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POSTER ABSTRACTS

Poster Session 12: Producer Adoption of Conservation Agriculture

Adoption of Conservation Agriculture in Tunisia: Approches and Strategies Implemented

Houcine Angar, Hayet Màaroufi, Mohamed Ali Hannechi, Slim Arfaoui, Sonia Msahli, Walid Hamdi, Radhouan Nciri and Halim Ben Haj Salah
National Institute for Field Crops (INGC)
B.P. 120 Bousalem, 8170, Tunisia angarhbb@gmail.com

Background

Conservation agriculture is based on the elimination of tillage and soil protection by crop residues or cover crops. Its Development worldwide is linked to its positive impacts in limiting soil degradation as well as environment preservation, while gradually improving production and reducing production costs.

Based on the experience available worldwide, the French Agency of Development (AFD) and the French Fund for World Environment (FFEM) engaged in Tunisia since 1999 a process of support to the development of conservation agriculture. This process was conducted in four successive steps which can be summarized as follows:

1) Initiation phase during the 1999-2000 cropping season, as tests and experiments of No Tillage and cover crops under a project supported by AFD and with technical support from the French International Center of Agronomic Research for Development (CIRAD).
2) Program of experimentation and research for development on three seasons (2000-2004) under the Integrated Agronomic and Rural Development Project (PDARI) in Kef and Siliana regions with a scientific support from the Tunisian Institution of Agricultural Research and Higher Education (IRESA), the Technical Center of Cereals (CTC) and the Graduate School of Agriculture of Kef (ESAK).
3) Project funded by FFEM (2002-2006): “Program for the Development of agro- ecology and carbon storage in tropical and Mediterranean agriculture – no tillage support” nearby farmers in rainfed agriculture in the north of Tunisia.
4) Project to support the development of conservation agriculture (PADAC), (2007-2012) ensuring the continuation of previous actions to consolidate the results, support the dissemination and explore new options allowed by conservation agriculture.

PADAC objectives were: (i) To support the development of conservation agriculture with an outreach program to small and medium farms, taking into consideration the agricultural practices of different types of farms, from modern mechanically well equipped to smaller without equipment’s or using animal traction, (ii) To enhance the development of conservation agriculture in large farms through knowledge sharing, technical advice and exchange of experiences developed by professional associations,(iii) To accumulate scientific and technical observations likely to analyze and explain the long-term changes, with the establishment of an observatory to monitor the project's impact in terms of reducing land degradation. Thereby PADAC provided implementation of: (i) an Extension program within the competence of the Technical Center of Cereals (CTC - Current National Institute for Field Crops (INGC)); (ii) a Research program with the Graduate School of Agriculture of Kef (ESAK); and (iii) support to the professional association created by farmers practicing conservation agriculture (APAD).

In order to facilitate the implementation of these activities with the needed effectiveness, autonomy management was adopted by each program under agreed procedures and these structures should be coordinated to maximize their efforts and synergies, and intensify collaboration with other stakeholders.

Throughout the process, intervention approaches have been designed to combine both simple comparison tests between conventional practice and no tillage, scientific trials incorporating crop sequences, economic evaluation and extension opportunities at the request of farmers.

These approaches were based on the principle of effective involvement and participation of farmers in research and development activities, extension and dissemination of experiences acquired through no tillage practices according to the concept of " research-action in farm , for and with farmers " as well as strengthening their capacities. They targeted from 2002 large cereal farms and planned to then touch the medium and small farms while expanding the scale of intervention to cover landscape units (watersheds).

In terms of relevance, it should be noted that the design and the implementation approach of interventions supported by FEEM and AFD that have marked the process of supporting the development of conservation agriculture since 1999 enroll consistently in strategies aimed to limit land degradation according to sustainable development principles (environmental integrity, economic efficiency, social equity and control of natural resources management by local communities).

Conservation agriculture, thanks to the practice of direct seeding is a strategic challenge for Tunisia to develop agriculture on new basis, adapted to an environment characterized by an advanced soil resources degradation, depletion and loss of quality of water resources in the majority of agro - ecological zones of the country. These phenomena are further amplified by the effects induced by climate change (erratic rainfall, increased frequency of extreme events such as droughts and torrential rains).

In this context, conservation agriculture should emerge as one of the pillars of agricultural development policy in Tunisia in terms of its potential, proven in many countries, to ensure: (i) improved agricultural soil protection, improving soil fertility and maintaining their potential of production ; (ii) enhanced water use efficiency; (iii) reduced labor time, by elimination of plowing, and avoid delays in sowing and yield losses related and generating an improvement in labor productivity; and (iv) improved economic results (decreased investment in machinery, decrease of fixed costs and in long-term variable costs, decrease of gross product) .

Results

Stakeholders involved in the process have adopted and implemented a strategy and approach of action mobilizing and involving motivated and interested farmers by new technologies, targeting those who have material and intellectual capacity to engage in a process of research and development, enhance their farms productivity and contribute to their dissemination. Targeting was oriented to involve farmers who can positively influence their neighborhood and facilitate changes in attitudes and behavior next to the practice of conservation agriculture and thus circumvent the reluctance of governments towards thereof.

The approach has been to carry out experiments and trials in farms, combining scientific experiments, observations on pilot farms and field experiments (promoting extension) , using proven No Till seeders (with an after-sales service) and providing an of proximity technical support.

The adopted research approach has allowed the opportunity to put into practice an innovative agricultural research and development model adapted to the Tunisian agriculture context. Results have confirmed the relevance of the practice of no tillage ecologically, environmentally and economically in the Tunisian context.

Actually, there are data and concrete results on conservation agriculture, confirmed in the field by a network of of reference farms spread in all field crops regions of Tunisia. These results focus on the direct impacts of conservation agriculture to limit more effectively erosion and avoid agricultural land degradation, maintain stable or increase yields, reduce production costs, improve access to fields in wet clay soils, and create favorable conditions for a better adaptation to climate hazards and a better valorization of rainfall. These results were a reference of the Tunisian experience on conservation agriculture at international level.

The combined research, experimentation and advisory support made at the extension clusters have contributed to the development of capacity and expertise of farmers. They have created and consolidated a dynamic exchange and positive competition among farmers and strengthening their commitment to the process of development and extension of the practice of no till. This dynamic is evident in the field and reflects the growing interest in conservation agriculture by neighbor farmers of extension clusters.

Dynamic exchange between targeted and engaged farmers in conservation agriculture was essential in the replication and dissemination thereof.

Moreover, the private sector, through the providers of no till seeders, played a leading role in the transfer, development and diffusion of conservation agriculture. The experience of COTUGRAIN, Company importing no till seeders to Tunisia since 2000, reflects the importance of this role. Indeed, the company has specialized on importing a Brazilian brand of no till seeder (SEMEATO) considered one of the most suitable on the international market.

In addition to this commercial role, the company has actively participated in the dissemination of the technique of no till in organizing demonstrations, putting at the disposal of some farmers no till seeders for rent and conducting free tests at small scale with motivated and interested farmers. In addition to the sale of seeders, that company provides after-sales service, technical support for its customers.

This way of working has allowed: 1) Production of results and scientific and economic experiments in a real situation that can be operated to develop a transversal and multidisciplinary study that was actually initiated in the framework of national and international meetings; 2) ensuring a adoption and diffusion of conservation agriculture in a difficult environment where political development of agriculture is fundamentally oriented to conventional techniques and practices (deep anchoring of tradition of plowing), and where strategies against land degradation are based on conventional techniques of soil and water conservation. There is now a need expressed by regional structures of the Ministry of Agriculture and major projects working in the field of supporting development and management of natural resources to inscribe development of conservation agriculture in their interventions.

To the balance of achievements and achievements to date, we can consider that the support to the development of conservation agriculture process, reached overall objectives that could reasonably be expected in a very unfavorable context to the promotion of this technic. Current and potential positive impacts of this process are important. PADAC was particularly successful in enhancing the development of this practice in large farms, in consolidating and extending the achievements.

In contrast, and despite the substantial efforts made by stakeholders directly involved in supporting this process, some aspects of the objectives have not been successful as expected. These are mainly the following aspects:

Inefficiencies in some areas were amplified by constraints and deficiencies that can be summarized in the following points: (i) The support to the development of conservation agriculture process was conducted without effective involvement and participation of administration of Agriculture which played a passive role, despite the importance of its regulatory function; (ii) There was no real operational strategy for involving socio-professional organizations and strengthening their capacities to enable them to be real reliable and credible partners in this process.

Conclusions and recommendations

Results and achievements to date in the support for the development of conservation agriculture process provide a favorable and supportive platform to continue and consolidate the process supported primarily by the FFEM / AFD. It is to move this process to a higher level to actually subscribe conservation agriculture, in the policies and sectorial strategies for agricultural development and sustainable management of natural resources.

Conservation agriculture should also be integrated into programs of research-development and vulgarization in order to provide practical solutions to constraints faced by farmers to effectively limit erosion maintain soil fertility and improve their potential of production. This anchoring necessarily needs better technical mastery of conservation agriculture and a true extension of its application to a larger scale. It also needs to train high-level skills in various areas of CA in order to be able to advocate a new vision of agricultural development based on this concept.

In this context, the implementation of the following recommendations would be very useful: For Research and development: (i) Continue the process of research action in a global context to support the implementation of a strategy to promote conservation agriculture as an essential component of sustainable development (scientific research , capacity building, vulgarization of proximity, equipment) ; (ii) Taking into account the constraints/problems faced by farmers and the results of their practical experience by studying and analyzing their scientific validity and identifying ways to their consolidation and dissemination; (iii) Establish technical packages accessible by different users capitalizing on achievements of research development actions and the experiences of farmers and develop communication tools to their disseminate; (iv) Subscribe conservation agriculture as a strategic priority in research development projects and different natural resource management and agricultural development programs. For capitalization and dissemination: (i) Strengthen the role and capacity of extension establishments to enable it to play a larger and more efficient dynamic role on establishing and managing the implementation of a strategy to promote the conservation agriculture under partnerships with various institutions; (ii) Insert conservation agriculture in a larger planning framework and management of natural resources; (iii) Integrate conservation agriculture in the range of managements and of agricultural land conservation technology and as eligible for subsidy actions, including seeders acquisition, biomass production and carbon sequestration; (iv) Establish a strategy and action plan to help farmers implementing operational local organizations to develop AC process (acquisition and management of equipment's, share information , awareness and dissemination) . This should be done in close collaboration with other actors.

As Prospects, the post- revolution context provides real opportunities in a favorable institutional environment to rethink agricultural policy and sectorial strategies derived by integrating the development of AC. This integration should be one of the pillars of this policy given the importance of obtained results and achievements to date. The very favorable position expressed by IRESA reflects this positive change. Indeed, IRESA expressed the willingness and commitment to support and strengthen the efforts to date, including putting the AC among the priorities for research and development and contributing to public policy makers. There are currently a large expertise and knowledge in conservation agriculture among key players who have contributed directly to the development of conservation agriculture (INGC , ESAK , farmers ...) that can be valued. There is a strong belief in the advantages of the CA by many farmers (extension clusters) on limiting land degradation and loss of fertility and a great motivation to help extend this practice.

Based on the current achievements, it is essential to continue to support the process of adoption of CA in the context of a global strategy of supporting the development of AC: (i) intensifying research and development in order to establish technical packages dealing with various aspects of this practice in the Tunisian context; and (ii) creating the necessary conditions for medium and small farmers to access this technology. One of the constraints mentioned in the extension of the practice is the high cost of no till seeders and unavailability, on the Tunisian market, of suited and affordable seeders to small farms. Once opportunities operated and constraints to the extension of CA removed, the different sizes of farms will be reached by development programs and the practice of CA will continue to widespread, and even faster if Administration establishes some encouragements (equipment subsidies, credit facilities, etc.).

