

EVERGREEN AGRICULTURE

EXTENSION MANUAL FOR FARMERS AND EXTENSION WORKERS IN MALAWI



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World Agroforestry Centre

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ABOUT THE WORLD AGROFORESTRY CENTRE

The World Agroforestry Centre (ICRAF) is the international leader in agroforestry – the science and practice of integrating trees on smallholder farms and in rural landscapes. Agroforestry is an effective and innovative means to alleviate poverty, create food security, and improve the environment. The centre and its many partners provide high quality agroforestry knowledge to small-scale tropical farmers and policy makers, helping them to adopt techniques that will enable them to improve their lives and the landscape. We combine excellence in scientific research and development to address global poverty, hunger and environmental needs through collaborative programs and partnerships that transform lives and landscapes, both locally and globally.

ACRONYM

ADD	Agricultural Development Division
AEDC	Agricultural Extension Development Co-ordinator
AEDO	Agricultural Extension Development Officer
AF	Agroforestry
AFSP	Agroforestry Food Security Programme
CA	Conservation Agriculture
CRS	Catholic Relief Services
DADO	District Agricultural Development Office(r)
DAES	Department of Agricultural Extension Services
EA	Evergreen Agriculture
EPA	Extension Planning Area
ICRAF	World Agroforestry Centre
LRC	Land Resource Centre
LRCO	Land Resources Conservation Department
NASFAM	National Smallholder Farmers Association of Malawi
NGO	Non Governmental Organisation
TLC	Total LandCare

TABLE OF CONTENTS

ACRONYM.....	4
ACKNOWLEDGEMENTS.....	6
EXECUTIVE SUMMARY.....	7
EVERGREEN AGRICULTURE: INTRODUCTION.....	8
MODULE 1: CONVENTIONAL TILLAGE.....	10
MODULE NOTES 1: RIDGE TILLAGE IN MALAWI (CONVENTIONAL TILLAGE).....	12
1.1 Introduction.....	12
1.2 Advantages of Ridge Tillage.....	12
1.3 Disadvantages of Ridge Tillage.....	12
MODULE 2: CONSERVATION AGRICULTURE.....	14
MODULE NOTES 2: CONSERVATION AGRICULTURE.....	16
1.1. Introduction.....	16
1.2 Minimum soil disturbance.....	16
1.3 Maximum Soil Cover.....	21
1.4 Crop Associations and Rotations.....	23
MODULE 3: AGROFORESTRY (FERTILIZER TREES).....	25
MODULE NOTES 3.1: CONCEPTS IN SIMULTANEOUS INTERCROPPING.....	27
1.1 What is simultaneous intercropping?.....	27
1.2 Advantages of simultaneous intercropping.....	27
1.3 What are the benefits of simultaneous intercropping?.....	27
MODULE NOTES 3.2: TEPHROSIA SIMULTANEOUS INTERCROPPING.....	29
1.1 What is Tephrosia?.....	29
1.2 Planting Tephrosia seeds.....	29
1.3 How does Tephrosia improve soil fertility?.....	30
1.4 How to collect Tephrosia seeds?.....	30
MODULE NOTES 3.3: GLIRICIDIA SEPIUM SIMULTANEOUS INTERCROPPING.....	32
1.1 Introduction.....	32
1.2 Nursery Management.....	33
1.3 Land Preparation.....	35
1.4 Transplanting.....	35
1.5 Field Management.....	36
REFERENCES.....	37

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EXECUTIVE SUMMARY

This product is a stepwise development in the food security sector as it will help a number of rural development agencies and practitioners in building their capacities to implement conservation agriculture and agroforestry. Over a number of years since colonial era, farming system has been characterized by ridge construction through the use of either ridgers or ploughs or hand hoes. The wholesome tillage of land during land preparation and the burning of crop residues scaled up and were widely adopted without questioning its subsequent ecological and socio-economic effects. The agricultural extension system and academic institutions promoted the tillage system as a recommended cultural practice. History indicates that there was a considerable huge enforcement of the construction of planting ridges, contour marker ridges and contour bunds in the colonial era and continued during post independence era.

Research on zero or minimum or reduced tillage gained footing in the 70's and 80's when Latin America and North America observed success stories on zero tillage. However, in Malawi there had been little counter-evidence against the former practice as a result the status quo remained until recently when there seems to be a conservation tillage movement across the world.

It should be emphasized that much as there have been both scientific and practical evidence that conservation agriculture and agroforestry work, evergreen agriculture is still in its infant stages in Malawi and across the continent, and gradual development will ensue and patience should be observed. Evidence on positive effects of both agroforestry and conservation agriculture have been obtained over a period of time and across a wide range of agro-ecological areas. These include improve yields, reduced amounts of chemical fertilizer application, improved soil fertility and reduced soil erosion among a number of benefits.

It has been widely observed in most local and international CA fora that for conservation agriculture to be widely adopted the knowledge and skills gaps need to be fulfilled with science based evidence. It is against this background that the Irish Aid Malawi supported World Agroforestry Center (ICRAF) to develop a master extension manual to be used by extension workers and farmers in training their fellow counterparts in the use of evergreen agriculture technology. We are proud that the concerted efforts from the Ministry of Agriculture and Food Security's departments of Agricultural Extension Services and Land Resources Conservation and partner NGO's such as National Smallholder Farmer's Association of Malawi (NASFAM), Catholic Relief Services (CRS) and Total LandCare (TLC) led to this timely resource in CA development in Malawi. It is our sincere hope that this manual will be endorsed by the Ministry of Agriculture and Food Security for scaling up. It is hoped that after endorsement the manual will be widely distributed and used by extension workers throughout Malawi and possibly southern Africa to guide farmers in migrating from conventional tillage to conservation tillage.

Finally, it is hoped that in the near future, evergreen agriculture will be widely adopted and smallholder and estate agriculture will be ecologically and economically sustainable in the sense that food security and rural economy will be greatly improved.

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Regional Co-ordinator (ICRAF-SA)

EVERGREEN AGRICULTURE: INTRODUCTION

Both during the colonial and post independence era, the agricultural extension system advocated ridging and burning of residues in Malawi (Mloza-Banda, 2002). As a result, ridge based tillage system is very predominant both in smallholder and estate agriculture sectors. Many farmers in Malawi consider farming as synonymous to ridging. Smallholder farmers use hand hoes for ridging and other cultivation practices in Malawi. This practice has created a hoe hard pan 10 cm below the top soil. Research indicates that ridge based cultivation has led to land degradation, loss of soil fertility, soil erosion which subsequently has led to poor crop productivity (CFU, 2007). A new thought is gaining ground which questions the effects the ridge based tillage on soil health and the entire farm ecosystem. Conservation agriculture (CA) is new agricultural practice which is being promoted as an alternative to conventional agriculture. Research in CA in Malawi dates back to the 1980's when Bunda College of Agriculture and Department of Agricultural Research Services (DARS) conducted on-station and on-farm trials on the effects on CA practices on maize performance and soil fertility enhancement (Mloza-Banda, 2002). The results of these studies have however been received with mixed reactions amongst scientists, extension workers, farmers and policy makers who raised questions regarding economic feasibility and appropriateness to smallholder farmers to change from conventional tillage to conservation tillage. CA is promoted for the positive benefits of increased organic matter, improved water retention, water infiltration, improved soil fertility, improved soil structure, reduced soil erosion, reduced weed infestation and increased maize yield (CFU, 2007; Giller *et al.*, 2009, Haggblade and Tembo, 2003).

