

Full Length Research Paper

# Up-scaling napier grass (*Pennisetum purpureum* Schum.) production using “Tumbukiza” method in smallholder farming systems in Northwestern Kenya

Elkana M. Nyambati<sup>1\*</sup>, Charles M. Lusweti<sup>1</sup>, Francis N. Muyekho<sup>1</sup> and Joseph G. Mureithi<sup>2</sup>

<sup>1</sup>Kenya Agricultural Research Institute (KARI), National Agricultural Research Center, P. O. Box 450 - 30200, Kitale, Kenya.

<sup>2</sup>Kenya Agricultural Research Institute (KARI), P. O. Box 57811 - 00200, Nairobi Kenya.

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Low and declining soil fertility and inadequate livestock feeds are major constraints limiting dairy productivity in smallholder farming systems in North-western Kenya. Napier grass (*Pennisetum purpureum* Schum.) is the most popular fodder used by dairy farmers. The farmer field school (FFS) and farmer participatory research (FPR) approaches were used to up-scale ‘tumbukiza’, a ‘Kiswahili’ word meaning placing in a hole, a new method of Napier grass production started by farmers which uses integrated nutrient management strategy to enhance efficient use of nutrients with sustained greater dry matter yields compared to the conventional method. In both methods, four fertilizer treatments were used: (1) 10 t ha<sup>-1</sup> farm yard manure (FYM); (2) 5 t ha<sup>-1</sup> FYM; (3) 5 t ha<sup>-1</sup> FYM + 30 kg ha<sup>-1</sup> N, and (4) 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> + 60 kg ha<sup>-1</sup> N. Treatments arising from the two methods and four fertilizer rates were laid out in a randomized complete block design (RCBD) where schools or farmers served as replicates. Napier grass under Tumbukiza yielded significantly greater dry matter (DM) from two cuts than the conventional method (P < 0.01). There were no statistically significant differences in DM yields among the different fertilizer treatments across the two methods, suggesting that farmers had a wide option of fertilization regimes. Dry matter, plant height and tiller number data collected by farmers using agro-ecosystem analysis (AESA) showed that Tumbukiza was more superior compared to the conventional method. The FFS approach strengthened the link between stakeholders, increased participation and information flow among farmers, particularly women on available agricultural technologies. Farmers formed FFS networks to sustain the up-scaling process.

**Key words:** Napier, Tumbukiza, tiller, dry matter, up-scaling.

## INTRODUCTION

Low and declining soil fertility and inadequacy of livestock feeds are major constraints limiting productivity in the crop-livestock mixed smallholder farming systems in North-western Kenya. Napier grass (*Pennisetum*

*purpureum* (Schum.) is the most popular fodder used by dairy farmers in these systems because of its high yield potential and drought tolerance, making it suitable as a cut-and-carry fodder compared to other tropical grasses (Boonman, 1997). Although Napier grass is a high yielding fodder, it mines a lot of nutrients, which in addition to the declining soil fertility, unpredictable weather conditions, diseases and pests (Farrell et al., 2001), and poor management result in low dry matter (DM) yields. Its quantity and quality also declines during the dry season (Anindo and Potter, 1994). Although soil fertility can be improved with inorganic fertilizers, their high cost, inaccessibility, and generalized

\*Corresponding author. E-mail: [elkananyambati@yahoo.co.uk](mailto:elkananyambati@yahoo.co.uk).  
Tel: 0722-576217. Fax: 054-31126.

**Abbreviations:** AESA, agro-ecosystem analysis; FFS, farmer field school; FPR, farmer participatory research; FYM, farm yard manure.

recommendations resulting in low, erratic and unprofitable crop responses limit their use, particularly on smallholder farms in Eastern Africa (Nandwa and Bekunda, 1998).

Farmers in the region started a new method of Napier production called 'Tumbukiza' (a Kiswahili word meaning placing in a hole), which ensures efficient use of nutrients with sustained dry matter yields compared to the conventional method (Otieno et al., 1999). In the tumbukiza method, 4 root splits or canes are planted in holes where nutrients have been concentrated. The holes also store water and the crop does not suffer from water stress during the dry season. Since 1995, the Kenya Agricultural Research Institute (KARI) has developed and tested several low cost soil management technologies (Nyambati et al., 2003) and one of these was the use of integrated soil fertility management (ISFM) strategy on both the conventional (planted in hills spaced at inter- and intra – row spacing of 1 × 1 m) (Ruto et al., 1999) and "Tumbukiza" (Muyekho et al., 2003) methods of Napier grass production using FPR approaches with a hope that farmers would quickly adopt them. However, adoption and impact assessment conducted in the region showed that the adoption of these technologies were low (Mose et al., 2003).