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Economics and Adoption of Conservation Agriculture in Cabo Delgado, Mozambique

Baqir Lalani and Peter Dorward
School of Agriculture, Policy and Development, University of Reading, PO Box 237, Reading RG6 6AR, UK email: B.Lalani@pgr.reading.ac.uk

Introduction

Conservation Agriculture (CA) is now practiced on more than 125 million hectares worldwide across all continents and ecologies (Friedrich et al., 2012). It is also practiced on various farm sizes from smallholders to large scale farmers and on a wide variety of soils from heavy clay to highly sandy (ibid). Within Southern Africa, where there is little mechanization, there have been mixed experiences with CA (Giller et al., 2009). Despite this and given the low rates of adoption in Southern Africa there is still controversy surrounding the benefits of CA both in terms of the private and social benefits accruing from adoption. These include a polarised debate on farm level costs/benefits, carbon sequestration and soil quality improvements. Other issues involve the particular time horizon for benefits to materialise and that farmers are concerned with immediate costs and benefits (such as food security) rather than the future (Giller et al 2009). Although some have questioned productivity enhancement, particularly in the short-run, economic analysis often fails to look at the effect on the whole farm budget i.e. profit (Baudron et al., 2007) or include comparisons over the long-term where farmers planning horizons, diversity in farming systems and risk preferences are considered (Pannell et al., 2014). In addition, particularly in Southern Africa, there has been scant research on smallholder farms that compares the economics of CA (which includes the simultaneous application of all three principles of CA) compared to partial adoption of CA (Pannell et al., 2014).[1]

A large number of studies have also only focussed on farm characteristics and socio-economic factors that influence adoption of CA. Little research, however, has focused on cognitive or social- psychological factors that influence farmers' decision making such as social pressure and salient beliefs (Garcia et al., 2013). Although previous research on farmers' decision making has employed The Theory of Planned Behaviour (TBP) (Azjen, 1991) that includes such cognitive and socio- psychological factors (See for example, Garforth et al., 2004; Hattam, 2006 and Garcia et al., 2013) this has seldom been done on CA adoption and within a developing country context.[2] Knowler and Bradshaw (2007) have shown through an aggregated analysis of CA adoption that there are very few if any universally significant independent variables (education, farm size etc.) that affect adoption. A number of authors have also shown that adoption should not be viewed as a single decision but rather a decision making process over time as farmers continually try, adapt and decide on when to use technologies (Fagerberg, 2003; Leeuwis and Van den Ban, 2004; Oladele, 2005 cited in Garcia et al., 2013). Within this process of 'adoption', innovation behaviour which includes, but is not exclusively limited to, behaviours such as 'experimenting', 'networking' and 'consultation' also impact on farmers' adoption process. Similarly, it is important to

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[1] Conservation Agriculture is defined by the FAO (2014) as (i) *Minimum Soil Disturbance*: Minimum soil disturbance refers to low disturbance no-tillage and direct seeding. The disturbed area must be less than 15 cm wide or less than 25% of the cropped area (whichever is lower). There should be no periodic tillage that disturbs a greater area than the aforementioned limits. (ii). *Organic soil cover*: Three categories are distinguished: 30- 60%, >60-90% and >90% ground cover, measured immediately after the direct seeding operation. Area with less than 30% cover is not considered as CA. (iii). *Crop rotation/association*: Rotations/associations should involve at least 3 different crops.

[2] Von Hase (2013) explores a small case-study of farmers' intention to use CA in Northern Namibia through employing the TPB.

explore what factors are involved in driving innovation behaviours (conventional or socio-psychological) and how these relate with the adoption process.

The following briefly introduces the objectives of the study; the theoretical framework that will be used and preliminary results from the first phase of the study.

Objectives of Study

1. Investigate the farm level economic costs/benefits to smallholders of using CA (i.e. application of all three principles as per the definition) through to farmer adaptation of CA (e.g. some components being used) and non –use of CA.

2. Using an appropriate econometric model (i.e. hierarchical multinomial model): (i) assess the relative impact on both innovation behavior and adoption of CA of differing factors associated with the technology adoption literature and Theory of planned behavior and (ii) examine the relationship between innovation behavior and adoption of CA.

Methodology

The data is being collected in two phases in the Metuge district of Cabo Delgado Province (Mozambique). The first phase of the study was carried out in early 2014 involving semi-structured interviews and focus group discussions with farmers that have used CA for several years, farmers not using CA and some which have discarded CA after several years. These interviews were used to elicit salient beliefs associated with the use or non-use of CA. The second phase involving a household survey will be administered in September 2014.

Figure 1 shows the framework by which adoption of CA and innovation behaviour will be analysed. The arrows indicate the particular relationships to be explored i.e. how does the Theory of Planned Behaviour (TPB) (Figure 2) relate to the adoption of CA compared to more conventional factors associated with the adoption of agricultural technologies? Likewise, how does the TPB influence innovation behaviour in relation to conventional factors that influence adoption but may also influence innovation behaviour. Finally, how does innovation behaviour relate to the use of CA.

Preliminary results and Implications for Conservation Agriculture

- Behavioural attitudes (positive) towards CA are strongly associated with the increase in yields, reduction in labour, less weeds due to organic mulch retention and improvements to the resource base i.e. soil quality. In contrast, lack of success on dark soil types and increased labour (associated with the added land preparation time to prepare micro- pits) were some of the negative attitudes expressed.
- Subjective norms (i.e. social pressures) play a strong role in influencing the process of 'adoption' and even innovation behaviours such as experimenting within a household. Unlike other countries in Sub-Saharan Africa where male and female spouses, within a household, may take control of different crops i.e. cash crop or those related to household food security; intra- household ownership of plots, particularly within this region of Mozambique, is common and had bearing on the use of CA within the household. For example, female spouses commonly had to convince their male counterparts to try CA on their plot of land and vice versa. Von Hase (2013) also found that for farmers in Namibia initial criticism of CA use did occur within the household and usually from the spouse.
- Whilst some farmers are practicing CA (i.e. all three principles simultaneously) there is evidence to suggest that farmers are actively observing, experimenting/testing and adapting by only using certain CA principles.

Conclusion

This study aims to make a contribution to the current literature on CA by addressing key areas of concern for farmers in Southern Africa namely, the viability of the economics of the new system with respect to areas of contention i.e. labour, yields and overall net returns. Early evidence has indicated the benefits of CA include, among other benefits, reduction in labour and increased yields (even in the first season); although there are instances where farmers may accept more labour if yields also increase in comparison to conventional agriculture i.e. use of micro-pits. Quantifying the costs and benefits will be important especially in relation to the number of years farmers have used CA. There are also factors normally associated with the technology adoption literature, which influence either adoption or disadoption of CA or particular components e.g. success in drought years encouraging adoption or lack of labour availability and pests/soil type discouraging adoption. However, other factors play a strong role. These include subjective norms (e.g. spousal attitudes) towards adoption of CA and innovation behaviours within the household (e.g. experimentation). The extent to which such norms outweigh more conventional factors involved in innovation behaviours and adoption may influence the design of future rural development programmes related to CA.

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Figure 1. Theoretical framework[3]

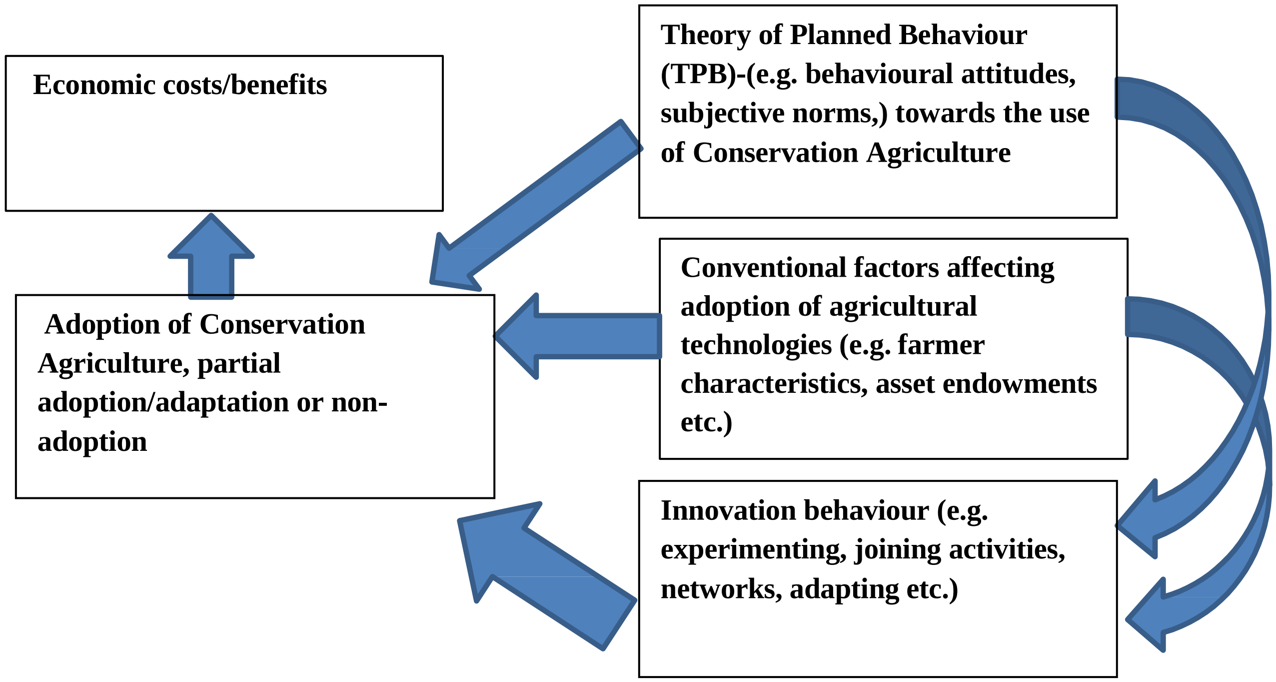
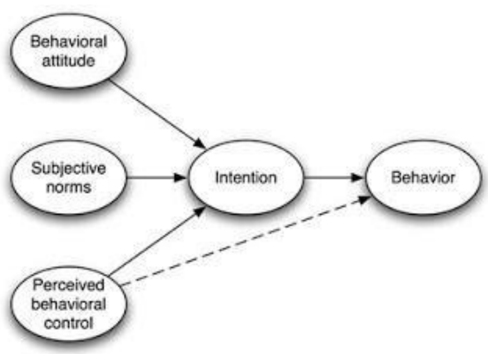


Figure 2. Theory of Planned Behaviour Source: Armitage, C. J. & Christian, J. (2004).



[3] Behavioural attitudes refer to positive and negative attitudes towards the behaviour. Subjective norms relate to the individual's own perception of the social pressure to perform certain behaviour.

Yield Performance and Agronomic N efficiency of a Maize-Rice Rotation under Strip and Conventional Tillage in Contrasting Environments in Bangladesh

T.J. Krupnik[1*], S. Yasmin[1], D. Pandit[1], M. Asaduzzaman[2], Md. S.I. Khan[1,2], K. Majumdar[3], A. McDonald[1], R. Buresh[4], and M. Gathala[1].

[1.] International Maize and Wheat Improvement Center. [2.] Bangladesh Agricultural Research Institute (BARI). [3.] International Plant Nutrition Institute (IPNI), [4.] International Rice Research Institute (IRRI).

* Corresponding Author: H. 10/B, R. 53, Gulshan-2, Dhaka, 1213. Bangladesh. t.krupnik@cgiar.org.

Background

In South Asia, most nutrient management recommendations for maize and rice are broad, zone-based recommendations that do not consider field-to-field differences in indigenous soil fertility (ISF) and crop yield potential as influenced by site and management factors such as irrigation or crop supplemental nutrient needs (Buresh et al., 2010). These approaches miss opportunities to fine-tune recommendations to specific fields, with attendant consequences for yield, profitability, and environmental quality, especially where agronomic efficiencies (AEs) are low from overuse of fertilizers. Globally, AE-N for maize and rice are far from optimal, averaging 24 and 22 kg kg^{-1} (Ladha et al., 2005).

This work represents an initial-step towards developing site-specific nutrient management (SSNM) recommendations for maize in Bangladesh with the decision support tools (DSTs) Maize Crop Manager (http://webapps.irri.org/bd/mcm/) and Nutrient Expert® (http://software.ipni.net//)). These DSTs use farmer surveys and computer software to make dynamic soil fertility recommendations (Buresh et al., 2010), but may require improvement for applications in conservation agriculture-based (CA) systems. Our research asks "Do yield patterns, ISF, and AE differ under CA compared to conventional tillage (CT)?" CA systems can result in changes in soil ecological processes over time, which may in turn influence nutrient supply (Grahmann *et al.* 2013), and thus CA specific SSNM recommendations. This preliminary work investigates if there are differences in yield and AE between the CA practice of strip tillage (ST) with residue retention and CT where nutrients are sequentially omitted to investigate patterns in INS.

Table 1. Maize, rice, and system (Maize + Rice) grain yields for Rotation year 1(2011-12 dry *Rabi* Season maize and 2012 monsoon rice season) and Rotation year 2 (2012-13 *Rabi* and 2012 *T. Aman*).