The soil fertility problems in smallholder agriculture require multiple approaches such as agroforestry, soil and water conservation technologies and breeding of crops tolerant to low soil fertility. The work by the World Agroforestry Centre (ICRAF) over the two decades shows that agroforestry systems involving fertilizer trees can significantly increase crop productivity and ensure food security (Akinnifesi *et al.*, 2008; Sileshi *et al.*, 2009). Vigorous research for development on fertilizer trees has been on-going in Malawi in the last two decades (Akinnifesi *et al.*, 2008). Results show that fertilizer trees can substantially increased maize yields in Malawi (Akinnifesi *et al.*, 2008). *Gliricidia sepium* intercropped with maize in southern Malawi increased maize yields more than three-fold and 100-400% increase for maize yield under *Faidherbia albida* (Akinnifesi *et al.*, 2008). A recent meta-analysis of data from more than 50 sites in Sub-Saharan Africa has also provided conclusive evidence that fertilizer trees can double or triple crop yield on poor to medium potential soils (Sileshi *et al.*, 2008).

The World Agroforestry Centre released a blue print for evergreen agriculture in Africa (World Agroforestry Centre, 2009; Garrity *et al.*, 2010). Conservation agriculture embodies the core of the evergreen agriculture. The fertilizer tree system and conservation agriculture discussed above evolved independently, and both have been refined through intensive work with farmers. Each system, however, has unique strengths and weaknesses. The use of tree legumes also helps to suppress weeds (Sileshi *et al.*, 2006), reducing the drudgery of hand weeding. Conservation agriculture, on the other hand, reduces the labour requirements and costs of land preparation. These benefits can be maximized by combining fertilizer tree systems with conservation agriculture. This integrated system is still under development, and will require much more farmer participatory research in the coming years. The World Agroforestry Centre and its partners in southern Africa are carefully observing farmer experiences with these practices, and are designing a new system – an

Evergreen Agriculture – that may combine the best of both practices (World Agroforestry Centre, 2009).

Evergreen Agriculture is defined by Garrity et al. (2010) as the as the integration of particular tree species into annual food crop systems. It has been emphasized by the same authors that the intercropped trees sustain a green cover on the land throughout the year to maintain vegetative soil cover, bolster nutrient supply through nitrogen fixation and nutrient cycling, generate greater quantities of organic matter in soil surface residues, improve soil structure and water infiltration, increase greater direct production of food, fuel, fiber and income from products produced by the intercropped trees, enhance carbon storage both above-ground and below-ground, and induce more effective conservation of above- and below-ground biodiversity.

The indicator of the effectiveness of intercropped trees is that of building a healthy soil and environment to enhance food crop production and increase household income, while increasing the resilience of the farm enterprise to a variety of risks. Additionally, the trees tend to extend growing seasons, increase productivity, better water utilization efficiency, and drought resilience. The overall benefits of an evergreen farming system are increased food crop yields and/or overall profitability, lower costs of production, and healthier soils (Garrity et al. 2010).

This extension manual has been developed from the five year experience with Agroforestry Food Security Programme (AFSP) and the one year experience with Evergreen Agriculture for Sustainable Food Production in Malawi project both funded by Irish Aid Malawi. The extension manual serves the purpose of transferring the knowledge of fertilizer agroforestry and conservation agriculture to extension workers and farmers in Malawi. The manual helps to change the mindset of extension workers and farmers from ridge based tillage to conservation tillage to later evergreen agriculture when coupled with fertiliser trees.

How to Use This Manual

This manual has been primarily developed as a guide for extension workers and lead farmers in evergreen agriculture training. The manual focuses on conservation agriculture and agroforestry technologies for sustainable soil fertility improvement. The training manual is organised into 3 modules namely Conventional Tillage, Conservation Agriculture and Fertilizer Tree Agroforestry. Each module is divided into the following sections; introduction, module objective, procedure and module notes. Each module introduction is aimed at giving training participants important background information about the module. Module objectives are the key lessons that participants need to learn by the end of each module. It is therefore important that as a trainer, you make sure that module objectives are clear to all your trainees as these will form a basis for evaluation of the module at the end of your lesson. The extension manual has been organised to employ both participatory and appreciative inquiry methodologies. Each module therefore has a procedure to help the trainer to facilitate the training course and ensures that you are on track i.e. all important areas are covered under each module. At the end of each module, there are module notes to help you explain in much detail about each lesson or module. These notes will help you make conclusive remarks about each module or lesson covered.

MODULE 1: CONVENTIONAL TILLAGE

“I wish if I had known this type of tillage long time ago. Now it is high time for backaches to stop” the testimony of a farmer in Mchinji highlighting the relief from backaches caused by ridge tillage.

Introduction

Ridge based tillage is the commonest tillage system in Malawi hence considered as a conventional tillage. Its history dates back from the colonial era when the Department of Agriculture enforced the use of ridges for planting and soil water conservation. It was perceived to be a good land husbandry practice to construct a variety ridges which ranged from tie boxes to contour marker ridges. The ridges were believed to aid drainage in water logged areas, to raise the planting beds for proper seed germination and root development for tuber crops, to enhance aeration of the soils, to help anchor the plants from lodging due to heavy wind. During post independence era, the agricultural extension system still maintained the ridge tillage as the default tillage for both smallholder and estate agriculture sectors. However, research on the effect of tillage on crop productivity and soil fertility enhancement started since in the 70's. The early scientific conviction was that effects of conservation tillage such as reduced tillage using rippers and planters could not outweigh the benefits of ridge based tillage (Mloza-Banda, 2003). The benefits of conservation tillage from local research and elsewhere like in Brazil were received with mixed reactions among scientists, policy makers, extension workers and farmers in Malawi. This knowledge transition has dragged in Malawi to an extent that ridging construction has remained the dominant force in smallholder agriculture albeit negative consequences on soil fertility and labour constraints (CFU, 2007). The understanding of the dynamics of conventional agriculture is very critical for the concept of conservation agriculture amongst farmers and extension workers. Probably the trademark of conventional agriculture is *ridge construction*.

Objectives

By the end of this module, participants should be able

- To discuss the concept of conventional tillage of ridge construction,
- To explain the advantages and disadvantages of conventional tillage (ridge construction)

Methods: Brainstorming, group discussions, lecturette, demonstration, and practical

Procedure:

- The facilitator should guide the participants to review the conventional tillage system in Malawi. This can be best done when the participants are divided into groups of 8 to 10 individuals per each group. Let the participants discuss the following issues;
- Ask the participants to discuss the types of tillage system they know. Ask the participants to explain the characteristics of the predominant tillage system in Malawi and record the responses on a flip chart.

- Ask them to discuss the background of extension system for ridge based tillage in Malawi. The participants should explain the central factors that encouraged the ridge tillage.
- After this exercise, summarise participants' inputs and add information from the module notes # 1.
- Divide participants into groups (8-12 individuals per group).
- Participants should explain the advantages and disadvantages of conventional tillage.
- Participants should review why farmers in Malawi predominantly practice ridge tillage up to now despite the disadvantages stated before.
- Each group should then present their findings in the plenary and issues should then be discussed.
- The facilitator should summarise participants' inputs and add information from the module notes # 1.

Conclusion

The facilitator should summarise the group discussions on the conventional agriculture on the flip chart. Distribute module notes # 1 on Ridge Tillage in Malawi to participants at the end of the session.