Community based farmer participatory approaches are a sustainable means to overcome the socio-economic constraints of new technologies at the farm level that limit the adoption of technologies that come from outside the system (Noordin et al., 2001). The FFS is one of these approaches started in 2001 in Northwestern Kenya (Mureithi et al., 2005, 2007) to scale up and disseminate the developed technologies to address the low and declining soil fertility and inadequacy of livestock feeds in the region. The approach relies on using existing village organizational structures through consultative meetings with groups of farmers (Minjauw et al., 2002; Mureithi et al., 2007). The specific objectives of the research were to: (1) To up-scale and increase the dissemination of "Tumbukiza" compared to the conventional method and the use of organic and inorganic fertilizer combination as low cost means of increasing the quantity and quality of Napier grass fodder; (2) Assess the performance and socio-economic merits of Napier grass production under "Tumbukiza", and (3) Train farmers and enhance information exchange between stakeholders on improved forage production.

## MATERIALS AND METHODS

### Study site

Up-scaling was conducted in three agro-ecological zones of Upper midland 4 (UM<sub>4</sub>) in Trans Nzoia District, Lower highland 3 (LH<sub>3</sub>) in Uasin Gishu District, and lower midland 4-5 (LM<sub>4-5</sub>) in West Pokot District (Jaetzold et al., 2005). The AEZs represent 38% of the 171,840 km<sup>2</sup> of the KARI Kitale regional mandate area in Northwestern Kenya (Nyambati et al., 2003). Farmers in these agro-ecological zones practice crop-livestock mixed farming where dairy is one of the major enterprises and Napier grass is the main

source of feed in these systems. The elevations vary from about 900 m in the Kerio Valley to 2700 m in the cool highlands of Elgeyo escarpment. Rainfall increases with altitude from 200 mm in the inner lowlands of Kerio valley to 2200 mm in the upper highlands. The rainfall pattern in is unimodal, which normally starts in April and continues to October/November. There is a long dry spell from end of November to early March when scarcity of feed is most severe. The major soils are humic Ferralsols in Trans Nzoia, humic Cambisols in West Pokot, ferralic Cambisols and ferraalic-chromic Acrisols in Uasin Gishu (FAO-UNESCO, 1994).

### Experimental procedure

The farmer field school approach (Mureithi et al., 2007) was used in the up-scaling process starting from April 2001 to November 2005 in Northwestern Kenya. After participatory consultations on constraints to farming and potential solutions using appropriate technologies, the farmers in the FFS selected 'Tumbukiza'. In the tumbukiza method of planting, 4 root splits were planted in manured holes. Holes measuring 90 cm diameter and 60 cm depth were dug at a spacing of one metre from edge hole to hole. Top soil was separated from subsoil. The top soil was mixed with farmyard manure or inorganic fertilizer depending on fertilizer treatment used. In the conventional method, one root split was planted in hills spaced at inter- and intra – row spacing of 1 × 1 m. In both the methods, four fertilizer treatments were used namely (1) 10 t ha<sup>-1</sup> farm yard manure (FYM); (2) 5 t ha<sup>-1</sup> FYM; (3) 5 t ha<sup>-1</sup> FYM + 30 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> at planting and 30 kg N ha<sup>-1</sup> as annual top-dress, and (4) 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> at planting and 60 kg ha<sup>-1</sup> N as annual top-dress. Farmers met regularly during the growing season to experiment with the new technology by comparing "Tumbukiza" with the conventional method of Napier grass production. The facilitators provided technical backstopping. The training followed the seasonal cycle of Napier grass production from planting in April until end of year for 13 weeks.