Factor effects	Rotation year 1 yields (t ha^{-1})			Rotation year 2 yields (t ha^{-1})		
	Maize[1]	Rice	System	Maize	Rice	System
Jamalpur						
Tillage (T)						
CT	6.6	6.6	12.7	9.7	5.5	15.2
ST	6.4	6.1	12.5	9.6	5.3	15.0
Nutrients (Nut)						
+NPK+Zn	8.6 a	6.7 a	15.3 a	11.8 a	5.9 a	17.7 a
+NPK-Zn	7.5 ab	6.4 a	13.9 b	10.8 b	5.6 ab	16.4 b
–N	2.8 d	4.9 b	7.7 d	5.1 d	4.9 c	10.0 d
–P	6.2 c	6.1 a	12.3 c	10.1 c	5.4 abc	15.5 c
–K	7.3 bc	6.3 a	13.6 b	10.4 bc	5.3 bc	15.7 b
F-Ratio						
T	0.9 ns	0.3 ns	0.7 n.s	0.0 ns	2.7 ns	2.3 n.s.
Nut	66.3***	9.2***	97.2***	34.2***	6.8**	41.2***
T × Nut	0.0 ns	0.1 ns	0.2 n.s.	0.0 ns	0.0 ns	0.1 n.s.
Barisal						
Tillage (T)						
CT	7.2 a	3.8	11.0 a	7.9 b	3.9 b	11.8 b
ST	5.7 b	3.7	9.5 b	8.5 a	4.1 a	12.6 a
Nutrients (Nut)						
+NPK+Zn	7.3 a	4.5 a	11.8 a	10.8 a	4.5 a	15.3 a
+NPK-Zn	7.3 a	4.2 a	11.6 a	9.3 b	4.2 b	13.5 b
–N	3.0 b	2.8 b	5.8 b	3.5 d	3.1 c	6.5 d
–P	7.1 a	3.5 ab	10.6 a	8.3 c	4.1 b	12.4 c
–K	7.5 a	3.8 ab	11.3 a	9.0 bc	4.2 b	13.1 bc
F-Ratio						
T	32.6***	0.0 n.s.	33.7***	11.6**	12.3**	21.2***
Nut	25.3***	5.4**	70.1***	116.5***	77.4***	289.3***
T × Nut[1]	1.7 n.s.	0.0 n.s.	0.3 n.s.	0.3 ns	1.0 ns	0.2 n.s.

In columns not separated by italicized model effects, values sharing the same letter are not significantly different according to the Student's-*t* test (main plots) or Tukey's protected HSD test for sub-plots ($\alpha = 0.05$). * Significance at $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$. ns means not significant. [1.] Data were squared to obtain normality; back-transformed data shown here. [2.] *T × Nut* data are not shown due to their lack of significance. [3.] As the ratio of additional grain yield from nutrient addition to the quantity of nutrients applied, AE data were not subjected to ANOVA.

Experimental Approach

Table 2. Main effect agronomic efficiency of N (AE_{-N}; kg kg^{-1}) for Rotation year 1(2011-12 dry *Rabi* Season maize and 2012 monsoon rice season) and Rotation year 2 (2012-13 *Rabi* and 2012 *T. Aman*).

Main effect	Year 1 AE_{-N} (kg kg^{-1})		Year 2 AE_{-N} (kg kg^{-1})	
	Maize	Rice	Maize	Rice
Jamalpur				
CT	24.2	18.3	26.0	10.6
ST	22.9	17.2	27.5	9.4
F-Ratio	0.3 ns	0.1 ns	0.2 ns	0.2 ns
Barisal				
CT	22.2	17.6	38.7	15.0
ST	20.5	16.6	38.9	14.3
F-Ratio	0.1 ns	0.0 ns	0.0 ns	0.0 ns

On-station split-plot experiments were initiated in 2011 with CT and ST as main plots, and with full +NPKZn, +NPK-Zn and -N, -P, and –K omission as sub-plots in a two-year rice-maize rotation in central (Jamalpur) and southern (Barisal) Bangladesh. In CT, tilled maize was rotated with puddled transplanted rice. ST included ST maize followed by unpuddled transplanted rice, both with 30% anchored residue retention. +NPKZn rates followed State recommendations by agroecological zone. In Jamalpur, rates were 250, 100 and 160 kg N, P, K ha^{-1} for maize with N applied in three splits. In Barisal, rates were 210, 80 and 12 kg NPK ha^{-1}, with N similarly applied. 100, 20 and 75 kg N, P, K ha^{-1} were used for rice in Jamalpur; in Barisal, rates were 15 kg ha^{-1} lower for P only. For rice and maize, 5 kg Zn ha^{-1} was also applied to the +NKPZn and each macro-nutrient omission plot. One additional +NKP plot was maintained without Zn to assess the importance of Zn on yields. In the NPK omission plots, the same rates for each nutrient were used as the +NKPZn plot, but with N, P and K sequentially excluded.

Results and Significance for Conservation Agriculture

No significant differences between ST or CT were observed for the 2011-12 *Rabi* season in Jamalpur, nor for the 2012 *T. Aman* rice season (Table 1). Conversely, significant differences were consistently found between the nutrient addition and omission plots, though no tillage system × nutrient addition or omission interactions were recorded. This pattern also extended to system (maize + rice) yields, and was maintained in the second year of the rotation.

In Year 1 in Barisal, significant ($P<0.001$) differences were observed between ST and CT. Lower ST yields may have been caused by poor stand establishment, and by cutworm (*Agrotis ipsilon*) in untilled soil. No differences were found for the nutrient addition and omission plots, and no system × nutrient addition or omission interactions were observed. In the 2013 *T. Aman* rice season, no tillage system differences were found. The lower preceding maize yields resulted in significantly lower ST system yields. But in Year 2, this pattern was reversed, with ST yielding more for maize and rice, respectively. Improved maize yields may have resulted from the increased confidence of the strip-till machinery operator and lack of observed *A. ipsilon* damage. Importantly, no system × nutrient addition/omission interactions were observed for either crop or on a systems basis. Examining agronomic N use efficiency (AE_{-N}), no tillage system differences were found in either Year 1 or Year 2 in both Barisal and Jamalpur.

CA systems have been described as having lower nitrogen use efficiency (see Grahmann *et al.* 2013). In the current study, the lack of tillage system × nutrient addition or omission interactions, indicate that ISF and the nutrient acquisition patterns between ST and CT are similar. This may be partly due to the sub-surface placement of basal fertilizers below the residue layer by machine, thereby avoiding N immobilization, and/or through the lack of residue incorporation by ST. Post-planting fertilizer banding, and the broadcast application of fertilizers into rice with maize stover still vertically anchored, may similarly avoid immobilization. Further research is needed to confirm these hypotheses, and to assess if current SSNM DSTs can provide dynamic recommendations appropriate to ST. Our preliminary data highlight similar IFS and yield patterns for ST, indicating that current DSTs may be appropriate without requiring further adjustment for use in CA-based cropping systems.

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Adaptations in Conservation Agriculture for Acceptance by Smallholder Farmers in the Hills of Nepal

Nirmal Gadal[1], D. KC[1], T.B. Karki[2], J. Dhakal[2], J. Dhakal[2], R.B. Katwal J. Dhakal[2],, T.B. Ghimire J. Dhakal[2], H. Prasai J. Dhakal[2] and B. Pokhrel

[1] International Maize and Wheat Improvement Center (CIMMYT) /SARO, Kathmandu, Nepal
[2] Nepal Agriculture Research Council (NARC), Kathmandu, Nepal
Author for correspondence: **n.gadal@cgiar.org**

Background

About six hundred youths out of 13 million economically active populations in Nepal migrate to abroad every day. Most of these migrants are youth (76%) and come from the rural areas (97%), leaving farming on the hands of women and elderly people (CBS). In addition, the country's agriculture is being hard hit by frequently occurring drought, landslides and flooding (MoAD). In recent years, attentions of the government and donor partners have increased significantly to figure out the future agriculture development landscape of the country under increasing pressure from migration and climate change in agriculture sector.

Agriculture systems in the hills of Nepal are dominated by maize based subsistence farming which is extremely complex and diversified involving combinations of crop production, livestock and agro-forestry evolved alongside of the distinct socio-economic and cultural contexts. Conservation Agriculture is recently initiated in Nepal to address some of the problems associated with the climate change and decreased labor forces in agriculture. Among others, the International Maize and Wheat Improvement Center (CIMMYT) and the Nepal Agriculture Research Council (NARC) are jointly engaged through the Hill Maize Research Project (HMRP) to evaluate various CA based technologies and examine required adaptations for acceptance by smallholder farmers in the hills of Nepal.

This paper examines the farmers' preferences for various CA based technologies and assess the required adaptations for acceptance by smallholder farmers in the hills of Nepal.

Experimental Approach

Six on-station trials in ARS-Pakhribas, HCRP- Kabre, NMRP-Chitwan, ARS-Surkhet, ARS-Dailekh and RARS-Dotee and five farmers' participatory trails in Dhankuta, Palpa, Syangja, Gulmi and Dotee districts were conducted in split-plot design in 2013 and is continued in 2014 (see table 1 below).

Table 1: Treatment combinations

SN	Factor A-Tillage	Factor B- Residues	Factor C- Rotation	Treatments
1	ZT	RK	(M+S)-W	ZT+RK+(M+S)-W
			M-W	ZT+RK+M-W
		RR	(M+S)-W	ZT+RR+(M+S)-W
			M-W	ZT+RR+Ms-W
2	CT	RK	(M+S)-W	CT+RK+(M+S)-W
			M-W	CT+RK+M-W
		RR	(M+S)-W	CT+RR+(M+S)-W
3	CT	RR	M-W	CT+RR+M-W

***ZT:** Zero Tillage; **CT:** Conventional Tillage; **RK:** Residues Kept; **RR:** Residues Removed; **(M+S):** Maize soybean Intercropping; **M:** Maize sole; W: Wheat*

To accomplish the second objective of this study on assessing required adaptations needed in CA for acceptance by smallholder farmers, a survey was carried out during February to April 2014. In this survey seventy eight farmers from five districts who involved in the evaluation of the various CA based technologies were interviewed using semi-structured questionnaire. Likewise five focus group discussions were conducted with these farmers groups. Farmers in the survey and FGDs were asked to provide score on the pre-defined indicators against each treatment on the scale of 1 (best) to 5 (worst).

Results and Discussion

The preliminary year-one data has shown that the yield of maize, soybean and wheat are non-significant among the treatments indicating CA based technologies can give comparable yields with the reduced cost of production to conventional plough based production systems. The average of scoring on various indicators against the treatments showed that plough-based tillage with residues retained on the soil surface and following maize + soybean intercropping with wheat in winter is the most preferred technologies followed by ZT+RK+(M+S)-W, ZT+RK+M-W, ZT+RR+(M+S)-W etc. The least preferred technologies (ranked 8th and 7th) were ZT+RR+M-W and CT+RR+M-W respectively.

Table 2: Average of the scores given by respondents (n=78) on indicators against the different treatment

SN	CA and conventional practice	Average score by respondents (N=78) (1=best and 5=worst)											Total score	Overall ranking
		Crop establishment	Weed incidence	Disease and pest incedence	Time and labour saving	Yield Improvement	Cost effectiveness	Soil fertility improvement	Conservation of soil moisture	Prevention of soil erosion	Easy to use	Reduction in lodging		
1	ZT+RK+(M+S)-W	3.4	4.1	3.6	2.2	2.5	2.0	2.7	2.2	2.4	4.8	2.0	29.9	II
2	ZT+RK+M-W	4.3	4.0	4.3	4.5	3.2	2.0	2.9	3.0	3.5	3.3	2.2	37.2	III
3	ZT+RR+(M+S)-W	5.0	5.0	4.0	3.2	4.2	3.8	3.2	4.1	3.9	5.0	4.2	45.6	VI
4	ZT+RR+M-W	5.0	4.2	4.0	3.7	5.0	4.2	5.0	5.0	4.7	5.0	5.0	50.8	VIII
5	CT+RK+(M+S)-W	1.0	1.0	3.2	3.5	1.2	3.0	3.0	2.1	2.2	2.5	4.0	26.7	I
6	CT+RK+M-W	1.2	2.8	3.0	5.0	4.8	4.0	3.2	3.5	3.8	3.5	5.0	39.8	IV
7	CT+RR+(M+S)-W	3.5	3.2	3.3	3.8	4.8	4.5	4.5	3.8	4.8	4.0	3.0	43.2	V
8	CT+RR+M-W	3.8	4.1	3.4	5.0	4.7	3.8	3.2	5.0	5.0	4.8	5.0	47.8	VII

ZT: Zero Tillage; **CT**: Conventional Tillage; **RK**: Residues Kept; **RR**: Residues Removed; (**M+S)**: Maize soybean Intercropping; **M**: Maize sole; **W**: Wheat

Note: Manual-conventional weed control in all treatments

This study showed that there are tremendous prospects to develop and promote CA among smallholder farmers in the hills. However, there is need to do further research to adapt CA in the diverse context especially in the areas development of CA based implements suitable for the hill environment and smallholder farmers. This study confirmed to the previous scientific findings that there are significant advantages of CA with regard to time and labor saving; sustainable yield improvement; improving soil properties and reduction in lodging in maize.