MODULE NOTES 1: RIDGE TILLAGE IN MALAWI (CONVENTIONAL TILLAGE)

1.1 Introduction

In Malawi, agriculture dominates the economy contributing 37% of GDP. Over 80% of the population is practicing smallholder agriculture which is characterized by ridge based tillage and burning of residue. Over 70% of smallholder farmer agriculture in Malawi is dominated by conventional tillage. Ridge construction is the cornerstone of conventional agriculture in Malawi. This construes the annual construction of ridges, burning of crop residues and monocropping in most areas of Malawi. Conventional tillage practices involve several operations in the preparation and maintenance of a seedbed suitable for seedling emergence and crop growth and development.

1.2 Advantages of Ridge Tillage

The ridge tillage involves inverting, cutting or shattering the soil to a depth of 15-36cm and usually this leaves the soil rough. This tillage is called primary tillage. The purpose of primary tillage include loosening and aerating the surface layer of soil, incorporating fertilizer, and mixing plant residues into the surface layer of soil. Secondary tillage prepares a final seedbed suitable for planting seed and its subsequent germination, seedling establishment and weed control. This type of tillage was mandated by colonial government through the department of agriculture as a recommended land husbandry practice in Malawi. It was proven that the local farming practices predisposed the agricultural land to heavy soil erosion and degradation and are responsible for low crop productivity. As a result, the colonial government vigorously reinforced the construction of a variety of ridges on smallholder farmer's crop field which ranged from tie box ridges, contour ridges, contour bunds to planting ridges. This extension system further encouraged residue burning and monocropping for clean agriculture. This hardly changed when Malawi became independent of the British rule during the Kamuzu Banda era. Consequently the crop field soils have undergone decades and decades of "*splitting and reforming*" every year.

1.3 Disadvantages of Ridge Tillage

This type of tillage practice causes the following effects; soil exposure, run off, erosion, oxidation of organic carbon etc. The effects are causative agents for poor soil health in Malawi. Nonetheless, the chemical fertilizer application has not reversed the soil health situation but has to some extent aggravated the sore conditions of the soils under smallholder agriculture. However, it is also worth noting to see how the farmers have religiously been following this tough and wearing out farming practice for many decades. This practice requires farmers to be splitting the ridges to form another ridges every year. Nearly 3 million smallholders tend to split and reform ridges before the planting rains. Surprisingly this practice appears to have gone unquestioned by just about every 'expert' connected with small-scale agriculture over the past 60 years.



Figure 1: Crop field tilled with hand hoe by a smallholder farmer

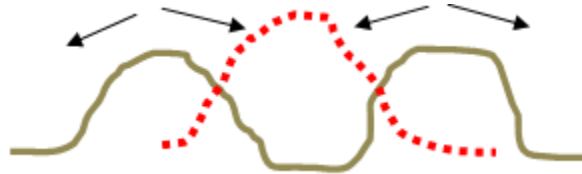


Figure 2: The cross section of conventional tillage (red= new ridge)

Ridge spacing ranges from 75 cm to 100cm. It is estimated that 300 tons per hectare of soil is moved by hoe farmers. Smallholders ridge about 1.7 million hectares a year so annual soil movement is 510 million tons with 17 million kilometres of new ridges being formed before the rains. Residues are either burnt off or consolidated in the furrows and buried under the new ridges.

MODULE 2: CONSERVATION AGRICULTURE

Introduction

Evergreen Agriculture is a combination of conservation agriculture and agroforestry practices within the same spatial and temporal dimensions. In other circles, evergreen agriculture is referred to as *agroforestry based conservation agriculture* or *conservation agriculture with trees (CAWT)*. Evergreen agriculture is being tested by ICRAF in conjunction with partners in Malawi and across Africa as the means for enhancing soil fertility, increasing crop productivity and increasing food production (Garrity *et al.*, 2010). The long term research in soil fertility enhancement through the use of agroforestry technologies conducted by ICRAF in Malawi and across Africa has shown that soil health and crop yield is improved (Akinnifesi, 2010; ICRAF, 2009). This section will focus on the principles and practices of conservation agriculture (CA). Conservation agriculture also improves the soil health and productivity as well as improves the crop production. ICRAF envisages that a combination of these two technologies together with other technologies will improve soil health and improve crop production and finally improves food security in Malawi.

Conservation agriculture has different meanings by different development agencies in Malawi. It is against this background that this extension guide was developed to harmonise the already existing extension messages on CA in Malawi to avoid confusing farmers and help up-scaling of CA in different agro-ecological zones. Research in CA in Malawi dates back to the 1980's when Bunda College of Agriculture and Department of Agricultural Research Services (DARS) conducted on-station and on farm trials on the effects on conservation tillage on maize performance and soil fertility enhancement (Mloza-Banda, 2002). The results of these studies have however been received with mixed reactions amongst scientists, extension workers, farmers and policy makers who raised questions regarding economical feasibility and appropriateness to smallholder farmers to change from ridge tillage to conservation tillage. Although CA is increasingly being tested by smallholder farmers and extension workers, there are a lot of misconceptions about it (Mloza-Banda and Nanthambwe, 2010).

Objectives

By the end of this session, participants should be able

- To understand the principles and practices of conservation agriculture
- To understand the benefits and challenges of conservation agriculture
- To appreciate the progress made in CA in Malawi and southern Africa

Methods: Brainstorming, group discussions, lecturrete, demonstration, and practical

Procedure:

- The facilitator should lead the participants to brainstorm on how they understand by conservation agriculture.
- The facilitator should write key words from the participants' comments on the flip charts.
- Ask the participants to explain how CA in their observation has been implemented in their area. And the participants should capture key words or elements from the participants' comments.

- Divide the participants into two or more groups depending on the number of participants (a group of 8 to 10 individuals per group).
- One group(s) should discuss the benefits that people are talking about CA in their areas.
- The other group(s) should reflect on what farmers and extension workers are saying and observing as challenges of CA practice on farmers' fields.
- Each group should present their findings in the plenary and the facilitator should let the whole participants discuss and record key questions and comments arising from the deliberations.
- The facilitator should explain in detail the core principles of conservation agriculture and the facilitator should also explain how different stakeholders are practicing CA to achieve the principles explained. Use Module Notes 2: Conservation Agriculture.
- After theory, the facilitator should choose an open field where to demonstrate how the participants can practically practice CA. Use the practical section 1.2.3 of the Module notes 2 to demonstrate the following;
 - Digging of planting basins
 - Use of old ridges
 - Spreading of crop residues
 - Use of legumes trees

MODULE NOTES 2: CONSERVATION AGRICULTURE

1.1. Introduction

Conservation agriculture employs the judicious use of conservation tillage, mulching and integrating of main crop with legume crops and/or trees to conserve natural resources of soil and water for improved and sustainable production. Conservation tillage is the core principle of conservation agriculture as it portrays the new tillage system from the predominant ridge based tillage system. It is so crucial in the social dynamics of tillage practices because burning of crop residues and ridging is strongly engraved in the social fabric of smallholder agriculture in Malawi. It requires a systematic transformation of the mindset of smallholder farmers to conservation tillage as economically viable, ecologically sustainable and smallholder friendly. Conservation agriculture enhances natural ecological processes to conserve moisture, enhance soil fertility and improve soil structure. CA also reduces soil erosion and emergence of pests and diseases.

