UNDER PEER REVIEW

Original Research Article

Ways of compost use and promotion in the north region in Malawi

ABSTRACT

Aims: This study aims at clarifying current status regarding land management practices and at identifying reasons inhibiting farmers from proactive use of compost in the north region of Malawi.
Study design: Smallholder's farming and land management practices including compost use were examined through the household survey. After examining conditions and inhibiting reasons of compost use, possible way to promote compost use in the region was proposed.
Place and Duration of Study: Four northern districts of Malawi, Mzimba North (N), Mzimba South (S), Nkhatabay, and Rumphi, in July 2012.
Methodology: The household survey was conducted for 432 households at 9 villages, 148 households in Mzimba N, 7 villages, 123 households in Mzimba S, 5 villages, 85 households in Nkhatabay, and 4 villages, 76 households in Rumphi regarding compost making/use/effect on crop yields.
Results: 47 % of income comes from agriculture in smallholder farmers. Soil fertilization highly relied on the use of chemical fertilizer. Compost use **is still**was limited in the northern region of Malawi nevertheless its effect was**is** recognized as 21 % of farmers found an increase of yield by compost application. However, 26 % of farmers just burn crop residue without any utilization. Compost material collection and transportation were two main constraints in compost application, and the equation; Application of compost = 0.41 x compost material collection + 0.33 x compost transportation- 0.14 (r^2=0.39, $p < 0.05$) was obtained to express the relationship.
Conclusion: Material collection and transportation stand for as the limiting factors against compost making. Compost making by farmer group which would solve constraints borne in compost making to some extent. such as material collection and transportation. Compost making on site where farmer practice agriculture would also help to reduce laborious compost transportation.

Keywords: household survey, smallholder farming, compost use, crop residue, Malawi

1. INTRODUCTION

Continuous cropping without fallow and insufficient organic matter input have attributed to deterioration of soil fertility resulting in a low crop productivity in most of smallholders in sub-Saharan Africa countries (Kumwenda *et al.*, 1997; Snapp 1998; Wall 2007). A decline of soil fertility has been one of crucial problems for the agriculture in Malawi. Smallholder agricultural sector in Malawi is characterized by low productivity. The national yields of maize have averaged 1.3 metric tons per hectare (t/ ha^{-1}) during the last 20 years (FAO 2008) which are three to four times lower than the world average yield. Furthermore, enhancement of land productivity is becoming crucial issue because of an increased population pressure.
Annual population growth rate between 1998 and 2008 was 2.8 % for the whole country and 3.3 % for the north region (National Sstatistical Ooffice. 2008). Soil fertility improvement thus has become one of the indispensable measures to alleviate poverty of smallholders.

A number of approaches has been conducted for soil fertility improvement. It includes wide ranged land management activities such as biomass transfer, mulching, compost, manure, agroforestry (Phiri *et al.*, 2012). All of them are obviously important because single measure cannot solve soil fertility problem.
Low soil fertility in Malawi northern region is partly attributable to poor crop residue management. Matsui *et al.* (2016) conducted soil fertility study in the study region, and which revealed that soils in the north

Formatted: Font: Italic, English (United States)

Formatted: Font: Italic, English (United States)

Formatted: Font: Italic, English (United States)

UNDER PEER REVIEW

region are lower fertility than those of central and south regions characterized by low organic matter content and a high sand content. These endows with low nutrient holding capacity so that effect of chemical fertilizer application is kept quite low.

Compost application shall be promising measure for enhancing soil fertility but organic matter based technologies including compost application has been minimal (Kumwenda *et al.*, 1997). However, compost use in Malawi is still limited comparing to other land management practices. Thus understanding an importance of compost use in the region and constraints against compost use, will be necessary. The household survey was conducted in 2012 at the initial stage of "Sustainable Land Management Promotion Project (SLMP)" in Malawi to understand smallholder's farming and management of agricultural activity. This study aims at clarifying current status regarding compost use and at identifying reasons which refrain from proactive use of compost.

Formatted: Font: Italic, English (United States)

Comment [FHY1]: No apostrophe, please.