### Data collection and analysis

Napier grass performance was assessed from two cuts in every growing season for two seasons. The first harvesting was done when the crop had reached 1.2 to 1.5 m height and the second cut done after 8 to 12 weeks. Agro-ecosystem analysis (AESA) data collection tool (Akuno et al., 2005) was used by farmers to establish the interaction between the crop and other environmental factors in the field and make measurements. During the AESA data collection session, farmers collect data, process it and present the data to the rest of the "class". Based on the results, farmers interpret the performance of the crop in relation to the treatment applied and make field management decisions on the next course of action. The farmers were divided into sub-groups such that each group made observations on a particular treatment on weekly routines when the AESA was taken in the field. The AESA was taken in a four step process which included: (1) General information; (2) Parameters; (3) Observations, and (4) Recommendations. For Napier grass production, the AESA was taken in a 13 week period and the parameters measured included plant morphology and growth, agronomic aspects such as fertilizer, soil, water, insect and disease systems and weather conditions. The AESA exercise requires several instruments (e.g., measuring tapes, scales, field notebooks and pens) and results in a great deal of data collection. Plant height and number of tillers were determined from 5-representative plants per treatment. Herbage yield was estimated from four "Tumbukiza" holes and from equivalent 16 holes (stools) in the conventional plots. Data used in this study were collected for two growing seasons from April 2001 to November 2002. Napier grass dry matter yields from the FFS and FPR sites was statistically analyzed

**Table 1.** Napier grass dry matter yields ( $\text{t ha}^{-1}$ )<sup>§</sup> under “Tumbukiza” and conventional methods grown in various farmer field schools in Northwestern Kenya.

| Fertilizer treatment  | Method           |                  | Mean             | Farmer ranking |
|---|------------------|------------------|------------------|----------------|
|   | Conventional     | Tumbukiza        |                  |                |
| 10 t ha <sup>-1</sup> FYM   | 5.3              | 9.9              | 7.6 <sup>a</sup> | 4              |
| 5 t ha <sup>-1</sup> FYM  | 4.2              | 8.5              | 6.3 <sup>a</sup> | 1              |
| 60 kg ha <sup>-1</sup> P <sub>2</sub> O <sub>5</sub> + 60 kg ha <sup>-1</sup> N | 4.7              | 8.2              | 6.4 <sup>a</sup> | 3              |
| 5 t FYM + 30 kg P <sub>2</sub> O <sub>5</sub> + 30 kg N ha <sup>-1</sup>        | 5.0              | 10.3             | 7.7 <sup>a</sup> | 2              |
| Mean  | 4.8 <sup>a</sup> | 9.3 <sup>b</sup> | 7.1              |                |
| CV  |                  |                  | 26.8             |                |

<sup>§</sup> Mean of two cuts measured during the FFS school season. Means in the same column or row followed by the same letter are not significantly different ( $P > 0.05$ ) according to Duncan's Multiple range test (DMRT).

as a randomized complete block design on-farm trial where schools/farmers served as replicates using General Linear Model of SAS (SAS, 2001). Treatment means were considered different at  $P \leq 0.05$ . AESA charts were summarized and information presented graphically. Farmer evaluations were conducted both during the AESA observations and during field days (open days for exchanging messages and information).

## RESULTS AND DISCUSSION

### Napier grass DM yields

“Tumbukiza” method yielded significantly higher DM from two cuts than the conventional method ( $p < 0.01$ ) (Table 1). The results are similar to those reported by Muyekho et al. (2003). The greater DM yields under Tumbukiza could be attributed to improved efficiency of nutrient and water use. The effect of fertilization regime was not significant ( $P > 0.05$ ) across the two methods, suggesting that farmers have a wide option of fertilization to use. The combination of 30 kg P<sub>2</sub>O<sub>5</sub> + 30 kg N ha<sup>-1</sup> + 5 t ha<sup>-1</sup> FYM and the recommended rate of FYM (10 t ha<sup>-1</sup> FYM) yielded an average of 1.2 t ha<sup>-1</sup> greater DM than the recommended rate of inorganic fertilizer (60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> + 60 kg ha<sup>-1</sup> N) or half FYM. This suggests that the slowly released nutrients after organic manure application are used more efficiently by the nutrient mining Napier grass. Contrast comparison analysis showed that Napier grass grown under Tumbukiza using 10 tons FYM ha<sup>-1</sup> tended to yield greater DM ( $P = 0.17$ ) than that grown using 5 tons FYM ha<sup>-1</sup>. The results of this study are in agreement with principles of integrated soil fertility management strategy that enhances nutrient use (Vanlauwe, 2004).