Conservation agriculture is a combined application of three non-negotiable principles which are

- Minimum soil disturbance
- Maximum soil cover and
- Crop associations and rotations

1.2 Minimum soil disturbance

The tendency of splitting the old ridges and forming new ridge year by year is so dominant among the smallholder farmers in Malawi. This type of tillage disturbs the soil so much that it encourages soil erosion and loss of soil fertility. This key principle stipulates that a farmer should till the soil as little as possible. The numerous on-farm research works indicate that maize and other crops can still grow well in less tilled or un-ridged fields. This principle encourages farmers to disturb the soil where strategic inputs such as the seed, fertilizer and manure are to be placed. CA promotes the minimum soil disturbance to 12%-15%. Under conventional agriculture, soil tillage is 100%. Minimum tillage overcomes many of the disadvantages of ridging. Ploughing and hoe ridging disturb soil layers and thereby destroying the structure of soil. When the soil structure is destroyed, water infiltration and soil organic matter are disturbed. Low levels of organic matter render soil less capable retaining nutrients and water in the soil. In conventional tillage, ridges are seldom constructed across the slopes as recommended hence promoting soil erosion and land degradation.

1.2.1 Benefits of conservation tillage

Conservation tillage entails reducing tillage operations to the minimum required to plant crops. In Malawi, this tillage would involve scratching or ripping out the soil where the crop is to be planted and leaving the rest of the land untilled until weeding is required. Alternatively, conservation tillage can be done by constructing planting basins where seeding would take place.

- Maintains soil structure
- Reduces soil erosion
- Improves water infiltration

- Retains and enhances build up of soil organic matter

1.2.2 Forms of conservation tillage

This is a very important cultural practice in conservation agriculture and it varies from one place to another and one farmer to another. In Malawi, in the first year to practice conservation tillage, farmers have difficulties to plant maize in old ridges which are usually infested with weeds. There is a chronic problem of weed infestation due to poor weeding practices farmer do. When the main crop has reached physiological maturity, they let the weed to flower and shed off seeds on and in the soil. This breeds fear by smallholder farmers of increased labour in weeding when they intend to practice conservation tillage. Despite extensive extension messages on the recommended ridge spacing to obtain recommended plant population for maize system, farmer have tended to construct either closer or wider planting ridges at 50-60 cm apart or 80-90 cm apart, respectively. This also predisposes difficulties among farmers in using right spacing during demonstrations. The planting of next maize because difficult because the planting stations become both on the ridges and on the furrows. Since labour is generally a problem during land preparation and CA is promoted as labour saving, it would not be wise to advice farmers to break the old ridges to start practicing CA.

i. Use of old ridges

Since no agro-ecological suitability studies have been conducted on conservation tillage in Malawi, the rule of thumb would be that farmer should be encouraged to use old ridges of previous ridge spacing to avoid breaking old ridges as such would be considered as conventional tillage.

There are many NGOs that promote the use of old ridge in the early years in CA. These include Total LandCare (TLC), National Smallholder Farmers Association of Malawi (NASFAM), Concern Universal, Development Aid from People to People (DAPP), Farm Income Diversification Programme (FIDP) and many others. ICRAF also conducted on farm demonstrations with farmers on the use of old ridges and farmers showed interest in the practice. Farmers indicated that the practice is easy to follow and is labour saving.

During planting period, the farmers should plant maize and agroforestry tree seeds in rows as recommended in specific areas. However, the rule of thumb is that maize should be planted one seed per planting station spaced at 15 cm apart and the row should be made across the slope spaced at 75 cm apart. It should be emphasized that row spacing was previously at 90 cm apart and this has been stopped because the current maize varieties do quite well at 75 cm apart.

The old ridge would die off as years go by. The rain splash and human activity play a great role in leveling the maize field down.



Figure 3: Maize field under “old ridge” tillage or flat tillage in Nkhota kota under MACC project of TLC in 2009

ii. Permanent planting basins

Climate change has affected the smallholder agriculture with increased temperature, change in rainfall pattern, erratic rainfall and drought. CA proves to be adaptive to climate change when permanent planting basins used as water conservation structures. It has been witnessed that farmers across the country during CA field days organized by CA practitioners that CA plots with permanent planting basins retained enough soil water for crops to survive three to four day dry spells. This could be a potential investment in water shadow areas and dry areas.

The permanent planting basins also act as focal points for strategic application of nutrients such chemical fertilizer, manure and biomass from agroforestry. Under conventional tillage, nutrients are not specifically directed to micro environments accessible by the crop roots. Year by year under conventional tillage, farmers change points for nutrient application because the ridge keep on changing. It then becomes cost effective when all strategic nutrients are precisely applied within the proximate root radius which is the farmers’ area of concern. All other land preparation operations will be carried out in the planting basins and these include weeding, fertilizer application, tillage, manure application and others.

The permanent planting basins also have recommended row and basin spacing depending on different agro-ecological zones. Since agro-ecological studies on suitability of CA and spacing trials on planting basins have not yet conducted in Malawi, the rule of thumb is to maintain the recommended spacing used in conventional tillage. However, suggestions have been developed on alternative planting basins spacing to be used by farmers depending on rainfall pattern and soil types (Table 1).

Table 1: Basin Spacing for different agro-ecological zones (with recommended seed density, basins density and plant population)

Zones	Row spacing	Basin spacing	Number of maize seed per basins	Number of planting basins per hectare	Plant populations per ha
Areas with summer rainfall (November to April) with relatively high temperatures and infrequent, heavy rainfalls, severe mid –season dry spells and sandy loams	75 cm	60 cm	3	22222	66666
Areas with rainfall subject to frequent seasonal droughts and severe dry spells and very erratic rainfall and sandy acidic soils	75 cm	75 cm	3	17777	53333
Across agro-ecological zones (generic approach)	60 cm	90 cm	4	18518	74074

Adapted from a guide to Conservation Agriculture in Zimbabwe (2009) and Sasakawa Global 2000



Figure 4: Land preparation for permanent planting basins



Figure 5: Maize planted in the permanent planting basins

1.2.3 Practical steps in constructing planting basins

Preparing the basins

It is very important for extension worker to get acquainted with the practical steps in constructing plantings basins. It is noted that a lot NGO's partners have disseminated confusing messages on

planting basins. These basins are meant to be permanent in the sense that the following years the farmer would not be required to construct new basins. It is encouraged that the farmers should prepare the basins during land preparation from June to October. Digging planting basins only requires few tools and these are;

- **a Malawian standard hoe or a chaka hoe**
- **strings to mark out planting rows**
- **measuring sticks or tape measure**
- **pegs**
- **bottle tops**

Weeding in cropped land and virgin land

If the family labour is not a problem and the field is relatively flat or a farrow, farmers should be encouraged to take time to re-align or dig basins correctly (as indicated in Table 1) so that in future years the same basins can be used.

If the farmer would like to use virgin land for CA, it is encouraged to cut down the stumps, roots and trees. Ploughing is discouraged to till the virgin land to be used for CA. Weeding is encouraged on previously cropped land prior to constructing basins.

Farmers are encouraged to start on a small area for them to learn from. Expansion of area will take place as farmers get more skilled and convinced. Farmers can start with 0.5 ha (2 acres) of land. This would require a total of 8888 basins using the current recommended plant population (Table 1).

Marking out Basins

Mark out a straight line at the end of the field across and along the slope to easily mark the basins spacing and row spacing, respectively. Use Table 1 for spacing dimensions.

Calibrate the strings with bottle tops clipped to mark the row spacing and basin spacing. For example, following the current recommended plant population 53333 per hectare, basin strings and row strings will be clipped with bottle tops at 75 cm and 75 cm, respectively. This will change with different configurations and plant population

Tie the calibrated strings to the peg at the end of the field and stretch the strings across the slope to the other peg to mark out the planting row where to dig the basins.