2. MATERIAL AND METHODS

The study region is located in the four northern districts of Malawi, namely, Mzimba North (N), Mzimba South (S), Nkhatabay, and Rumphi (Fig. 1). The mean annual rainfall over a 22-year period between 1989 and 2011 was 1,129 mm in Mzimba N, 702 mm in Mzimba S, 612 mm in Rumphi, and 1,610 mm in Nkhatabay. Rainfall patterns of the four districts were almost identical: high rainfall from November to April and low rainfall from May to October. Nkhatabay had very high rainfall in April and May. Number of households as of 2008 were 142,980 in Mzimba, 36,037 in Rumphi, 42,269 in Nkhatabay (National Sstatistical Ooffice, 2008).

The household survey was conducted in July 2012 for 432 households at 9 villages, 148 households in Mzimba N, 7 villages, 123 households in Mzimba S, 5 villages, 85 households in Nkhatabay, and 4 villages, 76 households in Rumphi. Among a number of surveyed items, issues regarding compost making and use were selected for this study.

For collected information, statistical analysis was conducted using the software JMP 8.0.2 version for Windows (SAS Inc., 2009). In which correlation analysis and multivariate analysis were conducted for all

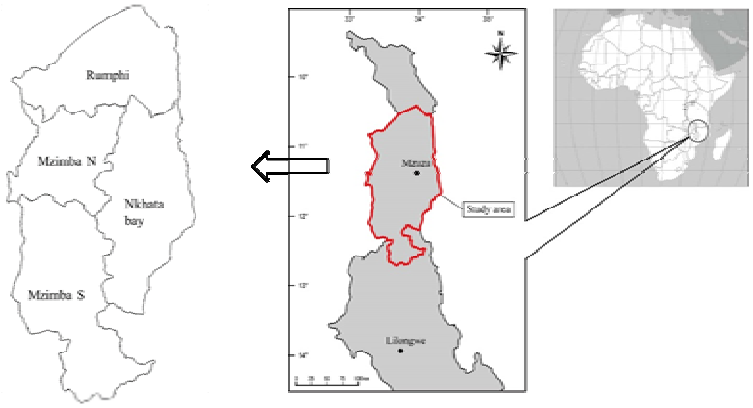


Figure. 1. Location of study site composed of four districts (Mzimba N, Mzimba S, Nkhatabay, and Rumphi).

Comment [FHY2]: Spell Fig. to become Figure.

UNDER PEER REVIEW

3. RESULTS AND DISCUSSION

3.1 Basic characteristics of farming in the region

The household survey reports cropping activities for 14 different crops. The ten most frequently grown crops across the four districts are, in descending order, maize, groundnut, cassava, tobacco, S/potatoes, finger millet, soya, beans, i/potato, field beans, banana, vegetable, paprika, coffee. Average owned land area of the study region is 1.98 ha, the lowest in Nkhatabay with 1.66 ha and the highest in Rumphi with 2.19 ha (Fig. 2). Average cultivated area is 0.81 ha for all districts, which is around 40 % of owned land area.

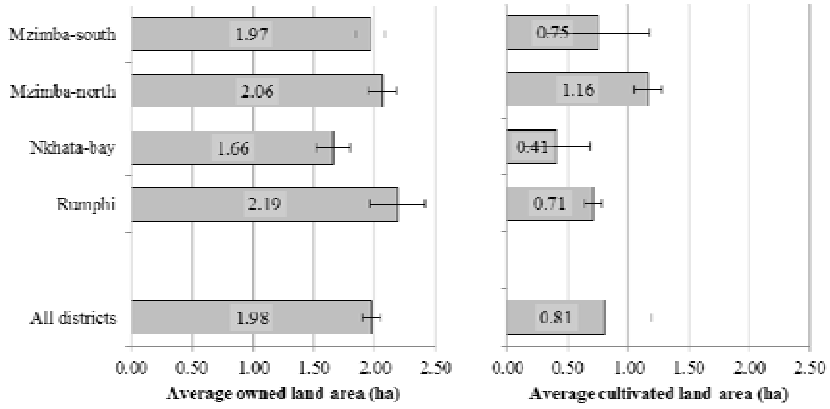


Figure. 2. Average land and cultivated area in the study region (Error bar indicates the standard deviation).

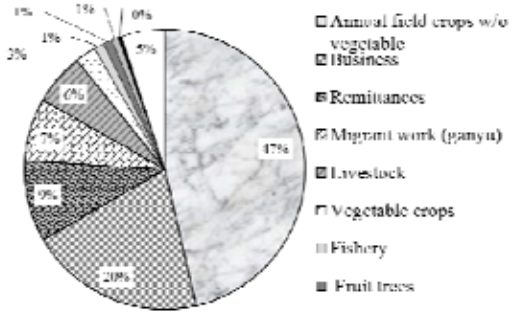


Fig. 3. Types of income and its proportion among the total.