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Productivity of Triple Cereal System under Double Zero-Tillage with Crop Residue Retention

M. Ataur Rahman*[*] and T. P. Tiwari

Wheat Research Centre, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh
*Corresponding author: Email: ataur67@yahoo.com

More food and feed demand couple with scarcity of arable land caused intensive cropping of cereals in Bangladesh. Maize intervention in existing rice-wheat cropping system will facilitates further intensification shifting the double cropping into triple cereal system. The system has practical significance in increasing the area and annual production of both wheat and maize without affecting rice production. Successfully adoption and up-scaling of this cropping system will improve productivity at farm level and thereby mitigate hunger and ensure food security of the country. But the triple cereal system with HYV of rice and wheat and hybrid maize may lead exhaustion of nutrients resulting decline in soil fertility. Before adoption and up-scaling of the system, due attention is essential to sustain the productivity and soil fertility with the intervention of conservation agricultural practices (CA). The major concepts of CA are the minimum disturbance of soil and keeping crop residue in the field which improves soil quality preventing erosion and nutrient leaching (Erenstien 2002) thus CA improves system productivity (Wall, *et al.* 2010). Also crop residue retention contributes to productivity by conserving residual moisture (Sharma and Acharya 2000), controlling weeds and improving N use efficiency (Rahman *et al.* 2005). However, most of the CA works reported either in single cropping or double cropping system. The present experiment was under taken to evaluate the CA practices in improving the productivity of component crops of wheat, maize and rice under the triple cereal cropping system.

The field experiment was initiated at Bangladesh Agricultural Research Institute, Gazipur (lat 24° N, long 90°3´E, 8 m elev) starting with a wheat crop in 2010-11. The experiment was laid out in a randomized complete block design with three replications of four packages of treatments imposed on the component crops within a wheat-maize-rice cropping system. The four treatments are: T_1 = Conventional practices; T_2 = Conservation practices; (Wheat was sown in post rice harvest field with standing crop residue using PTOS (Power tiller operated seeder) followed by no-till maize and then puddle transplanted rice (PTR)); T_3 = Bed planting; (Wheat was sown by power tiller operated bed planter followed by no-till maize then PTR); T_4 = Conservation practice in Bed; (Same as T_3 with standing residue retention of rice and wheat). The crop varieties used are BARI GOM 26, BARI hybrid Maize-7 and BINA Dhan 7 for wheat, maize and rice respectively. The recommended rates of fertilizers for wheat ($N_{120}P_{30}K_{50}S_{20}B_1$), maize ($N_{200}P_{50}K_{80}S_{40}Zn_5B_2$) rice ($N_{80}P_{25}K_{50}S_{20}$) were applied in all the plots. The size of each plot was 10m X 6m and there were gaps of 1m between the plots. The wheat crop was irrigated thrice (crown root initiation, booting and grain filling stages), two irrigations were applied in maize (post sowing and after germination) to ensure germination and stand establishment and rice was rain-fed. After harvest, the grains were dried and grain moisture was measured to converted grain yields to t ha^{-1} at 12% moisture content for wheat and maize and 14% moisture for rice. Soil samples were collected after each cycle of cropping and analyzed following standard method to estimate organic matter (OM) and available nutrient contents in soil.

Three years experimental result indicated that CA practices of double zero tillage with standing crop residue (T_2 and T_4) influences soil hydraulic properties resulting in higher soil moisture between the irrigation intervals in wheat during the dryer period of the year. On the contrary, the excessive water was well-drained from the plots under CA during early monsoon causing favorable moisture regimes in maize field. By altering the soil moisture regime CA contributed to better stand establishment resulting higher number of spikes/m^2 of wheat and the cobs/m^2 of maize. Thus CA practices either in bed or in flat (T_2 and T_4) were equally effective in improving grain yield of wheat and maize for the last 3 years (Table 1). The residual effect of CA imposed on wheat and maize crop had the similar non-significant effect on rice yield until second year then became significant in third year. Soil OM did not declined due to intensive cropping of triple cereals for 3 years but improved under CA compare to initial soil and conventional practices (Fig. 1). Total N, available K and S content were slightly reduced in conservation practices than initial soil. On the contrary, under CA the intensive wheat-maize-rice cropping system did not caused decline in any soil nutrient. Furthermore, most of the nutrient content including N, P, S and B was increased under CA.

Table. 1. Effect of CA on grain yield (t ha^{-1}) of component crops in the system for 3 years.

	2010-11			**2011-12**			**2012-13**		
Treat.	Wheat	Maize	Rice	Wheat	Maize	Rice	Wheat	Maize	Rice
T_1	3.2 c	5.8 b	4.3 a	3.5 c	6.1 b	4.4 a	3.8 c	5.9 b	4.3 b
T_2	4.4 a	6.7 a	4.4 a	4.4 a	7.1 a	4.5 a	5.4 a	7.5 a	4.7 ab
T_3	4.2 a	6.1 ab	4.1 a	4.1 b	6.2 b	4.2 a	4.5 b	6.2 b	4.3 b
T_4	4.5 a	6.6 a	4.2 a	4.6 a	6.9 a	4.4 a	5.6 a	7.5 a	4.9 a
CV (%)	7.8	6.3	8.2	7.5	7.4	8.8	7.6	6.8	7.4

T_1, T_2, T_3 & T_4 are defined in text (methodology); the values followed by common letter within a column are not different at 5% significance level.

Improved and sustainable productivity of wheat-maize-rice cropping system was achieved under the conservation practice of double zero tillage with residue retention. The intensive triple cereal system under CA contributed to increase in available nutrient content in soil.

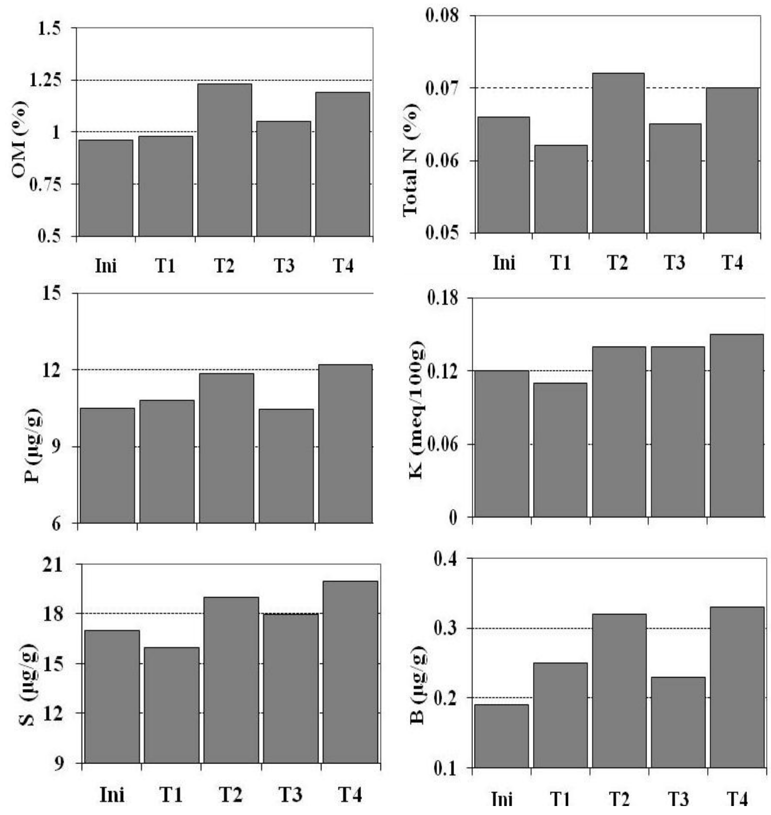

Fig. 1. Effect of CA on available nutrient content in soil after 3 years of wheat-maize-rice cropping in relation to initial soil (Ini= Initial soil)

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Improving Productivity of Maize-Legume Farming Systems Through CA. Evidences and Lessons from SIMLESA Mozambique

Dias, D.[1] & Nyagumbo, I.[2]

[1] Instituto de Investigação Agrária de Moçambique (IIAM), Centro Zonal Centro, Estação Agrária de Sussundenga, Manica, Moçambique, djosedias@gmail.com
[2]CIMMYT, International Maize and Wheat Improvement Centre, Box MP163, Mt. Pleasant, Harare, Zimbabwe

Background

Mozambique experiences low average maize yields around 0.8 t/ha due to low uptake of improved technologies). For example the use improved maize varieties are estimated at 4 % with a requirement of 1,300 tonnes per annum. Fertilizer use is also lower than 5% while mechanization is less than 2% (TIA, 2005). Since 2010, the Australian Funded and CIMMYT managed 'Sustainable intensification of Maize Legume systems in Eastern and Southern Africa' (SIMLESA) program has been evaluating the merits of a variety of maize-legume systems under Conservation Agriculture in contrasting agro-ecologies of Central Mozambique. This study presents highlights of evaluations of soil moisture and crop productivity under various conservation agriculture based maize-legume cropping systems from the last 3 seasons since 2010 from a few selected communities in semi-arid Sussundenga district, Manica province and sub-humid Angonia district of Tete province.

Materials and Methods

On-farm experiments were established in six communities of Central Mozambique in 2010 following stakeholder consultations. Trials with 6 farmers per community (district) with each farmer representing a replicate, were established with six treatments involving conventional farmer practice, Conservation Agriculture techniques and different crop establishment techniques such as CA jab planter and CA basins. The CA cropping systems also involved maize –cowpea / common beans rotation or intercropping systems. One open pollinated maize variety (Tsangano) was used throughout the sites while intercropping and rotation combinations with cowpea (Variety IT-16) were used in Sussundenga and Gorongosa districts. In Angonia common beans were used in a similar fashion. Other improved technologies included the application of fertilizers, row planting and inclusion of herbicides for weed management. In all CA systems maize or grass residues were applied at 2.5-3 t/ha and glyphosate was also applied prior to planting for weed control. Among other measurements, top soil moisture on some sites was measured periodically using a Time Domain Reflectometry (TDR) with probes measuring down to 20 cm depth. Maize yields were measured at the end of each cropping season. Farmer feedback was obtained through participatory evaluations made 3 times per season.

Results and Discussions

Generally CA systems resulted in significantly ($p<0.005$) higher relative top soil moisture content and in Angonia was above 70% compared to conventional treatment (Figure 1). Soil moisture in the ridge and furrow conventional practice which was left bare was always lower in moisture status compared to CA. There was however no evidence of soil moisture reduction from the CA intercrops where the common beans were inter-planted between the maize rows. CA plots thus benefitted from extra moisture content due to residue cover as found in other studies suggesting higher water infiltration, reduced run-off and improved moisture storage (Thierfelder et al., 2014). The conventional ridge and furrow system was also prone to soil erosion after heavy rainfall especially when ridges were oriented run up and down the slope.

Yield performance

Despite huge gains in soil moisture in Angonia, yields from both Ciphole and Cabango communities (Figure 2) showed no significant differences ($p>0.05$) between the conventional farmer practice and CA practices with the magnitude of differences pronounced in seasons with low rainfall (+/- 600 mm) and suppressed in seasons with high rainfall (+/- 1000 mm). Due to the high rainfall experienced in Angonia excessive soil moisture in the CA systems often led to water logging thereby resulting in insignificant yield differences between CA and the conventional farmer practices over the three seasons. However in the drier Sussundenga and Gorongosa communities , combined Analyses of Variance Across Sites across sites for the two communities resulted in significant ($p<0.05$) yield increases from the CA systems involving sole maize and rotations (Table 1). Results showed that yield differences between conventional farmer practices and CA progressively increased over time while superior yield gains from CA systems were also observed in seasons with low rainfall (+/- 650 mm) suggesting moisture savings from CA thus contributing to the observed CA yields. Improved maize yields were also realized from the CA maize-cowpea rotation systems which resulted in a mean yield increase of 32 % above the Conventional farmer practice (Table 1). Generally on all 6 sites CA Maize-legume rotation systems generally produced the highest yields although in some cases not significant. However the most preferred system by farmers was the maize-cowpea intercrop system due to the ability to generate two crops from the same piece of land despite compromised maize and legume yields compared to corresponding yields of the same crops in rotation systems.