Constructing basins

Starting at the first bottle clip at one end of the string, stand facing across the slope (the way farmers were standing in making ridges) and construct each basin about 30cm long, 15cm wide and 20cm deep. The width of the basin is determined by the blade of the type of hoe used. In Zambia and Zimbabwe, farmers use chaka hoes which are of the width of 15cm but the Malawi Standard hand hoe is about 20cm. Farmers therefore construct planting basins wider than 15cm.

When the basins in the row have been completed to the end of the line, use the tape measure or measuring stick to mark the next row using the recommended spacing of 75cm.

Repeat the process of constructing planting basins. The rows of basins can be constructed in linear or staggered format. Some NGO's promote the use of staggered basins over linear basins in order to capture water and reduce run off. This should be encouraged in running slopes.

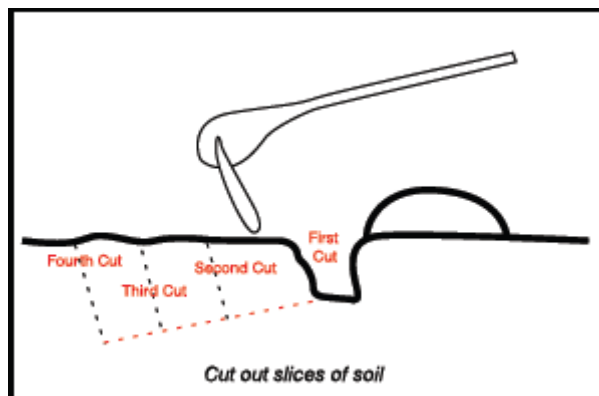


Figure 6: Cross section of a planting basin under construction (adapted from CFU, 2007)

Well constructed basins will allow farmers to use correct amounts of seed, fertilizer and manure at the right place. This reduces wastage of resources, money and time.

1.3 Maximum Soil Cover

1.3.1 Retaining Residues

Conventional tillage system encourages the clearing of crop and weed residues during land preparation. The cleared residues are burnt to control weeds, pests and diseases. However, the residues go away with residual nutrients in their stalks rendering nutrient cycling impossible and difficult. This burning of residues also predisposes the clear soil to run off by early heavy rains leading to soil erosion and land degradation. Due to continuous clearing of residues and rain splash for a number of years coupled with continuous hoeing, hoe hand pan is created rendering root penetration and water infiltration difficult. It is against this background that conservation tillage encourages the incorporation or spreading of crop residues. The residues are supposed to come from the same crop field unless otherwise. For instance, cotton and tobacco residues are commanded to be burnt to avoid sustaining pest and disease build up. However, the fields which can be spread with tobacco and cotton residues can be rotated with other crops (See crop association section).

Residue management and challenges

In maize based system, the multiple uses of maize stover render them scarce and unavailable for farmers to cover their field (Sosola et al., 2010). In southern region, maize stover is so scarce that farmers spread old grass thatch or combed grass on their crop fields. The maize stover is used for cooking and construction of fences due to scarcity of firewood. In the central region, farmers use

maize stover for fumigating tobacco seedbed nurseries and feeding livestock. They usually burn them when hunting for mice. In northern region, the maize stover is also used for feeding livestock and fumigating tobacco seedbed nurseries. These are potential challenges for scaling up conservation agriculture in Malawi. There is a tendency that a farmer only possesses ownership rights on crop produce and losses them on crop residues (Sosola, et al., 2010). This attitude predisposes crop residues as open access resources which can be utilized by any member of the community. It is a common practice in Malawi to see farmers feeding their livestock on other farmer's field without any form of reciprocity. ICRAF mobilized farmers through traditional leadership and extension workers to develop livestock byelaws to control free roaming of livestock during and after growing season. Communities willing practice CA should be encouraged to manage their livestock properly because CA is still compatible with livestock systems. The livestock when well managed would provide manure and draught power to CA farmers.

The culture of heaping maize stalks with cobs for drying up and harvesting makes the work of spreading maize stover laborious to farmers. The CA farmers usually tend to take back the stover to where the practice is being done and find this work tedious. Some farmers have commended the heaping practice because it makes their stover secure at one place and protected from mice hunters and roaming livestock. Farmers can harvest their maize from the standing stalks and the harvested stalks can be cut and laid down whilst harvesting the field. This reduces the double operation of taking away and bringing back of maize stover. The only challenge with this early spreading of stover is roaming livestock and lack of tenure over residues. If this improves farmers find this practice doable and time and labour saving.

Spreading of soil cover

Farmers can use soil cover materials such crop residues, old thatch grass and combed grass (flower heads removed). Caution should be made when farmers want to retain weed residues in the early stages of CA. Most weed residues have seeds which will infest the field because tillage will be minimized.

The crop residues should be spread systematically around the planting basins and planting stations. It is a little bit tasking for farmers in the first year of doing CA. In the subsequent years, farmers will mark where the old maize stumps are and crop residue will be spread around them.

Studies are currently being conducted to determine the recommended amount of stover or soil cover at smallholder scale. It is really envisaged that maize stover will soon be an economic commodity.

Benefits of maximum soil cover

- Well placed residues reduce the impact of rain splash and runoff. This checks soil erosion and land degradation.
- The residues promote biological activity by the soil fauna and flora. These activities facilitate the breakdown of residues into small particles that turn into humus or soil organic carbon. The increased fauna activity improves nutrient cycling from sub soil to top soil.

- In termite infested areas, the residues divert the attack on green growing maize to the decomposing stover or residues.
- Residues retain soil moisture by reducing evaporation and evapotranspiration. One farmer noted during ICRAF field days that CA plots with maximum mulch had turbid leaves whilst non-mulched plots had withered leaves.
- Crop residues release trapped mineral nutrients in the stalks through mineralization and are made available to the roots of the main crop. This is cost effective as the amount of fertilizer to be applied will reduce.
- Soil temperature is regulated by the crop residues which as heat insulators. This promotes biological activity and reduces volatilization of mineral compounds from the soil.
- Soil aggregate stability and porosity increases

1.3.2 Cover Crops

Alternatively, cover crops are intercropped with main crop to serve the physical attributes of soil cover, biological nitrogen fixation and mineralization from the N rich biomass. Although this could be classified as following the third principle of crop association or crop intercrop, it however needs to be emphasized that farmers who have problems of scarcity of maize stover and crop residues due to their multiple uses can use crop crops to attain maximum soil cover. The cover crops include *compeas, velvet beans, soya beans, common beans*. After harvest of the main crop, the cover crops should be well managed against livestock and fire.

Care should be observed when intercropping with cover crop. Recommended spacing for cover crop under intercrop should be followed to avoid light, space and nutrients competition with crops.

1.3.3 Dealing with livestock problems

Livestock problem has been cited as one of the challenges of adoption of CA by farmers in Malawi and other areas with agro-pastoral systems. It has to be emphasized that livestock and CA are still compatible but proper management system has to be put in place. Currently, in Malawi after crop harvest, livestock are let loose to forage or

1.4 Crop Associations and Rotations

Main crops are planted in different associations and rotations with legume crops or grain crops in space and over time. Crop association is when the main crop and sub crop are planted in the space and time whereas crop rotation is when the crops are planted on the same piece of land on different times. Both crop associations and rotations help control pests and diseases by breaking their cycles. Some crops help suppress weeds by producing allelopathic substances which kill the weeds. The legume intercrops help fix nitrogen in the soil through the nodules and biomass incorporation from the leaves. Soil structure is improved through the penetration of different root system across the soil layers.