As regards with the income of households, 47% of income comes from agriculture while 20% from business (Figure. 3). Due to unstable and insufficient income from agriculture, farmers have to find another income. Business in Figure. 3 means extra work, for example farmers make local beer at home and sell, or buy fish, maize or cow at low price in one place and sell them at higher price in another place.

UNDER PEER REVIEW

Remittance means money transfer from working abroad, mostly from South Africa. Migrant work which is called "*ganyu*" in Malawi, means work within the country. Off-farm activity is increasing and becoming social problem. Thus enforcement of agriculture sector is greatly needed for farmers' stable livelihood.

Comment [FHY3]: Words in other languages must be written in italic.

Formatted: Font: Italic

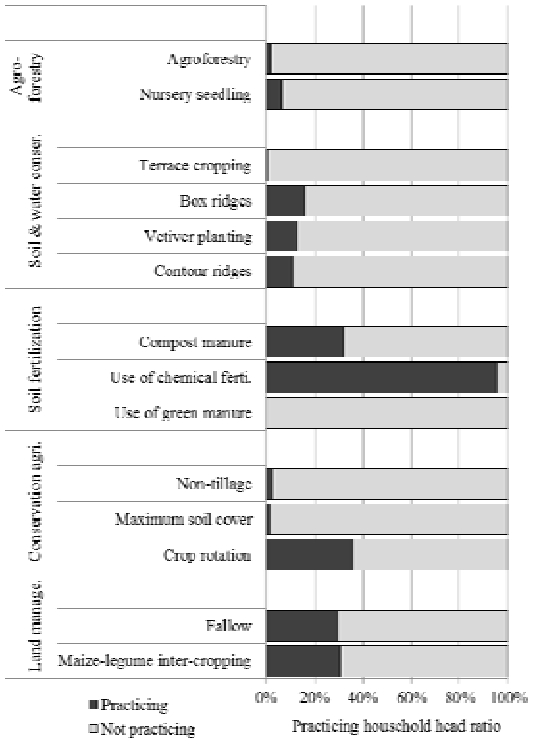
3.2 Land management practice

For sustainable land management, several technologies are believed to be useful. Maize cultivation with legume intercropping is one of the effective measures since **nitrogen** N can be fixed and supplied from leguminous crops. Crop rotation is helpful to recover soil fertility by soil enrichment plants. Since continuous cropping often induces plant infection, changes of crops may prevent through diversification of microbial community. Non-tillage would be effective especially if soil is erodible where land is located in a high slope. Agroforestry is also effective if land use is not competitive between forestry use and agriculture use.

The household survey demonstrated that 30% of farmers practiced maize cultivation with legume intercropping and 36% crop rotation (Figure**.** 4). Both non-tillage and agroforestry were not popular land management in the region. In terms of soil fertilization, 95% used chemical fertilizer but not green manure. Compost/manure were used in 32% of farmers.

Soils in the study region contain around 0.5 % of soil organic carbon (SOC) (Matsui *et al.* 2016). Increasing SOC is quite important in terms of soil fertility improvement, but which cannot be met by sole conservation practice like intercropping, therefore organic matter input such as compost application can be recommended.

Formatted: Font: Italic



UNDER PEER REVIEW

Figure. 4. Land management practice in the studied region

3.3 Compost application in the region

Use of compost/manure is not yet common in the northern districts. Except for one village (No. 17) in Mzimba N, compost use is quite low in most of villages (Figure. 5). Farmers who were**are** utilizing manure, just had**ve** several years' experience. Very few farmers have more than five**5** years use. Nkhatabay had a low % of compost user. This was**is** partly related with animal husbandry activity. Compost is normally prepared using cattle dung, but cattle is not popular in Nkhatabay (Figure. 6). Also maize residue is mainly used for compost making, but cassava is more grown than maize in Nkhatabay. These matters have driven to lower make compost making in Nkhatabay.