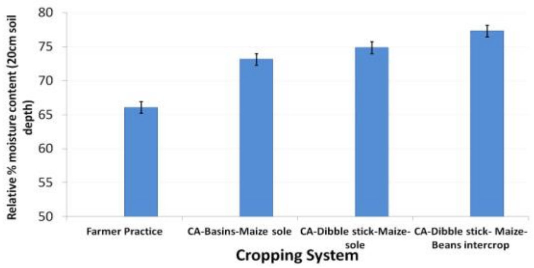

Figure 1. Mean relative soil moisture content in the top 20 cm over 12 farm sites comparing different cropping systems in Angonia district, Mozambique in March 2012. Note: Measurements made with the Time Domain Reflectometry (TDR 300). Error bars denote l.s.d $_{(0.05)}$.

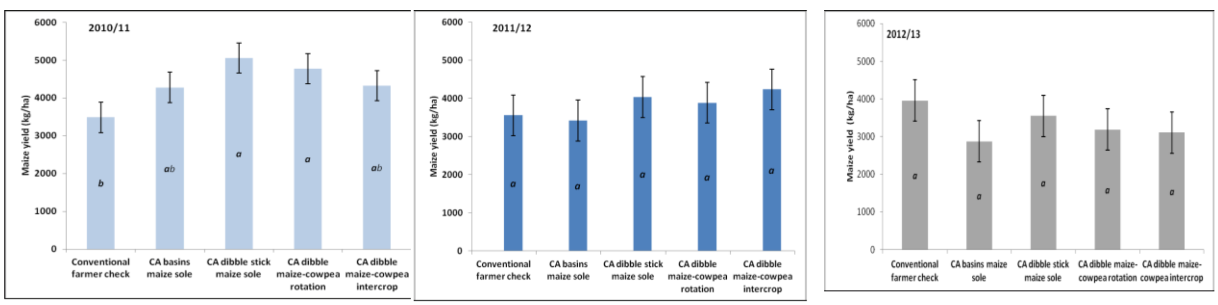

Figure 2. Mean Maize grain yields over 3 cropping seasons 2010/11-12/13 in Kabango community, Angonia district (+/- 1000 mm annual rainfall). Note error bars denote l.s.d(0.05) used for separation of means.

Table 1. Mean maize yields over 3 seasons using different cropping systems across two districts (Sussundenga and Gorongosa) between 2010 and 2013 in central Mozambique

Cropping System	**3-yr mean Maize yield**	**% yield increase**
Farmer Check	1487^{a}	0
CA maize-cowpea intercrop	1686^{ab}	13
CA jab planter maize sole + glyphosate	1734^{bc}	17
CA basins maize sole + glyphosate	1812^{bc}	22
CA maize-cowpea rotation	1972^{c}	33

N=30; L.S.D$_{(0.05)}$=233 kg/ha. Means in the same column followed by the same letter are not significantly different at p=0.05

Conclusions

Increased soil moisture from CA suggest the possibility of intensified cropping by relay cropping with legumes to utilize the extra moisture in CA. Superiority of CA in very wet environments is diminished in high rainfall environments +/- 1000 mm /yr) as found in Angonia district while larger productivity gains from CA were generated in lower rainfall environments (+/- 600 mm /yr) as in Sussundenga district and Gorongosa districts. Farmer preferences for maize-legume intercrop systems suggest the importance of intensification to maximize land utilization.

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Does Gender Matter? Findings From SIMLESA Mozambique

Ângela M. Manjichi[1] and Domingos Dias
Instituto Superior Politécnico de Manica, Mozambique
Correspondent author: djosedias@gmail.com

Abstract
In most of development project gender is one of the key category to be consider for transformative change in rural communities. The participation and benefits for women in conservation agriculture. Using a gender analysis and surveys in this paper we analyzed the gender dimensions of conservation agriculture, how men and women participate and how they benefit from conservation agriculture. We found that gender influences the type of technology and reasons for adopting, but the choices on investment of benefits does not vary which shows a shift on the perception that gender influences the decision of benefit investment household versus personal gain.

Background
The role of women in agriculture has been widely presented (Croppenstedt, Goldstein, & Rosas, 2013)(World Bank, FAO and IFAD, 2009)(Ogunlela & Mukhtar, 2009) (Momsen, 2004). In most of development countries, including Mozambique women and girls are the one who are involved in the majority of farm and households activities but benefit less of it.

In Mozambique, women are accountable for 90% of the work force in agriculture, and are involved mostly in subsistence farming with very few in commercial farming. However, they cannot yet achieve food security and sustainable development. Several factors contribute to this including: low level of literacy among women, access to services (e.g extension and financial) and ultimately the social and cultural issues at community level.

Gender mainstreaming in development programs and projects is seen as key aspect to break the poverty cycle in the communities. Within Sustainable Intensification of Maize and Legume cropping systems in Eastern and Southern Africa (SIMLESA) the gender has been integrated and the present report aims to analysis the gender dimension in SIMLESA based on evidences from Mozambique.

Methodology
The study was conducted in 4 villages in Central Mozambique, located in Sussundenga, Manica, Rotanda and Angónia where the SIMLESA Project is being implemented. A total of 820 households (455 men and 365 women) were interviewed using randomized sampling. To understand the perceptions and get qualitative information three focus discussion groups were held with men and women separately. The villages are in two agro-ecologic zones R4 and R10 and they are different socio and cultural characteristics, which extends to differences on development of the agriculture practices. For the study, data on socio economics, agronomic practices, access to new technologies, adoption of technology and access to markets were collected.

Results and Discussion
The assessment of technologies showed that intercropping (29% of men and 21% of women), rotation (24% of men and 15% of women), new maize varieties (28% of men and 20% of women), sowing in line (43% of men and 34% of women) are the preferred technology for both men and women and have high rates of adoption. On the other hand two technologies had high rates when as not favorable to the farmers. The minimum tillage (25% of farmers) and residue retention (31% of farmers) are practices, which were not preferred by the farmers. The availability of residue and the workload to look and collect and apply is the reason behind the preferences once they will have to hire people or buy the residues.

Men and women have the same reason to adopt the technology the only difference is that are in market access and soil fertility. Men gives preferences to technologies which increases access to markets, with 13% of men and less than 1% of women choosing access to market. Both groups agree that they will adopt technologies that increase crop yields (50.8% of men 40% of women) and are easy to use (20.9% of men and 12.7% of women). However, the groups do not take into account the labor saving when deciding which technology to adopt (0,03 % of men and 0.02% of women), which is often considered one of criteria's for technology adoption.

Table 1. Gender Roles, access to resources and technology preference

	Men	**Women**
Gender Roles	Land preparation Looking after cattle Paid jobs Market	Household activities Weeding and support the man on other Farm activities Fetching water
Access to resources	Yes	Different from village to village (cultural issues plays a major role)
Preferred technologies	High yield maize and hybrids Fertilizer Crop rotation	Early maturity maize varieties and OPV Crop rotation and intercropping
Where to invest	School for children Seed and fertilizer Construction materials (for house) and transport	Schools for children Blankets, cloths and food Seed

An important aspect to notice is that men and women have same technologies preferences (improved seed) and priority to invest (children school fees) which does not follow under the stereotypes created for rural women and men, in which women tend to invest on aspects that will benefit the household and food security (Mallick and Mohammad, 2010; Okali, 2006). They are also investing in improved seed, which for long was considered a men's priority.

Conclusion

The Mozambique experience shows there are very few differences between men and women as related to preference and adoption of conservation agriculture technologies. The insight in the study is that labor saving at the farm level is not used as criteria for selecting and adoption of the technology but its availability and benefit. The women are involved in conservation agriculture, and they see the benefits. The common perception of gender roles is changing, and is seen by the way women invest the benefit; they are also investing in improved seeds and looking for markets. The study also shows that the cultural issues and the location of the villages influence the gender roles of the village.

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Maize-Bean Farming System Under Conservation Agriculture: *Assessing Productivity and Sustainability in Eastern Kenya*

Alfred Micheni[1], James Ouma[1] and Fred Kanampiu[2] David Mburu[3] and Njue Mugai[3]
[1]Kenya Agricultural Research Institute. P.O. Box 27-60100, Embu, Kenya
Corresponding Author: alfredmicheni@yahoo.com; Tel.+254 720 705 625
[2]International Maize and Wheat Improvement Centre. P.O. Box 1041-00621, Nairobi, Kenya
[3]Jomo Kenyatta University of Agriculture and Technology. P.O. Box 62000, Nairobi Kenya

Introduction

Maize *(Zea mays L.)* and beans *(Phaseolus vulgaris)* are most important food crops to over 85% of households in eastern Kenya (Rockström et al., 2009). Despite their economic importance, production of the two crops has overtime lagged behind at 1.8 and 0.5 t ha^{-1} for maize and beans against expected potentials of 6 and 2.5 t ha^{-1}, respectively (Jagtap & Abamu, 2003). The low crop productivity is attributed to frequent dry spells and soil fertility depletion coupled with poor farming practices are some of the main biophysical factors limiting per capita food production in the regions (Recha et al., 2012). As part of the coping strategies, farmers look upon embracing sustainable agricultural approaches such as conservation agriculture (CA), with ability to conserve water and recycle nutrients to revert the low soil fertility situations (FAO, 2009). Vanlauwe et al., (2014) argues that fertilizer use may essential CA component for enhancing SOM and crop balances. While improved soil and crop yield dynamics is reported elsewhere in the world, only scanty information is available highlighting the benefits of CA adoption by eastern Kenya farmers (Derpsch, 2005). It is on the above background that a four season study was conducted to determine the effects of CA practices on grain yields of maize and beans and profits in humid zones of eastern Kenya.

Materials and Methods

The study was conducted for four seasons from short rains 2011 at the Kenya Agricultural Research Institute (KARI)-Embu located 00^0 33.18'S; 037^0 53.27'E; 1420 m asl and in the upper midlands zone. The area rainfall annual is rainfall bi-modal averages at 1250 mm, with wet seasons being from March to May and October to December (Nicholson, 2000). The area has a mean annual temperature of 21 and 14.1^0 C maxima and minima, respectively. The soils are mainly humic nitosols, derived from basic volcanic rocks, a are deep highly weathered with moderate to high inherent soil fertility due to their high minerals, available water and cation exchange capacity (Gitari and Friesen, 2001). Over years the soil fertility has declined due to inappropriate soil management and nutrients depletion (Ngetich et al., 2012). The farming system is mainly of dairy cattle rearing and growing cash and food crops (maize, common bean, potatoes and bananas) (Lara et al., 2012). Tillage methods, cropping-systems, nitrogen fertilizer application rates and residue management methods were the four farm management main plots (factors) laid out on a randomized complete split-split-plot block design with three replicate (blocks). The crop residue management and nitrogen fertilizer application rates were the sub-sub-plots in the experimental design structure. The tillage methods were made of two CA practices (furrows/ridges (FR) and zero tillage (ZT). A third tillage method was a conventional tillage (CVT) practice. Maize (Var. DK 8031) and beans (Var. Embean-14) were the test crops and planted every season either as intercrop or sole crop arrangements.

Results and Discussion

The three seasonal rainfall amounts were well distributed within the crop crowing period, leading to production of over 50% mean maize grain yields increase at 4.00, 2.91 and 3.65 t ha^{-1} for LR2012, SR2012 and LR2012, respectively, against 1.47 t ha^{-1} from SR2011. From the second season onwards, FR tillage mode performed significantly better than either the CVT or ZT practices. The higher yields under FR were associated to extra moisture retention and nutrients concentration by mulch left on the soil surface. Beans grain yields averaged at 1.00 t ha^{-1} in the first season. This low yield was attributed to poor rainfall distribution during the SR2011 in-crop period. Relatively higher yields were observed from FR tillage in the last three seasons of experimentation. Like the case of maize performance, improved bean yields under FR might have been caused by nutrients concentration and moisture conservation. Moisture retention in this case might have been caused by furrows that harvested more rain water for crop use. Alternatively the extra moisture might have come from low evaporation from the soil surface due to mulch left on the soil surface. Except for the SR2011, higher net-benefits (NB) were obtained under FR and ZT practices compared to CVT. Lowe profit under CVT practices were associated to costly labour for land preparation and weeding. Higher benefits under CA practices were most likely due to increased yields resulting from extra soil nutrients and moisture availability. This was further attributed to reduced land preparation and weeding labour costs under the CA compared farm operations in CVT practices.