Farmers can choose among a number of cropping systems for crop associations and rotations. The following cropping systems have been proved to be successful in achieving the above benefits;

- Crop rotation; different crops are planted one after the other in the same field at different seasons. Where there is land shortage, farmers find it difficult to practice it.
- Sequential cropping: Two different crops are grown in the same field, one after the other in the same year.
- Relay cropping: a crop is planted before the main crop is harvested.
- Intercropping: two or more crops are grown at the same time and in the same field.
- Strip cropping: Several different crops are grown in strips at the same time in the same field.

Generally arable land is scarce in Malawi due to increased population pressure on the land. Despite continuous extension message on crop rotations, the technology has hardly been adopted. In the interest of land shortage, farmers are strongly encouraged to invest in a number of crop association specified above.

Since agroforestry technology technically employs an intercropping system between main crop and legume fertilizer trees and shrubs, it is the rationale of this manual to emphasize the economic and ecological importance of agroforestry as a farmer friendly crop association. For further details and to meet the purpose of this extension manual, agroforestry with fertilizer trees will be dealt with in the next module.

MODULE 3: AGROFORESTRY (FERTILIZER TREES)

Introduction

Smallholder farmers in Malawi have been forced to abandon traditional rotation-fallow practices due to growing populations and reductions in landholdings. As a result, farmers are forced to cultivate the same plot of land every year, often without organic and inorganic fertilizers. These farmers have experienced steady decreases in yields, soil fertility, and thus their food security. While many smallholder farmers intend to address these issues with inorganic fertilizers, they are often unable to apply recommended amounts due to high costs, limited access to credit facilities, delivery delays due to poor logistics, and low variable returns (Buresh *et al.*, 1997). Food shortages that have resulted from poor access to fertilizers, depleted soils, and smaller landholdings have compounded the social and economic hardships brought on by HIV/AIDS in Malawi.

Agroforestry is a set of tools which farmers can use to increase yields, build soil fertility, raise their income, and boost their food security. ICRAF and its partners have worked closely with farmers for decades to promote and develop simultaneous intercropping practices to address the challenges in soil fertility facing smallholder farmers.

As supplementary technology in evergreen agriculture, agroforestry module will focus on the concept of simultaneous intercropping of proven fertilizer trees in replenishing soil fertility and increasing crop yields. *Simultaneous intercropping* was adapted from existing technologies in order to meet the needs of smallholder farmers with limited access to credit or land. Simultaneous intercropping has improved on current agroforestry techniques by:

- eliminating land lost to agroforestry trees;
- increasing leafy biomass through pruning management, and
- allowing for both annual and one-time planting of agroforestry tree species

While simultaneous intercropping requires additional labour compared to conventional monocropping practices, farmers have seen dramatic increases in crop yields with or without additional inorganic fertilizer applications. Research has shown maize increases when intercropped with fertilizer trees such *Gliricidia sepium*, *Tephrosia candida*, *Sesbania sesban*, *pigeon peas*, *Faidherbia albida* (Akinnifesi *et al.*, 2003). The nitrogen and organic matter that *fertilizer trees* add to the soil in simultaneous intercropping are essential in maintaining soil fertility, whilst reducing erosion and leaching of soil nutrients.

Simultaneous intercropping with *fertilizer trees* is a technology with which smallholder farmers can face the challenges of decreasing soil fertility and food insecurity. Although simultaneous intercropping is not complex, knowledge of some establishment and management techniques is

necessary for it to succeed. The following chapters explain in detail the principles of simultaneous intercropping as well as the management techniques required for successful field management under evergreen agriculture system.

Module objectives

By the end of this module participants should be able to;

1. Define simultaneous intercropping
2. Explain the advantages of a simultaneous intercrop
3. List the benefits of simultaneous intercropping
4. Explain the types of fertilizer trees used in simultaneous intercropping
5. Understand the agronomic practices of simultaneous intercropping for specific fertilizer tree species

Procedure

1. Brainstorm with the participants about the meaning of the words ‘simultaneous’ and ‘intercropping’. Record the participants’ contributions on a flipchart.
2. Summarise the participants’ contribution by adding information on each word provided in the module notes.
3. After defining simultaneous intercropping, ask participants about the advantages of a simultaneous intercrop and record responses on a flip chart. Then summarise using information provided in the modules.
4. Participants should then discuss on what they think would be the benefits of simultaneous intercropping.
5. Each group should then present their findings in the plenary and issues should then be discussed.
6. Summarise participants’ inputs and add information on benefits of simultaneous intercropping provided in the modules notes.

MODULE NOTES 3.1: CONCEPTS IN SIMULTANEOUS INTERCROPPING

1.1 What is simultaneous intercropping?

Simultaneous intercropping is an agroforestry technique whereby nitrogen-fixing woody trees are *simultaneously* grown with annual crops on the same piece of land at the same time. This is done in order to improve soil fertility and increase yields. While the trees are on the land throughout the year, the crops planted at the beginning of the rainy season dominate during the growing season.

1.2 Advantages of simultaneous intercropping

Simultaneous intercropping has improved upon existing agroforestry techniques such as alley cropping and hedgerow intercropping by:

- Eliminating land lost to woody plants
- Increasing biomass production through reduced alley sizes and pruning management
- Incorporating more tree's biomass directly into the soil where it is readily available to crops (e.g. maize)
- Requiring a one-time planting only (*Gliricidia sepium*). However, annual fertilizer trees are recommended to be planted every year.

1.3 What are the benefits of simultaneous intercropping?

The benefits of simultaneous intercropping *fertilizer* trees with maize are numerous, including:

1. Increased Yields

Maize yields increase just 2 years after establishment. These increases can be sustained for at least 15 years. Simultaneous intercropping can be used alone or can be combined with inorganic fertilisers. When inorganic fertilisers are combined with organic matter from fertilizer trees, yields increase even further.

2. Improved soil fertility

The fertilizer trees in the simultaneous intercropping act as a 'fertiliser factory' supplying nutrients to the soil for many years and thus constantly improving the soil fertility. When incorporated into the soil, the organic matter from fertilizer trees increases nitrogen (N), phosphorus (P), and potassium (K) concentrations. In fact, organic additions to the soil can be comparable to inorganic fertilisers.

In addition, the organic matter from fertilizer trees can raise and stabilize pH, which can be a problem after repeated inorganic fertilizer applications.

3. Improved Soil Structure

By improving the soil microclimate, structure, and biological activities, fertilizer trees can help reduce erosion, leaching, and nutrient losses. The deep-penetrating roots of legume fertilizer trees help break the hard soil pan, reduce water logging, and recycle nutrients from the subsoil to the topsoil, where crops can use them.

4. Reduced Erosion

Soil organic matter helps bind soil particles together which reduces erosion. Organic matter also serves to capture nutrients that can be made available for plant use. The biomass from fertilizer trees will also help protect the soil from wind and rain that can carry topsoil off the site.

5. One-Time Planting

Unlike other intercropping strategies, simultaneous fallow intercropping with *Gliricidia sepium* requires one planting which increases the long-term benefits of this strategy. Research has shown that *Gliricidia* trees can coppice and produce biomass for more than 15 years. This greatly reduces labour and seed requirements to the smallholder farmer. However, other fertilizer trees need to be replanted annually.

6. Low Financial Cost

Although intercropping with fertilizer trees requires increased input in labour, it demands very limited financial investment as opposed to the use of inorganic fertilizers.

7. Weed Control

Fertilizer trees have shown to be an effective tool against weeds, including *striga*, also known as witch weed. Farmers have testified that plots with fertilizer trees have reduced *striga* incidences as compared to plots without. This is due to the continuous applications of organic matter, which improves soil fertility and suppresses the germination of *striga*. Fertilizer trees can shade out many of the shallow-rooted weeds that compete with maize for water and nutrients.