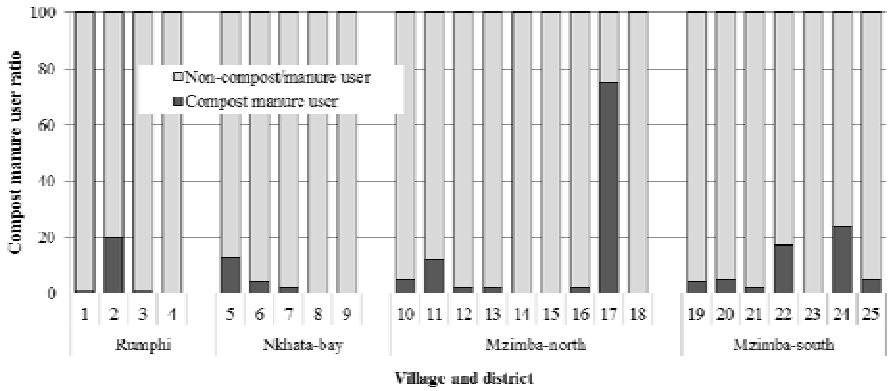
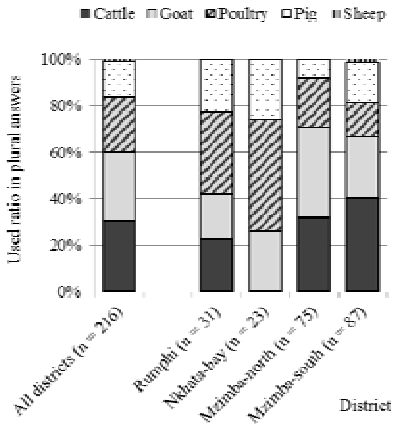


Figure. 5. Compost/manure use in the study region.



UNDER PEER REVIEW

Figure. 6. Type of livestock owned by farmers in the study region

30 % of farmers incorporate crop residues such as maize stalk into soils, but 26 % of farmers just burn without any proper utilization (Figure. 7). 25 % of farmers just leave residues in crop land and 14 % of farmers use as animal feed. In the study region, incorporation of crop residues started in the late 90s, maize residue is buried with ridge. Its effect is not yet approved but decomposition of residues are quite high due to termite. Same thing also happens in mulching. Accumulation of organic carbon in soils is important for soil fertility improvement, but this is a real challenge in the study region.

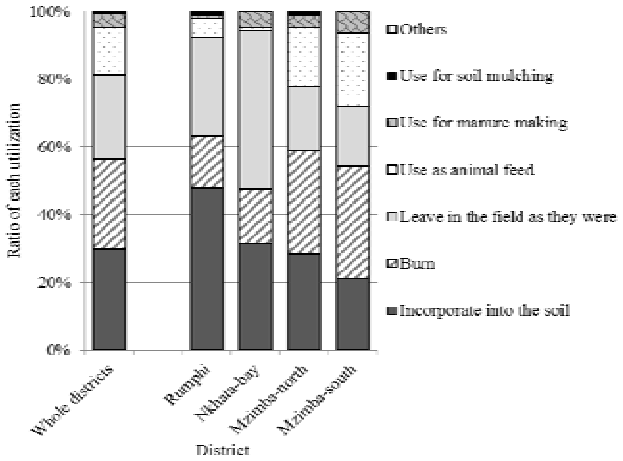


Figure. 7. Ways of crop residue use in the study region.

UNDER PEER REVIEW

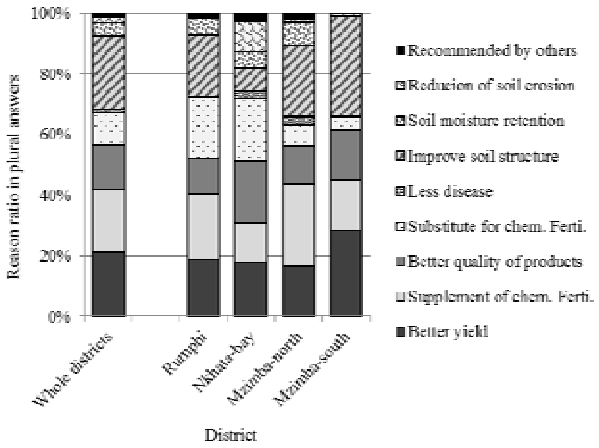


Figure. 8. Perceived effect of compost use by farmers.