### Napier grass plant height and tiller number

Napier grass plant height was significantly taller ( $P < 0.05$ ) in the “Tumbukiza” method than the conventional method, both during the initial establishment and re-growth phases (Figure 1). This suggests that growth was faster under “Tumbukiza” than in the conventional

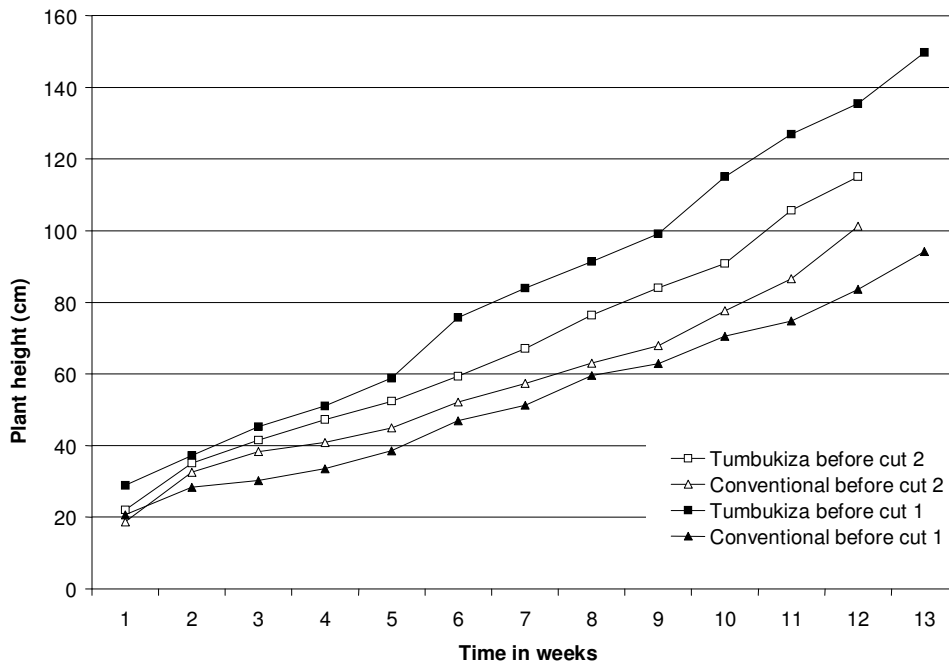
method, showing a positive relationship between plant height and DM yield as similarly reported by Tessema et al. (2003). The rate of tillering was higher after cutting than the phase following establishment (Figure 2) and this could be due to the perennial nature of napier grass, which produces more tillers and vegetative growth as the pasture period increases. The number of tillers was more under the conventional method than “Tumbukiza”. The slower rate of tillering under “Tumbukiza” did not affect herbage DM yield (Table 1) probably because of faster growth rate under this method (Figure 1).

### Economic evaluation

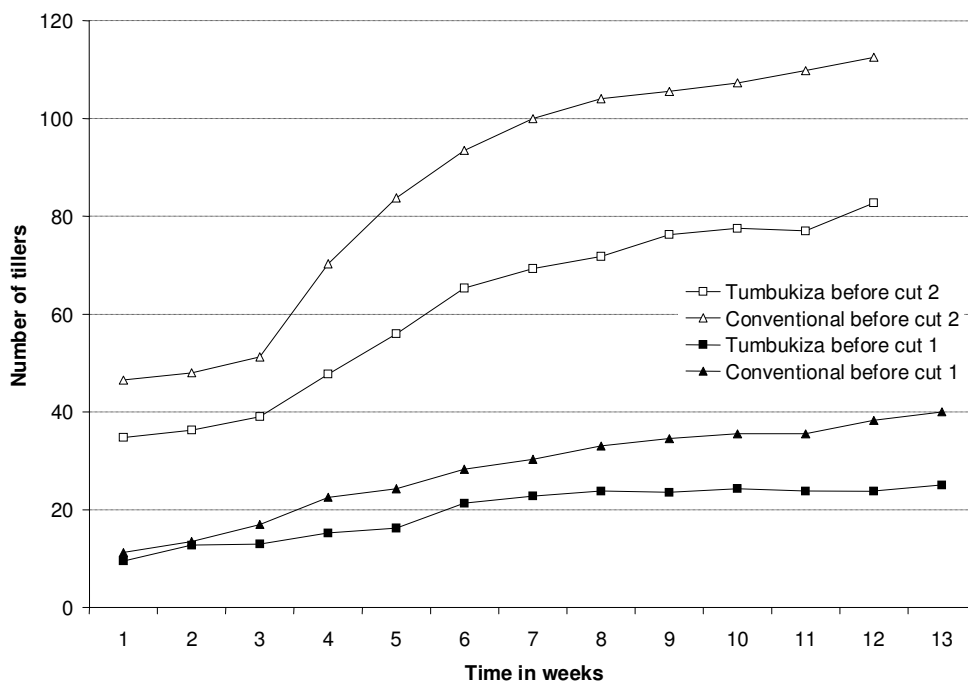
The economic evaluation was done together with farmers as part of AESA based on best three high yielding fertilizer treatments for easy perception of the results by farmers (Table 2). Although the total cost for “Tumbukiza” was higher due to the additional cost of digging the holes, the gross margin for “Tumbukiza” was similar to the conventional method. The ranking of fertilizer treatments showed that farmers preferred “Tumbukiza” than the conventional method, particularly when 5 t ha<sup>-1</sup> organic manure was used alone because that is the amount they could easily get, its low cost and its effect on napier growth. This was followed by the combination of half the recommended rate of 5 t ha<sup>-1</sup> FYM plus 30 kg P<sub>2</sub>O<sub>5</sub> and 30 kg N ha<sup>-1</sup>. Farmers observed that “Tumbukiza” method resulted in higher herbage yields even during the dry season and that it had greener and healthier foliage and longer persistence. This was attributed to efficient nutrient use, better water retention and less competition in the hole. However some of the farmers felt that the “Tumbukiza” method requires a lot of time and money to dig the holes.