MODULE NOTES 3.2: TEPHROSIA SIMULTANEOUS INTERCROPPING

1.1 What is Tephrosia?

There are two species of Tephrosia in Malawi namely *vogelli* and *candida*. *Tephrosia vogelli* is a shrubby legume naturally distributed in some parts of Africa. This herbaceous shrub is also known as Fish bean. Some farmers have planted Tephrosia as a cover crop across the tropics. The shrub favours dry savannah areas and a range of habitats. The trees may grow up to 4 metres in height. Its leaves are compound, velvety and have a greenish colour. The bark of the tree is smooth and its colour is dark grey. Flowers are white or purple and similar in form to those of common bean or pigeon peas. Depending on environment, the flowers are both self and cross-pollinated. A wide range of insects is believed to carry pollen from male to female parts of the flowers. *Tephrosia vogelli* usually flowers and produces fruits before the trees are one year old whereas *Tephrosia candida* when they are about two years old. Flowering normally occurs once a year. The tree has a deep-rooting system.

Tephrosia establishes easily and grows faster on various types of soils including acidic soils. Its performance is high in medium and high altitudes. It has a heavy leaf fall and has nitrogen-fixing nodules that improve soil fertility. Tephrosia has three main weaknesses. The trees do not take many years in the field, they do not respond positively to pruning and finally, the roots are easily attacked by nematodes especially *Tephrosia vogelli*.

1.2 Planting Tephrosia seeds

Tephrosia seeds are sown directly. The procedure below is usually followed before sowing seeds in the field:

- i. Put some seeds in a bucket (equivalent to the size of the field where you plan to plant seeds)
- ii. Pour some water into the bucket (usually three times the quantity of seed)
- iii. Soak the seeds overnight
- iv. Remove floating seeds (floating seeds cannot germinate)
- v. Empty water from the bucket
- vi. Take seeds to the field where you want to plant

In simultaneous cropping, Tephrosia seed should be sown at two weeks after planting maize. This prevents maize from shading young Tephrosia plants. On the other hand, it gives a chance to the *vogelli* trees to flower and seed before the next growing season. Tephrosia seeds are sown between maize planting basins. The recommended number of seeds per planting station is 3 seeds. The seeds take about a week to germinate. After harvesting maize, the trees are left to grow in the field until the next growing season. As already explained, the trees do not disturb the crop in the field. Growth usually accelerates after harvesting the crop.

1.3 How does Tephrosia improve soil fertility?

Since Tephrosia is a shrubby legume, its leaves are rich in nitrogen content. Nitrogen is one of the crucial elements a crop needs for growth. This element is usually responsible for the green pigment in leaves. If the element is deficient, the leaves usually turn yellow. The idea behind leaving Tephrosia trees for almost one year in the field is to allow the trees grow several leaves. Biomass is incorporated into the soil before the next crop-planting season.

Recommended Spacing for Tephrosia species under CA		
Row spacing	Planting spacing	Number of seed per station
150cm (jump one row)	75 cm (in or between the planting basins)	3 (thin out to 2)

Figure 7: Recommended spacing for Tephrosia and other fertilizer trees

During biomass incorporation, the trees are cut and leaves plucked off from the branches. The biomass is incorporated in the basins immediately during land and basin preparation. If the leaves are left to dry for some time, the nitrogen volatilizes from the leaves because of sunlight. Farmers cut down trees whose biomass would be incorporated on the same day or the following day.

1.4 How to collect Tephrosia seeds?

Farmers should be able to collect seed from trees they already have on the farm in order to make agroforestry sustainable. If Tephrosia is planted at the same time with or before two weeks after maize, there is high probability that the vogelli trees could produce seeds. If the seeds are planted late, the probability of trees producing seeds is low. If this is the case, it is advisable to leave some trees in the field for seed production during the next growing season especially candida trees because they usually take 1.5 year to produce seeds.

The best time to collect seeds from Tephrosia trees between July and September (Tephrosia trees may continue producing seeds after September but the seeds are not very good because of pest infection). It takes about 5-8 weeks for Tephrosia flowers to produce mature seeds depending on weather conditions. Seeds usually mature faster if the weather condition is dry or sunny. Pods which may contain up to 20 seeds are brown and brittle. Mature pods are hairy, usually 15cm long and 1.5cm in diameter. Mature seeds are grey-black and hard to the extent that it cannot be crushed between thumb and forefinger.

Once the seeds become mature, it is advisable to harvest immediately to avoid increase of pest and disease attack on the seeds. During collection, seeds should be harvested from a number of trees to ensure diversity. Exchanging seeds with neighbours also ensures diversity of seeds. Diversity of

seeds is important for genetic reasons and protection from pests and diseases. Ensure that only high quality seed is harvested. Avoid collecting seed from the ground because pests and diseases may have contaminated it.

After harvesting, pods should be dried in the sun on a mat for a maximum of three days until the pods start showing cracks on the sides. Put the pods into an old sack and bit it gently with a stick. Sieve the mixture to separate seeds from the broken pods. Well-dried Tephrosia seed can remain up to two years in store as long as the storage is dry and cool. After two years, the germination percentage becomes low.

MODULE NOTES 3.3: GLIRICIDIA SEPIUM SIMULTANEOUS INTERCROPPING

1.1 Introduction

Gliricidia is a fast-growing, nitrogen-fixing leguminous tree that is used in agroforestry to add nitrogen and organic matter to the soil. The nitrogen fixing ability and nitrogen-rich leaves of *Gliricidia sepium* make it an ideal intercropping plant in the nitrogen deficient soils in Malawi.



Figure 8: Flowering *Gliricidia sepium* trees during during season

When intercropped with maize, *Gliricidia* can dramatically increase crop yields with or without additional inorganic fertilizers within two to three years of planting. The roots are able to fix nitrogen in the soil and make it available for the maize. The leaves, which are high in nitrogen content, are incorporated into the soil to increase fertility as in simultaneous intercropping.

When managed properly, the *Gliricidia sepium* plants will not compete with maize for sunlight, soil nutrients, or moisture. Regular pruning of *Gliricidia* during the cropping season reduces the shading effect of the trees on crops. Differential root stratification of the trees and crops, i.e. high rooting density of maize in the top soil 0-40cm whereas the tree roots density is low in the surface and increases in the sub-soil below 40cm, reduces the competition for below ground resources. This increases the stability of soil particle aggregates hence reduces soil erosion.

Often the first two seasons are necessary for proper establishment of the trees, but in the course of time, the organic matter and nitrogen that *Gliricidia* provides, makes the soil more tillable and fertile. In addition, the organic matter that is added to the soil through the application of *Gliricidia sepium* prunings, will reduce erosion as well as leaching of nutrients from inorganic fertilizers.

In most cases, *Gliricidia* takes two to three years to become fully established, and to produce sufficient biomass to increase maize yields substantially. After the establishment period, the farmer will be able to double or triple maize yields, using the leafy prunings of *Gliricidia sepium*. Farmers practising simultaneous intercropping only need a major investment in labour during the first two cropping seasons. Simultaneous intercropping will begin to impact positively on soil fertility and yields from the third season onwards.