3.4 Recognition of compost application effects

Farmers understand about positive effects of compost application through their experience (Figure. 8). 21% of farmers obtained an increase of yield by compost use. The combination of inorganic fertilizers and organic manures from cattle, compost, green manures, grain legume, is recognized as one of alternatives to reduce inorganic fertilizer consumption (Snapp 1998; Sakala *et al.*, 2003; Tittonell *et al.*, 2008; Chivenge *et al.* 2011; Vanlauwe *et al.* 2011). Mixed use of compost with chemical fertilizer increased efficiency of fertilizer use possibly because of lowered nutrient leaching and increased nutrient holding capacity (Matsui *et al.*, 2016). Due to an increased price of chemical fertilizer, an efficient and economical use of chemical fertilizer is highly demanded by farmers. Mixed use with compost will greatly attribute to solve this challenge.

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Font: Italic

Compost production mostly falls far short of annual needs. Average area of compost application in the northern three districts was 0.38 ha with 0.55 ha of the highest in Rumphi and 0.23 ha of the lowest in Nkhatabay. Compared with the average cultivated area (Figure. 2), merely a half of crop land has received compost.

3.5 Obstacles in compost making

Reasons to obstacle compost making were collected and summarized. Compost making is divided into three processes which are material collection, material preparation and compost transportation. Material collection is made for maize stalk, legume, gaga (maize bran) and animal manure. Material preparation consists of chopping, turning and watering.

No single reason couldn't explain compost application as shown by no relevant significant correlation with compost application (Table 1). Collection of maize stalks and legume residues are highly correlated. Maize and legume are grown together as intercropping in many of farmlands so that collection of these two residues are well correlated. Turning compost heap and chopping materials are also closely correlated. It is likely that these two operation are done at the same time.

UNDER PEER REVIEW

Multivariate analysis was conducted to find variables to correlate with compost application and revealed that compost application was explained by compost material (maize residue) collection and its transportation, expressed by the following equation.

Application of compost = 0.41 x compost material collection + 0.33 x compost transportation
- 0.14 (r^2=0.39, $p < 0.05$)

This indicates that compost material collection and transportation are two main key issues for compost application. There is a room to increase compost application if these are improved.
Snapp *et al.*, (2002) pointed out reasons to obstacle farmers from applying green manure, which were high labor requirements, skillful management, delayed application effect. Chinangwa *et al.*, (2006) showed other challenges to application such as water, livestock manure shortage and lack of interest. Opportunity for farmers to access an information of compost making is still limited. Farmer training and knowledge on compost manure making are listed as barriers for its adoption in the southern Malawi (Mustafa-Msukwa *et al.*, 2011). As such conditions to enable farmers to apply compost differs according to the regions. Available compost materials, accessibility to water and labor condition are different among the districts in the northern region so that strategy to promote compost application shall be planned according to the regional condition.

Table 1. Correlation matrix of constraints on compost making

	Maize stalks collection	Legume residue collection	Animal manure collection	Gaga collection	Chopping materials	Turning compost heaps	Watering	Compost transportation
Legume residue collection	0.77**							
Animal manure collection	0.23	0.14						
Gaga collection	0.40*	0.36*	0.06					
Chopping materials	0.05	0.22	0.10	0.01				
Turning compost heaps	0.32	0.14	0.00	0.11	0.68**	0.52*	0.09	
Watering	0.18	0.07	0.05	0.09	0.34	0.05		
Compost transportation	0.08	0.08	0.14	0.07	0.09	0.13	0.17	
Compost application	0.28	0.14	0.17	0.18	0.00			0.40

** and * mean significance level at 0.01 and 0.05, respectively

An increase of farmer's participation in farmer's group helps to increase compost application through enhancement of knowledge and understanding on compost application (Chinangwa *et al.*, 2006). Fig. 9 shows sources where farmers in the study region got an information on land management technologies. Around half of farmers have acquired an information and 55 % of them got from governmental staff, 21 % and 16 % obtained from neighbor/relative and lead farmers (FF) or follower farmer (FF), respectively. Farmers group plays a great role in rural activity in Malawi, such the case that fertilizer loan is given

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Font: Italic

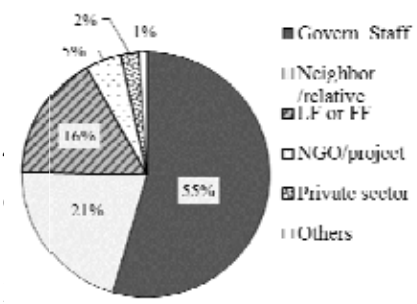
Comment [FHY4]: Make each column with proper rows according to items, so that every correlation coefficient will be in a certain cell.