Conclusions and recommendation

The short term benefits of CA practices were defined on basis of crop grain yields and also on profit(s) made out of the investment. The CA based treatments exhibited higher crop yields and profits compared to CVT. The achieved profits resulted from land preparation and weeding labour savings. Besides the effect of the CA practices, crop performance is greatly affected by the amount and distribution of in-crop rainfall. The study therefore concluded that the effect of CA practices on crop performance should be tied to the amount and distribution of in-crop rainfall.

Acknowledgements

The authors are grateful for financial support from the ACIAR. They are further thankful to CIMMYT, KARI and JKUAT managements for their technical supports.

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AN ASSESSMENT OF POTENTIAL BENEFITS OF CA FOR SMALL HOLDER FARMERS: LESSONS FROM SIMLESA TANZANIA

John E. Sariah[1] , Lucas M. Mugendi, G. Iranga, B. Makoko , Ruth Madulu , Theresia Gregory and Fred Kanampiu . [1]Selian Agricultural Research Institute; jsariah@yahoo.com

Back ground

Livelihood of small scale farmers in Tanzania depends mainly on crop production and livestock keeping. The main cropping system is intercropping of maize and legumes. Productivity has persistently been low for many years due to many reasons including biotic, abiotic and management factors. Abiotic factors include drought, low soil fertility etc. Biotic factors include weed and insect pressure, use of unimproved genotypes , management factors including low plant population, physical post harvest losses. Production per unit area is very low, farmers are getting as low as 1.5t/ha and 0.5t/ha for maize and legumes respectively (SIMLESA baseline survey 2011).

Results

Relatively high increase in yields was observed in CA treatment compared to other treatments (fig1). Over time, high moisture retention and increased organic matter in CA treatment was observed (table 1). Less time was involved in CA treatment especially prior sown (table1). CA treatment has shown high profitability (table 2).

Application and implication

In maize-legume based farming systems, in both low and high production potentials practicing conservation agriculture especially zero tillage coupled with crop residue retention, ensure timely seeding which is crucial to catch nitrogen flush which could otherwise lost because of delay seeding caused by time spent to plough land before sowing, also zero tillage save farmers precious time, that can be used in other economic activities. Crop residue on top of the soil conserve the highly needed moisture especially in marginal areas.

Experimental approach

An on-farm exploratory trials involving three treatments namely Conservation agriculture (CA), Current applied recommended practice (CAP) and Farmers practice (FP) were conducted for three seasons in 10 communities distributed in high and low crop production potential areas in Tanzania. A plot size of $1000m^2$ for each treatment was adopted. An equal size of data collection area in each plot was marked. Crop yields, labor productivity, economic and different soil parameters were analysed.

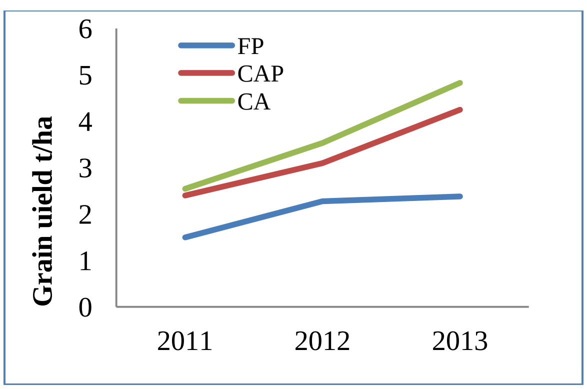

Fig 1 Average maize yields for 3 seasons in

Table 1. Average time (h/ha) spent in different activities for different practices, % MC and % OM at plant flowering for 3 seasons in 9 different communities in Tanzania.

Practice	Herbicide application (h/ha)	Ploughing (h/ha)	Weeding (h/ha)	Total (h/ha)	% MC	% OM
FP	-	13.58	91.84	105.42	18	1
CAP	-	13.32	100.16	113.48	18	1
CA	9.86	-	74.87	84.72	20	1.5

Table 2. Average Farm partial budget for different practices for different communities

Costs that vary	CAP	CA	FP
Cost of cultivation/ha	109.375	0	109.375
Cost of fertilizer basal (100kg DAP/ha) + Top dressing (100kgN/ha)	168.75	168.75	0
Cost of fertilizer application/ha	28.125	28.125	0
Cost of herbicide/ha	0	18.75	0
Cost of herbicide application/ha	0	28.125	0
Cost of weeding/ha	234.375	78.125	234.375
Cost of maize Stover per ha	0	31.25	0
Total cost that vary (USD)	540.625	353.125	343.75
Gross yield of maize t/ha	3.03	2.9	1.52
Gross revenue-maize (USD)	851.43	814.9	427.12
Gross revenue stover/ha	62.5	31.25	62.5
Gross yield of Pigeonpea t/ha	0.961	0.9	0.064
Gross revenue-Pigeopea usd/ha	420.4375	393.75	28
Total revenue USD	1338.359	1243.7	519.204
Net benefit (USD)	**797.7335**	**890.575**	**175.454**

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Can We Alleviate Food Insecurity Using Conservation Agriculture Technologies Among Smallholder Farmers of Malawi? Emerging Lessons from SIMLESA Malawi

[1]Kamalongo, D[*].,[3]Nyagumbo, I. [1]Siyeni, D., [1]Kamwana, F. [3] [2]Chaula, K, Mulugetta, M [3],
[1]Department of Agricultural Research Services, Chitedze Agricultural Research Station, P.O. Box 158, Lilongwe, Malawi. Email: dkamalongo@yahoo.com
[2]Department of Agricultural Extension Services-Malawi
[3]International Maize and Wheat Improvement Centre (CIMMYT), Southern Africa Regional Office.

Introduction

In Malawi , maize (*Zea mays)* is the staple food crop with a per capita consumption of 181 kg/yr (Hassan et., al, 1988). Among others, Conservation Agriculture (CA) is a production technology that could potentially alleviate food insecurity among Malawi's smallholder farmers. As a consequence, Conservation Agriculture(CA) based Sustainable Intensification (Garnett *et al.*, 2013) technologies have been evaluated in the last three cropping seasons through the programme '*Sustainable Intensification of Maize legume systems in Eastern and Southern Africa* (SIMLESA) since 2010 under different agro-ecologies in Malawi. This study highlights the potential contribution of these CA cropping systems towards alleviating food insecurity through assessing their maize yield impacts also the extent to which these technologies have been outscaled to farmers across six districts of Malawi.

Methodology

Exploratory on-farm trials were conducted in two contrasting agro-ecologies from 2010/11 to 2012/13 cropping seasons. Five different cropping systems were tested in three districts of the mid-altitude agro-ecology (*760-1300 m a.s.l; 600-1000 mm /yr rainfall*) while 6 different cropping systems were tested in another 3 districts in the low-altitude agro-ecology (*200-760 m a.s.l; 500-600 mm/yr rainfall*). Six farmers per community/district hosted the trials with each farmer representing a single replicate. In each agro-ecology locally recommended fertilization rates were applied uniformly to all treatments including the control conventional ridge/furrow farmer practice along with newly released improved maize and legume varieties. Key measurements included rainfall, maize yields, soil water infiltration and in-season farmer evaluations to generate farmer feedback on the technologies.

Results and Discussion

Within each community maize yield differences between conventional farmer practices against CA based cropping systems progressively increased over time and were thus mostly not significant in the first two seasons, particularly in the mid-altitude agro ecology. Furthermore, although herbicides were a major incentive to farmers, no significant differences were obtained from systems employing herbicides and those in which weeds were controlled mechanically. A similar pattern was observed in the lowlands with the maize-groundnut rotation system increasingly becoming superior to the rest of the systems over time. Across both agro-ecologies and 3 seasons, significantly higher yields were realised from maize-legume rotation CA systems compared to the farmer check. Using the 'time to pond' technique, CA based cropping systems also portrayed higher water infiltration rate as compared to the farmers conventional practice in both agro-ecologies (table 2.0)

Results emerging from the three seasons of this ongoing work suggest that maize yield differences between CA based cropping systems and conventional farmer practices, generally depended on season quality in terms of rainfall amount and distribution. CA based legume rotations have the potential to alleviate food insecurity in terms of maize yield increases as these amounted to 21 % in the mid-altidude region and 41 % in the lowlands compared to the farmer practice over the three seasons. Similar results regarding rotation benefits have been reported in Malawi (Thierfelder *et al.*, 2012). Results also suggest that in the mid-altitude regions, CA can be successfully achieved without herbicides with no consequent yield penalties at all despite the fact that herbicide use proved to be popular with farmers in Malawi. CA based cropping systems also enabled better water infiltration in both locations based on the time to pond assessments (Table 2). Through partnerships with NGOs, farmers associations and extension, Innovation platforms enabled these technologies to be reached out to at least 1600 farmers in the six districts.

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Tables

Table 1. 3-yr mean maize yields (kg/ha) by cropping system in contrasting agro-ecologies of Malawi between 2010 and 2013.

Malawi Mid-Altitude Regions	
Cropping system	3yr mean Maize yield (kg/ha)
Conventional Farmers check	3743[a]
CA Dibble stick maize sole no herbicide	3867[ab]
CA Dibble stick maize sole+ herbicide	4303[bc]
CA Dibble stick maize-soya rotation	4524[c]

Note: *N=36, df=24, LSD(0.05)=529kg/ha*
Data from Kasungu, Mchinji and Lilongwe districts.

Malawi Lowland Region	
Cropping system	3yr mean Maize yield (kg/ha)
Conventional Farmers check	3034[a]
CA Basins Maize/p.pea intercrop	3295[ab]
CA Dibble stick Maize sole	3807[bc]
CA Dibble stick Maize-p.pea intercrop	3824[bc]
CA Dibble stick Maize-g/nuts rotation	4267[c]

Note: *N=36, df=24; LSD(0.05)=757*
Data from Ntcheu, Salima and Balaka districts

Table 2 Mean time to ponding (sec) by cropping system in contrasting agro-ecologies of Malawi at the end of the 3rd season in 2013.

Malawi Lowland agroecology sites

Cropping system	Salima	Ntcheu
Farmers check	5.12a	5.02a
Basins + maize/pigeonpea intercrop	11.20b	8.15b
Dibble maize/pigeonpea intercrop	11.13b	9.52bc
Dibble sole maize	10.27b	7.07b
Dibble maize groundnuts rotation	8.88c	7.40b
Dibble groundnuts-maize rotation	11.15b	8.25b
Mean	9.63	7.57

Lsd (0.05) Treatments (T)= 0.928***;Lsd (0.05) Sites (S) = 1.713*;Lsd (0.05) TxS 2.166*; CV% =17.0

Malawi Mid agroecology sites

Cropping system	Kasungu	Mchinji
Farmers check	3.90a	5.18a
CA + Sole maize no herbicides	11.25b	19.40b
CA + Sole maize with herbicides	10.88b	16.17b
CA + Maize-soyabean rotation	9.70b	15.40b
CA + Soyabean-maize rotation	13.60b	16.23b
Mean	9.87	14.48

Lsd (0.05) Treatments (T) 4.725***; Lsd (0.05) Sites (S) 6.221ns **Lsd (0.05) TxS** 7.881ns; CV% = 47.0

Bridging the Maize Yield Gap among Smallholders: Preliminary Findings of SIMLESA Uganda

Drake N. Mubiru, Godfrey A. Otim, Jalia Namakula, William Nanyeenya, and John Elem
National Agricultural Research Laboratories – Kawanda/ National Agricultural Research Organization (NARO) P.O. Box 7065 Kampala, Uganda
dnmubiru@kari.go.ug

Background

Precision Conservation Agriculture (PCA) has demonstrated that it is possible to bridge the maize yield gap among smallholder farmers in Uganda. Precision Conservation Agriculture is a technology that entails four basic principles: minimum tillage; precision application of micro-doses of fertilizer (inorganic and organic); use of improved seed; and use of available crop residues for soil cover (Twomlow, 2012).

Actual maize yield in Uganda is estimated to range from 3.8 to 8.0 t/ha (Semaana, 2010). However, due to several biophysical and socio-economic factors maize yields on smallholder farms are consistently low, ranging from 1.0 to 1.8 t/ha with a yield gap averaging more than 80% (RATES, 2003; Otunge *et al*., 2010). At its introduction in Uganda, PCA consistently increased maize yields by more than 30%. Subsequently, a study was conducted to adapt the PCA technology to the Ugandan conditions by establishing PCA optimum plant populations for maize in pure stand at research stations in the Lake Victoria Crescent Agro-ecological Zone (AEZ) and North Western Savannah Grasslands AEZ.