1.2 Nursery Management

The first step in simultaneous intercropping with *Gliricidia sepium* is to raise healthy, vigorous seedlings for transplanting into your field. Proper establishment and management of seedlings in the nursery will help ensure the survival of your seedlings after transplanting. Nursery establishment should begin in September to allow seedlings to be in the nursery for at least 6 weeks before transplanting. The good site for nursery establishment should be established close to a water source and your home. A fence should be constructed around the perimeter of the nursery to avoid damage from livestock, people, and wind.

There are two main methods for raising *Gliricidia sepium* seedlings in the nursery; in seedbeds or in containers. Both methods have advantages and disadvantages, and it is important to pick the most appropriate method given local conditions and resources.

Table 2: Advantages and disadvantages of various nursery methods

Nursery method	Advantages	Disadvantages
Nursery Bed/ Bare root	<ul style="list-style-type: none"> - Inexpensive - No containers required - Less labour costs 	<ul style="list-style-type: none"> - More prone to root damage - Lower survival rate after transplanting
Containers	<ul style="list-style-type: none"> - Easier to transplant - Less prone to damage during transplanting 	<ul style="list-style-type: none"> - More labour required (filling containers) - More expensive - May require capital for the container

Source: Extension Guide for Agroforestry Practices in Malawi: Simultaneous Intercropping of Gliricidia sepium, 2005

1.2.1 Seed Treatment

Treating *Gliricidia sepium* seeds will help them establish more quickly in the nursery. The seeds should be soaked in water for 24 hours before planting. After 24 hours, the seeds that are floating on the top of the water can be removed and discarded because these seeds are typically not viable.

1.2.2 Planting

Gliricidia sepium seeds should be planted in September. This will allow for the seedlings to grow for 6-8 weeks before transplanting. If grown for more than 8 weeks, the seedlings will become overgrown and difficult to transplant. In less than 6 weeks the seedlings will not be fully established. To plant the seed in a nursery bed, first drag a stick or a panga knife in a straight line 5 cm from the edge of the bed. Continue to make lines 1 cm deep, and 5 cm away from previous line. After these small furrows (grooves) have been made, place *Gliricidia sepium* seeds along the lines with 5 cm space in between each seed. After all the seed have been spaced properly in the bed, plant each 1 cm deep. Water the bed thoroughly after planting.

For *planting in containers*, use a stick to loosen up 2 cm of soil in the middle of the tubes. Plant 1 seed in the centre of the tube, 1 cm deep. Water the tubes thoroughly.

1.2.3 After sowing

After seeds are sown, dried grass should be placed on top of the raised beds or containers to avoid water loss and damage from watering. When the seeds have germinated, a shade “roof” should be constructed to protect the seedlings for a few weeks. The “roof” should be approximately 70 cm high. The roof should be removed to expose the seedlings to full sun in the weeks before transplanting.



Figure 9: Nursery roof for seedling



Figure 10: Well managed nursery with a shed.

Water the nursery once in the morning and once in the evening everyday until germination. After germination, watering should be reduced to once a day, depending on local weather and soil conditions. Inadequate or excess water will slow the development of the seedlings, and will hamper field establishment. Seeds and seedlings should be protected from water damage by applying water slowly through grass, a gentle watering can or a plastic bag with small holes.

1.2.4 Root Pruning

The pruning of the roots of the seedlings will stimulate the development of lateral roots, which will help the seedling establish quickly in the field once transplanted. Root pruning will also prevent

roots from growing too deeply into the soil below the seedling bed or container. When this occurs, it is very difficult to remove the seedling without damaging it.

Root pruning should be done every week after germination of the seeds. By dragging a panga knife under the nursery bed, taproots from the seedlings will be cut. The panga knife should be held level to the ground, and gently moved back and forth from each side of the bed. This will ensure that the roots of all seedlings are pruned. Roots should be pruned a few days before transplanting, but not on the same day! The seedlings need time to recover from the pruning shock before being transplanted.

1.2.5 Hardening-Off

In the last two weeks before they are transplanted, the seedlings should be watered less frequently and exposed to full sunlight. If seedlings were being watered daily, they should be watered once every two days, or the amount of water should be reduced. The purpose of this practice is to help the seedlings adapt to conditions they will experience in the field but not to damage them! By adapting seedlings to field conditions, you will improve the survival rate and help avoid water stress.

1.3 Land Preparation

Before transplanting, make your planting site or planting basins for the upcoming growing season. You should start tilling the planting basins in September/October. Preparing the sites for transplanting will help ensure that the seedlings can be planted quickly and in good health. Two weeks after planting maize, plant the trees between the planting basins at the recommended spacing as indicated below. Prepare the planting holes for the trees one or two days prior to planting. The preparation of planting holes and planting can be done simultaneously the same day if a farmer has adequate labour.

1.4 Transplanting

Holes should be dug between the planting basins at 75 cm apart and jump a row of basins at 150 cm. Dig the holes in the weeks before planting. Holes should be 20cm deep and 10cm wide. After the planting stations have been completed and the rains have completely soaked the soil, it is time to transplant the seedlings. Seedlings are very delicate, and should be handled with extreme care! They should not be exposed to direct sunlight and if possible, should be planted in the late afternoon or early morning on cloudy days after a rainfall.

The holes that have been dug and marked will make planting the seedlings quick and easy! Plant the seedlings properly without bending the roots. The roots should be placed carefully in the hole by keeping all roots in their natural position. The roots should not be bent or curled on the sides or bottom of the hole. This will slow down the establishment of the seedling.

1.5 Field Management

In the first year of growth, if the *Gliricidia sepium* trees are growing very fast, pruning in February might be necessary to minimize competition with maize plants for the aboveground resources. Pruning will also encourage more branching. When pruning the trees, cut all vegetation and branches above 30cm.

After the first year of establishment, the *Gliricidia sepium* trees should be pruned *at least* three times every year. The first pruning will occur in October/November, or in the weeks before planting. The second and third prunings should be done during the growing season, to boost soil fertility, encourage growth, and to avoid competition with maize plants. Usually the second and third prunings coincide with the time of first and second weeding. The prunings are incorporated.

The first prunings will occur between October and November of every year. This is the time that the leaves and young branches are pruned from the *Gliricidia sepium* trees and incorporated into the planting basins or laid down with maize stover. The pruning and incorporation should occur in the following steps:

1. Split the crop residues on either side of the basins of *Gliricidia sepium* trees. The split should be large enough to hold the leaves and young tender stems that are pruned.
2. Prune the *Gliricidia sepium* trees by removing all biomass **above 30 cm** with a panga knife.
3. Set aside any woody branches for firewood or poles. Wood should not be incorporated into the field, as this may not decompose fast enough to provide nutrients to the growing crop.
4. Evenly distribute the leaves and young, tender branches in the planting basin. Make sure to distribute the biomass evenly throughout both rows.
5. Cover the leaves and young branches by building the crop residues over them

During the rainy season, the *Gliricidia sepium* trees will produce a lot of biomass, therefore you should prune with the first weeding in December/January. This second pruning also provides nutrients for the growing maize plants at an important stage in their development. In this way, it is much like a top fertilizer dressing.

1. Prune all biomass above 30cm. Pruning is done by cutting all the branches that have grown from the stump from the height of 30 cm above ground. The tree will die if it is cut at the ground level.
2. Remove any woody biomass from the prunings, that is the branch part that has a brown colour.
3. During the second application arrange the tree prunings in the sides of the planting basins or planting row and bury them during weeding. Avoid placing the leaves too close to the maize plant this will induce termite attack on the maize.

The third pruning should be done during the second weeding, usually in February. The third pruning requires less labour than the first two prunings, as the biomass is placed around the maize stalks. The third pruning will act as mulch and help the soil hold moisture and add nutrients.

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