Formatted Table

Formatted: Font: Italic

UNDER PEER REVIEW

through farmers group (called as “farmer club” in Malawi). For compost use more to be disseminated, farmer group also could be as important as NGO whose role is also increasing in the region. Compost making on site where farmer practice agriculture would also help to reduce laborious compost transportation.



ormation on land management technologies

hern region of Malawi. Effects of compost use hadve been ased yield. However, still 26 % of farmers just burn crop like compost making. Material collection and transportation ıse. Compost making by farmer group would solve problems f compost use.

CONSENT

All authors declare that ‘written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial Ooffice/Chief Editor/Editorial Board members of this journal.

REFERENCES

1. Barron J., Damgaard-Larsen S. Conservation farming strategies in East and Southern Africa: a regional synthesis of crop and water productivity from on-farm action research. Soil and Tillage Research 2009;103:23–32.
2. Chinangwa L. Adoption of soil fertility improvement technologies among small holder farmers in southern Malawi. Norway. (www.umb.no/noragric) 2006.
3. Chivenge P, Vanlauwe B, Gentile R, Wangechi H, Mugendi D, van Kessel C, Six J. Organic and mineral input management to enhance crop productivity in Central Kenya. Agron J 2009;101:1266–1275.
4. FAO. FAOSTAT database. Production: Crops. 2008: http://faostat.fao.org/site/567/default.aspx.
5. Kumwenda JDT, Waddington SR, Snapp SS, Jones RB, Blackie MJ. Soil fertility management in southern Africa. In: Byerlee, D. and Eicher, C.K. (eds) Africa's emerging maize revolution. Lynne Rienner Publishers, Boulder, Colorado, 1997;157-172
6. Matsui M, Nakata K, Cornelius C and Macdonald M. Improvement of maize yield and soil fertility by 2years compost application in Malawi’s northern districts. African Journal of Agriculture Research 2016;11(30):2708-2719. DOI: 10.5897/AJAR2016.10884
7. Mustafa-Msukwa AK, Mutimba JK, Masangano C and Edriss AK. An assessment of the adoption of compost manure by smallholder farmers in Balaka district, Malawi. S. Afr. J. Agric. Ext. 2011;39:1725.
8. National statistical office. 2008 population and housing census. Preliminary report. 2008.
9. Phiri AT, Mhango WG, Njoloma JP, Kanyama-Phiri GY, Lowole MW. Farmers' evaluation of integrated soil fertility management methods in Northern Kasungu Central Malawi. J. of Agricultural Extension and Rural Development 2012;4(1):340-346.

UNDER PEER REVIEW

10. Sakala WD, Ligowe I, Kayira D. Mucuna-maize rotations and short fallows to rehabilitate smallholder farms in Malawi. In:Waddington SR (ed) Grain Legumes and Green Manures for Soil Fertility in Southern Africa. Proceedings of a conference held 8-11 October 2002 at the Leopard Rock Hotel, Vumba, Zimbabwe. Harare, Zimbabwe: Soil Fert Net and CIMMYT-Zimbabwe, 2003;161-163.
11. SAS Institute Inc. SAS/STAT® 9.2User's Guide, Second Edition.2009: Cary, NC: SAS Institute Inc.
12. Snapp S.S., P.L. Mafongoya and S. Waddington. Organic matter technologies to improve nutrient cycling in smallholder cropping systems of Southern Africa. Agriculture, Ecosystems and Environment 1998;71:187-202.
13. Snapp S, Rohrbach D, Simtowe F, Thombozi J, Freeman HA. Sustainable soil management options for Malawi: can smallholder farmers grow more legumes? Agriculture, Ecosystems & Environment 2002;91:151–174.
14. Tittonell P., Corbeels M., van Wijk M.T., Vanlauwe B. and Giller K.E. Combining organic and mineral fertilizers for integrated soil fertility management in smallholder farming systems of Kenya – explorations using the crop-soil model FIELD. Agron. J., 2008:100:1511–1526.
15. Vanlauwe B, Descheemaeker K, Giller KE, Huising J, Merckx R, Nziguheba G, Wendt J, Zingore S. Integrated soil fertility management in sub-Saharan Africa: unravelling local adaptation. SOIL 2015;1:491–508. doi:10.5194/soil-1-491-2015.
16. Wall P.C. Tailoring Conservation Agriculture to the Needs of Small Farmers in Developing Countries : An Analysis of Issues. Journal of Crop Improvement 2007;19:137–155.