Methods

Agronomic trials were conducted in 2013 at the National Agricultural Research Laboratories – Kawanda in the Lake Victoria Crescent AEZ and Ngetta Zonal Agricultural Research and Development Institute in the Western Savannah Grasslands AEZ. Kawanda is located 0°25′05″ N and 32°31′54″ E at 1190 meters above sea level (masl). The average rainfall is 1224mm per annum and the temperature ranges from 15 – 30^{o}C. The soils are sandy clay. Ngetta is 1,180 masl and average rainfall is 1400mm per annum. Temperature ranges from 15 – 32.5°C and the soils are sandy loamy.

Experimental set up

The experimental design was Randomized Complete Block Design with 3 replications. The treatments were: 44,400; 59,200; and 74,000 plants/ ha, that is, 3; 4; and 5 seeds per planting basin, respectively. The 3 plants/basin (as recommended by the Conservation Agriculture Regional Programme) was the control treatment. An open pollinated Longe 5 maize variety was used. Fields were slashed and sprayed with glyphosate (500 mg/l) at a rate of 7.5 l/ha 2 weeks after slashing. Planting basins were marked out using planting lines and digging basins of 35 cm (long) × 15 cm (width) × 15 cm (deep), with spacing of 90 cm between rows and 75 cm within rows from center to center of the basin, before the onset of rains. Available crop residues were laid between rows to create a mulch cover. Cow dung manure at a rate of 1 mug per planting basin (approx. 7,400 kg/ha) and micro-doses of basal fertilizer (DAP) at a rate of 1 water bottle cap per pit (148 kg/ha) was applied and covered with top soil before planting the seeds. Urea-nitrogen (150 kg/ha) was evenly side dressed within the planting basins when maize was at knee height.

Data Collection and Analysis

Maize yield was determined by harvesting the whole plot and adjusting to 14% moisture content. Data was examined by ANOVA to determine significant ($P < 0.05$) treatment effects. Comparison of means were made by LSD all-pair-wise comparisons. All analyses were done using Statistix V. 2.0 (Statistix for Windows, 1998).

Results

At Kawanda, there were significant yield differences (*$P < 0.05$*) from the different plant populations (Fig. 1). Planting basins with 3 seeds/basin (44,400 plant/ha) had significantly lower grain yield than basins planted with 4 (59,200) and 5 seeds/basin (74,074). However, the yield difference between basins with 4 and 5 seeds/basin was not significant. There was 27% more grain yield in the 4 seeds/basin than the 3 seeds/basin treatment. At Ngetta, for two seasons there were no significant yield differences among the different plant populations (Fig. 2).

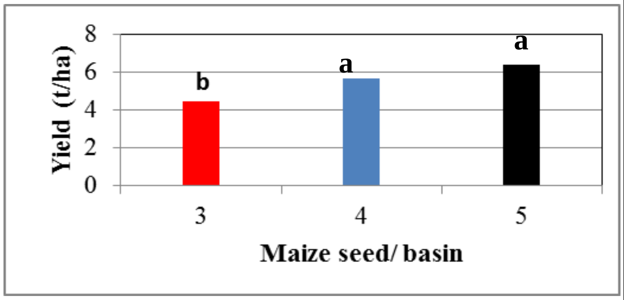

Figure 1: Effect of varying plant populations in PCA on maize grain yield at Kawanda

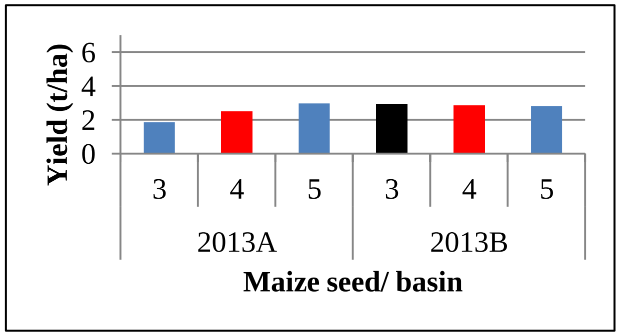

Figure 2: Effect of varying plant populations in PCA on maize grain yield for the 2013A & B seasons at Ngetta

Discussion:

The differences observed between the two agro-ecologies (Kawanda and Ngetta) could be attributed to the differences in the soil moisture regimes, soil types and fertility. While the soils at Kawanda are heavy in texture and with higher organic matter content, the soils at Ngetta are light and with lower OM content. These different soil environments are expected to impart different soil moisture regimes in the two agro-ecologies. The Kawanda site with heavy textured soils and medium OM within a bimodal rainfall regime is representative of areas below latitude 3^{o}N, while the Ngetta site with light textured soils and low OM within a mono-modal rainfall regime is representative of areas above latitude 3^{o}N.

Application and implications for CA

It can therefore be tentatively concluded that in Uganda, under PCA areas below latitude 3^{o}N a plant population of 59,200 plants/ha (4 seeds per planting basin) is optimum while in areas above latitude 3^{o}N a plant population of 44,000 plants/ha (3 seeds per planting basin) is the optimum. Precision Conservation Agriculture coupled with the optimum plant populations in the different agro-ecologies has the potential to bridge the maize yield gap among smallholder farmers in Uganda

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Sustainable Intensification Based CA for Sustainable Food Security and Poverty Reduction: Initial Evidences from SIMLESA

Mulugetta Mekuria SIMLESA Program Leader – CIMMYT Southern Africa Regional Office, Harare Zimbabwe --M.Mekuria@cgiar.org and Menale Kassie ,CIMMY Kenya, Nairobi

Introduction

SIMESA Vision of Success: **To increase maize and legume yields by 30% while sustaining the environment through:** Conservation agriculture practices; Improved maize and legume varieties development of markets and value chains, from input supplies to output markets; **reduce downside yield risks by 30%; to benefit 650,000 farm households** within 10 years. This presentation focuses on sharing the findings and implications of SIMLESA's approach in enhancing the development and adoption of CA based sustainable intensification technologies. Successes on the use of Innovation plat forms as a scaling out mechanism, bridging the gender gap and capacity building are not presented.

The Sustainable Intensification of Maize-Legume cropping systems for food security in Eastern and Southern Africa (SIMLESA) is a multi-stakeholder collaborative research programme managed by the International Maize and Wheat Improvement Centre (CIMMYT) and implemented by national agricultural research systems (NARS) in Kenya, Tanzania, Ethiopia, Malawi and Mozambique with backstopping inputs from other partners. The programme focuses on leveraging science and technology to develop and deliver technological and institutional innovations in relation to maize-legume production systems. In turn it is envisaged that these will make significant measurable positive changes in the livelihoods of all categories of smallholder farmers.

The aim of SIMLESA program is to improve farm-level food security, in the context of climate risk and change, through the development of more resilient, profitable and sustainable farming system that overcome food insecurity for significant numbers of farm families in eastern and southern Africa. SIMLESA Program, is being funded by the Australian Centre for International Agriculture Research (ACIAR) launched as phase1(2010-2013) and phase 2 (2014-2018).

Research Methods, **Evidences and Findings:** SIMLESA Country teams, CIMMYT and Australian partners analysed a comprehensive baseline survey data, developed household typologies, undertook value chain analysis, adoption monitoring and community surveys. Baseline survey data produced a series of journal articles and policy briefs Initial result of Adoption monitoring surveys in Ethiopia reported in 2013 indicated a 30% adoption of SIMLESA practices in the targeted areas.

SIMLESA implemented CA along with improved maize and legume varieties, in order to develop resilient and sustainable cropping systems and improved food security and incomes. To date farmers participating in the SIMLESA program, among many other benefits have realized that maize yields in CA systems involving crop rotations and intercropping with legumes increase yields. Furthermore results from the field also show that CA saves labor and hence enable farmers to plant timely and also often leads to improved profitability. The use of herbicides in CA, which saves labor in managing weeds, is popular among farmers in all the five SIMLESA partner countries – Ethiopia, Kenya, Tanzania, Malawi and Mozambique. In Malawi's mid-altitude agro-ecology, for example, CA systems resulted in significant maize yield increases, ranging between 3% and 21%, above the extension recommended conventional farmer practices . Extension recommended conventional farmer practices refer to widely used cropping systems recommended by extension in each community based on manual hoe ploughing or animal drawn mouldboard ploughing with seed and fertilizer applied at the same rate as the tested CA systems. Maize yields from the maize-soybean rotation system in Kasungu, Mchinji and Lilongwe districts, significantly out yielded both the conventional ridge/furrow farmer practice and CA hand weeded with no herbicide use. Likewise in the lowlands agro-ecology, maize grain yield was increased CA practices in the range of 8 to 40%. The highest increase was from the maize-groundnut rotation (40%). Thus, maize-ground nut rotations were the best system across the different sites in Salima, Ntcheu and Balaka districts.

SIMLESA has contributed to the release of 40 maize varieties, including 24 hybrids and 16 open pollinated varieties (OPVs). Selection of the varieties was undertaken with active participation of farmers and other partners. Yield advantages of 10% - 30% were noted for these new varieties as compared to the existing commercial varieties. Based on farmers' selection criteria, varieties that showed desirable agronomic performances and better adaptation to the local conditions were identified for registration and commercialization. Production and supply of different seed classes for selected varieties were implemented in close collaboration among national agricultural research systems (NARS) and seed companies. A large number of farmer households in the region have been reached with the seeds. To overcome the problem of low adoption of the newly released legume varieties, SIMLESA researchers and partners used participatory variety selection (PVS) approach that offered farmers a chance to select varieties according their own preferences. A total of 378 legumes based PVSs were conducted.

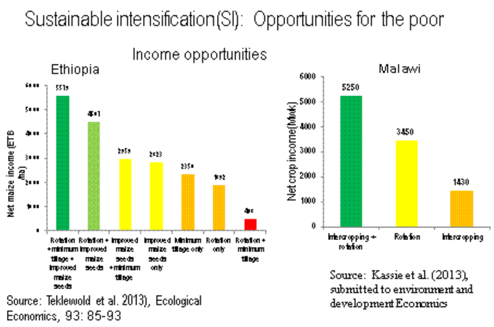
Economic benefits of CA options Field level evidences

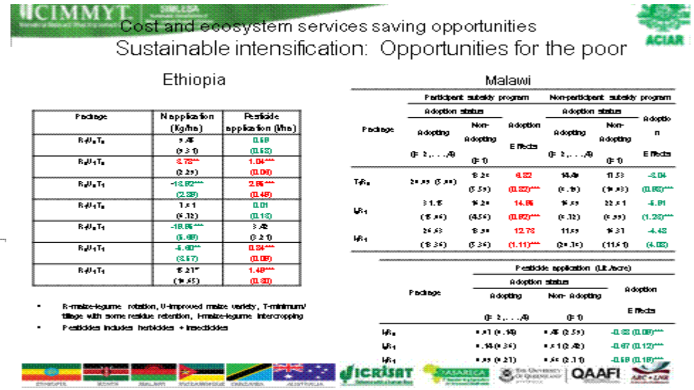
- In Ethiopia using the baseline survey data collected from 900 farm households we examined the impact of the adoption of CA options (maize-legume rotation and minimum tillage with some residue retention) in combination with improved maize varieties on net maize income. This is the net maize income after fertilizer, seed, labor and pesticide costs have been accounted for.
- The empirical evidence showed that the adoption of CA options increased net maize income by about 9-35% compared with non-adoption of these options
- This increases further to 47-67% when CA practices were adopted in combination with complementary inputs (e.g., improved maize varieties). The highest income was obtained when both CA practices were combined with use of improved maize varieties Figure 1). The results were based on the counterfactual framework of intervention evaluation.
- Similarly, using 1925 sample farm households in Malawi, we also found similar evidence where combinations of CA components provided higher benefit than adopting them individually.

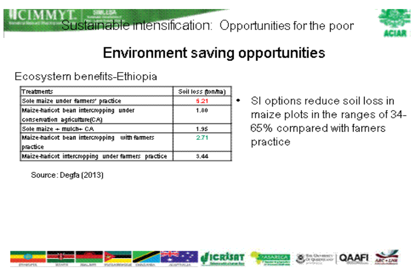
Implications

Some key messages from empirical economic analyses strongly suggest that adopting technologies in combination provides the highest crop income and agro-chemical use reduction rather than adopting them in isolation. For instance, famers in Ethiopia were able to increase their net maize income by more than 66-92% when they adopted improved maize varieties together with maize-legume rotations and minimum tillage. In Malawi the increase in net maize and legume income ranged between 52-267% and pesticides reduction in the range of 0.4-0.6 lit/acre when farmers combined legume-maize intercropping and legume-maize rotations.

