td>
<td>3.0 b</td>
<td>2,431.74</td>
</tr>
<tr>
<td>Short rains</td>
<td>53.10 b</td>
<td>4.1 a</td>
<td>a</td>
</tr>
<tr>
<td>Mean</td>
<td>65.49</td>
<td>3.5</td>
<td>936.51 b</td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>1.78</td>
<td>0.3</td>
<td>129.81</td>
</tr>
<tr>
<td>C.V. (%)</td>
<td>4.26</td>
<td>14.4</td>
<td>12.1</td>
</tr>
</tbody>
</table>

Means followed by the same letter in a column are not different (P ≥ 0.05)

Comparisons across planting seasons showed that finger millet yields were higher (P ≤ 0.05) during long rains season when compared to the short rains season. In terms of height, finger millet plants were taller (P ≤ 0.05) during the long rains season when compared to the short rains season. Finally, finger millet plants produced significantly higher number of tillers during the short rains season when compared to the long rains season.

### DISCUSSION

Response of finger millet to additional application of poultry manure during the long rains season in this study indicates that finger millet has potential to yield higher when nutrient supply is increased and moisture supply adequate. These results compare with those of Damar et al. (2016) who studied the effect of poultry manure on growth and yield of finger millet in Nigeria. In this study, higher rates of poultry manure produced better finger millet yields. This increase in yield with increasing application rates of poultry manure indicates that the amount of nutrients available for finger millet production may have increased with additional manure application. Besides phosphorus (P) and potassium (K), poultry manure is rich in nitrogen (N). Nitrogen is an essential element for finger millet growth during early vegetative growth (pre-anthesis). When plants receive adequate supply of nitrogen during pre-anthesis, they form adequate chloroplasts allowing photosynthesis to occur leading to increased plant biomass and crop yields (Wu et al., 2018). Rhoads and Stanley Jr. (1981) studied fertilizer scheduling, yield and nutrient uptake of irrigated corn and reported that yield positively correlated with dry matter and nutrient accumulation. Other studies conducted on wheat indicated that grain yield depends on translocation of pre-anthesis assimilates and N accumulation (Cox et al., 1985; Papakosta and Gagianas, 1991).

In the current study, increased finger millet yield observed during the long rains season indicates that there may have been an increase in biomass accumulation in finger millet as a result of higher N with additional quantities of poultry manure applied. A study by Boateng et al. (2006) on the effects of poultry manure on growth and yield of maize in Ghana indicated that poultry manure application registered over 53% increase of N levels in soil and exchangeable cations increased with manure applications leading to improved maize yields.

Nitrogen uptake by plants triggers growth in height and girth leading to improved plant architecture, enabling plants to draw adequate nutrients from soil. Maqsood and Azam (2007) studied the effects of environmental stress on growth and radiation use efficiency (RUE) of finger millet in semi-arid tropics of Asia and Africa. They reported nitrogen and phosphorus to be critical determinants of growth and productivity, with plant growth and root morphology as important parameters for evaluating effects of supplied nutrients. Their study indicated that finger millet height increased with N application. Finger millet plants in the current study may have received adequate N supply throughout their growth period as a result of adequate soil moisture resulting to taller plants observed during the long rains season when compared to the short rains season.

The poor response of finger millet despite additional application of poultry manure during short rains indicates that nutrient uptake by finger millet plants was affected by other factors. One factor that may have contributed to the poor uptake of nutrients may have resulted from the low rainfall experienced. Poultry manure contains all the essential nutrients that plants require for crop growth, main ones being Nitrogen, Phosphorus and Potassium (Amanullah et al., 2010). Readily available forms of P and K are released in soil over time and can be easily taken up by plants. On the other hand, N from manure is in two forms; that is, organic N and inorganic N. A significant portion of the manure is in organic form not immediately
available for plant uptake. About 25% of N found in poultry manure is inorganic N and immediately available for plant uptake (Gordon, 2011). The rest is organic form and has to undergo mineralization to become available for plant uptake. Mineralization converts organic forms of plant nutrients into plant-available inorganic forms through decomposition of manure by soil microbes (Leikam and Lamond, 2003). Mineralization is affected by temperature, soil moisture, soil properties and manure characteristics. Mineralization increases with increasing temperatures and adequate soil moisture (Eghball et al., 2002). However, when soil temperatures are too high, inorganic N is lost through volatilization. For nutrients to be taken up by plants, adequate soil moisture is required since nutrients move with water as it being taken up by plants. Water, therefore, serves as a medium for diffusion and mass flow of nutrients into plant roots (Oliveira et al., 2010). The prolonged drought experienced during the short rainy season may have led to loss of plant available N through volatilization. Low soil moisture may have led to poor mass flow of water and nutrients from soil into roots of finger millet, depriving plants of adequate nutrients hence poor yields during the short rains season. The numerous tillers produced during short rains season did not translate to high yield indicating that tillers produced were non-productive. Productive (fertile) tillers in grasses are induced to flower and contribute to increased seed yields. For flowering to occur, tillers have to receive adequate N supply (Chastain et al., 2017). Most tillers produced during the short rains season in this study may have lacked adequate N supply during floral initiation, resulting from poor mass flow of nutrients to plant roots. This poor mass flow of nutrients may have been caused by limited soil moisture experienced during the short rainy season; hence, formation of numerous non-productive tillers, contributing to poor finger millet yield when compared to the long rainy season. Finger millet plants in the short rains season were also shorter compared to plants in the long rains season. This reduction in plant height may have resulted from environmental stress (moisture and nutrients) experienced during the short rains season. It is likely that the stressful environment caused stunting and prevented finger millet plants from achieving their height potential.

CONCLUSION AND RECOMMENDATIONS
Application of poultry manure to finger millet variety U-15 increased finger millet yield with each additional rate of application during the long rains season. This clearly indicates that smallholder farmers can consider using poultry manure for finger millet production when soil moisture is adequate. According to this study, the rate of 5-20 t/ha is recommended since there were no significant differences in yield beyond 20 t/ha of the manure application. In the future, it would be worthwhile to look at the effects of poultry manure application on soil health and soil physical characteristics since this study only focused on the effects of poultry manure on finger millet yield and yield parameters.

ACKNOWLEDGEMENT
This research was funded by the McKnight Foundation and logistics provided by Kenya Agricultural and Livestock Research Organization.

REFERENCES