### Achievements, impacts and lessons learnt with FFS approach

One of the main successes of the FFS approach was that



**Figure 1.** Change in Napier grass plant height under ‘Tumbukiza’ and conventional methods of production on farmers’ fields in Northwestern Kenya.



**Figure 2.** Rate of Napier grass tillering under “Tumbukiza” and conventional methods of production during the 2001 growing season on farmers fields at Kitale.

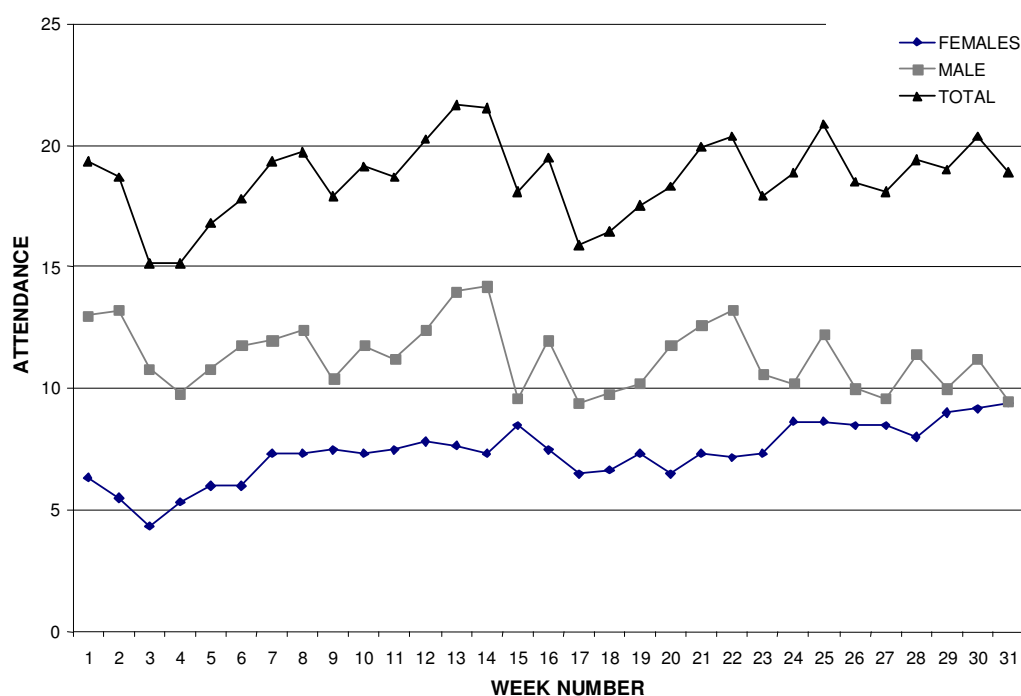
the participation of women farmers was enhanced. About 15 to 20 (mean 19; 60% men and 40% women) farmers regularly attended and successfully completed school

season. An average of 137 farmers (55% men and 45% women) attended field days. Although the initial attendance in FFS was high for men than women (Figure 3),

**Table 2.** Economic evaluation of Napier grass under Tumbukiza and conventional methods in FFS in Northwestern Kenya (KSh.)