Impact analysis results also showed that farmers can significantly reduce risk of crop failure by adopting crop diversification practices (legume intercropping and rotations) and minimum tillage in combination; suggesting technologies promoted by SIMLESA have win-win-win outcomes: increased crop income, reduction risk of crop failure and improved environmental quality.


Sustainable intensification(SI): Opportunities for the poor
Income opportunities
Ethiopia
Net maize income (ETB /ha)
Rotation + minimum tillage + improved maize seeds
Rotation + improved maize seeds
Improved maize seeds + minimum tillage
Improved maize seeds only
Minimum tillage only
Rotation only
Rotation + minimum tillage
Malawi
Net crop income(Mwk)
5250
3450
1430
Intercropping + rotation
Rotation
Intercropping
Source: Teklewold et al. 2013), Ecological Economics, 93: 85-93
Source: Kassie et al. (2013), submitted to environment and development Economics


CIMMYT
Cost and ecosystem services saving opportunities
Sustainable intensification: Opportunities for the poor
ACIAR
Ethiopia
Malawi
Package
N application (Kg/ha)
Pesticide application (l/ha)
Participant subsidy program
Non-participant subsidy program
Adoption status
Adopting
Non-Adopting
Adoption Effects
Pesticide application (Lit./acre)
ICRISAT
QAAFI


CIMMYT
Sustainable intensification: Opportunities for the poor
ACIAR
Environment saving opportunities
Ecosystem benefits-Ethiopia
Treatments
Soil loss (ton/ha)
Sole maize under farmers' practice
5.21
Maize-haricot bean intercropping under conservation agriculture(CA)
1.80
Sole maize + mulch+ CA
1.95
Maize-haricot bean intercropping with farmers practice
2.71
Maize-haricot intercropping under farmers' practice
3.44
SI options reduce soil loss in maize plots in the ranges of 34-65% compared with farmers practice
Source: Degfa (2013)
ICRISAT
QAAFI

Maize and Forage Breeding for CA Compatibility and System Intensification: Farmers' Voice and Scientists' Assessment in North West Ethiopia

Melkamu Elmeyehun, Fentaw Abate, Likawent Yeheyes, Wondimeneh Mekonnen and Yeshitla Merene
Amhara Agricultural Research Institute (ARARI)
P.O.Box 527, Bahir Dar, Ethiopia
Merene73et@yahoo.ca

Background
Food security is a major concern in Ethiopia. Among the food crops, cereals including maize are the main staple and legumes are an important dietary protein source for the rural poor. Ethiopian maize based cropping systems is highly characterized by repeated(4 to 5) farmland cultivation using ox-pulled plow (*Maresha*), hand weeding, manual harvesting and threshing. This traditional farming practice resulted in soil fertility decline, disease and pest build up and low productivity. In Ethiopia average productivity of maize is 3.06 ton/ha (CSA, 2013). In mixed crop-livestock systems, crop residue is used for livestock feed and retention of crop residue in the field is hardly possible. Hence it requires options to increase availability of livestock feeds such as integration of forage legumes with maize in the smallholder crop livestock farming systems

With the support of SIMLESAs program, developed by CIMMYT in collaboration with African and Australian stakeholders this research is conducted with the objective of increasing the range of maize and forage legume varieties available for sustainable intensification and promotion of CA based smallholders' maize farming system.

Results and their implications for conservation agriculture
Through farmers and researchers joint selection criteria three maize varieties (BHQPY-545, AMH-851 and BH-661) are recommended and two sweet lupin forage varieties (Vitabor and Sanabor) are released in Ethiopia for the first time. The identified maize and forage varieties show better performance for disease and drought tolerance, high yielding and they are compatible for intercropping under CA. Hence, these technologies will be used for scaling up of conservation agriculture to small holder farmers in North West Ethiopia.
Experimental Approach

- Participatory variety selections were conducted using eight maize hybrids and four sweet lupin varieties in West Gojam zone at two districts in 2012 and 2013 cropping season.
- Verification of four candidate sweet lupin varieties on 100m^2 each in seven locations for evaluation by national variety releasing committee in 2013.
-

Results and Discussion
The combined grain yield mean performances of the tested hybrid maize varieties indicated that AMH-851, BH-661 and PHB-3253 were identified as the three best performing hybrids across tested areas (table1). On the other hand based on farmers' selection criteria BHQPY-545 and AMH-851 were selected first and second respectively (table 1). Considering both researchers and farmers selection criteria the two maize varieties (BHQPY-545 and AMH-851) were recommended for the area. From sweet lupine variety development two varieties (Sanabor and Vitabor) were officially released for production in Ethiopia in 2014. These sweet lupin varieties are high yielders, with low alkaloid content (0.02%), used for feed and food and are compatible for intercropping with maize. Therefore, the recommended maize and released sweet lupin varieties will be used for system intensification under CA in maize growing areas of Jabitehinan and South Achefer districts and similar agro ecology in North West Ethiopia.

Table 1. Mean grain yield and maturity date of tested maize hybrids

Hybrids	Yield (t/ ha)	Days to maturity	Ranks of farmers selection
BH-542	5.67	154.0	8
BH-545	7.14	156.0	1
BH660	6.69	174.0	5
BH661	7.43	178.7	3
BH-673	7.07	174.7	4
PHB-3253	7.42	149.3	6
AMH-850	7.35	169.1	7
AMH-851	7.80	171.6	2
CV	15.03	1.03	
LSD (0.05%)	0.54	0.87	

References

CSA, 2013. The federal democratic republic of Ethiopia central statistical agency agricultural sample survey. Area and production of major crops. Statistical Bulletin 532. Ethiopia, Addis Ababa.

Weed management in conservation agriculture in North Algeria

Djenadi Farida[1], Laouar Abdelmalek[1]
Institutions Institut technique des Grandes Cultures. BP 16 Alger, 16200 Algeria

Introduction

Conservation agriculture (CA) is being promoted as an alternative to conventional cropping practices in Algeria for increasing crop yields and conserving soil resources. Weeds have been identified as a major limitation to the adoption of CA and for increasing crop yields. Improved weed management is being assessed across research farm trials in Setif province within the framework of ACIAR funded project on conservation agriculture.

Weed surveys revealed the occurrence of about 50 different species mainly belonging to Poaceae, Apiacea, Brassicaceae and Asteraceae. Major weed species in the region included ripgut grass (*Bromus rigidus*), rigid ryegrass (*Lolium rigidum*), sterile oat (*Avena sterilis*), phalaris sp., *Sonchus oleraceus*, *Veronica* spp., cleavers (*Galium aparine*) pignut (*Bunium bulbocastanum*), and wild mustard (*Sinapis arvensis*).

Available herbicides for control of grasses and broadleaf weeds in cereals or pulses include pendimethalin, simazine, clethodim, pyroxsulam, clodinafop + pinoxaden, iodosulfuron + mesosulfuron, tribenuron, diclofop + fenoxaprop, prosulfocarb, bentazone, clodinafop-propargil and sulfosulfuron.

Weed control in lentils using a combination of glyphosate pre-plant, simazine pre-emergence, and quizalofop post-emergence decreased weed densities by 50 to 80% and increased grain yields from 0.8 in untreated plots up to 2.6 t/ha in the treated plots averaged over four sites. Sowing durum wheat in November combined with the application of glyphosate pre-plant, pyroxsulam, clodinafop + pinoxaden and tribenuron post emergence, resulted in up to 90% reductions in weed densities and increased grain yield from 2.0t/ha in untreated plots to 5.9 t/ha in treated plots averaged over three sites. When sowing in December grain yield of untreated plots was reduced to 2.1t/ha compared with 3.7t/ha in untreated plots. Application of glyphosate pre-plant and diclofop, phenoxaprop and triasulfuron + dicamba post emergence in barley resulted in a significant decrease in densities of most weed species. Weed densities were reduced by 50 to 80%, resulting in increases in grain yield from 2.1 in untreated plots up to 4.3t/ha in treated plots averaged over four sites.

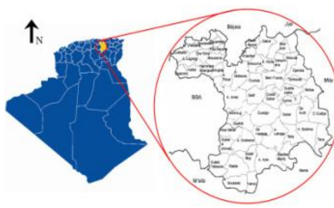


Figure #1 *Setif province localization*

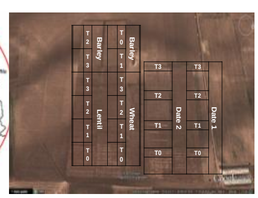


Figure #2 Areal view of Koli's experimental weed management site

Objectives

1. The effect of chemical weed control on reducing level of infestation by weeds in wheat, barley and lentil crops conducted in CA,
2. The effect of rotation on reducing the level of infestation by weeds in wheat conducted in CA
3. The effect of rotation combined with chemical weed control on improving the behavior and performance of wheat, barley and lentil crops conduct in CA
4. The combined effect of planting date and chemical weed control on weed control in wheat crop in CA

Methods

Cropping season :2012-2013
Implementation sites:
Khababa (6.3ha), Tabhirt (1.8 ha),
koli (1.8ha), Dahal (0.9ha)

Sowing date for wheat: tow levels
1 Sowing of november
2 Sowing of december

Herbicide application for the three crops: 4 levels
•T0: CHECK not weeded;
•T1: Weeding Glyphosate only;
•T2: Glyphosate weeding + Early weed control at three-leaf stage;
•T3: Glyphosate weeding + Early weed control at three-leaf stage + Remedial Spring weeding

•**Notation on weeds**
•Identification of weeds before each weeding ;
•Level of infestation and density of weeds / m² in the plots by dicots and monocots before any chemical kind weed control;
•Level of infestation and density of weeds / m² in the plot s by dicots and monocots after 20 days, 3 and 6 weeks after each weeding;

Notations on crop
•Number of emerged plants / m²
•Observation on seedling vigor;
•Yield and yield components

Results

The level of weed infestation is verry imortant in the fore sites 178.5 and 236.2 plt/m²

The application of Glyphosate before sowing contributed significantly in reducing *Bromus rigidus* population , the decreasing can reach 9% comparing with the plots not teated with Glyphosate T0 because the application coincided withe the small stage of this spicies , Because of their late emergence *Veronica* spp, *Sonchus oleraceus, polygonum* species escaped to the effect of Glyphosate

Veronica sp is not controled by all the traitement in different sites and in differente crops

- Application of glyphosate only allows **40%** of weeds populationt reduction ;
- Application of Glyphosate + Early weed control at three-leaf stage reduces **60 to 80%** of weeds population until April (new emergence of weeds);
- Application of Glyphosate + Early weed control at three-leaf stage + Remedial Spring weeding allows **90%** of weed population reduction

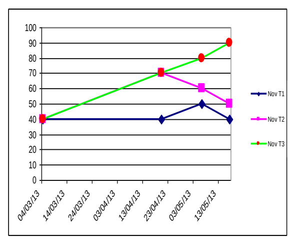


Figure #3 % of decreasing weeds density in relation with herbicide control for sowing of november (TABHIRT site)

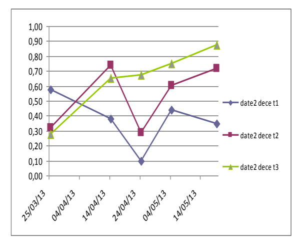


Figure #4 % of decreasing weeds density in relation with herbicide control for sowing of December(Khababa site)

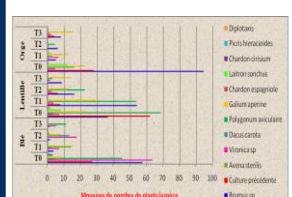


Figure #5 Main weed:species recorded in khababa experimental site

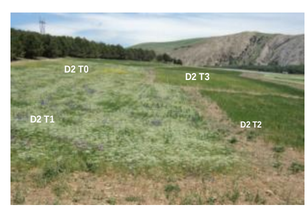


Figure #6 weeds infestation in no treated plots Tabhirt Site

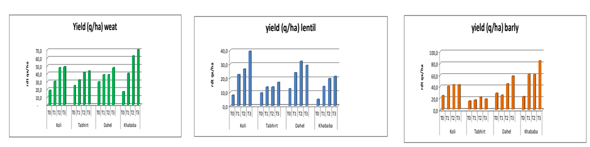


Figure #7 evolution of wheat ; lentil and barley yield in relation with herbicide control treatments in the fore site

Figure #8 pignut weed with it tuber escaped to herbicide treatments

Figure #9 Grass weeds treatment in Lentil

Conclusion

The study of the dynamics of weeds (emergence, populations and growth) in the aim to develop an integrated management of weeds in CA system for this cropping season showed the major importance of the use of chemical products although before and after plants emergence
The perception of crop rotation effects is still earlier and needs repeating trials for collecting data on weed population evolution