|                              | Tumbukiza               |       |       | Conventional |       |       |
|------------------------------|-------------------------|-------|-------|--------------|-------|-------|
|                              | Treatments <sup>§</sup> |       |       | Treatments   |       |       |
|                              | 1                       | 2     | 3     | 1            | 2     | 3     |
| Land preparation             | 2200                    | 2200  | 2200  | 2200         | 2200  | 2200  |
| Tumbukiza holes              | 480                     | 480   | 480   | -            | -     | -     |
| Splits                       | 1000                    | 1000  | 1000  | 1000         | 1000  | 1000  |
| FYM                          | 300                     | 150   | -     | 300          | 150   | -     |
| DAP                          | -                       | 600   | 1200  | -            | 600   | 1200  |
| Labour for planting          | 400                     | 400   | 400   | 200          | 200   | 200   |
| Transport                    | 320                     | 170   | 50    | 320          | 170   | 50    |
| Weeding                      | 600                     | 600   | 600   | 600          | 600   | 600   |
| Harvesting                   | 15000                   | 15000 | 15000 | 15000        | 15000 | 15000 |
| Total variable cost per acre | 20300                   | 20600 | 20930 | 19620        | 19920 | 20250 |
| Income                       | 90000                   | 90000 | 90000 | 90000        | 90000 | 90000 |
| Gross margin                 | 69700                   | 69400 | 69070 | 70380        | 70080 | 69750 |

<sup>§</sup> 1 = 10 t ha<sup>-1</sup> FYM, 2 = 60 kg P<sub>2</sub>O<sub>5</sub> + 60 kg N ha<sup>-1</sup>, and 3 = 5 t ha<sup>-1</sup> + 30 kg P<sub>2</sub>O<sub>5</sub> + 30 kg N ha<sup>-1</sup>.

**Figure 3.** Mean weekly attendance of farmers in various FFS during the 2001 and 2002 growing seasons in northwestern Kenya.

the men comprised most of the dropouts whereas the proportion of women increased steadily and at graduation time the proportion of men and women attending the school were about the same. This suggests that FFS group approach was more effective in catalyzing the participation of women who could otherwise be bypassed

by conventional approaches in agreement with Sanginga et al. (2001).

Despite the fact that several ISFM are available, the dissemination and adoption of these technologies is limited. Education level of the farmers is one of the major determinants of uptake ISFM practices (Odendo et al.,

2009). The FFS created cohesiveness and togetherness among community members (Mwegi et al., 2005), enhancing level of understanding and information exchange resulting in dissemination (Bunyatta et al., 2005). The use of these community based approaches ensures that dissemination of information among group members and to other groups is active and fast leading to significant multiplier effect in disseminating technologies to a wider scale since these approaches have the support of village groups at the grassroots.

The FFS helped farmers to get acquainted with each other and to understand technical messages behind the results they saw. The FFS enhanced farmers' ability to perceive, interpret and respond to new knowledge intensive technologies and react faster. Despite the high labour requirement in "Tumbukiza" method of planting Napier grass, farmers still preferred it due to high yields. Farmers learnt that "Tumbukiza" had wider spaces between the Napier grass stools where they could interplant with other crops with less competition to enhance crop diversification. They intercropped Napier grass with sweet potatoes which is an important crop for food security in the region and which provides nutritious fodder to be fed together with Napier grass. The farmers requested for exchange and study tours which acted as an eye-opener and an inspiration to be more innovative and receptive to new technologies.

One major challenge in up-scaling this technology is the high expectation of farmers to be provided with inputs or finance to purchase dairy cows and non-adoption by farmers without dairy animals. This resulted in high dropouts from the schools. However, the strategy is to continue working with self-supporting groups and members who have realized that the benefit is mainly through gained knowledge. Those farmers without dairy animals were encouraged to sell the Napier grass and earn some income. Where feasible, farmers were advised and guided to write proposals that could secure them support from potential sources or get loans from microfinance institutions. They were also assisted to form FFS network that could empower them and bring them close to government institutions and other service providers such as micro-credit institutions and research and development organizations to sustain the up-scaling process.

## CONCLUSION AND RECOMMENDATIONS

The farmers were able to see the merits of the "Tumbukiza" method of Napier grass production in reducing the shortage of feed that is a major constraint to dairy production. The farmers also learnt the benefit of ISFM practices that make best use of inherent soil nutrient stocks, locally available soil amendments and inorganic fertilizers, to minimize costs of production and increase land productivity. The FFS enhanced the vital

link between farmers, extension and research. Dissemination of information among group members and to other groups was active and fast, leading to significant multiplier effect in disseminating the technology on a wide scale since these approaches had the support of village groups at the grassroots. To sustain up-scaling process farmers from the various farmer field schools that exist in the region were advised to form farmer networks that can empower them to bring them close to government institutions and other service providers such as micro-credit institutions and research and development organizations.

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